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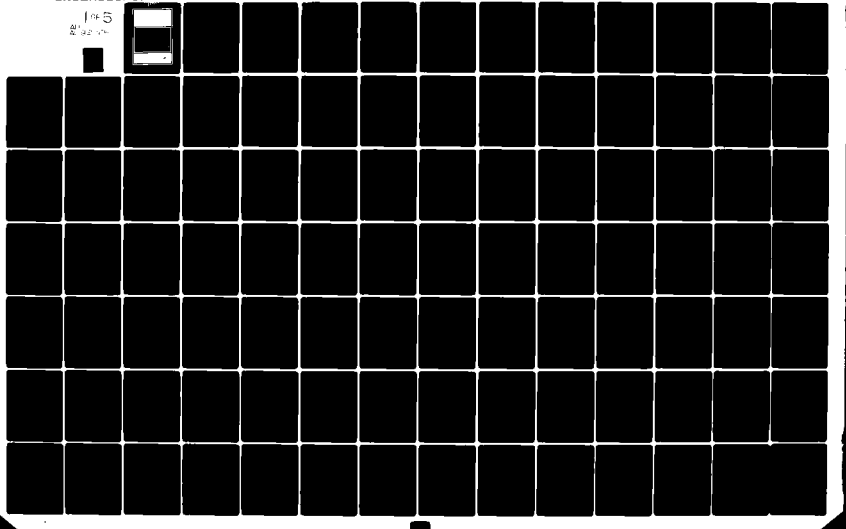

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ADVISORY GROUP FOR AEROSPACE RESEARCH AND DEVELOPMENT

(ORGANISATION DU TRAITE DE L'ATLANTIQUE NORD)

(6) AGARD INDEX OF PUBLICATIONS

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- Exchanging of scientific and technical information;
- Continuously stimulating advances in the aerospace sciences relevant to strengthening the common defence posture;
- Improving the co-operation among member nations in aerospace research and development;
- Providing scientific and technical advice and assistance to the North Atlantic Military Committee in the field of aerospace research and development;
- Rendering scientific and technical assistance, as requested, to other NATO bodies and to member nations in connection with research and development problems in the aerospace field;
- Providing assistance to member nations for the purpose of increasing their scientific and technical potential;
- Recommending effective ways for the member nations to use their research and development capabilities for the common benefit of the NATO community.

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PREFACE

This volume provides abstracts and indexes for AGARD publications published during the period 1977 - 1979. By an arrangement with the U.S. National Aeronautics and Space Administration (NASA) in Washington, the NASA computerized data base has been used to prepare this publication.

Full bibliographic citations and abstracts for all the documents in this publication are given in the abstract section, which is organized in the major subject divisions and specific categories used by NASA in its abstract journals and bibliographies. The major subject divisions are listed in the Table of Contents, together with a note for each that defines its scope and provides any cross-references. Category breaks in the abstract section are identified by category number and title, and a scope note. Within each category, the abstracts are arranged by series and year. Items from *Scientific and Technical Aerospace Reports (STAR)* appear before the unclassified items of limited circulation and the classified documents (entries here are unclassified). Examples of the typical citations with abstracts are given following the Table of Contents.

There are five indexes: Subject (based on *NASA Thesaurus* nomenclature); Personal Author; Corporate Source; Report/Accession Number; and Accession/Report Number. Sample entries are shown on the first page of each index.

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Part 1: Abstracts

AERONAUTICS

Includes aeronautics (general); aerodynamics; air transportation and safety; aircraft communications and navigation; aircraft design, testing and performance; aircraft instrumentation; aircraft propulsion and power; aircraft stability and control; and research and support facilities (air).

For related information see also *Astronautics*.

01 AERONAUTICS (GENERAL) 1

02 AERODYNAMICS 35
Includes aerodynamics of bodies, combinations, wings, rotors, and control surfaces; and internal flow in ducts and turbomachinery.
For related information see also *34 Fluid Mechanics and Heat Transfer*.

03 AIR TRANSPORTATION AND SAFETY 44
Includes passenger and cargo air transport operations; and aircraft accidents.
For related information see also *16 Space Transportation* and *85 Urban Technology and Transportation*.

04 AIRCRAFT COMMUNICATIONS AND NAVIGATION 47
Includes digital and voice communication with aircraft; air navigation systems (satellite and ground based); and air traffic control.
For related information see also *17 Spacecraft Communications, Command and Tracking* and *32 Communications*.

05 AIRCRAFT DESIGN, TESTING AND PERFORMANCE 59
Includes aircraft simulation technology.
For related information see also *18 Spacecraft Design, Testing and Performance* and *39 Structural Mechanics*.

06 AIRCRAFT INSTRUMENTATION 73
Includes cockpit and cabin display devices; and flight instruments.
For related information see also *19 Spacecraft Instrumentation* and *35 Instrumentation and Photography*.

07 AIRCRAFT PROPULSION AND POWER 74
Includes prime propulsion systems and systems components, e.g., gas turbine engines and compressors; and on-board auxiliary power plants for aircraft.
For related information see also *20 Spacecraft Propulsion and Power*, *28 Propellants and Fuels*, and *44 Energy Production and Conversion*.

08 AIRCRAFT STABILITY AND CONTROL 97
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09 RESEARCH AND SUPPORT FACILITIES (AIR) 117
Includes airports, hangars and runways; aircraft repair and overhaul facilities; wind tunnels; shock tube facilities; and engine test blocks.
For related information see also *14 Ground Support Systems and Facilities (Space)*.

ASTRONAUTICS

Includes astronautics (general); astrodynamics; ground support systems and facilities (space); launch vehicles and space vehicles; space transportation; spacecraft communications, command and tracking; spacecraft design, testing and performance; spacecraft instrumentation; and spacecraft propulsion and power.

For related information see also *Aeronautics*.

12 ASTRONAUTICS (GENERAL) N.A.
For extraterrestrial exploration see *91 Lunar and Planetary Exploration*.

13 ASTRODYNAMICS N.A.
Includes powered and free-flight trajectories; and orbit and launching dynamics.

14 GROUND SUPPORT SYSTEMS AND FACILITIES (SPACE) N.A.
Includes launch complexes, research and production facilities; ground support equipment, e.g., mobile transporters; and simulators.
For related information see also *09 Research and Support Facilities (Air)*.

15 LAUNCH VEHICLES AND SPACE VEHICLES 122
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16 SPACE TRANSPORTATION N.A.
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17 SPACECRAFT COMMUNICATIONS, COMMAND AND TRACKING N.A.
Includes telemetry; space communications networks; astronavigation; and radio blackout.
For related information see also *04 Aircraft Communications and Navigation* and *32 Communications*.

18 SPACECRAFT DESIGN, TESTING AND PERFORMANCE N.A.
Includes spacecraft thermal and environmental control; and attitude control.
For life support systems see *54 Man/System Technology and Life Support*. For related information see also *05 Aircraft Design, Testing and Performance* and *39 Structural Mechanics*.

19 SPACECRAFT INSTRUMENTATION **N.A.**
For related information see also *06 Aircraft Instrumentation* and *35 Instrumentation and Photography*.

20 SPACECRAFT PROPULSION AND POWER **124**
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For related information see also *07 Aircraft Propulsion and Power, 28 Propellants and Fuels,* and *44 Energy Production and Conversion*.

CHEMISTRY AND MATERIALS

Includes chemistry and materials (general); composite materials; inorganic and physical chemistry; metallic materials; nonmetallic materials; and propellants and fuels.

23 CHEMISTRY AND MATERIALS (GENERAL) **N.A.**
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24 COMPOSITE MATERIALS **129**
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25 INORGANIC AND PHYSICAL CHEMISTRY **N.A.**
Includes chemical analysis, e.g., chromatography; combustion theory; electrochemistry; and photochemistry.
For related information see also *77 Thermodynamics and Statistical Physics*.

26 METALLIC MATERIALS **130**
Includes physical, chemical, and mechanical properties of metals, e.g., corrosion; and metallurgy.

27 NONMETALLIC MATERIALS **N.A.**
Includes physical, chemical, and mechanical properties of plastics, elastomers, lubricants, polymers, textiles, adhesives, and ceramic materials.

28 PROPELLANTS AND FUELS **131**
Includes rocket propellants, igniters, and oxidizers; storage and handling; and aircraft fuels.
For related information see also *07 Aircraft Propulsion and Power, 20 Spacecraft Propulsion and Power,* and *44 Energy Production and Conversion*.

ENGINEERING

Includes engineering (general); communications; electronics and electrical engineering; fluid mechanics and heat transfer; instrumentation and photography; lasers and masers; mechanical engineering; quality assurance and reliability; and structural mechanics.
For related information see also *Physics*.

31 ENGINEERING (GENERAL) **133**
Includes vacuum technology; control engineering; display engineering; and cryogenics.

32 COMMUNICATIONS **155**
Includes land and global communications; communications theory; and optical communications.
For related information see also *04 Aircraft Communications and Navigation* and *17 Spacecraft Communications, Command and Tracking*.

33 ELECTRONICS AND ELECTRICAL ENGINEERING **N.A.**
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34 FLUID MECHANICS AND HEAT TRANSFER **186**
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For related information see also *02 Aerodynamics* and *77 Thermodynamics and Statistical Physics*.

35 INSTRUMENTATION AND PHOTOGRAPHY **N.A.**
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For aerial photography see *43 Earth Resources*. For related information see also *06 Aircraft Instrumentation* and *19 Spacecraft Instrumentation*.

36 LASERS AND MASERS **N.A.**
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37 MECHANICAL ENGINEERING **193**
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38 QUALITY ASSURANCE AND RELIABILITY **195**
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39 STRUCTURAL MECHANICS **205**
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GEOSCIENCES

Includes geosciences (general); earth resources; energy production and conversion; environment pollution; geophysics; meteorology and climatology; and oceanography.
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42 GEOSCIENCES (GENERAL) **215**

43 EARTH RESOURCES 218
Includes remote sensing of earth resources by aircraft and spacecraft; photogrammetry; and aerial photography.
For instrumentation see *35 Instrumentation and Photography*.

44 ENERGY PRODUCTION AND CONVERSION 220
Includes specific energy conversion systems, e.g., fuel cells and batteries; global sources of energy; fossil fuels; geophysical conversion; hydroelectric power; and wind power.
For related information see also *07 Aircraft Propulsion and Power, 20 Spacecraft Propulsion and Power, 28 Propellants and Fuels,* and *85 Urban Technology and Transportation*.

45 ENVIRONMENT POLLUTION N.A.
Includes air, noise, thermal and water pollution; environment monitoring; and contamination control.

46 GEOPHYSICS 221
Includes aeronomy; upper and lower atmosphere studies; ionospheric and magnetospheric physics; and geomagnetism.
For space radiation see *93 Space Radiation*.

47 METEOROLOGY AND CLIMATOLOGY N.A.
Includes weather forecasting and modification.

48 OCEANOGRAPHY N.A.
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LIFE SCIENCES

Includes life sciences (general); aerospace medicine; behavioral sciences; man/system technology and life support; and planetary biology.

51 LIFE SCIENCES (GENERAL) 222
Includes genetics.

52 AEROSPACE MEDICINE 235
Includes physiological factors, biological effects of radiation; and weightlessness.

53 BEHAVIORAL SCIENCES 249
Includes psychological factors, individual and group behavior; crew training and evaluation, and psychiatric research.

54 MAN/SYSTEM TECHNOLOGY AND LIFE SUPPORT 250
Includes human engineering, biotechnology, and space suits and protective clothing.

55 PLANETARY BIOLOGY N.A.
Includes exobiology; and extraterrestrial life.

MATHEMATICAL AND COMPUTER SCIENCES

Includes mathematical and computer sciences (general); computer operations and hardware; computer programming and software; computer systems; cybernetics; numerical analysis; statistics and probability; systems analysis; and theoretical mathematics.

59 MATHEMATICAL AND COMPUTER SCIENCES (GENERAL) 260

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61 COMPUTER PROGRAMMING AND SOFTWARE N.A.
Includes computer programs, routines, and algorithms.

62 COMPUTER SYSTEMS N.A.
Includes computer networks.

63 CYBERNETICS N.A.
Includes feedback and control theory.
For related information see also *54 Man/System Technology and Life Support*.

64 NUMERICAL ANALYSIS N.A.
Includes iteration, difference equations, and numerical approximation.

65 STATISTICS AND PROBABILITY N.A.
Includes data sampling and smoothing; Monte Carlo method; and stochastic processes.

66 SYSTEMS ANALYSIS N.A.
Includes mathematical modeling; network analysis; and operations research.

67 THEORETICAL MATHEMATICS N.A.
Includes topology and number theory.

PHYSICS

Includes physics (general); acoustics; atomic and molecular physics; nuclear and high-energy physics; optics, plasma physics, solid-state physics; and thermodynamics and statistical physics.
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70 PHYSICS (GENERAL) N.A.
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71 ACOUSTICS 268
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72 ATOMIC AND MOLECULAR PHYSICS N.A.
Includes atomic structure and molecular spectra.

73 NUCLEAR AND HIGH-ENERGY PHYSICS N.A.
Includes elementary and nuclear particles; and reactor theory.
For space radiation see *93 Space Radiation*.

74 OPTICS 271
Includes light phenomena.

75 PLASMA PHYSICS N.A.
Includes magnetohydrodynamics and plasma fusion.
For ionospheric plasmas see *46 Geophysics*. For space plasmas see *90 Astrophysics*.

76 SOLID-STATE PHYSICS N.A.
Includes superconductivity.
For related information see also *33 Electronics and Electrical Engineering* and *36 Lasers and Masers*.

77 THERMODYNAMICS AND STATISTICAL PHYSICS N.A.
Includes quantum mechanics; and Bose and Fermi statistics.
For related information see also *25 Inorganic and Physical Chemistry* and *34 Fluid Mechanics and Heat Transfer*.

SOCIAL SCIENCES

Includes social sciences (general); administration and management; documentation and information science; economics and cost analysis; law and political science; and urban technology and transportation.

80 SOCIAL SCIENCES (GENERAL) N.A.
Includes educational matters.

81 ADMINISTRATION AND MANAGEMENT 277
Includes management planning and research.

82 DOCUMENTATION AND INFORMATION SCIENCE 278
Includes information storage and retrieval technology; micrography; and library science.
For computer documentation see *61 Computer Programming and Software*.

83 ECONOMICS AND COST ANALYSIS N.A.
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84 LAW AND POLITICAL SCIENCE N.A.
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85 URBAN TECHNOLOGY AND TRANSPORTATION 284
Includes applications of space technology to urban problems; technology transfer; technology assessment; and surface and mass transportation.
For related information see *03 Air Transportation and Safety*, *16 Space Transportation*, and *44 Energy Production and Conversion*.

SPACE SCIENCES

Includes space sciences (general); astronomy; astrophysics; lunar and planetary exploration; solar physics; and space radiation.
For related information see also *Geosciences*.

88 SPACE SCIENCES (GENERAL) N.A.

89 ASTRONOMY N.A.
Includes radio and gamma-ray astronomy; celestial mechanics; and astrometry.

90 ASTROPHYSICS N.A.
Includes cosmology; and interstellar and interplanetary gases and dust.

91 LUNAR AND PLANETARY EXPLORATION N.A.
Includes planetology; and manned and unmanned flights.
For spacecraft design see *18 Spacecraft Design, Testing and Performance*. For space stations see *15 Launch Vehicles and Space Vehicles*.

92 SOLAR PHYSICS N.A.
Includes solar activity, solar flares, solar radiation and sunspots.

93 SPACE RADIATION N.A.
Includes cosmic radiation; and inner and outer earth's radiation belts.
For biological effects of radiation see *52 Aerospace Medicine*. For theory see *73 Nuclear and High-Energy Physics*.

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99 GENERAL 285

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TYPICAL CITATIONS AND ABSTRACTS

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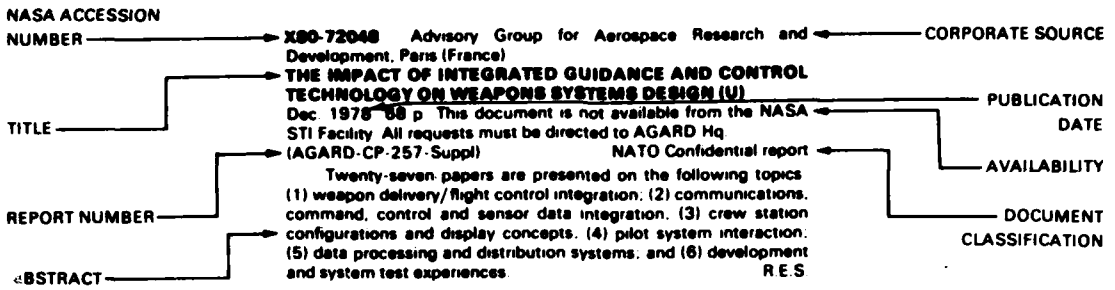

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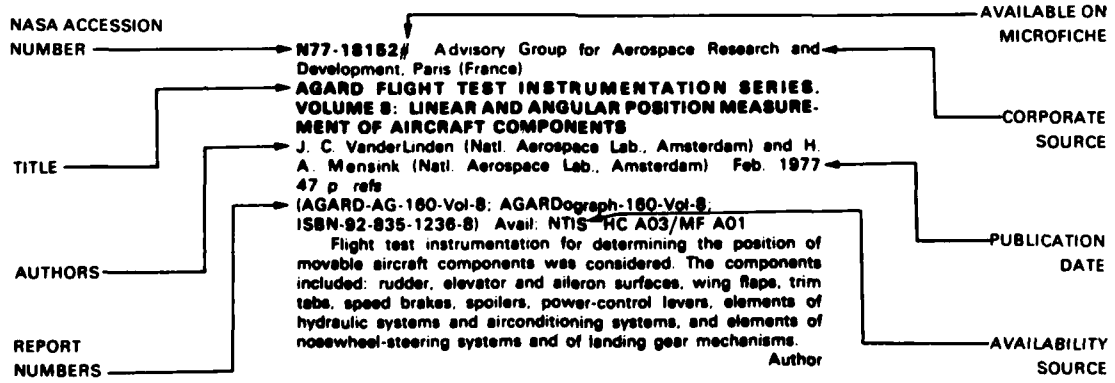

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ABSTRACT SECTION

01 AERONAUTICS (GENERAL)

N77-18994# Advisory Group for Aerospace Research and Development, Paris (France)
AERODYNAMIC NOISE
Jan. 1977 306 p refs Presented at the Von Karman Inst., Rhode St. Genese, Belgium, Dec. 1976
(AGARD-LS-80) Avail: NTIS HC A14/MF A01

An appraisal of aerodynamic noise concepts, theory, and experiments is given. Practical methods are given for the prediction, measurement, and reduction of external noise from aircraft. A bibliography of 171 abstracts is included. For individual titles, see N77-18995 through N77-19005.

N77-18995# Royal Aircraft Establishment, Farnborough (England). *Aerodynamic Dept.*
INTRODUCTORY COMMENTS ON AERODYNAMIC NOISE CONSIDERATIONS IN AIRCRAFT DESIGN AND OPERATION
John Williams *In* AGARD Aerodynamic Noise, Jan. 1977 10 p (For primary document see N77-18994 10-01)
Avail: NTIS HC A14/MF A01

Engine design, airframe design, aircraft flight performance, and engine/airframe aeroacoustic interference must be analyzed with a significant bias towards the reduction of noise annoyance on the ground caused by takeoff, landing, and other low altitude subsonic operations. The static specific thrust is discussed as a *more comprehensive engine cycle parameter* than the bypass ratio. Aerodynamic noise reduction in turbofan engines is explored. Author

N77-18996# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Berlin (West Germany). Institut fuer Turbulenzforschung
BASIC AERODYNAMIC NOISE THEORY
Helmut V. Fuchs *In* AGARD Aerodynamic Noise, Jan. 1977 26 p refs (For primary document see N77-18994 10-01)
Avail: NTIS HC A14/MF A01

The identification of and physical and analytical modeling of the major sound sources associated with turbulent airflows are discussed. Deficiencies of existing theories with respect to the turbulent source models used are revealed. The importance of *source coherency with regard to flow inhomogeneities is outlined.* The relevance of studies in sound propagation from acoustic singularities embedded in a sheared flow is explored with respect to the jet noise problem. Author

N77-18997# Southampton Univ. (England). Institute of Sound and Vibration Research
JET NOISE
M. J. Fisher and C. L. Morfey *In* AGARD Aerodynamic Noise, Jan. 1977 23 p refs (For primary document see N77-18994 10-01)
Avail: NTIS HC A14/MF A01

Total noise is composed of several components which must be considered separately. The most fundamental of these, and the most difficult to eliminate is jet mixing noise. In incorrectly expanded jet exhaust flows, the presence of resulting shock waves leads to a set of discrete tones referred to as screech, together with a more broad band radiation. The advent of high bypass ratio, relatively low jet efflux velocity engines reveals additional sources of noise, variously referred to as excess noise, tailpipe noise, or core noise. Each of the noise components is reviewed for consideration in determining whether the shock associated noise is generated within the engine or originates as the result of interaction between vorticity and the nozzle termination. Author

N77-18998# Rolls-Royce Ltd., Derby (England).
GAS TURBINE ENGINE EXHAUST NOISE
Kenneth W. Bushell *In* AGARD Aerodynamic Noise, Jan. 1977 35 p refs (For primary document see N77-18994 10-01)
Avail: NTIS HC A14/MF A01

The sources of noise which emanates from the exhaust of a gas turbine engine are reviewed. The most important of these are considered to be associated with the combustion system, the turbine, the exhaust system, obstructions, and turbulence/noise interaction with the jet structure. Also considered is the jet mixing noise due to single and coaxial streams. Prediction methods for these sources are given and reviewed. Reflections from the ground are also discussed because of the influence these can have in the lower frequency part of the spectrum. The effects of flight or forward speed on these noise sources are considered. Author

N77-18999# Rolls-Royce Ltd., Derby (England).
FAN NOISE
B. W. Lowrie *In* AGARD Aerodynamic Noise, Jan. 1977 21 p refs (For primary document see N77-18994 10-01)
Avail: NTIS HC A14/MF A01

Spectral and radiative properties of aeroengine fan-generated noise are described statistically and, wherever possible, in flight. Basic concepts and theoretical approaches are considered, including dimensional analysis and features of the sources deduced. It is found that fans produce both tonal and random noise. While the sources of the tonal noise are several, they can be defined quite specifically, and consist in the main of regular lift fluctuations created on individual blades by inflowing distortions. For the exceptional case of supersonic relative velocity the tonal noise is dominated by the steady pressure field relative to the blade row becoming, at high supersonic speeds, a shockwave-expansion pattern. The significant sources of broad band noise are less well defined but could be produced equally well by self-excited phenomena on blade rows as by fluctuations in the inflowing airstream. Author

N77-19000*# National Aeronautics and Space Administration, Langley Research Center, Langley Station, Va.
AIRPLANE SELF-NOISE - FOUR YEARS OF RESEARCH

Jay C. Hardin *In* AGARD Aerodynamic Noise, Jan. 1977 19 p refs (For primary document see N77-18994 10-01)
Avail: NTIS HC A14/MF A01

A critical assessment of the state of the art in airframe self-noise is presented. Full-scale data on the intensity, spectra, and directivity of this noise source are evaluated. Vibration of panels on the aircraft is identified as a possible additional source of airframe noise. The present understanding and methods for prediction of other component sources (airfoils, struts, and cavities) are discussed, and areas for further research as well as potential methods for airframe noise reduction are identified. Various experimental methods which have been developed for airframe *noise research are discussed, and sample results are presented.* Author

NOTICE

The single asterisk following the accession number indicates that the report is NASA sponsored.

N77-19001# Southampton Univ (England) Institute for Sound and Vibration Research.
AERO-ACOUSTIC MEASUREMENT AND ANALYSIS TECHNIQUES
Michael E House *In* AGARD Aerodynamic Noise, Jan 1977 48 p refs (For primary document see N77-18994 10-01)
Avail NTIS HC A14/MF A01

The main source characteristics for aerodynamically generated multipoles are summarized. Information theory is applied with respect to data acquisition rates, signal information, and transformations Data collection, test environment, instrumentation, storage and display, signal analysis, and specialized measurement techniques are discussed Author

N77-19002# Southampton Univ. (England). Inst. for Sound and Vibration Research
AIRCRAFT FLYOVER MEASUREMENTS
Michael E House *In* AGARD Aerodynamic Noise, Jan 1977 14 p refs (For primary document see N77-18994 10-01)
Avail NTIS HC A14/MF A01

Influences of in-flight conditions on aircraft engine noise are discussed. Topics include engine cycle conditions, intake flow, aircraft and nacelle aerodynamic flow, convected motion effects, Doppler source-to-receiver effects, aircraft attitudinal and atmospheric or ground propagation effects The aircraft's relative motion must be determined and tracked to the measuring position on the ground. Author

N77-19003# Office National d'Etudes et de Recherches *Aerospatiales, Paris (France).*
COMPARISON OF DIFFERENT METHODS OF LOCALISATION AND IDENTIFICATION OF NOISE SOURCES IN TURBOJET ENGINES [COMPARISON DE DIFFERENTES METHODS DE LOCALISATION ET D'IDENTIFICATION DE SOURCES SONORES DE TURBOREACTEURS]
Mariano Perulli *In* AGARD Aerodynamic Noise, Jan. 1977 13 p refs In FRENCH (For primary document see N77-18994 10-01)
Avail: NTIS HC A14/MF A01

Techniques developed for measuring and processing the signals from turbojet engine noise are discussed. Special emphasis is given to those concerned with measuring near and far pressure fields. The source media is characterized, and a virtual distribution of noise sources is furnished. In rare cases, these investigations lead to a real distribution of the noise sources. Trans. by A.R.H.

N77-19004# Royal Aircraft Establishment, Farnborough (England).
GROUND-BASED FACILITIES WITH FORWARD-SPEED REPRESENTATION FOR AIRCRAFT NOISE RESEARCH

John Williams *In* AGARD Aerodynamic Noise, Jan. 1977 43 p refs (For primary document see N77-18994 10-01)
Avail: NTIS HC A14/MF A01

The special merits, deficiencies, and problem areas arising with several particular types of ground based facilities are analyzed and quantified in basic practical terms. The complementary usage of more than one facility type is shown to be desirable to ensure checks on each other, and to widen the range of experiments possible. Topics discussed include: (1) subsonic windtunnel development and operation for noise testing; (2) special factors in acoustic tunnel design and application; (3) tracked vehicle development and operation for noise model testing; (4) other mobile ground based facilities for noise testing; and (5) model scale simulation of propulsion and powered lift noise sources. Author

N77-19005# Advisory Group for Aerospace Research and Development, Paris (France).
A BIBLIOGRAPHY OF SELECTED LITERATURE PUBLISHED BETWEEN 1973 AND 1976 WITH EMPHASIS ON EXPERIMENTAL STUDIES
In its Aerodynamic Noise, Jan 1977 46 p refs (For primary document see N77-18994 10-01)
Avail NTIS HC A14/MF A01

One hundred seventy-one abstracts are presented from Scientific and Technical Aerospace Reports (STAR) and from International Aerospace Abstracts (IAA). Categories are (1) aerodynamic sound (general reviews), (2) measurement techniques, (3) jet noise, (4) noise associated with lift augmentation devices, (5) airframe noise, (6) fan noise, and (7) noise prediction A.H.

N77-19990# Advisory Group for Aerospace Research and Development, Paris (France)
PREDICTION OF AERODYNAMIC LOADING
Feb 1977 330 p refs Conf. Proc. of the Fluid Dynamics Panel Symp., NASA Ames Research Center, Moffett Field, Calif., 27-29 Sep 1976
(AGARD-CP-204, ISBN-92-835-1238-4) Avail NTIS HC A15/MF A01

Theoretical and semiempirical methods for determining expected aerodynamical loads and comparison with experimental data from wind tunnels or flight tests For individual titles, see N77-19991 through N77-20016

N77-19991# Hawker Siddeley Aviation Ltd., Kingston upon Thames (England)
EXAMPLES OF LOAD PREDICTION DIFFICULTIES
C. L. Bore *In* AGARD Prediction of Aerodynamic Loading Feb 1977 6 p refs (For primary document see N77-19990 11-01)
Avail NTIS HC A15/MF A01

An interactive engine surge example of load prediction is used to show how novel design features cause major prediction problems It is also shown that loads due to pressure fluctuations under separate boundary layer conditions, loads arising from uncommanded maneuvers, control actions of pilots that dominate the fatigue spectrum, and various aspects of fin loads are difficult to predict G.G.

N77-19992# Vereinigte Flugtechnische Werke-Fokker G.m.b.H., Bremen (West Germany) Dept. of Aerodynamics
SECTIONAL LOADS TECHNIQUE. PART 1: TEST TECHNIQUE. PART 2: TEST RESULTS
H. P. Franz and B. Ewald *In* AGARD Prediction of Aerodynamic Loading Feb 1977 16 p refs (For primary document see N77-19990 11-01)
Avail: NTIS HC A15/MF A01

A sectional load model technique is reported that measures aerodynamic loads of nearly arbitrarily split sections of the wind tunnel model separately by means of strain gage balances This method provides both the overall aerodynamic loads acting on the model and the integral partial loads acting on those structural components of the airplane which are of particular interest for the design of the aircraft G.G.

N77-19993# Royal Netherlands Aircraft Factories Fokker, Schiphol-Oost Dept. of Aerodynamics
PREDICTION OF AERODYNAMIC LOADINGS ON THE LEADING-EDGE SLATS OF THE FOKKER F 28 AIRLINER

In AGARD Prediction of Aerodynamic Loading Feb 1977 13 p (For primary document see N77-19990 11-01)
Avail: NTIS HC A15/MF A01

Prediction of aerodynamic loadings on leading edge slats of modern airliners is considered Component load data are specified, which are based on wind tunnel data, test conditions thereof cover only a part of the complete field This discrepancy is bridged by data extrapolation Determination at the relevant conditions of more realistic loadings is an elaborate second phase of the prediction process The whole procedure is illustrated for the slats, introduced on later versions of the F 28 airliner, with some discussion on problems for that particular case Author

N77-19994# British Columbia Univ., Vancouver Dept. of Mechanical Engineering
PREDICTION OF AERODYNAMIC EFFECTS OF SPOILERS ON WINGS

G. V Parkinson and P Tam Doo *In* AGARD Prediction of Aerodynamic Loading Feb 1977 9 p refs (For primary document see N77-19990 11-01)
Avail: NTIS HC A15/MF A01

The prediction of aerodynamic loading on two dimensional airfoils with spoilers is extended to an experimental study of effects of base venting on two-dimensional spoiler performance, and to a theoretical and experimental study of effects of finite span of spoilers and wings. The effects of realistic amounts of base venting on lift and pressure distribution proved small, so that unvented spoiler theory can be used with acceptable accuracy. Lifting line theory, requiring the sectional values of lift curve slope and zero lift angle as inputs, was used for the finite span study, and the theoretical predictions were compared with experimental data from reflection plane wind tunnel tests. Results are presented for lift and rolling moment, and agreement is good. The overall result is that the performance of finite span, base vented spoilers on finite span wings can be predicted with acceptable accuracy, with only the spoiler base pressure as an empirical input. Author

N77-19995# Vought Corp., Dallas, Tex. Systems Div.
A TECHNIQUE FOR PREDICTING EXTERNAL STORE AERODYNAMIC LOADS
A. R. Rudnicki, Jr., E. G. Waggoner, Jr., and R. D. Gallagher *In* AGARD Prediction of Aerodynamic Loading Apr 1977 13 p refs (For primary document see N77-19990 11-01)
Avail: NTIS HC A15/MF A01

A technique has been developed for predicting six-component airloads on captive stores for single and multiple carriage configurations. The prediction method includes techniques for predicting the basic airload as well as the incremental airloads due to aircraft yaw and adjacent store interference. The single carriage prediction technique is valid for the Mach number range 0.5 to 2.0 while the multiple carriage technique was developed for the Mach range 0.5 to 1.6. The basic approach to the prediction technique was an empirical correlation of a large experimental data base consisting of literature survey data and data obtained from a parametric wind tunnel test. Author

N77-19996# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick (West Germany). Institut fuer Aerodynamik
PREDICTION OF EXTERNAL STORES AND TIP-TANK LOADS ON WING-FUSELAGE CONFIGURATIONS
S. R. Ahmed *In* AGARD Prediction of Aerodynamic Loading Feb 1977 18 p refs (For primary document see N77-19990 11-01)
Avail: NTIS HC A15/MF A01

An evaluation of a first order panel method to predict the six component aerodynamic forces and moment on captive stores and tip-tanks mounted on a wing-fuselage configuration is presented. The method has been tested on two accounts: prediction of surface pressure distribution, and estimation of the resulting forces and moments. The main investigation dealt with three geometric parameters: store chordwise and spanwise location below the wing, and the wing mid-chord sweep. Influence of Mach number was investigated separately over a range of 0 to 0.9. Store/pylon/fin and wing/tip-tank interactions were studied on basis of calculated surface flow patterns. The method was next applied to calculate the forces and moments acting on an extreme forward, central and extreme rearward located tip-tank on the swept wing-fuselage configuration. Comparisons between wind tunnel data and results of inviscid flow analysis are included for high subsonic speeds. Author

N77-19997# Saab-Scania, Linkoping (Sweden)
COMPARISON OF PREDICTED AERODYNAMIC LOADING WITH FLIGHT TEST RESULTS
Jan Kloos *In* AGARD Prediction of Aerodynamic Loading Feb 1977 7 p refs (For primary document see N77-19990 11-01)
Avail: NTIS HC A15/MF A01

Four load prediction problems of the more intricated kind are considered. In the first three cases, prediction of loads on wing mounted external stores during rolling pull-outs, prediction of fin loads during fast rolling maneuvers, effect of airframe elasticity on load distribution, it is shown how wind tunnel data, combined with fairly simple computation procedures, provide adequate load predictions that are in good agreement with flight test results. Results from the first stage of a flight test program to study loads due to encounter with wing-tip vortices from aircraft at high load factors are shown. Author

N77-19998# Systems Research Labs., Inc., Newport News, Va. RASA Division.
WING-VORTEX LIFT AT HIGH ANGLES OF ATTACK
Richard P. White, Jr. *In* AGARD Prediction of Aerodynamic Loading Feb. 1977 12 p refs (For primary document see N77-19990 11-01)
(Contract N00014-74-C-0091)
Avail: NTIS HC A15/MF A01

It has been determined that the maximum lift generated by a low aspect ratio swept wing can be increased by 60 percent due to the suction and induced effects of attached vortex flows. The manner in which the vortex flows effect the performance characteristics of the lifting surface is discussed in terms of the measured performance characteristics, surface pressure distribution and the results of flow visualization studies. Methods of further enhancing the performance characteristics of low aspect ratio wings by means of controlled vortex flows are discussed briefly. In addition, the correlation of theoretical predictions based on a refined theoretical analysis technique with experimental results is presented. Author

N77-19999# Lockheed-Georgia Co., Marietta
VORTEX/JET/WING INTERACTION BY VISCOUS NUMERICAL ANALYSIS
R. M. Scruggs (Sybucon, Inc.), J. F. Nash (Sybucon, Inc.), and Charles J. Dixon *In* AGARD Prediction of Aerodynamic Loading Feb 1977 12 p refs Sponsored by the Office of Naval Research (For primary document see N77-19990 11-01)
Avail: NTIS HC A15/MF A01

A computational model has been developed for analyzing the flow mechanism of vortex/wing/jet interactions. The model is applicable to a wide class of viscous flows but is particularly suitable for calculating vortex-type flows near no-slip or solid boundaries. Examples are leading edge vortices formed on highly swept delta wings or on moderately swept wings with active control by jets or passive control by strakes. The model is based on reducing the full Navier-Stokes equations to parabolic form with respect to one of the three space coordinates. Examples of computations for various vortex/wing/jet interactions are presented. Experimental pressure, laser velocimeter, and flow visualization data are presented for an unswept wing with leading edge vortex control by spanwise blowing. These data are used to analyze the formation and strength of the leading edge vortex and as examples of typical input/output data for the computational model. Author

N77-20000# National Aeronautics and Space Administration Langley Research Center, Langley Station, Va.
COMPARISONS OF THEORETICAL AND EXPERIMENTAL PRESSURE DISTRIBUTIONS ON AN ARROW-WING CONFIGURATION AT SUBSONIC, TRANSONIC, AND SUPERSONIC SPEEDS
Marjorie E. Manro (Boeing Commercial Airplane Co., Seattle), Percy J. Bobbitt, and John T. Rogers (Boeing Commercial Airplane Co., Seattle) *In* AGARD Prediction of Aerodynamic Loading Feb 1977 14 p refs (For primary document see N77-19990 11-01)
Avail: NTIS HC A15/MF A01

A wind tunnel test of an arrow wing body configuration consisting of flat and twisted wings, as well as a variety of leading- and trailing-edge control surface deflection has been conducted at Mach numbers from 0.40 to 2.50 to provide an experimental data base for comparison with theoretical methods. Theory-to-experiment comparisons of detailed pressure distributions have been made using current state-of-the-art attached- and separated-flow methods. The purpose of these comparisons was to delineate conditions under which these theories are valid for aeroelastic calculations and to explore the use of empirical methods to correct the theoretical methods where theory is deficient. It was determined that current state-of-the-art attached flow and empirical methods were inadequate to predict aeroelastic loads for this configuration. Author

N77-20001# Politecnico di Torino (Italy) Istituto di Macchine e Motori per Aeromobili.

THREE DIMENSIONAL SUPERSONIC FLOW ABOUT SLICED BODIES

Guido Colasurdo and Maurizio Pandolfi *In* AGARD Prediction of Aerodynamic Loading Feb 1977 7 p refs (For primary document see N77-19990 11-01)

Avail NTIS HC A15/MF A01

Three dimensional supersonic flows about aircrafts or reentry vehicles are computed by a marching technique along the body axis. Beside the well known features of these flows (3D bow and imbedded shocks, entropy layers, etc.) difficulties arise when the body surface presents lines of discontinous variations of its slope. It is shown that the numerical prediction of the pressure at the body comes out quite wrong if the slope discontinuities of the surface of the body are not taken in the proper consideration. A methodology is given in order to implement easily the capabilities of existing computer programs in case of these kinds of bodies. It is based on the explicit computation of the flow properties on the two sides of the discontinuity at the body by using there a local analysis. Author

N77-20002# National Aeronautical Establishment, Ottawa (Ontario).

A METHOD FOR ESTIMATING THE LOADING DISTRIBUTION ON LONG SLENDER BODIES OF REVOLUTION AT HIGH ANGLES OF ATTACK IN INCOMPRESSIBLE FLOW

E. Atraghji *In* AGARD Prediction of Aerodynamic Loading Feb. 1977 20 p refs (For primary document see N77-19990 11-01)

Avail NTIS HC A15/MF A01

The three dimensional flow over long slender bodies of revolution at high angles of attack is treated by relating it to the oscillatory two-dimensional flow over a circular cylinder normal to the stream. The approach leads to simple algebraic expressions for the local normal and side forces as functions of the cross flow Strouhal number and the ratio d/l (where d is the body diameter and l is the pitch length of the Karman vortex street observed in the cross flow plane). A FORTRAN computer program has been generated for determining these forces, once a proper value is specified for the ratio d/l. Sample solutions have been computed and are compared with experiment. The analysis reveals that small changes in the applied value of the ratio d/l can result in large changes in the predicted magnitude of the forces, particularly, of the normal force. The effects of boundary layer displacement thickness, location of the point at which separation of the shear layers begins, and the impulsiveness of vortex shedding are studied and discussed. Comparisons with experimental data, obtained at Mach 0.5 at a Reynolds number 1.4x10 based on maximum diameter and free stream flow conditions, show good predictions of the normal force coefficient and its center of pressure location for a variety of body lengths and nose shapes when a specific value of the ratio d/l is applied. Author

N77-20003# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

ASSESSMENT OF EXISTING ANALYTIC METHODS FOR PREDICTION OF HIGH ANGLE-OF-ATTACK LOADS ON DELTA WINGS AT SUPERSONIC SPEEDS

Emma Jean Landrum and James E. Townsend *In* AGARD Prediction of Aerodynamic Loading Feb. 1977 7 p refs (For primary document see N77-19990 11-01)

Avail NTIS HC A15/MF A01

An assessment of the applicability of four loading prediction methods to high angle-of-attack conditions for simplified wing-body configurations is provided. The methods are: The tangent wedge approximation, the linear theory methods of Middleton and Woodward, and a shock-fitting finite-difference technique. Estimates obtained by these methods were compared with experimental pressure data on delta wings to examine the effects of Mach number, camber, sweep angle, and angle of attack. Results indicate that all of the methods provided reasonable estimates at moderate angles of attack. At these moderate angles of attack, the methods of Middleton and Woodward provided good estimates at Mach numbers higher than those usually associated with linear theory. Only the finite-difference method provided reasonable load estimates at high angles of attack. Author

N77-20004# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (West Germany)

ON THE CALCULATION OF THE PRESSURE DISTRIBUTION OF WING-BODY COMBINATIONS IN THE NON-LINEAR ANGLE OF ATTACK RANGE

Gregor Gregoriou *In* AGARD Prediction of Aerodynamic Loading Feb. 1977 11 p refs (For primary document see N77-19990 11-01)

Avail NTIS HC A15/MF A01

Based on the potential theory, an iterative singularity method was developed which yields the pressure distribution of symmetric wing-body configurations in the nonlinear angle of attack range at subsonic speeds. The body is axis-symmetric and of finite length. The wing is infinitely thin and located at mid-wing position. The following mathematical model was used: (Wing) lattice method, free vortices partially inclined to the wing plane, and (Body) ring sources over the body surface. Theoretical results show good agreement with wind tunnel tests. Author

N77-20005# Vereinigte Flugtechnische Werke-Fokker G.m.b.H., Bremen (West Germany). Dept. of Aerodynamics

PREDICTION METHOD FOR STEADY AERODYNAMIC LOADING ON AIRFOILS WITH SEPARATED TRANSONIC FLOW

P. G. Thiede *In* AGARD Prediction of Aerodynamic Loading Feb. 1977 12 p refs (For primary document see N77-19990 11-01)

Avail: NTIS HC A15/MF A01

A method is outlined for transonic flows on airfoils, extending the boundary layer concept to regions of flow separation by coupling a viscous boundary layer solution with an inviscid external flow solution iteratively. For viscous flow in the separated region an inverse integral method is developed, defining the surface pressure as a dependent variable with a prescribed streamline angle at the boundary layer edge. For the inviscid flow, a finite difference method is used, which satisfies the complete transonic equation. Two coupling schemes with different boundary conditions for both the interacting flow fields are considered. Tangential coupling along the boundary layer displacement thickness, and tangential and normal velocity coupling along the boundary layer edge. The above method was verified with tests on a two dimensional bump in a transonic duct, and on a circular arc transonic airfoil, for which results of the Navier-Stokes solutions have been published. Results indicate that with the second boundary condition the present method is accurate enough for practical purposes provided that the separated regions have a moderate extension. Author

N77-20006# Aeronautical Research Inst. of Sweden, Bromma.

PRESSURE DISTRIBUTIONS FOR A SWEPT WING BODY CONFIGURATION OBTAINED FROM COUPLING TRANSONIC POTENTIAL FLOW CALCULATIONS AND BOUNDARY LAYER CALCULATIONS

Sven G. Hedman *In* AGARD Prediction of Aerodynamic Loading Feb. 1977 9 p refs (For primary document see N77-19990 11-01)

Avail: NTIS HC A15/MF A01

A series of swept wings on cylindrical bodies has been designed, tested and analyzed. The wings have a common planform, a 35 deg swept quarter chord line, an aspect ratio of 4, and a taper ratio of 0.4. The relative thickness of the wings generally exceeds 8.5%. Comparisons between calculated and measured pressure distributions at two supercritical flow conditions M = 0.8, alpha = 6 deg and M = 0.9, alpha = 0 deg are reported. The pressures were calculated with a relaxation method based on the transonic small disturbance equation. Boundary layer displacement thicknesses were calculated both with an integral method and a finite difference method for three dimensional turbulent flow. It was found that the use of the simplified or the full boundary condition and of including the velocity potential function in the flow calculation affected the results only slightly. Addition of the boundary layer thickness to the wing thickness into an equivalent wing surface improved the agreement between calculated and measured pressures. Author

N77-20007# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

AERODYNAMIC LOADS NEAR CRANKS, APEXES, AND

TIPS OF THIN, LIFTING WINGS IN INCOMPRESSIBLE FLOW

Richard T. Medan *In* AGARD Prediction of Aerodynamic Loading Feb 1977 12 p refs (For primary document see N77-19990 11-01)

Avail: NTIS HC A15/MF A01

The calculation of the incompressible and irrotational flow in the vicinity of tips and corners of thin, lifting wings is considered. It is shown that the important characteristics of the flow are governed by an eigenvalue problem, which is nonlinear at the trailing edge because of the shed wake (assumed to be in the wing plane). A new solution method was devised because either the existing methods were not valid for the trailing edge case or they would have required excessive amounts of computer time. The new method, which is fundamentally different than the previous ones, was used to calculate solutions for a number of cases, including some for which correct answers had not previously been obtained. Two of these solutions were used to determine the validity of drag and leading-edge-suction distributions near the tips of a delta wing and a swept wing as calculated by using both the vortex lattice method and a kernel function method. The calculations for the swept wing resolved the question of whether or not the induced drag should be zero at the wing tip Author

N77-20008# Dornier-Werke G.m.b.H., Friedrichshafen (West Germany). Theoretical Aerodynamics Group

VORTEX LATTICE APPROACH FOR COMPUTING OVERALL FORCES ON V/STOL CONFIGURATIONS

Ciro W. Lucchi and Wolfgang Schmidt *In* AGARD Prediction of Aerodynamic Loading Feb. 1977 8 p refs (For primary document see N77-19990 11-01)

Avail: NTIS HC A15/MF A01

The vortex lattice method to handle lifting configurations of arbitrary shapes is described. Details on force computation when additional lift is induced by a deflected jet are also included. Vortex lattice methods improved computational accuracy so that induced drag and force distributions are now reliable results. Results are presented for such problems as mass flow control, jet definition, lattice arrangements on the centerbody, shroud and jet for wing tip winglets or shrouded propellers with highly deflected jets. Author

N77-20009# General Dynamics/Fort Worth, Tex.

AIRCRAFT MANEUVERS AND DYNAMIC PHENOMENA RESULTING IN RAPID CHANGES OF LOAD DISTRIBUTIONS OR/AND FLUCTUATING SEPARATION

David B. Benepe, Sr. *In* AGARD Prediction of Aerodynamic Loading Feb 1977 13 p refs (For primary document see N77-19990 11-01)

Avail: NTIS HC A15/MF A01

Flight data are presented from several maneuvers which produce rapid changes in aircraft component load distribution or/and fluctuating flow separations. The maneuvers include an abrupt pullup, slow and fast windup turns, a slowdown turn at elevated load factor, a rolling pullout at elevated load factor, a sustained rudder roll followed by a spin and recovery and a one g deceleration terminating in a slow nose slice and recovery, where feasible, wind tunnel model pressure measurements illustrate the character of the aerodynamic loadings. Comparisons between measured structural loads and predictions are presented and discussed Author

N77-20010# Royal Aircraft Establishment, Farnborough (England). Dept. of Structures.

THE THEORETICAL PREDICTION OF STEADY AND UNSTEADY AERODYNAMIC LOADING ON ARBITRARY BODIES IN SUPERSONIC FLOW

D. L. Woodcock *In* AGARD Prediction of Aerodynamic Loading Feb. 1977 21 p refs (For primary document see N77-19990 11-01)

Avail: NTIS HC A15/MF A01

A method is developed for the determination of aerodynamic forces on arbitrary oscillating (and possibly deforming) bodies in linearized irrotational supersonic flow. Use is made of an approximation to the body by a many sided polyhedron. The problem is reformulated as an integral equation of the second kind and its solution is obtained by collocation at the centroids of a large number of regions arranged in bands round the body. The number of regions is much larger than the number of facets of the polyhedron. The steady perturbation potential on the body is obtained as a necessary intermediate result. From the calculated velocity potential the steady and oscillatory components of the loading distribution and the overall forces are simply evaluated. The method is demonstrated by application to a fighter aircraft fuselage Author

N77-20011# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick (West Germany).

THE PREDICTION OF BUFFET ONSET AND LIGHT BUFFET BY MEANS OF COMPUTATIONAL METHODS

G. Redeker and H.-J. Proksch (Dornier G.m.b.H., W. Germany) *In* AGARD Prediction of Aerodynamic Loading Feb. 1977 10 p refs (For primary document see N77-19990 11-01)

Avail: NTIS HC A15/MF A01

Computational methods are reported which are able to provide the project engineer with buffeting boundaries as a first design step of an aircraft. Discussed are (1) the method of Thomas for predicting buffet onset for wing sections including supercritical airfoils at higher angles of attack, (2) the method of Redeker for predicting buffet onset for infinite yawed wings, and (3) the method of Proksch for predicting light buffeting for finite wings. The basic ideas of these methods are outlined and their applications are shown in comparison with experimental results. Author

N77-20012# Royal Aircraft Establishment, Bedford (England). Dept. of Aerodynamics

PRELIMINARY EVALUATION OF A TECHNIQUE FOR PREDICTING BUFFET LOADS IN FLIGHT FROM WIND-TUNNEL MEASUREMENTS ON MODELS OF CONVENTIONAL CONSTRUCTION

G. F. Butler and G. R. Spavins *In* AGARD Prediction of Aerodynamic Loading Feb. 1977 11 p refs (For primary document see N77-19990 11-01)

Avail: NTIS HC A15/MF A01

A technique is described for predicting buffet loads in flight from wind tunnel measurements of the response of models of conventional construction. The rms response and damping ratio in each mode are used to calculate non-dimensional buffet excitation and aerodynamic damping parameters, which are used in combination with the aircraft structural damping to predict the buffeting response under flight conditions. Results are presented from wind tunnel tests on a model of a small combat trainer aircraft and predictions made using these results are compared with flight measurements. In addition, some remarks are made on methods for determining rms response and damping ratio from accelerometer or strain gauge signals recorded under buffeting conditions Author

N77-20013# Lockheed Missiles and Space Co., Sunnyvale, Calif.

QUASI-STEADY AND TRANSIENT DYNAMIC STALL CHARACTERISTICS

Lars E. Ericsson and J. Peter Reding *In* AGARD Prediction of Aerodynamic Loading Feb. 1977 11 p refs (For primary document see N77-19990 11-01)

Avail: NTIS

Dynamic airfoil stall is characterized by two separate events. There is a substantial overshoot of the static stall angle and stall lift maximum before bona fide separation occurs, and after separation has occurred, a spilled lending edge vortex travels downstream over the chord causing large changes in the aerodynamic force distribution. The first event can be characterized as quasi-steady, whereas the second event is truly a transient phenomenon. An analysis is presented which extends the earlier developed quasi-steady theory to include the transient effect of the spilled leading edge vortex. The large effects of compressibility on the dynamic stall characteristics are also accounted for in the analysis. The analytic results are in good agreement with available dynamic experimental data. Author

N77-20014# General Dynamics/Convair, San Diego, Calif.

THEORY OF WING SPAN LOADING INSTABILITIES NEAR STALL

E. S. Levinsky *In* AGARD Prediction of Aerodynamic Loading Feb. 1977 16 p refs (For primary document see N77-19990 11-01)
(Contract N62269-75-C-0356)
Avail: NTIS HC A15/MF A01

A nonlinear, lifting line procedure with unsteady wake effects has been developed for predicting wing-body aerodynamic characteristics up to and beyond stall. A discrete vortex lattice representation is used for the time dependent wake, whereas the wing load distribution is assumed concentrated along the 25% chord line. Each chordwise section is assumed to act aerodynamically (including stall) like a 2D airfoil in steady flow at an effective angle of attack, which may be time dependent. Other assumptions are incompressible flow, moderate sweep, large aspect ratio and conditions for stall progression across the span. Comparisons are made with existing theory and test data. Effects of planform geometry and of airfoil section characteristics on stall are presented. For airfoils with a large post-stall negative lift curve slope, the solutions sometimes exhibit lift hysteresis and zero-beta rolling and yawing moments. These results are due to the existence of multiple solutions of the lifting line equations. Increasing aspect ratio and decreasing negative lift curve slope ameriorates the severity of these adverse stalling characteristics. Author

N77-20015# Air Force Academy, Colo
DYNAMIC LOADING ON AN AIRFOIL DUE TO A GROWING SEPARATED REGION
James D. Lang and Michael S. Francis *In* AGARD Prediction of Aerodynamic Loading Feb. 1977 12 p refs (For primary document see N77-19990 11-01)
Avail: NTIS HC A15/MF A01

Experiments examining the unsteady growth of a separated region on an airfoil in incompressible flow are employed to verify aspects of a semi-empirical model which attempts to predict the loading and unsteady flow effects associated with the region. Measurements of surface pressures downstream of an oscillating fence-type spoiler confirm the existence of the two essential features of the model, namely, a lag in the growth of the separation zone due to the unsteady nature of the flowfield, and modification of the approximate roof-top pressure distribution associated with a separating and reattaching shear layer which occurs on a surface in steady flow. Also examined briefly are the effects of Reynolds number variation and the observation of secondary flow phenomena. Limitations of the model, including its inability to predict detailed spatial and temporal distributions of pressure behavior, are discussed along with recommendations for improvements. Author

N77-20016# Office National d'Etudes et de Recherches Aerospatiales, Modane (France)
PRESSURES OVER A SHARP-EDGED AIR INTAKE FUNCTIONING IN SUBSONIC FLOW AT REDUCED FLOWRATE
Gerard Laruelle and Paul Levart *In* AGARD Prediction of Aerodynamic Loading Feb 1977 12 p refs In FRENCH, ENGLISH summary (For primary document see N77-19990 11-01)
Avail: NTIS HC A15/MF A01

A wind tunnel test set-up has been designed for studying the flow around the cowl with sharp leading edge of an air intake functioning at subsonic velocity and with a reduced flowrate. A comparison of the pressure fields around the intake lip, calculated in an approximate configuration for the free light and for that particular set-up, shows that local flows are correctly simulated in the case of moderately reduced flowrates. The forces acting on the air intake casing are dependent upon a separation bubble that forms on the external lip of the intake when the flowrate is sufficiently reduced. The method used for calculating the potential flow has been adapted to take account of this bubble, through parameters characterizing it. Author

N77-25055# Advisory Group for Aerospace Research and Development, Paris (France).
INTEGRITY IN ELECTRONIC FLIGHT CONTROL SYSTEMS
Apr. 1977 367 p
(AGARD-AG-224; ISBN-92-835-0192-6) Avail: NTIS HC A16/MF A01

Flight control systems are described for aircraft safety and reliability. Primary, automatic, and manual controls are discussed. For individual titles, see N77-25056 through N77-25079.

N77-25056# Systems Technology, Inc., Hawthorne, Calif.
A HISTORICAL PERSPECTIVE FOR ADVANCE IN FLIGHT CONTROL SYSTEMS
Duane McRuer and Dunstan Graham (Princeton Univ., New Jersey) *In* AGARD Integrity in Electron. Flight Control Systems Apr. 1977 7 p refs (For primary document see N77-25055 16-01)
Avail: NTIS HC A16/MF A01

The history of flight control systems is discussed emphasizing early development of theory and practice and automatic control. Several early control approaches are described, showing improvements and changes in the onset of aircraft control systems. M.C.F

N77-25057# Sperry Flight Systems, Phoenix, Ariz.
CHRONOLOGICAL OVERVIEW OF PAST AVIONIC FLIGHT CONTROL SYSTEM RELIABILITY IN MILITARY AND COMMERCIAL OPERATIONS
S. S. Osder *In* AGARD Integrity in Electron. Flight Control Systems Apr. 1977 17 p refs (For primary document see N77-25055 16-01)
Avail: NTIS HC A16/MF A01

Flight control system mechanization advances are traced from the perspective of reliability. Despite dramatic advances in device technology and miniaturization, the demand for more functions tended to exceed the progress in electronics. By the latter 1960's, complexity growth related to system monitoring and redundancy management reached limitations of analog technology and set the stage for introduction of digital flight control systems. Author

N77-25058# Civil Aviation Authority, Redhill (England).
SAFETY CRITERIA FOR FAIL-OPERATIONAL AUTOLAND SYSTEMS AND THEIR APPLICATION
D. V. Warren *In* AGARD Integrity in Electron. Flight Control Systems Apr. 1977 9 p ref (For primary document see N77-25055 16-01)
Avail: NTIS HC A16/MF A01

The airworthiness requirements for the certification of automatic landing systems in civil aircraft include an explicit statement of the safety level to be achieved. For compliance with these requirements, a safety assessment of the system must be made, and accepted by the airworthiness authority. It must contain a logical analysis which identifies all critical failure conditions of the system and shows that the probability of each is appropriate to the degree of hazard associated with it. It should also examine the factors which influence the performance of the system and show by means of analysis, simulation, and flight testing that the safety level will be acceptable. The analysis will establish the maintenance checks necessary together with their frequency, and any other limitations on the use of the system. Author

N77-25059# Boeing Co., Wichita, Kans.
FUTURE TRENDS IN HIGHLY RELIABLE SYSTEMS
James I. Arnold *In* AGARD Integrity in Electron. Flight Control Systems Apr. 1977 14 p refs (For primary document see N77-25055 16-01)
Avail: NTIS HC A16/MF A01

The need for highly reliable flight control systems in both control configured vehicles and conventionally designed aircraft is discussed. Technology trends in the area of control system computation, electronics, sensors and actuation are addressed. Increased use of digital computation and signal multiplexing in future control systems is considered inevitable. Recent technology developments in high density electronic packaging, large scale integration, and fiber optics will be applied to achieve highly reliable electronic systems. Component designs will be required to withstand potentially severe environments in the presence of lightning or nuclear phenomena. Redundancy management will continue to be a prime driving force in reliable system designs.

The use of in-line monitoring to limit the proliferation of redundant channels should find application in future systems. Maintenance and preflight self-test systems will play an increasingly vital role in assuring the integrity of redundant flight-critical systems.
Author

N77-25060# Massachusetts Inst. of Tech., Cambridge. Electronic Systems Lab.
A SURVEY OF DESIGN METHODS FOR FAILURE DETECTION IN DYNAMIC SYSTEMS
Alan S. Willsky. *In* AGARD Integrity in Electron. Flight Control Systems. Apr. 1977. 14 p. refs (For primary document see N77-25055 16-01)
Avail: NTIS HC A16/MF A01

A number of methods for the detection of abrupt changes (such as failures) are surveyed in stochastic dynamical systems. The class of linear systems is concentrated, but the basic concepts, if not the detailed analyses, carry over to other elements of systems. The methods range from the design of specific failure-sensitive filters, to the use of statistical tests on filter innovations, to the development of jump process formulations. Tradeoffs in complexity versus performance are discussed.
Author

N77-25061# Ultrasystems, Inc., Irvine, Calif.
CAST: A COMPLEMENTARY ANALYTIC-SIMULATIVE TECHNIQUE FOR MODELING COMPLEX, FAULT-TOLERANT COMPUTING SYSTEMS
R. B. Conn, P. M. Merryman, and K. L. Whitelaw. *In* AGARD Integrity in Electron. Flight Control Systems. Apr. 1977. 27 p. refs (For primary document see N77-25055 16-01)
Avail: NTIS HC A16/MF A01

The complementary analytic-simulative technique (CAST) evolved as it became evident that neither analysis nor simulation alone could satisfy the evaluation requirements of complex computer systems. Analytic modeling provides flexibility and rapid, economical data generation. Simulation permits computer system details to be included easily, but extensive data generation is slow and expensive. CAST permits the user to obtain the best features of both analytic modeling and simulation. CAST is based on the desirability of accurately modeling complex computer systems, utilizing closed-form mathematical expressions for the computer system failure probability. This is achieved through the use of analytic models which utilize parameters determined both by simulation and engineering characterization of the computer system.
Author

N77-25062# Polytechnic Inst. of New York, Brooklyn. Div. of Computer Science.
SOFTWARE RELIABILITY: ANALYSIS AND PREDICTION
Martin L. Shooman. *In* AGARD Integrity in Electron. Flight Control Systems. Apr. 1977. 17 p. refs (For primary document see N77-25055 16-01)
(Contract N00014-67-A-0438-0013)
Avail: NTIS HC A16/MF A01

The types and causes of software errors are described, which provides working definitions of software errors and software reliability. Some of the basic data on frequency of occurrence of errors are discussed. Some of the software reliability models which were proposed are summarized. This newly developed probabilistic model predicts reliability based on the initial number of errors in a program, the number removed, and the number remaining in the program. The model constants are calculated from operational test data taken on the software performance.
Author

N77-25063# Marconi-Elliott Avionic Systems Ltd., Rochester (England). Flight Controls Div.
SOFTWARE INTEGRITY THROUGH VISIBILITY
G. Belcher and T. Egan. *In* AGARD Integrity in Electron. Flight Control Systems. Apr. 1977. 6 p. refs (For primary document see N77-25055 16-01)
Avail: NTIS HC A16/MF A01

Visibility in the construction, testing and safety analysis of flight control systems is discussed. A computer readable single source software specification which allows information to be retrieved in a more automated manner is used to improve the visibility. A test structure that can display a complete correlation between control functions as specified and as implemented also increases the visibility of the test results. A data flow analysis based on a complete cross reference and symbol table is used as the basis of a method for increasing the visibility of the dormant and common mode failure analysis.
Author

N77-25064# IBM Watson Research Center, Yorktown Heights, N.Y.
TECHNIQUES FOR MICROPROGRAM VALIDATION
W. C. Carter, H. A. Ellozy, W. H. Joyner, Jr., and G. B. Leeman, Jr. *In* AGARD Integrity in Electron. Flight Control Systems. Apr. 1977. 19 p. refs (For primary document see N77-25055 16-01)
Avail: NTIS HC A16/MF A01

A method for computer-assisted verification of systems controlled by microcode is presented, with examples of its application to actual implementations. Such systems may be a computer with operations emulated by microcode action on a simple processor or a microprocessor coded to perform a fixed task. The specifications for such a design and those for the processor on which it is to be implemented are both described formally, with the code to be certified supplied as data to the low-level description. Informally, correctness of the implementation means that if the specification description and the machine description begin computation with identical inputs, they will get identical results. An interactive system of programs for carrying out mathematical proofs of a formalization of this correspondence has been written. Its application-independent monitor provides a framework for a goal-directed attack on the problem, allowing the user to reduce it to subproblems. programs are invoked to perform symbolic interpretation of the descriptions, generation of sufficient conditions for correctness, theorem proving, and simplification. This system is running and was used to detect and correct errors in an actual microcode implementation. preliminary results of these experiments are described.
Author

N77-25065# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick (West Germany). Inst fuer Flugfuehrung.
SYSTEM INTEGRITY BY USE OF SELFDIAGNOSING FAILURE DETECTION
R. Onken. *In* AGARD Integrity in Electron. Flight Control Systems. Apr. 1977. 18 p. (For primary document see N77-25055 16-01)
Avail: NTIS HC A16/MF A01

A definition of the system integrity function is given in order to enable comparative evaluation of different design approaches for digital flight control systems with respect to the system integrity and mission survival. Two main failure detection methods are analytically investigated with respect to the integrity function, the passive failure detection and the selfdiagnosing active failure detection. The HFB 320 experimental system is briefly described as an example of the selfdiagnosing active failure detection method.
Author

N77-25066# Bodenseewerk Geraetetechnik G.m.b.H., Ueberlingen (West Germany).
FAILURE SELF-DETECTION IN DIGITAL FLIGHT GUIDANCE SYSTEMS
H. Drtil and W. Meyer. *In* AGARD Integrity in Electron. Flight Control Systems. Apr. 1977. 7 p. (For primary document see N77-25055 16-01)
Avail: NTIS HC A16/MF A01

Procedures for detecting failures in the hardware of the signal processing are developed. This failure self-detection is carried out by means of suitable test programs, and it is supervised by an external supervisor. The design of this supervisor is based on the principle of a watch-dog-timer. Two supervisor systems are developed on the basis of this principle. The improved version allows, in addition, the execution of nominal/actual value comparisons in the supervisor and this increases the failure self-detection probability. The possible applications of the failure self-detection are discussed.
Author

N77-25067# Boeing Co Houston Tex
SNEAK CIRCUIT ANALYSIS APPLICATION TO CONTROL SYSTEM DESIGN
Joe L Wilson and Robert C Clardy *In* AGARD Integrity in Electron Flight Control Systems Apr 1977 6 p refs (For primary document see N77 25055 16 01)
Avail NTIS HC A16/MF A01

The development and application of a circuit analysis technique is presented The technique is based on an aerospace discovery that topological criteria exist that can be used to recognize unplanned operational modes of a circuit The analysis technique involves encoding circuitry data from detailed schematics for computer processing The computer processing produces simplified, topological network trees which represent the system circuitry The network trees are analyzed by the application of sneak circuit conditions The results obtained from a variety of complex electrical systems analyses are also presented as positive collaboration for this circuitry analysis technique Author

N77-25068# Honeywell, Inc St Louis Park Minn
BUILT-IN TEST TECHNIQUES FOR DIGITAL FLIGHT CONTROL SYSTEMS
W A Price *In* AGARD Integrity in Electron Flight Control Systems Apr 1977 13 p refs (For primary document see N77 25055 16 01)
Avail NTIS HC A16/MF A01

The techniques discussed are suitable for use while the flight control system is performing its normal task Most of these techniques are also applicable on the ground Since many inputs and outputs of a digital flight control system are analog signals, some analog testing capability is required The basic concepts of analog testing may often be carried into digital testing It is shown that stimulated monitoring is possible where the item under test is time multiplexed or where the stimulus can be designed to have a negligible effect on the system performance Author

N77-25069# Wales Univ Inst of Science and Technology, Cardiff
PRE-FLIGHT DYNAMIC CHECKOUT
D R Towill *In* AGARD Integrity in Electron Flight Control Systems Apr 1977 15 p refs Sponsored by the UK Ministry of Defence and the UK Sci Res Council (For primary document see N77-25055 16-01)
Avail NTIS HC A16/MF A01

The advent of Fast Fourier Transform algorithms coupled to the increasing availability of data processing facilities has resulted in transfer function testing increasing enormously in popularity System impulse response, step response, or frequency response are all satisfactory dynamic signatures related to the transfer function of the system under test It is sufficient for many pre-flight checkout applications to estimate the signature at just a few carefully selected data points, thus considerably reducing test time and computational capacity required This in turn permits the use of special purpose hardware such as Fourier Response Analyzers when justified on cost-benefit or logistic grounds as an alternate to spectral analysis methods The basic ground rules for selecting system test stimuli and test features for both manual and automatic testing are provided Author

N77-25070# Northrop Corp, Norwood, Mass Dept of Precision Products
THRESHOLDLESS REDUNDANCY MANAGEMENT WITH ARRAYS OF SKEWED INSTRUMENTS
J E Potter and M C Suman *In* AGARD Integrity in Electron Flight Control Systems Apr 1977 25 p refs (For primary document see N77-25055 16-01)
Avail NTIS HC A16/MF A01

The design and implementation of redundant instrument systems are discussed, which provides a basis for further work on practical thresholdless fault-tolerance A worst-case performance index is developed which requires no knowledge about the statistics of the instrument errors It is shown that the least squares estimator minimizes this index, but that the resulting algorithm is not fault-tolerant A fault-tolerant algorithm is then defined which uses the worst-case performance index to bound the estimation error by the product of the index and the RSS of the individual instrument errors with the largest error ignored, the algorithm chooses as the estimate the value which minimizes the worst-case index Numerical results indicate that useful error bounds are realized Author

N77-25071# Aeronautical Systems Div, Wright-Patterson AFB, Ohio
TIME-DIVISION MULTIPLEXED DATA BUS INTEGRATION TECHNIQUES
Erwin C Gangel *In* AGARD Integrity in Electron Flight Control Systems Apr 1977 9 p refs (For primary document see N77 25055 16-01)
Avail NTIS HC A16/MF A01

Today, avionics are demanding an increasing proportion of the resources available for aircraft weapons systems These avionics are providing increased capability and accuracy to the aircraft weapon system but, also are a prime contributor to increased complexity and decreased reliability of the system Digital avionics appear to offer the desired increase in capabilities and performance without the normal companions of low reliability complexity, and high cost because it is amenable to mechanization via solid state devices, it is more orderly and systematic, and provides growth and change without major hardware modification Digital avionic integration, in order to reap these benefits requires standard equipment interfaces and a standard approach to data intercommunication The time division data bus is the technique that permits this new concept of system integration to emerge The data bus evolutions, its standardization and application are presented The acquisition management and logistic benefits are discussed Author

N77-25072*# National Aeronautics and Space Administration Langley Research Center Langley Station, Va
HIGHLY RELIABLE MULTIPROCESSORS
Nicholas D Murray, Albert L Hopkins (Charles Stark Draper Lab, Inc), and John H Wensley (Stanford Res Inst, Menlo Park, Calif) *In* AGARD Integrity in Electron Flight Control Systems Apr 1977 17 p refs (For primary document see N77-25055 16-01)
Avail NTIS HC A16/MF A01

Highly reliable fault-tolerant computer systems are discussed for use in flight-critical avionic and control systems of future commercial transport aircraft Such aircraft are envisioned to have integrated systems, to be terminally configured, and to be equipped with fly-by-wire flight control systems, all of which require highly reliable, fault-tolerant computers Two candidate computer architectures are identified as having the potential of satisfying the commercial transport aircraft requirements Author

N77-25073# Air Force Flight Dynamics Lab, Wright Patterson AFB, Ohio Control Systems Development Branch
OBJECTIVES FOR THE DESIGN OF IMPROVED ACTUATION SYSTEMS
B H Earley *In* AGARD Integrity in Electron Flight Control Systems Apr 1977 16 p refs (For primary document see N77-25055 16-01)
Avail NTIS HC A16/MF A01

Actuation system reliability is particularly critical to the success of modern Flight Control System (FCS) techniques which utilize high authority electrical controls The reliability combined with typical performance requirements have a substantial effect on the actuator resulting in a high level of sophistication, complexity attendant high cost, and reduced maintainability A description of actuation systems evolution and several redundant system approaches are included Significant redundant system criteria are discussed followed by a series of design objectives pertinent to relief of typical actuator problems A basic design approach is also recommended to assure timely integration of the FCS in the vehicle design process and proper interfacing of the primary technical disciplines The implementation and benefits of actuation system development programs are discussed, and several new actuation concepts are mentioned Author

N77-25074# Aeronautical Systems Div, Wright-Patterson AFB, Ohio

F-16 FLIGHT CONTROL SYSTEM DEVELOPMENT
David L Carleton *In* AGARD Integrity in Electron Flight Control Systems Apr 1977 9 p refs (For primary document see N77-25055 16-01)
Avail NTIS HC A16/MF A01

The purpose of this paper is to outline development procedures required to implement the fly-by-wire flight control system in the F-16 aircraft Several developmental efforts were required to implement the flight control system into the aircraft These efforts include the design and development of specific hardware, including the sensors, actuators, and the flight control computer itself Once the subsystems were developed, the process of integration and definition of the flight control system became a developmental effort Once the hardware was integrated into the aircraft, the developmental effort then swung towards on-aircraft tests to ensure that the flight control system was compatible with the airframe within the operational flight envelope Once these ground tests were completed, the development effort then concentrated on the flight test portion of the program where the flight control system was optimized precision tracking in the air superiority and ground attack role The F-16 flight control system development was rather unique inasmuch as it was a two-fold effort A development effort was undertaken to ensure that the prototype aircraft could indeed meet the safety of flight requirements and then the effort swung towards full scale development of the fly-by-wire flight control system for a production aircraft application The process is illustrated to expand upon the development process and show how the various steps interact It also demonstrates the iterative nature of the process Author

N77-25076# Honeywell Inc St Louis Park Minn Government and Aeronautical Products Div
JA-37 DIGITAL AUTOMATIC FLIGHT CONTROL SYSTEM (DAFCS)
D G Bailey and Kjell Folkesson (SAAB SCANIA Linkoping, Sweden) *In* AGARD Integrity in Electron Flight Control Systems Apr 1977 11 p (For primary document see N77-25055 16-01)
Avail NTIS HC A16/MF A01

Adequate in-flight fail safety was verified by demonstrating that the in flight monitoring function was extremely effective in detecting potentially catastrophic failure modes (Potentially catastrophic failure modes are those that produce transients in excess of specified limits) Effectiveness in detecting potentially catastrophic failure modes was demonstrated to be well above 99 percent Overall fault detection including potentially catastrophic as well as non catastrophic failure modes was closer to 97 percent The effectiveness of the in flight monitoring function was demonstrated to be compatible with the allowable one millionth catastrophic failure probability for a 90 minute mission Author

N77-25078*# National Aeronautics and Space Administration Hugh L Dryden Flight Research Center, Edwards, Calif
DESIGN AND TEST EXPERIENCE WITH A TRIPLY REDUNDANT DIGITAL FLY-BY-WIRE CONTROL SYSTEM
Kenneth J Szalai Philip G Fellemen (Charles Stark Draper Lab, Inc) Joseph Gera (NASA Langley Res Center), and Richard D Glover (NASA Johnson Space Center) *In* AGARD Integrity in Electron Flight Control Systems Apr 1977 30 p refs (For primary document see N77-25055 16-01)
Avail NTIS HC A16/MF A01

A triplex digital fly-by-wire flight control system was developed and then installed in a NASA F-8C aircraft to provide fail-operative, full authority control Hardware and software redundancy management techniques were designed to detect and identify failures in the system Control functions typical of those projected for future actively controlled vehicles were implemented The principal design features of the system the implementation of computer, sensor and actuator redundancy management, and the ground test results are described An automated test program to verify sensor redundancy management software is also described Author

N77-25077# Lockheed-California Co, Burbank
L-1011 FLIGHT CONTROL SYSTEM
J A Flapper and E O Throndsen *In* AGARD Integrity in Electron Flight Control Systems Apr 1977 24 p refs (For primary document see N77-25055 16-01)
Avail NTIS HC A16/MF A01

The L-1011 flight controls primary and automatic are described which are of interest because of the state of the art advancements and the improvements which they represent The flying tail primary control system, its rationale and design features are dealt with in some detail Integration of primary controls with automatic flight controls is treated and the direct lift control system and roll control briefly described The automatic controls are described with emphasis on the yaw stability augmentation system and the automatic landing system The former is in concept an active control system in that design loads are predicated on its availability The latter, for the final stage of landing in Category 3 conditions, is the forerunner of the fly by wire concept for commercial transports System rationale or design features which enhance safety and reliability are treated Author

N77-25078# Aerospatiale Usines de Toulouse (France)
FLIGHT CONTROLS FOR THE CONCORDE [LES COMMANDES DE VOL DE CONCORDE]
M Bossard and R Deque *In* AGARD Integrity in Electron Flight Control Systems Apr 1977 12 p *In* FRENCH (For primary document see N77-25055 16-01)
Avail NTIS HC A16/MF A01

A description of various flight controls for Concorde is presented System components are listed, and performance characteristics are discussed Electrical flight systems based on the utilization of digital techniques which can be applied to supersonic transport aircraft of second generation were briefly evaluated Transl by B B

N77-25079# Royal Aircraft Establishment Farnborough (England) Dept of Flight Systems
A HIGH-RELIABILITY, HIGH INTEGRITY FLIGHT CONTROL SYSTEM FOR HELICOPTERS
P Robinson J Mesdows (Smiths Industries Ltd Gloucestershire, Engl) and C M Copage (Smiths Industries Ltd Gloucestershire, Engl) *In* AGARD Integrity in Electron Flight Control Systems Apr 1977 15 p refs (For primary document see N77-25055 16-01)
Avail NTIS HC A16/MF A01

Some of the operations which helicopters may be required to carry out at night and in poor visibility are briefly described Because of the high pilot work load likely to arise in these situations, it is argued that the helicopter should be equipped with an autostabilization system having a defect-survival capability One system to meet this requirement, together with quantitative system reliability and integrity requirements, was developed and manufactured for a Sea King helicopter This system is triplex, with digital computation, and has the development potential to include autopilot facilities, more sophisticated control techniques, and extended system redundancy The redundancy philosophy and the approach to assessment of system reliability and integrity are described, together with salient design and engineering details of the system Also an indication is given of future trends in the technology Author

N77-31073# Advisory Group for Aerospace Research and Development, Paris (France)
UNSTEADY AIRLOADS IN SEPARATED AND TRANSONIC FLOW
Apr 1977 273 p *In* ENGLISH partly in FRENCH Presented at the 44th Meeting of the AGARD Struct and Mater Panel, Lisbon, 19-20 Apr 1977
(AGARD-CP-226; ISBN-91-835-0197-7) Avail NTIS HC A12/MF A01

The prediction and description of the separated flow environment and the essential effects of airframe response on individual aircraft components is reviewed along with flutter, aeroelastic instabilities, and other static and dynamic aeroelastic problems. Analytical approaches, wind tunnel tests as well as flight test techniques are included For individual titles, see N77-31074 through N77-31091.

N77-31074# Hawker Siddeley Aviation Ltd., Kingston upon Thames (England)
UNSTEADY AIRLOADS IN SEPARATED AND TRANSONIC FLOW
C. L. Bore *In* AGARD Unsteady Airloads in Separated and Transonic Flow Apr. 1977 9 p (For primary document see N77-31073 22-01)
Avail: NTIS HC A12/MF A01

The papers dealing with unsteady loads arising from separated flow that were presented at the AGARD Fluid Dynamics Panel's symposium on Prediction of Aerodynamic loading are reviewed. The principal topics discussed include dynamic phenomena arising from aircraft maneuvers *transient dynamic stall loads, and* methods for predicting buffet. Author

N77-31075*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
SEPARATED-FLOW UNSTEADY PRESSURES AND FORCES ON ELASTICALLY RESPONDING STRUCTURES
C. F. Coke, D. W. Riddle, and C. Hwang (Northrop Corp., Hawthorne, Calif.) *In* AGARD Unsteady Airloads in Separated and Transonic Flow Apr. 1977 25 p refs (For primary document see N77-31073 22-01)
Avail: NTIS HC A12/MF A01 CSCL 01C

Broadband rms, spectral density, and spatial correlation information that characterizes the fluctuating pressures and forces that cause aircraft buffet is presented. The main theme is to show the effects of elasticity. In order to do so, data are presented that were obtained in regions of separated flow on wings of wind-tunnel models of varying stiffness and on the wing of a full-scale aircraft. Reynolds number effects on the pressure fluctuations are also discussed. Author

N77-31076# General Dynamics/Fort Worth, Tex.
PREDICTION OF TRANSONIC AIRCRAFT BUFFET RESPONSE
Atlee M. Cunningham, Jr. and David B. Benepe, Sr. *In* AGARD Unsteady Airloads in Separated and Transonic Flow Apr. 1977 21 p refs (For primary document see N77-31073 22-01)
Avail: NTIS HC A12/MF A01

A method for predicting aircraft buffet response is briefly reviewed. Rigid wind tunnel model fluctuating pressure data are used to form buffet forcing functions to which airplane responses are calculated with a mathematical dynamic model of the airplane. Buffet pressure data on the wing are used to estimate fluctuating loads on the horizontal tail. By including the extremes of phasing and contributions of symmetric and antisymmetric airplane responses, predicted upper and lower bounds are established. The method is applied to a variable sweep fighter aircraft and predicted results are compared with flight test data. The types of buffeting flow considered for various wing sweep angles include separated and vortex flows as well as oscillating shocks. The current method is compared with three other methods in the correlation with flight test data. The inherent scatter of flight data is discussed as well as probable sources of the scatter. A mechanism is described by which wing torsional motion and shock oscillation couple to produce relatively severe buffeting conditions at a forward wing sweep. The importance of considering buffet fatigue damage on secondary structure is discussed.
Author

N77-31077# Royal Aircraft Establishment, Farnborough (England). Aerodynamics Dept.
THE DYNAMIC RESPONSE OF WINGS IN TORSION AT HIGH SUBSONIC SPEEDS
G. F. Moss and D. Pierce *In* AGARD Unsteady Airloads in Separated and Transonic Flow Apr. 1977 21 p refs (For primary document see N77-31073 22-01)
Avail: NTIS HC A12/MF A01

The structural response of aircraft wings to aerodynamic excitation at conditions appropriate to maneuvers at high subsonic speeds is discussed. Reference is made to wind tunnel experiments using models specially designed to deform under test in a realistic way as well as 'rigid' models of conventional construction. The primary torsion mode of vibration of the wings tended to be strongly excited under some aerodynamic flow conditions on the flexible models used, and in some cases the amplitude was large and similar to single-degree-of-freedom flutter in character. Data from some flight tests is quoted to demonstrate that this type of response may well occur in practice. Author

N77-31078# Messerschmidt-Boelkow G.m.b.H., Munich (West Germany).
EVALUATION OF VIBRATION LEVELS AT THE PILOT SEAT CAUSED BY WING FLOW SEPARATION
J. Becker and K. Dau (Vereinigte Flugtechnische Werke-Fokker GmbH, Bremen, West Germany) *In* AGARD Unsteady Airloads in Separated and Transonic Flow Apr. 1977 28 p refs (For primary document see N77-31073 22-01)
Avail: NTIS HC A12/MF A01

Examples of the evaluation of vibration levels on the pilot seat are presented. The first deals with the results of low speed measurements on a strake wing model with and without flap and slats, including the effect of leading edge blowing, in the incidence region 0 less than or equal to alpha less than or equal to 90 deg. The second example demonstrates the results obtained by the method based on measurements of fluctuating pressures on rigid models for two configurations with 25 and 45 degree wing sweep in the high subsonic region (0.7 less than or equal to M less than or equal to 0.85). Author

N77-31079# Royal Aircraft Establishment, Bedford (England)
MEASUREMENTS OF BUFFETING ON TWO 65 DEG DELTA WINGS OF DIFFERENT MATERIALS
D. C. Mabey and G. F. Butler *In* AGARD Unsteady Airloads in Separated and Transonic Flow Apr. 1977 14 p refs (For primary document see N77-31073 22-01)
Avail: NTIS HC A12/MF A01

Measurements of buffeting were made on two 65 deg delta wings, one made of steel and the other of magnesium. A nondimensional buffet excitation parameter was derived from measured values of the rms buffeting response and total damping ratio. The materials were selected so that the resonant frequencies of the wings were almost the same, while giving a significant variation of response and damping ration under identical free stream conditions. The wings were tested at Mach numbers of 0.35, 0.7 and 1.4 and the Reynolds number was varied over a wide range. The results showed that the buffet excitation parameter for the first bending model was virtually identical for both wings and was independent of Reynolds number, except at very low Reynolds numbers. A significant level of aerodynamic damping was measured on the magnesium wing, and the experimental values agreed well with estimates made using slender wing theory. Author

N77-31080# British Aircraft Corp., Preston (England). Military Aircraft Div.
DYNAMIC LOADING OF AIRFRAME COMPONENTS
C. G. Lodge and M. Ramsey *In* AGARD Unsteady Airloads in Separated and Transonic Flow Apr. 1977 26 p refs (For primary document see N77-31073 22-01)
Avail: NTIS HC A12/MF A01

The design of modern combat aircraft is discussed in terms of structural fatigue life. Unsteady loads due to separated flow conditions in maneuvering flight are examined. Dynamic loads on a modern variable sweep wing combat aircraft are predicted making use of wing tunnel model tests and results from flight tests. The predictions are compared with available prototype flight measurements. Author

N77-31081# Vereinigte Flugtechnische Werke G.m.b.H., Bremen (West Germany).
AIRFRAME RESPONSE TO SEPARATED FLOW ON THE SHORT HAUL AIRCRAFT VFW 614
Helmut Zimmermann and Guenter Krenz *In* AGARD Unsteady Airloads in Separated and Transonic Flow Apr. 1977 9 p refs (For primary document see N77-31073 22-01)
Avail: NTIS HC A12/MF A01

Using the VFW 614 aircraft as an example the influence of an intermittent jet flow on sub-structures outside known jet

boundaries is illustrated. Effects comparable to those due to the engine jet are caused also by the wake of movable wing parts such as spoilers and airbrakes. The VFW 614 is used again as an example to illustrate the occurrence of horizontal tail buffet due to flow disturbances for outside the spoiler wake region, and to describe the steps taken to eliminate this type of buffet. Several examples of flow separation with ensuing buffeting which typically occur in the course of flight trials, and measures to combat these disturbances are discussed. Author

N77-31082# Aeritalia S. p. A., Torino (Italy)
TAIL RESPONSE TO PROPELLER FLOW ON A TRANSPORT AIRPLANE
L. Chesta *In* AGARD Unsteady Airloads in Separated and Transonic Flow Apr. 1977 13 p (For primary document see N77-31073 22-01)
Avail: NTIS HC A12/MF A01

The results of a flight investigation on tail vibrations on transport aircraft and the measures taken to overcome the subsequent problems are described. Factors studied include: (1) the source of vibrations; (2) the flight conditions in which they occur; and (3) the impact of the vibration level on the fatigue life. It is concluded that the three propeller blades and the associated airscrews are the excitation source of the vibrations. Author

N77-31083# Saab-Scania, Linkoping (Sweden). Aerospace Div.
FLUTTER CALCULATION FOR THE VIGGEN AIRCRAFT WITH ALLOWANCE FOR LEADING EDGE VORTEX EFFECT
In AGARD Unsteady Airloads in Separated and Transonic Flow Apr. 1977 7 p refs (For primary document see N77-31073 22-01)
Avail: NTIS HC A12/MF A01

An application in a flutter calculation for the Viggen aircraft of a program system for aeroelastic calculations is briefly described. The result which is checked against an indepedent calculation shows that a large flutter margin exists. For increasing angle of incidence, however, the margin may decrease due to the effect of the leading edge vortices. An estimate of the decrease was obtained by applying a correction factor based on measured pressure distributions for steady flow to the calculated lift distribution. Author

N77-31084# Air Force Flight Dynamics Lab., Wright-Patterson AFB, Ohio. Dynamics Lab.
A BRIEF OVERVIEW OF TRANSONIC FLUTTER PROBLEMS
Walter J. Mykytow *In* AGARD Unsteady Airloads in Separated and Transonic Flow Apr. 1977 13 p refs (For primary document see N77-31073 22-01)
Avail: NTIS HC A12/MF A01

A framework of industrial flutter problems with particular emphasis on the impact for the speed region is provided. Flutter stability boundaries are given re-emphasizing the critical design conditions present in the transonic flight region. The re-emphasis is accomplished using results from research flutter model tests, aircraft design, and development model tests, and aircraft flight damping measurements. B.B.

N77-31085# National Aerospace Lab., Amsterdam (Netherlands)
UNSTEADY AIRLOADS ON AN OSCILLATING SUPERCRITICAL AIRFOIL
N. Tijdeman, P. Schippers, and A. J. Pearsoon *In* AGARD Unsteady Airloads in Separated and Transonic Flow Apr. 1977 15 p refs (For primary document see N77-31073 22-01)
Avail: NTIS HC A12/MF A01

Results are presented of unsteady pressure measurements on a two-dimensional model of the supercritical NLR 7301 airfoil performing pitching oscillations about an axis at 40 per cent of the chord. Author

N77-31086# General Dynamics/Convair, San Diego, Calif.
THE TRANSONIC OSCILLATING FLAP: A COMPARISON OF CALCULATIONS WITH EXPERIMENTS
R. Magnus and H. Yoshihara (Boeing Co., Seattle) *In* AGARD Unsteady Airloads in Separated and Transonic Flow Apr. 1977 5 p refs Sponsored by AF (For primary document see N77-31073 22-01)
Avail: NTIS HC A12/MF A01

Finite difference calculations based on the exact inviscid equations for an oscillating flap on an airfoil at M = 0.875 are compared to the Tijdeman-Schippers experimental results. Viscous effects were incorporated in a phenomenological manner using viscous displacement ramps. Reasonably good agreement was obtained, but with a significant discrepancy in the shock motions attributable to a mismatch in the surface pressures upstream of the shock. Recalculation at M = 0.854 yielded results in good overall agreement with the experiments at M = 0.875 for both the steady and the unsteady cases. Author

N77-31087*# National Aeronautics and Space Administration, Ames Research Center, Moffett Field, Calif.
EFFICIENT SOLUTION OF UNSTEADY TRANSONIC FLOWS ABOUT AIRFOILS
W. F. Ballhaus and P. M. Goorjian (Informatics Corp., Palo Alto, Calif.) *In* AGARD Unsteady Airloads in Separated and Transonic Flow Apr. 1977 11 p refs Prepared in cooperation with AAMRDL (For primary document see N77-31073 22-01)
Avail: NTIS HC A12/MF A01 CSCL 01A

An implicit finite difference procedure was developed for the efficient solution of unsteady transonic flow fields. Sample computations illustrate applications of procedures to aerodynamic problems. Solutions are presented that illustrate three types of shock wave motion that can result from airfoil control surface oscillations. The significant effect of wind tunnel wall conditions on these shock wave motions is demonstrated. Solutions are also presented for a simple aeroelastic problem in which the flow field equations and the structural motion equations are integrated simultaneously in time. Both stable and unstable aeroelastic interactions are considered. The procedure is adapted to compute unsteady aerodynamic force coefficients by the indicial method. Author

N77-31088# Office National d'Etudes et de Recherches Aerospatiales, Paris (France)
NUMERICAL CALCULATION OF UNSTEADY TRANSONIC FLOWS
Alain Lerat and Jacques Sides *In* AGARD Unsteady Airloads in Separated and Transonic Flow Apr. 1977 10 p refs *In* ENGLISH and FRENCH (For primary document see N77-31073 22-01)
Avail: NTIS HC A12/MF A01

A finite difference method is presented for the calculation of inviscid transonic flow over an airfoil in arbitrary rigid body motion. The two dimensional unsteady Euler equations in conservation law form are solved in a transformed plane defined through a time dependent mapping. The numerical scheme makes use of several variants of MacCormack scheme in the space domain with suitable matchings. A mesh refinement is used in the vicinity of shock waves. The slip condition is satisfied on the exact airfoil surface and the boundary condition at downstream infinity takes into account the nonhomentropy of the flow. Calculations are made of the unsteady flow over the airfoil oscillating in pitch at Mach 0.8. Author

N77-31089# Royal Aircraft Establishment, Farnborough (England). Structures Dept.
A PRACTICAL FRAMEWORK FOR THE EVALUATION OF OSCILLATORY AERODYNAMIC LOADING ON WINGS IN SUPERCRITICAL FLOW
H. C. Garner *In* AGARD Unsteady Airloads in Separated and Transonic Flow Apr. 1977 15 p refs (For primary document see N77-31073 22-01)
Avail: NTIS HC A12/MF A01

An approximate theoretical treatment is devised in terms of nonlinear steady surface pressure and linear oscillatory loading

The steady data are taken either from transonic small perturbation theory or from static measurements of surface pressure. The resulting theoretical or semi-empirical method can take account of stream Mach number, mean incidence, mode of oscillation, frequency and amplitude. The calculations are organized into a computer program, the scope and broad details of which are outlined. Its first application is in support of a wind tunnel study of a rigid half wing with freedom to rotate about a swept axis. The experiment provides measurements of steady and oscillatory pressure distributions over the range of Mach number from 0.60 to 0.86. The oscillatory results are compared with calculations from linearized theory and from the present method in its theoretical and semi-empirical forms. Like the dynamic experiments, the calculations show large differences between oscillatory chordwise load distributions under subcritical and supercritical conditions. In particular, the region surrounding a shockwave exhibits large and rapid changes in both amplitude and phase of the measured loading, which are reproduced qualitatively in the calculations. The resulting generalized aerodynamic forces are found to depend significantly on the development of supercritical flow. The method should provide an economical indication of the influence of mean flow on the flutter aerodynamics in the lower transonic regime. Author

N77-31080*# Boeing Commercial Airplane Co., Seattle, Wash. Flutter Research Group

APPLICATION OF A FINITE DIFFERENCE METHOD TO THE ANALYSIS OF TRANSONIC FLOW OVER OSCILLATING AIRFOILS AND WINGS

Warren H. Weatherill, James D. Sebastian (Boeing Computer Services, Inc., Seattle), and F. Edwards Ehlers. *In* AGARD Unsteady Airloads in Separated and Transonic Flow, Apr. 1977, 13 p. refs (For primary document see N77-31073 22-01)
(Contract NAS1-14204)
Avail: NTIS HC A12/MF A01; CSCL 01A

A finite difference method for solving the unsteady flow about harmonically oscillating wings is investigated. The procedure is based on separating the velocity potential into steady and unsteady parts and linearing the resulting unsteady differential equation for small disturbances. Solutions are obtained using relaxation procedures. The means for improving the solution stability characteristics of the relaxation process are explored. A direct procedure is formulated which permits obtaining solutions for combinations of Mach number and reduced frequency for which the relaxation process has proved unstable. The pressure distribution for an aspect ratio 5 rectangular wing oscillating in pitch is presented. Author

N77-31091# Flow Research, Inc., Kent, Wash.

NUMERICAL SOLUTION OF THE UNSTEADY TRANSONIC SMALL-DISTURBANCE EQUATIONS

M. M. Hafez, M. H. Rizk, and E. M. Murman. *In* AGARD Unsteady Airloads in Separated and Transonic Flow, Apr. 1977, 13 p. refs (For primary document see N77-31073 22-01)
(Contract F33615-76-C-3067)
Avail: NTIS HC A12/MF A01

Problems that occur in the small unsteady harmonic perturbation approach of calculating transonic flutter problems are examined. Numerical instability that occurs in the relaxation procedure for solving the reduced potential equation is studied, the instability results in a critical reduced frequency (for a given Mach number) beyond which relaxation solutions are divergent. A numerical treatment of Helmholtz's equation by iterative techniques studied and a one dimensional model is computed to demonstrate a suggested solution. The second problem is to properly treat the movement of a shock wave caused by the harmonic perturbation of the body. The shock movement is described by a special equation, which is derived from a consistent perturbation expansion for the nonlinear differential equation and from shock jump relations. Author

N78-10006# Advisory Group for Aerospace Research and Development, Paris (France)

SELECTED PAPERS ON ADVANCED DESIGN OF AIR VEHICLES

Antonio Ferri. Aug. 1977, 133 p. refs
(AGARD-AG-226; ISBN-92-835-1253-7) Avail: NTIS HC A07/MF A01

Research and Development on SST project in the U.S.A. are presented. Engine design, air pollution, and aerodynamic drag are emphasized. For individual titles, see N78-10006 through N78-10015.

N78-10008*# Advisory Group for Aerospace Research and Development, Paris (France)

POSSIBILITIES AND GOALS FOR THE FUTURE SST

Antonio Ferri. *In its* Selected Papers on Advanced Design of Air Vehicles, Aug. 1977, p. 3-12. refs. Repr. from J. Aircraft, v. 12, no. 12, Dec. 1975, p. 919-929. Presented at 13th AIAA Aerospace Sci. Meeting, Pasadena, Calif., 20-22 Jan. 1975 (For availability see N78-10005 01-01)
(Grants NGL-33-016-119, NGR-33-016-131)
(AIAA-Paper-75-254) Avail: NTIS HC A07/MF A01; CSCL 01C

An analysis and evaluation of the social value of the SST project are presented. It is emphasized that the means of civil mass transportation reaching the same range available to military decrease the tension among neighboring nations and reduce human fatigue. The present status of the SST in the United States, together with the future goals are described. I.M.

N78-10007*# Advisory Group for Aerospace Research and Development, Paris (France)

REVIEW OF PROBLEMS IN APPLICATION OF SUPERSONIC COMBUSTION

Antonio Ferri. *In its* Selected Papers on Advanced Design of Air Vehicles, Aug. 1977, p. 13-30. refs. Repr. from J. Roy. Aeronaut. Soc. (Engl.), v. 68, no. 645, Sep. 1964, p. 575-595. (For availability see N78-10005 01-01)
(Contracts NAS8-2686, AF 49(638)-991, AF 33(657)-10463)
Avail: NTIS HC A07/MF A01; CSCL 21B

The problem of air-breathing engines capable of flying at very high Mach numbers is described briefly. Possible performance of supersonic combustion ramjets is outlined briefly and the supersonic combustion process is described. Two mechanisms of combustion are outlined, one is supersonic combustion controlled by convection process, and the second is controlled by diffusion. The parameters related to the combustion process are discussed in detail. Data and analyses of reaction rates and mixing phenomena are represented, the flame mechanism is discussed, and experimental results are presented. Author

N78-10008# Advisory Group for Aerospace Research and Development, Paris (France)

A CRITICAL REVIEW OF HETEROGENEOUS MIXING PROBLEMS

Antonio Ferri. *In its* Selected Papers on Advanced Design of Air Vehicles, Aug. 1977, p. 31-41. refs. Repr. from Astronaut. Acta (Austria), v. 13, nos. 5-6, 49681, p. 453-465. Presented at Intern. Acad. of Astronautics Symp. on Fluid Dyn. of Heterogeneous Multi-Phase Continuous Media, Naples, 3-6 Oct. 1966 (For availability see N78-10005 01-01)
(Contract AF 33(615)-2215, AF Proj. 7064)
Avail: NTIS HC A07/MF A01

A critical review of available analyses of mixing phenomena is presented. The limitations of the assumption of the boundary layer types of approximation in the analysis of mixing and of viscous flows at high Mach numbers are discussed. Methods of analysis are described where the shortcomings introduced by any boundary layer type of approximation are avoided. The application of such type of analysis to supersonic mixing problems which produce large pressure variation, and to low density hypersonic flow is outlined. The problem of obtaining information on transport properties from experimental measures is discussed. The difficulties of producing, experimentally, a well-defined turbulent mixing of two streams, especially at low speed, are pointed out. It is shown that small pressure gradients usually present in any experiment of mixing produces strong effects on the velocity profiles of axially symmetric jets where focusing of waves is possible. New types of phenomena occurring in mixing in the presence of pressure gradients and chemical reaction are

discussed. Formation of reverse flow in axially symmetric streams far from the axis of mixing, due to small pressure gradients, when mixing with combustion takes place is demonstrated analytically and experimentally. Author

N78-10009# Advisory Group for Aerospace Research and Development, Paris (France)
ANALYSIS OF FLUID DYNAMICS OF SUPERSONIC COMBUSTION PROCESS CONTROLLED BY MIXING
Antonio Ferri and Herbert Fox. *In its* Selected Papers on Advanced Design of Air Vehicles. Aug. 1977. p 43-49. refs. Presented at 12th Intern. Symp. on Combust. p 1105-1112. (For availability see N78-10005 01-01)
(Contract F33615-68-C-1114)
Avail: NTIS HC A07/MF A01

The fluid dynamics of supersonic combustion is discussed. The interference between the combustion process and the supersonic flow secondary to the combustion region is described. Multiple injector flow fields are described from the point of view of mixing and of interaction with the external flow. It is shown that the selection of injector location and combustion process can be utilized to produce compression waves of controlled strength. Such waves can be utilized to reduce the flow Mach number in front of subsequent injectors. This effect is called thermal compression. Engineering criteria for utilization of thermal compression are presented. An example of such utilization is described. The example indicates that the interaction between combustion and geometry is of primary importance for the fluid-dynamic process. The effect of this interaction cannot be accounted for by a simple one-dimensional analysis. Only a judicious combination of mixing analyses and more complex analyses, that takes into account the formation and propagation of the waves due to combustion, can give detailed qualitative information on the fluid dynamics of supersonic combustion.
Author

N78-10010*# Advisory Group for Aerospace Research and Development, Paris (France).
EFFECTS OF LENGTHWISE LIFT DISTRIBUTION ON SONIC BOOM OF SST CONFIGURATIONS
Antonio Ferri and Ahmed Ismail. *In its* Selected Papers on Advanced Design of Air Vehicles. Aug. 1977. p 51-54. refs. Repr. from J. Aircraft, v. 12, no. 12, Dec. 1975. p 919-929. (For availability see N78-10005 01-01)
(Grant NGR-33-016-119)
Avail: NTIS HC A07/MF A01. CSCL 20A

Sonic Boom signatures produced by possible SST configurations during cruise were investigated. It is shown that optimization based on a far field analysis is not necessarily the optimum for these conditions. For an airplane length of 300 ft, near-field effects can be obtained when sufficient lift is generated near the nose of the airplane. Because of the near-field effects, sonic booms with maximum overpressures of the order of 1 lb/square foot can be obtained with possible airplane configurations having the same flight conditions at cruise. Author

N78-10011*# Advisory Group for Aerospace Research and Development, Paris (France).
PRACTICAL ASPECTS OF SONIC BOOM PROBLEMS
Antonio Ferri. *In its* Selected Papers on Advanced Design of Air Vehicles. Aug. 1977. p 55-63. refs. Presented at 7th Congr. of the Intern. Council of the Aeronautical Sci., Consiglio Nazl. delle Ricerche, Rome, 14-18 Sep. 1970. (For availability see N78-10005 01-01)
(Grant NGL-33-016-119)
(ICAS-Paper-70-23) Avail: NTIS HC A07/MF A01. CSCL 20A

SST configurations selected from the point of minimizing sonic booms are investigated. It is indicated that for a total length of 300 ft and total initial weight of the same order as the present U.S. SST designs, sonic booms having shock pressure rise of the order of 0.6 lb/square foot can be obtained. Values as low as 0.3 are possible for airplanes designed for cross-country flights. Author

N78-10012*# Advisory Group for Aerospace Research and Development, Paris (France)
SONIC BOOM ANALYSIS FOR HIGH-ALTITUDE FLIGHT AT HIGH MACH NUMBER
Antonio Ferri, Michael Siclari, and Lu Ting. *In its* Selected Papers on Advanced Design of Air Vehicles. Aug. 1977. p 65-74. refs. Repr. from Progr. Astronaut. Aeronaut., v. 38, 1975. p 301-320. Presented at AIAA Aero-Acoustics Conf., Seattle, 15-17 Oct. 1973. (For availability see N78-10005 01-01)
(Grant NGL-33-016-119)
(AIAA-Paper-73-1034) Avail: NTIS HC A02/MF A01. CSCL 20A

Numerical programs for the computation of the flow field from the airplane at the flight altitude to the ground are presented. They take into account the nonlinear effects of high Mach number, the entropy change across the shock, the entropy and enthalpy variations in the atmospheric layer, and the gravitational effect. Extension of the programs for the axisymmetric problems to handle nonaxisymmetric terms is described. The asymmetry can be caused by the geometry of the body and the lift, and also by the fact that the variations in the atmospheric layer are two-dimensional. Numerical results for ground level signatures of several configurations at various flight conditions are presented and compared with existing approximate theories to demonstrate the influences of these nonlinear effects. Author

N78-10013# Advisory Group for Aerospace Research and Development, Paris (France)
BETTER MARKS ON POLLUTION FOR THE SST
Antonio Ferri. *In its* Selected Papers on Advanced Design of Air Vehicles. Aug. 1977. p 75-78. Repr. from J. Aircraft, v. 12, no. 12, Dec. 1975. p 919-929. (For availability see N78-10005 01-01)
Avail: NTIS HC A02/MF A01

The SST engine was investigated in terms of acceptable levels of nitrogen oxides and appropriate specifications for engine design, as in other pollution problems. It was found that neither the SST nor other aircraft using conventional chemical fuel will harm the upper atmosphere by water injection, and propulsion stratagems can reduce the figure of oxides of nitrogen from the 400 parts per million in exhaust used two years ago to 1 or 2 parts through the technology possible now. Author

N78-10014*# Advisory Group for Aerospace Research and Development, Paris (France).
THE JET ENGINE DESIGN THAT CAN DRASTICALLY REDUCE OXIDES OF NITROGEN
Antonio Ferri and Anthony Agnone. *In its* Selected Papers on Advanced Design of Air Vehicles. Aug. 1977. p 79-88. refs. Presented at 12th AIAA Aerospace Sci. Meeting, Wash., D. C., 30 Jan. - 1 Feb. 1974. (For availability see N78-10005 01-01)
(Grant NGR-33-016-131)
(AIAA-Paper-74-160) Avail: NTIS HC A07/MF A01. CSCL 21E

The NOx pollution problem of hydrogen fueled turbojets and supersonic combustion ramjets (scramjets) was investigated to determine means of substantially alleviating the problem. Since the NOx reaction rates are much slower than the energy producing reactions, the NOx production depends mainly on the maximum local temperatures in the combustor and the NOx concentration is far from equilibrium at the end of a typical combustor (L approximately 1 ft). In diffusion flames, as used in present turbojets and scramjets combustor designs, the maximum local temperature occurs at the flame and is equal to the stoichiometric value. Whereas, in the heat conduction flames, wherein the flame propagates due to a heat conduction process away from the flame to the cooler oncoming premixed unburnt gases, the maximum temperature is lower than in the diffusion flame. Hence the corresponding pollution index is also lower. Author

N78-10015*# Advisory Group for Aerospace Research and Development, Paris (France).
THE PROBLEM OF POLLUTION FOR THE SST
Antonio Ferri. *In its* Selected Papers on Advanced Design of Air Vehicles. Aug. 1977. p 89-96. refs. Presented at the 9th Congr. of the Intern. Council of the Aeron. Sci., Haifa, Israel

25-30 Aug 1974 (For availability see N78-10005 01-01) (Grant NGR-33-016-131)
(ICAS-Paper-74-29) Avail NTIS HC A07/MF A01 CSCL 21E

A qualitative review of the possible effects of the exhaust gases discharged by a large fleet of SST's in the upper atmosphere is given. The review indicates the importance of the NO production in the exhaust gases. The mechanism of NO formation by the combustion process is described. A method for reduction of the NO formation is presented. Author

N78-26049# Advisory Group for Aerospace Research and Development, Paris (France)
GUIDANCE AND CONTROL DESIGN CONSIDERATIONS FOR LOW-ALTITUDE AND TERMINAL-AREA FLIGHT
Apr. 1978 316 p refs *Papers presented at* Guidance and Control Panel Symp., Dayton, Ohio, 17-20 Oct. 1977
(AGARD-CP-240; ISBN-92-835-1278-2) Avail: NTIS HC A14/MF A01

Navigational problems and collision avoidance are considered for low altitude and terminal area flights. Operational problems, terrain following, terminal area, landing, weapon delivery, and system integration are included. For individual titles, see N78-26050 through N78-26073.

N78-26050# Ministry of Defence, London (England)
GUIDANCE AND CONTROL FOR LOW LEVEL OFFENSIVE AIRCRAFT: A ROYAL AIR FORCE VIEW
G. A. Barnes *In* AGARD Guidance and Control Design Considerations for Low-Altitude and Terminal-Area Flight Apr. 1978 5 p (For availability see N78-26049 17-01)
Avail: NTIS HC A14/MF A01

The operational requirements for guidance and control systems for offensive aircraft, in the central region of Europe, depend both on the weapon delivery accuracy and on the penetration tactics and weapon delivery profiles. The profiles are affected by the enemy's anti-aircraft defense system and by weather conditions. Possible parameters are suggested for aircraft use in counter air, interdiction, and close air support roles. J.A.M.

N78-26051# National Aerospace Lab., Amsterdam (Netherlands).
THE GROUND-ATTACK/PENETRATION MODEL: A MONTE CARLO SIMULATION MODEL TO ASSESS THE SURVIVABILITY AND TO EVALUATE TACTICS FOR LOW-ALTITUDE MILITARY MISSIONS IN AN ENVIRONMENT OF GROUND-BASED AIR DEFENCE SYSTEMS
M. H. W. Bovy *In* AGARD Guidance and Control Design Considerations for Low-Altitude and Terminal-Area Flight Apr. 1978 5 p refs (For availability see N78-26049 17-01)
Avail: NTIS HC A14/MF A01

In the ground attack/penetration model, the following sets of parameters, each describing an essential component of the aircraft defense system interaction, were established: (1) defense system data (such as detection performance data, fire control computer performance data, missile data); (2) environmental factors (such as terrain features, meteorological conditions); and (3) aircraft characteristics (aircraft trajectory, radar cross section, ECM capabilities, etc.). This model was used for assessing aircraft vulnerability to air defense systems. J.A.M.

N78-26052# Technische Universitaet, Brunswick (West Germany)
OPEN-LOOP COMPENSATION OF WIND-SHEAR EFFECTS IN LOW LEVEL FLIGHT
Rudolf Brockhaus and Peter Wuest *In* AGARD Guidance and Control Design Considerations for Low-Altitude and Terminal-Area Flight Apr. 1978 19 p refs (For availability see N78-26049 17-01)
Avail: NTIS HC A14/MF A01

Since efficient *closed loop control of wind shear* produces high throttle activity, an open loop control law was developed that proved to be very efficient without the shortcomings of closed loop control. An open loop activation of throttle and spoilers was adequate to minimize the wind shear effects and thereby to discharge the closed loop system. A very simple Kalman filter with nonlinear limitation of the second derivative of wind velocity was found adequate to solve the separation problem. J.A.M.

N78-26053# Royal Aircraft Establishment, Farnborough (England). Flight Systems Dept.
AIRCRAFT RIDE-BUMPINESS AND THE DESIGN OF RIDE-SMOOTHING SYSTEMS
J. C. Jones and D. E. Fry *In* AGARD Guidance and Control Design Considerations for Low-Altitude and Terminal-Area Flight Apr. 1978 12 p refs (For availability see N78-26049 17-01)
Avail: NTIS HC A14/MF A01

Aircraft longitudinal ride-bumpiness due primarily to aircraft rigid-body response is discussed. Results for flight at high speeds and low altitude are described and the implications for aircraft design deduced, both in terms of basic airframe considerations and the use of active controls. Bumpiness is distinguished from vibration, the former being characterized by a sequence of separately identifiable g fluctuations, referred to as bumps, the latter being associated with quasi-sinusoidal oscillations. Using statistical discrete gust theory, bumpiness is described in terms of g counts per unit time. In addition to providing a quantitative measure of exceedance counts of arbitrary g levels, this theory allows the straightforward computation of the sharpness of a bump in the sense of the rise-time of a typical discrete fluctuation in normal acceleration. J.A.M.

N78-26054# Northrop Corp., Hawthorne, Calif. Aircraft Group.
FLIGHT CONTROL SYSTEM DESIGN FOR RIDE QUALITIES OF HIGHLY MANEUVERABLE FIGHTER AIRCRAFT
J. F. Moynes and J. T. Gallagher *In* AGARD Guidance and Control Design Considerations for Low-Altitude and Terminal-Area Flight Apr. 1978 21 p refs (For availability see N78-26049 17-01)
Avail: NTIS HC A14/MF A01

A flight control system design is presented that utilizes a ride improvement mode system (RIMS) in conjunction with a control augmentation system to achieve desired ride smoothing for low altitude high speed flight conditions. *The large amplitude* flight simulator and the continuous system modeling program were used as the tools to analyze and evaluate ride qualities of a highly maneuverable fighter aircraft in low altitude, high speed flight conditions. Analysis included the effect of the first body bending mode on ride quality and pilot evaluations of the RIMS as flown on the large amplitude flight simulator. It is demonstrated that significant improvement in ride quality on a low wing loaded multipurpose combat airplane could be achieved without adverse impact on the handling qualities. J.A.M.

N78-26055# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick (West Germany). Inst. Fuer Flugfuehrung.
FLIGHT PERFORMANCE AND PILOT WORKLOAD IN HELICOPTER FLIGHT UNDER SIMULATED IMC EMPLOYING A FORWARD LOOKING SENSOR
R. Beyer *In* AGARD Guidance and Control Design Considerations for Low-Altitude and Terminal-Area Flight Apr. 1978 9 p refs (For availability see N78-26049 17-01)
Avail: NTIS HC A14/MF A01

A study was made giving particular emphasis to flight *performance and pilot workload in* flights under simulated IMC, *employing a forward* looking sensor, as well as to the layout of the display and the sensor system. The experiments were flown in a Bell UH-1D helicopter. The technical approach and some results are presented. J.A.M.

N78-26056# Forschungsinstitut fuer Anthropotechnik, Meckenheim (West Germany).
HUMAN ENGINEERING EVALUATION OF A COCKPIT DISPLAY/INPUT DEVICE USING A TOUCH SENSITIVE SCREEN
Klaus-P. Gaertner *In* AGARD Guidance and Control Design Considerations for Low-Altitude and Terminal-Area Flight Apr. 1978 13 p refs (For availability see N78-26049 17-01)
Avail: NTIS HC A14/MF A01

A cockpit touch input/output system is described which integrates and combines several control and display functions of

airborne systems into one space which can be located in the primary control and display areas of the cockpit. This integration is accomplished by the use of touch sensitive virtual switching arrays on a CRT driven by sophisticated computer software. Various technical approaches to the touch sensitive aspect of this system are described. The touch input control device and its possible application to airborne systems are discussed in terms of its advantages and reliability requirements. Several unique ergonomic problems associated with these devices are identified. A case history application for selected airborne systems involving use of menu-select hierarchies of virtual keyboards is presented. J.A.M.

N78-26057# Stuttgart Univ. (West Germany). Inst. Fuer Flugnavigation.

PROPOSAL FOR A COST EFFECTIVE RADAR NAVIGATION SYSTEM FOR LOW ALTITUDE AND TERMINAL AREA FLIGHT

E. Wildermuth. *In* AGARD Guidance and Control Design Considerations for Low-Altitude and Terminal-Area Flight Apr. 1978 13 p refs (For availability see N78-26049 17-01)

Avail: NTIS HC A14/MF A01

The combination of already existent, well proved, and reliable navigational components or systems may be integrated to an effective navigation system. The usefulness of this concept was demonstrated on a practical example, where a dead reckoning navigation system and a radar set, belonging to the navigation equipment of a close support aircraft, were integrated to a cost effective radar navigation system. The utility and advantage of this system were proved in navigation test flights. Results showed that the system could be a valuable navigational aid for low altitude and terminal area flight. J.A.M.

N78-26058# British Aircraft Corp., Preston (England). Military Aircraft Div.

DESIGN CONSIDERATIONS FOR A GROUND AVOIDANCE MONITOR FOR FIGHTER AIRCRAFT

D. A. Whittle. *In* AGARD Guidance and Control Design Considerations for Low-Altitude and Terminal-Area Flight Apr. 1978 13 p refs (For availability see N78-26049 17-01)

Avail: NTIS HC A14/MF A01

The problem of ground avoidance, as a consequence of maneuvers executed by fighter aircraft, is considered, and a relatively simple form of monitor is proposed to provide a pilot warning in the event of the aircraft being subjected to a hazardous trajectory. The parametric requirements of the ground avoidance monitor are discussed, along with difficulties associated with selection of suitable and available sensors. J.A.M.

N78-26059# Marconi-Elliott Avionic Systems Ltd., Rochester (England). Flight Control Div.

SYSTEM INTEGRATION AND SAFETY MONITORING TO ACHIEVE INTEGRITY IN LOW ALTITUDE FLIGHT CONTROL SYSTEMS

D. Sweeting. *In* AGARD Guidance and Control Design Considerations for Low-Altitude and Terminal-Area Flight Apr. 1978 16 p refs (For availability see N78-26049 17-01)

Avail: NTIS HC A14/MF A01

Problems of monitoring the key flight control system elements were examined, in particular the primary terrain following (TF) sensor. The TF sensors are proposed that take advantage of the digital computing system capability (which was not available on first generation TF sensors). Improvements in navigation systems, such as strapdown IN and NAVStar when combined with stored map information, can be employed during low altitude operation to warn of hazardous situations relative to terrain. J.A.M.

N78-26060# Air Force Flight Dynamics Lab., Wright-Patterson AFB, Ohio.

TERRAIN FOLLOWING CRITERIA: THE NEED FOR A CANNON MEASURE

A. F. Barfield. *In* AGARD Guidance and Control Design Considerations for Low-Altitude and Terminal-Area Flight Apr. 1978 13 p (For availability see N78-26049 17-01)

Avail: NTIS HC A14/MF A01

A research program was undertaken to organize meaningful terrain following criteria. The standards were required to be independent of system mechanization. Initially, a literature search was conducted to obtain data on various terrain following systems and previously used criteria. Terrain following concepts were categorized and used to define common system elements that would be considered in the study. Criteria were then established based on this previous work and a current simulation effort. Performance measures were quantified and a performance index established. The performance index, in conjunction with a checklist, provided a means of comparing terrain following techniques. A handbook was then formulated but remains to be validated before incorporation into applicable Air Force Specifications. The proposed criteria are intended for use not only in writing terrain following system specifications, but also in determining terrain following equipment design, equating and ranking alternate terrain following methods, and allowing the merits of modifications to be assessed. J.A.M.

N78-26061# Air Force Flight Test Center, Edwards AFB, Calif.

B-1 TERRAIN-FOLLOWING DEVELOPMENT

Charles W. Brinkley, Patrick S. Sharp, and Richard Abrams (Rockwell International, Edwards, Calif.). *In* AGARD Guidance and Control Design Considerations for Low-Altitude and Terminal-Area Flight Apr. 1978 13 p (For availability see N78-26049 17-01)

Avail: NTIS HC A14/MF A01

The B-1 terrain following (TF) system and low altitude penetration capabilities were evaluated. The B-1 mission, flight test program goals, and test philosophy are discussed. The operating theory of the TF system is outlined, including the forward looking radar, TF computer, radar altimeter, TF/flight control system adapter, automatic throttle system, and autopilot. Ground tracking requirements and types of maneuvers flown are also considered. J.A.M.

N78-26062# Royal Aircraft Establishment, Bedford (England). Operational Systems Div.

STEEP GRADIENT APPROACH SYSTEMS RESEARCH FOR ALL-WEATHER OPERATIONS

A. D. Brown. *In* AGARD Guidance and Control Design Considerations for Low-Altitude and Terminal-Area Flight Apr. 1978 15 p refs (For availability see N78-26049 17-01)

Avail: NTIS HC A14/MF A01

Some aspects are described of steep gradient approach research carried out at RAE Redford using flight trials, piloted simulation and theoretical studies. Because only conventional aircraft were available, the flight program was oriented towards establishing the limitation of such types and their associated avionics equipment when used for R/STOL operations. Only performance data for the twin turbojet BAC 1-11 and the twin turboprop HS 748 are presented. Aspects considered include the determination of the maximum useable glideslope angle and the optimum bandwidths for azimuth and elevation ratio guidance to permit R/STOL operations using a standard autopilot. It is suggested the MLS with DME range information will overcome some of the limitations identified. Manual approach performance results are also presented which indicate the need for 150-200 ft decision heights. Piloted simulation research has shown a requirement for approach lighting comparable to existing Category 2 patterns for poor visibility operations. Even then, it is unlikely that acceptable missed approach rates can be achieved unless RVRs are in excess of 1000 metres. L.S.

N78-26063*# National Aeronautics and Space Administration Langley Research Center, Langley Station, Va. Flight Research Div.

RECENT FLIGHT TEST RESULTS USING AN ELECTRONIC DISPLAY FORMAT ON THE NASA B-737

Samuel A. Morello. *In* AGARD Guidance and Control Design Considerations for Low-Altitude and Terminal-Area Flight Apr. 1978 10 p refs (For availability see N78-26049 17-01)

Avail: NTIS HC A14/MF A01 CSCL 01D

The results of a flight evaluation of two electronic display formats for the approach to landing under instrument conditions. The evaluation was conducted for a baseline electronic display format and for the same format with runway symbology and track information added. The evaluation was conducted during

3 deg, manual, straight in approaches with and without initial localizer offsets. Flight-path tracking performance data and pilot subjective comments were examined with regard to pilot's ability to capture and maintain localizer and glideslope using both display formats. The results of the flight tests agree with earlier simulation results and show that the addition of a perspective runway symbol with an extended centerline and relative track information to a baseline electronic display format improved both lateral and vertical flight-path tracking. Pilot comments indicated that the rental workload required to assess the approach situation was reduced as a result of integrating perspective runway with extended centerline along with relative track information into the vertical situation display L.S

N78-26064*# National Aeronautics and Space Administration Langley Research Center, Langley Station, Va.
AIRLINE PILOT SCANNING BEHAVIOR DURING APPROACHES AND LANDING IN A BOEING 737 SIMULATOR
Amos A. Spady, Jr. *In* AGARD Guidance and Control Design Considerations for Low-Altitude and Terminal-Area Flight Apr. 1978 5 p refs (For availability see N78-26049 17-01)
Avail: NTIS HC A14/MF A01 CSCL 05J

A series of approaches using airline-rated Boeing 737 pilots in an FAA qualified simulator was conducted. The test matrices include both manual and coupled approaches for VFR, Category 1 and Category 2 conditions. A nonintrusive oculometer system was used to track the pilot's eye-point-of-regard throughout the approach. The results indicate that, in general, the pilots use a different scan technique for the manual and coupled (auto-pilot with manual throttle) conditions. For the manual approach 73 percent of the time was spent on the Flight Director and 13 percent on airspeed as opposed to 50 percent on Flight Director and 23 percent on airspeed for the coupled approaches. For the visual portion of approach from less than 100m to touchdown or when the touchdown point came into view, the pilots tend to fixate on their aim or touchdown area until the flare initiation, at which time they let their eye-point-of-regard move up the runway to use the centerline lights for rollout guidance. L.S

N78-26065# Analytic Sciences Corp., Reading, Mass.
EVALUATION OF DIGITAL FLIGHT CONTROL DESIGN FOR VTOL APPROACH AND LANDING
Paul W. Berry, John R. Broussard, and Robert F. Stengel (Princeton Univ., N. J.) *In* AGARD Guidance and Control Design Considerations for Low-Altitude and Terminal-Area Flight Apr. 1978 21 p refs (For availability see N78-26049 17-01)
Avail: NTIS HC A14/MF A01

Methods and results in the design and evaluation of a digital flight control system (DFCS) for a CH-47B helicopter are presented. The DFCS employs proportional-integral control logic to provide rapid, precise response to automatic or manual guidance commands while following conventional or spiral-descent approach paths. It contains attitude- and velocity-command modes, and it adapts to varying flight conditions through gain scheduling. Extensive use is made of linear systems analysis techniques -- the DFCS is designed using linear-optimal estimation and control theory and the effects of gain scheduling are assessed by examination of closed-loop eigenvalues and time responses. The pre-flight-test evaluation described provides a direct comparison of alternate navigation, guidance, and control philosophies; confirms the practical merits of the DFCS design approach; and demonstrates techniques which will aid the development of future guidance and control systems. L.S.

N78-26066*# National Aeronautics and Space Administration, Langley Research Center, Langley Station, Va.
AUTOMATIC FLIGHT PERFORMANCE OF A TRANSPORT AIRPLANE ON COMPLEX MICROWAVE LANDING SYSTEM PATHS
Thomas M. Walsh and Earl F. Weener (Boeing Co., Seattle) *In* AGARD Guidance and Control Design Considerations for Low-Altitude and Terminal-Area Flight Apr. 1978 12 p refs (For availability see N78-26049 17-01)
Avail: NTIS HC A14/MF A01

During this demonstration the microwave landing system was utilized to provide the terminal configured vehicle B-737 airplane with guidance for automatic control on complex, curved descending paths with precision turns into short final approaches terminating in landing and roll-out, even when subjected to strong and gusty tail- and cross-wind components and severe wind shear. The data collected from more than fifty approach flights during the demonstration provided an opportunity to analyze airplane flight performance on a statistical basis rather than on a single flight record basis as is customarily done with limited data replication. Mean and standard deviation data are presented for approach flight path tracking parameters. In addition, the adverse wind conditions encountered during these flights are described using three-dimensional wind vector characteristics computed from the extensive on-board sensor data. L.S

N78-26067# Centre d'Etudes et de Recherches, Toulouse (France).
ACCURATE TIMING IN LANDINGS THROUGH AIR TRAFFIC CONTROL
Marc Pelegrin and Nicole Imbert *In* AGARD Guidance and Control Design Considerations for Low-Altitude and Terminal-Area Flight Apr. 1978 14 p refs (For availability see N78-26049 17-01)
Avail: NTIS HC A14/MF A01

In order to increase the accuracy of the landing time, corrections of speed and heading to be made during the approach of the aircraft are proposed. Numerical simulations including instrumentation, localization, navigation errors and wind were performed for four different aircraft on four approach trajectories. The comparison of the results of 200 simulations in each case, with and without the corrections, point out the improvement of the accuracy of the landing time due to these corrections. Flight tests also were made on commercial flights and the results of these tests are included L.S

N78-26068# Army Avionics Research and Development Activity, Fort Monmouth, N. J.
PROPAGATION INTEGRITY FOR MICROWAVE INSTRUMENT LANDING SYSTEMS
Paul S. Dimko *In* AGARD Guidance and Control Design Considerations for Low-Altitude and Terminal-Area Flight Apr. 1978 8 p refs (For availability see N78-26049 17-01)
Avail: NTIS HC A14/MF A01

Testing at airfields at microwave landing system frequencies, using typical realistic multipath geometries and prototypical microwave landing system antenna radiation patterns, indicated the existence of a multipath problem that must be reckoned with if the next generation microwave landing system, whatever it may be, is to provide the utmost in operational utility and safety. There is strong evidence to support a contention that the choice of the correct polarization is fundamentally the surest way to relieve the next generation precision approach and landing systems from the burden of unnecessary multipath signals. The data weigh heavily in favor of circular polarization L.S

N78-26069# Standard Electrik Lorenz A.G., Stuttgart (West Germany).
DME-BASED SYSTEM FOR ENROUTE/TERMINAL NAVIGATION, ALL-WEATHER LANDING AND AIR TRAFFIC CONTROL
K. D. Eckert *In* AGARD Guidance and Control Design Considerations for Low-Altitude and Terminal-Area Flight Apr. 1978 13 p (For availability see N78-26049 17-01)
Avail: NTIS HC A14/MF A01

An analysis is given of the various subsystems of the DME system detailing its advantages over other installations. The areas of operational performance and economic efficiency are studied L.S

N78-26070# National Aerospace Lab., Amsterdam (Netherlands)
THE ANALYSIS OF OPERATIONAL MISSION EXECUTION: AN ASSESSMENT OF LOW-ALTITUDE PERFORMANCE, NAVIGATION ACCURACY AND WEAPON DELIVERY PERFORMANCE

T J Stahlie *In* AGARD Guidance and Control Design Considerations for Low-Altitude and Terminal Area Flight Apr 1978 10 p (For availability see N78 26049 17-01)
Avail NTIS HC A14/MF A01

A description is given of characteristics of the mission analysis programs as carried out for the Royal Netherlands Air Force by the National Aerospace Laboratory Although the program objectives can differ from trial to trial, they have a number of common properties: the use of onboard instrumentation/recording equipment, no need for ground equipment, specific, high accuracy, techniques for the determination of aircraft position with the aid of aerial photographs etc All the programs are aimed at the analysis of relevant mission parameters, e g low-altitude performance, navigation accuracy, execution of attack maneuver, score of the (simulated) attack Apart from this primary objective, the additional intentions are: a realistic training opportunity for fighter pilots, the evaluation of new tactics and the acquisition of realistic input data for simulation studies The main point in the description is the technical set-up including instrumentation and data reduction techniques, calculation techniques applied and typical results obtained L S

N78-26071*# National Aeronautics and Space Administration Langley Research Center Langley Station, Va
EXPERIMENTAL DETERMINATION OF THE NAVIGATION ERROR OF THE 4-D NAVIGATION, GUIDANCE, AND CONTROL SYSTEMS ON THE NASA B-737 AIRPLANE

Charles E Knox *In* AGARD Guidance and Control Design Considerations for Low-Altitude and Terminal-Area Flight Apr 1978 14 p (For availability see N78-26049 17-01)
Avail NTIS HC A14/MF A01 CSCL 17G

Navigation error data from these flights are presented in a format utilizing three independent axes - horizontal, vertical, and time The navigation position estimate error term and the autopilot flight technical error term are combined to form the total navigation error in each axis This method of error presentation allows comparisons to be made between other 2-, 3-, or 4-D navigation systems and allows experimental or theoretical determination of the navigation error terms Position estimate error data are presented with the navigation system position estimate based on dual DME radio updates that are smoothed with inertial velocities, dual DME radio updates that are smoothed with true airspeed and magnetic heading, and inertial velocity updates only The normal mode of navigation with dual DME updates that are smoothed with inertial velocities resulted in a mean error of 390 m with a standard deviation of 150 m in the horizontal axis, a mean error of 1.5 m low with a standard deviation of less than 11 m in the vertical axis; and a mean error as low as 252 m with a standard deviation of 123 m in the time axis. L S

N78-26072# Technische Universitaet, Brunswick (West Germany).
DIRECT LIFT CONTROL FOR FLIGHT PATH CONTROL AND GUST ALLEVIATION
Gunther Shaenzer *In* AGARD Guidance and Control Design Considerations for Low-Altitude and Terminal-Area Flight Apr 1978 14 p refs (For availability see N78-26049 17-01)
Avail NTIS HC A14/MF A01

Most of the results from the use of direct lift controls have not been very encouraging. The main reason for this is the coupling of desirable lift change with undesirable change of drag and pitch moment This leads to unfavorable cross couplings with respect to handling qualities Another reason is a design problem that can occur due to the high actuator rate, required for the DLC device. High actuator rate leads to high costs of the control actuator and actuator power supply as well as to drawbacks in the reliability of the system An analysis is given to illustrate some of the problems, to point out the main cause of these problems and to indicate when DLC can be used successfully L S

N78-26073# Elektronik-System G m b H., Munich (West Germany)
NAVIGATION SYSTEM ASPECTS OF LOW ALTITUDE FLIGHT
Paul A Bross *In* AGARD Guidance and Control Design Considerations for Low-Altitude and Terminal-Area Flight Apr 1978 13 p (For availability see N78-26049 17-01)
Avail NTIS HC A14/MF A01

The requirements deriving from accurate weapon delivery in enemy controlled areas are examined Specifically, the requirements imposed on precision and integrity and safety are investigated. The need for an integration navigation system is stressed Principal design criteria for low altitude flight are suggested L S

N78-26074# Advisory Group for Aerospace Research and Development, Paris (France).
PERFORMANCE PREDICTION METHODS
May 1978 355 p refs Partly in ENGLISH and FRENCH Presented at Flight Mech Panel Specialists Meeting on Performance Prediction Methods, Paris, 11-13 Oct 1977
(AGARD-CP-242; ISBN-92-835-1282-0) Avail NTIS HC A16/MF A01

Most of the analyses involve extrapolation of wind tunnel data to full scale flight conditions In addition to performance prediction, the fields of flight mechanics, flight path optimization, and engine performance prediction are discussed Pilot input and the question of performance method standardization are also discussed For individual titles, see N78 26075 through N78 26094

N78-26075# Air Force Flight Dynamics Lab., Wright-Patterson AFB, Ohio
PERFORMANCE METHODS FOR AIRCRAFT AND MISSILES
L Earl Miller and Burtis R Benson *In* AGARD Performance Prediction Methods May 1978 16 p refs (For availability see N78-26074 17-01)
Avail NTIS HC A16/MF A01

Approximate closed form solutions are derived for a typical fighter mission. Also, flyout range and maneuvering requirements are derived for missiles These solutions are suitable for the initial stages of preliminary design analysis The state of the art of trajectory optimization and air to air analysis are reviewed The development of singular perturbation theory has eliminated some of the numerical difficulties associated with two point boundary value problems P R A

N78-26076# Technische Hochschule, Darmstadt (West Germany) Fachgebiet Flugtechnik
A SIMPLE CRITERION TO DISTINGUISH BETWEEN POINT AND INTEGRAL PERFORMANCE PROBLEMS AND ITS USE TO SIMPLIFY FLIGHT PROFILE OPTIMIZATIONS
Bernd Faber *In* AGARD Performance Prediction Methods May 1978 15 p refs (For availability see N78-26074 17-01)
Avail NTIS HC A16/MF A01

Cookbook rules to simplify the mathematical model to a point performance problem and a procedure to its solution are given Many flight-path optimization problems can be described adequately by such a point performance model This will be demonstrated by two examples the minimum time-to-climb path and the minimum-distance takeoff P R A

N78-26077# Technische Hogeschool, Delft (Netherlands)
PREDICTION OF OFF-DESIGN PERFORMANCE OF TURBOJET AND TURBOFAN ENGINES
H Wittenberg *In* AGARD Performance Prediction Methods May 1978 31 p refs (For availability see N78-26074 17-01)
Avail NTIS HC A16/MF A01

A simple method is developed to estimate the off-design performance of engines, fixed by the design point conditions This method is based on gasdynamics relationships only and does not require a priori information from detailed fan, compressor or turbine performance maps The method is based on the assumption of a choked exhaust nozzle or a choked turbine, through which the working points of the engine components upstream of these aerodynamic throats are developed Single and two spool turbojet engines and two and three spool turbofan engines are considered The calculation method is illustrated by some examples for existing engine types the predicted off design performance shows, at least, fair agreement with experimental and engine manufacturers data P R A

N78-26078# Technische Universitaet, Munich (West Germany). Lehrstuhl fuer Flugmechanik und Flugregelung

THE ON-BOARD CALCULATION OF OPTIMAL CLIMBING PATHS

Gerhard Bruening and Peter Hahn (Messerschmitt-Boelkow-Blohm G m b H., Ottobrunn, West Ger.) *In* AGARD Performance Prediction Methods May 1978 15 p refs (For availability see N78-26074 17-01)
Avail: NTIS HC A16/MF A01

Whereas subsonic aircraft perform their climbing flight phases according to optimal strategies in regular service, the corresponding strategies for supersonic aircraft are most difficult and time consuming to compute and tough to follow by the pilot, because complicated relations between altitude and Mach number must be observed. The methods developed so far are, therefore, not suitable for an application on-board the aircraft. Optimal climbing flight schedules computed by strong mathematical methods can be replaced to a high degree of accuracy by a series of arcs flown with constant load factor. The pertinent computer programs are simple and can be implemented with on-board computers.
P R A

N78-26079*# National Aeronautics and Space Administration, Washington, D. C.

PROPULSION-AIRFRAME INTERACTIONS PREDICTABILITY

Ronald H. Smith *In* AGARD Performance Prediction Methods May 1978 20 p refs (For availability see N78-26074 17-01)
Avail: NTIS HC A16/MF A01

An illustration of the possible magnitude of the transonic performance prediction problem is shown. These results derived from a careful and systematic set of tests run on a jet effects model, an aerodynamic and force model, and a pressure model, evaluated test techniques and wind tunnel effects. The results were then carefully compared with flight test data where significant discrepancies in zero-lift drag were observed. A vigorous review of the test techniques identified a number of potential error sources. Some of these were thought to be aircraft roughness and protuberances, tunnel anomalies, sting/model support corrections, and hot gas effects. In addition, there were questions on model metric splitline location and magnitude of corrections for scale and Reynolds number. Flight test inlet/engine characteristics were thought to differ, also, from those of the calibration settings in the ground facilities.
P R A

N78-26080# Messerschmidt-Boelkow G.m.b.H., Munich (West Germany). Unternehmensbereich Flugzeuge.

DRAG MEASUREMENT IN TRANSONIC WIND TUNNELS

Felix Awehla *In* AGARD Performance Prediction Methods May 1978 18 p refs (For availability see N78-26074 17-01)
Avail: NTIS HC A16/MF A01

In order to increase the accuracy it is recommended to take into account the simultaneously measured wall pressure. By linking these wall pressures with theoretical wall interference computations it seems possible to approach the absolute limit of accuracy. This requires, however, consideration of axial pressure gradients produced by the tunnel wall or by inappropriate model suspensions. An example shows that these pressure gradients can cause errors in the absolute pressure drag of more than 100% and even in the drag differences of about 20% respectively. The influence of Reynolds number on afterbody drag and on wing shock locations is critically reviewed and the variation of wind tunnel boundary layer is suggested as prime cause for these affects. Lastly, unsteady flow separation problems are briefly touched and general recommendations for improved drag assessment are made.
P R A

N78-26081# Royal Aircraft Establishment, Farnborough (England)

PERFORMANCE IMPLICATIONS OF SOME RECENT ADVANCES IN WEAPON CARRIAGE RESEARCH

L. Davies *In* AGARD Performance Prediction Methods May 1978 18 p refs (For availability see N78-26074 17-01)
Avail: NTIS HC A16/MF A01

The possibilities that exist, and are being developed, for reducing the drag penalties associated with the carriage of weapons on combat aircraft are discussed. Performance implications of drag reduction for large weapon loads are discussed, not only in terms of speed and radius of action for existing aircraft, but also in terms of sizing a new aircraft to attain a specified performance.
P R A

N78-26082# Hawker Siddeley Aviation Ltd., Kingston upon Thames (England)

VTOL PERFORMANCE ESTIMATION FOR JET LIFT AIRCRAFT

C. M. Milford *In* AGARD Performance Prediction Methods May 1978 10 p refs (For availability see N78-26074 17-01)
Avail: NTIS HC A16/MF A01

The development of a semi-analytical model for VTOL performance estimation is described. Only vertical motion is considered, the calculation takes account of engine acceleration time, changes in vehicle mass due to fuel flow, and the vertical drags due to aircraft motion. Hot gas recirculation and ground effects are obtained from temperature and force measurements on model test rigs. The calculated height time histories show good agreement with measurements of actual aircraft VTOs, the available full scale VL data is more limited, but also shows satisfactory agreement with prediction.
P R A

N78-26083# Vereinigte Flugtechnische Werke-Fokker G.m.b.H., Bremen (West Germany).

COMPARISON OF ESTIMATED AND FLIGHT DATA FOR ROLLING TAKE-OFF AND TRANSITION OF A VTOL AIRCRAFT

Guenter Kollokowski and Richard Smyth *In* AGARD Performance Prediction Methods May 1978 19 p refs (For availability see N78-26074 17-01)
Avail: NTIS HC A16/MF A01

The accurate prediction of multi-engine VTOL-aircraft performance during rolling take-off and transition must take a larger number of parameters into consideration than conventional aircraft. These additional parameters are strongly interconnected and have a large influence of overall aircraft performance. A suitable performance prediction model will be defined for a lift plus lift cruised aircraft with two lift engine performance into account. The predicted results will be compared with data from flight test for typical railing take-off and transition operations.
Author

N78-26084# British Aerospace Aircraft Group, Woodford (England). Manchester Div.

A COMPUTERIZED AIRCRAFT PERFORMANCE SYSTEM

John Richardson *In* AGARD Performance Prediction Methods May 1978 16 p (For availability see N78-26074 17-01)
Avail: NTIS HC A16/MF A01

The system, referred to as CAPS, is a group of computer programs or modules covering the essential elements of performance evaluation and prediction and also the subsequent processing of results. The relationship and interfaces of CAPS with other technical disciplines, for example, aircraft systems, power plant, flight test, and technical publications is discussed and the need to integrate CAPS into the overall design process is emphasized. The use of the system in conjunction with on-line terminals and interactive graphical visual display units is also discussed.
P.R.A.

N78-26085# Avions Marcel Dassault-Breguet Aviation, Saint-Cloud (France). Div. des Etudes Avancees.

PERFORMANCE PREDICTIONS OF MARCELL DASSAULT-BREGUET AVIATION AIRCRAFT [PREVISIONS DES PERFORMANCES AUX AVIONS MARCEL DASSAULT-BREGUET AVIATION]

Pierre Bohn *In* AGARD Performance Prediction Methods May 1978 12 p In FRENCH (For availability see N78-26074 17-01)
Avail: NTIS HC A16/MF A01

Results of performance predictions for numerous Marcel Dassault-Breguet aircraft were examined, and reference was given to nominal and safety performances. Most of the performances measured were closely related to predictions, however, it was suggested that an improvement in methods of aerodynamic theory would reduce the present diversity in results.
Transl. by B.B.

N78-26086# National Aerospace Lab., Amsterdam (Netherlands) Performance and Evaluation Dept

PREDICTION OF OPERATIONAL COMBAT PERFORMANCE

H Tellegen *In* AGARD Performance Prediction Methods May 1978 7 p (For availability see N78-26074 17-01)

Avail NTIS HC A16/MF A01

There are indications that further improved performance of future fighter aircraft will no longer result into a proportional improvement in combat capability and that therefore, in order to obtain superior combat capability, other means must be found. One of these is to improve tactics and, in particular, assisting pilots in the execution of complex tactical maneuvers. This includes the design of maneuvers which are sound from a flight mechanics point of view and the identification of key points in the maneuver which can be handled by the pilot as reference, provided that he has available, in a suitable form, the required information with respect to the flight conditions. As an example of maneuver design a pitch-up type ground attack maneuver is considered. G.Y.

N78-26087# Dornier-Werke G m.b.H., Friedrichshafen (West Germany).

ANALYSIS OF ERROR SOURCES IN PREDICTED FLIGHT PERFORMANCE

Michael Lotz and Heribert Friedel *In* AGARD Performance Prediction Methods May 1978 11 p (For availability see N78-26074 17-01)

Avail: NTIS HC A16/MF A01

The errors involved in the flight performance prediction before the first flight stem in the case of point performances (SEP, load factor etc.) from uncertainties in the prediction of aerodynamic and engine data and in the case of integral performances (take off, landing, climb etc.) also from improper assumptions in the procedures for their calculation. The results of an analysis of these errors are shown for a typical CAS aircraft G.Y.

N78-26088# Office National d'Etudes et de Recherches Aerospatiales, Leclerc (France).

PREDICTION OF AERODYNAMIC CHARACTERISTICS OF AN AIRCRAFT FROM A CORRELATION OF RESULTS ON A CALIBRATION MODEL TESTED IN VARIOUS LARGE TRANSONIC TUNNELS

Ph. Poisson-Quinton and X. Vaucheret *In* AGARD Performance Prediction Methods May 1978 17 p refs In FRENCH; ENGLISH summary (For availability see N78-26074 17-01)

Avail: NTIS HC A16/MF A01

A program was initiated in 1969 to test a series of similar calibration models, representative of a transport aircraft, in various transonic tunnels of seven countries. The configuration was chosen to have a typical design Mach number (M approximately 0.84) for a transport aircraft, with very specific aerodynamic troubles at given Mach numbers and angles of attack, for the purpose of a precise comparison between various wind tunnel results on flight envelop prediction. This paper is restricted to the results obtained with the largest model, tested in the U.S.A., Canada, England, Holland, and France. The aerodynamic characteristics obtained are recalled to show that, in general, the results obtained are more and more misleading when the Reynolds number decreases below two (2) million. From this experiment, it is still impossible to define a magic Reynolds number above which there is no more effect on the aerodynamic characteristics G.Y.

N78-26089# Naval Air Systems Command, Washington, D C

DEVELOPMENT OF TECHNIQUES AND CORRELATION OF RESULTS TO ACCURATELY ESTABLISH THE LIFT/DRAG CHARACTERISTICS OF AN AIR BREATHING MISSILE FROM ANALYTICAL PREDICTIONS, SUB-SCALE AND FULL SCALE WIND TUNNEL TESTS AND FLIGHT TESTS

E. C. Rooney and R. E. Craig (General Dyn./Convair, San Diego, Calif.) *In* AGARD Performance Prediction Methods May 1978 18 p refs (For availability see N78-26074 17-01)

Avail NTIS HC A16/MF A01

The aerodynamic correlations provide information for validating or improving current lift/drag prediction techniques. Correlations for the various prediction/documentation procedures are presented for linear range lift variations with angle of attack, maximum drag, induced drag and skin friction drag over the subsonic and low transonic mach regimes. The correlations for lift and induced drag characteristics show generally good to excellent agreement. The minimum drag prediction procedures for transonic drag rise is poor for all prediction procedures compared to flight test. Analytical prediction methods and subscale model test results for subsonic minimum drag (which do not totally account for the effects of manufacturing tolerances, protuberances and excrescences) require an increase of approximately 8% to produce agreement with the minimum drag level obtained from powered full scale wind tunnel and flight tests. G.Y.

N78-26090# McDonnell Aircraft Co., St. Louis, Mo. Aerodynamics Dept.

FLIGHT TEST VERIFICATION OF F-15 PERFORMANCE PREDICTIONS

J. M. Abercrombie *In* AGARD Performance Prediction Methods May 1978 13 p refs (For availability see N78-26074 17-01)

Avail: NTIS HC A16/MF A01

The prediction of the performance characteristics of the F-15 Eagle was based primarily on data obtained in an extensive wind tunnel test program. This test program was designed to determine the basic lift and drag characteristics for all flight conditions. In addition, the effects of engine operating conditions as reflected in inlet mass flow and engine nozzle geometry and jet plume characteristics were carefully measured. Inlet performance model tests served to provide accurate definition of recovery characteristics for calculation of net propulsive forces. The test techniques and the methods used to adjust the wind tunnel results to predicted flight performance are discussed. A description of the flight test program for performance with flight qualification is also included. Selected comparison of predicted performance with flight test results are presented. Assessment of the performance prediction methods used, based on the degree of verification available from flight test data, is also included. The results prove that with sufficiently sophisticated wind tunnel models and through test techniques, satisfactory performance predictions can be made. G.

N78-26091# Northrop Corp., Hawthorne, Calif. Aircraft Group.

YF-17 FULL SCALE MINIMUM DRAG PREDICTION

H. W. Grellmann *In* AGARD Performance Prediction Methods May 1978 12 p (For availability see N78-26074 17-01)

Avail: NTIS HC A16/MF A01

The problem of predicting the full scale minimum drag of supersonic fighter aircraft is addressed. The YF-17 aircraft is used to illustrate the various factors which must be taken into account. Two comparisons of YF-17 minimum drag are presented. The first comparison is between analytical estimates and wind tunnel results. The second comparison is between the full scale predicted minimum drag based on wind tunnel data and the flight test drag level based on in flight measured thrust. The data presented show in detail how the YF-17 full scale minimum drag was predicted. Areas of uncertainty are discussed which may contribute to the differences between the predicted and measured flight test minimum drag. G.Y.

N78-26092# General Dynamics, Fort Worth, Tex.

CORRELATION OF F-16 AERODYNAMICS AND PERFORMANCE PREDICTIONS WITH EARLY FLIGHT TEST RESULTS

T. S. Webb, D. R. Kent, and J. B. Webb *In* AGARD Performance Prediction Methods May 1978 17 p refs (For availability see N78-26074 17-01)

Avail NTIS HC A16/MF A01

F-16 design objectives and pertinent configuration features are reviewed, and the major external configuration differences between the YF-16 prototype and the F-16 full-scale development airplanes are discussed. The approach to predicting F-16 aerodynamics was to use YF-16 flight-test-derived data corrected for YF-16-to-F-16 configuration differences as determined from wind tunnel tests. A comparison of YF-16 and F-16 wind tunnel lift, drag, and pitching-moment data reflects the close similarity between the F-16 and YF-16 configurations. Early F16 flight test results show similar differences between wind tunnel and flight test lift and drag as experienced on the YF-16 and, therefore, validate this empirical approach. The untrimmed drag due to lift generally appears lower in flight than in the wind tunnel, and

the subsonic lift in the intermediate angle of attack range is higher inflight than in the wind tunnel. The trim horizontal tail deflections, however, are larger than indicated by the wind tunnel, which was not the case for the YF-16 and therefore was not predicted. This results in a small increase in trim drag. G.Y.

N78-26093# Societe Nationale Industrielle Aerospatiale, Paris (France).
A COMPARISON OF PREDICTIONS OBTAINED FROM WIND TUNNEL TESTS AND THE RESULTS FROM CRUISING FLIGHT (AIRBUS AND CONCORDE) [COMPARISON ENTRE LES PREVISIONS DEDUITES DES ESSAIS EN SOUFFLERIE ET LES RESULTATS DE VOL EN CROISIERE (AIRBUS ET CONCORDE)]
J. Berger *In* AGARD Performance Prediction Methods May 1978 50 p refs In FRENCH (For availability see N78-26074 17-01)
Avail: NTIS HC A16/MF A01

A review of methods to establish aerodynamic and propulsion data is presented. Comparison was made between flight tests results and predictions made from the data. Various theories and improvements in the aerodynamic data are used to explain the slight deficiency found on the Airbus and Concord. Thrust characteristics, air flow and consumption in the gas generator assembly must be established. Transl. by B.B.

N78-26094# Lockheed-California Co., Burbank.
CORRELATION OF WIND-TUNNEL AND FLIGHT-TEST DATA FOR THE LOCKHEED L-1011 TRISTAR AIRPLANE
R. H. Hopps and E. C. B. Danforth *In* AGARD Performance Prediction Methods May 1978 12 p (For availability see N78-26074 17-01)
Avail: NTIS HC A16/MF A01

The methodology of prediction, and the degree of correlation between wind tunnel test and flight test results are presented. Included in the presentation are the general lift and drag characteristics, minimum airspeed, buffet characteristics, and static and dynamic longitudinal and lateral/directional stability characteristics. G.Y.

N79-10002# Advisory Group for Aerospace Research and Development, Paris (France).
ICING TESTING FOR AIRCRAFT ENGINES
Aug. 1978 206 p refs In ENGLISH and FRENCH Presented at the 51st Propulsion and Energetics Panel (A) Spec. Meeting, London, 3-4 Apr. 1978
(AGARD-CP-236; ISBN-92-835-0217-5) Avail: NTIS HC A10/MF A01

Meteorological icing conditions, the microphysical structure of icing clouds and the measurement of snow concentration were discussed. Icing test facilities and their instrumentation current used in the U.S., U.K., and France were reported. Measurement systems, icing of aircraft engines either installed in aircraft and helicopters, or when taken into test facilities were also considered. For individual titles, see N79-10003 through N79-10015.

N79-10003# National Research Council of Canada, Ottawa (Ontario). Div. of Mechanical Engineering.
SNOW CONCENTRATION MEASUREMENTS AND CORRELATION WITH VISIBILITY
J. R. Stallabrass *In* AGARD Icing Testing for Aircraft Eng. Aug. 1978 10 p refs (For primary document see N79-10002 01-01)
Avail: NTIS HC A10/MF A01

To allow meaningful design, testing and qualification of aircraft engine intake systems for operation in snow, a program was initiated to measure the snow content of the air. In conjunction with the measurements of snow concentration, various other meteorological parameters were measured. It was found that the snow concentration may be estimated from the visibility with reasonable accuracy, thus permitting concentration statistics to be derived for locations where visibility data exist. Examples of such derived snow concentration probability distributions are presented. J.A.M.

N79-10004# Clermont Ferrand Univ. (France). Lab. Associe de Meteorologie Physique
MICROSTRUCTURE OF CLOUD GLACIATION [STRUCTURE MICROPHYSIQUE DES NUAGES GIVRANTS]
J. F. Gayet and R. G. Soulage *In* AGARD Icing Testing for Aircraft Eng. Aug. 1978 12 p refs In FRENCH (For primary document see N79-10002 01-01)
Avail: NTIS HC A10/MF A01

Results obtained according to the following investigations: (1) June 1975 in the Clermond-Ferrand region, (2) 1976 and (3) January -February 1977 in the Parisian region are reported with reference to cloud drop size and water content. Data were compared with standard icing conditions utilized in the U.S., England, and France. Factors influencing icing were mentioned briefly. Transl. by B.B.

N79-10005# Luftfahrt-Bundesamt, Brunswick (West Germany).
METEOROLOGICAL ICING CONDITIONS
K. A. Vath *In* AGARD Icing Testing for Aircraft Eng. Aug. 1978 22 p refs (For primary document see N79-10002 01-01)
Avail: NTIS HC A10/MF A01

The meteorological influences leading to ice formation on aircraft and engines, their causes and effects, as well as the meteorological icing parameters specified in the airworthiness requirements for public transport airplanes in Europe, the USA, and the USSR are presented. J.A.M.

N79-10006# National Gas Turbine Establishment, Pyestock (England).
ICING TEST FACILITIES AT THE NATIONAL GAS TURBINE ESTABLISHMENT
R. D. Swift *In* AGARD Icing Testing for Aircraft Eng. Aug. 1978 22 p refs (For primary document see N79-10002 01-01)
Avail: NTIS HC A10/MF A01

The extensive capacity of the NGTE Engine Test Facility enabled a close representation of the conditions encountered during flight in icing conditions achieved on a scale such that tests can be made on complete propulsion units (intake, engine and propelling nozzle) or on full scale aircraft components, such as a helicopter fuselage complete with its engines and air intakes. The compressor/exhauster machinery, the test cells, the water spray equipment and the associated instrumentation and calibration gear are described. Illustrations of its use for icing tests on Pegasus and RB211 engines and on the Sea King and Lynx helicopters are given. J.A.M.

N79-10007# Centre d'Essais de Propulseurs, Saclay (France).
INSTALLATION OF ICING TESTS [INSTALLATIONS D'ESSAIS DE GIVRAGE]
Jacques Bongrand *In* AGARD Icing Testing for Aircraft Eng. Aug. 1978 9 p refs In FRENCH (For primary document see N79-10002 01-01)
Avail: NTIS HC A10/MF A01

Flow velocity and freezing conditions as well as a means for control are described with emphasis placed on measuring procedures for liquid water concentration and droplet size. Various types of tests currently utilized were reviewed. Two test installations utilized in France for ice testing are briefly described. Transl. by B.B.

N79-10008# ARO, Inc., Arnold Air Force Station, Tenn.
ENGINE ICING MEASUREMENT CAPABILITIES AT THE AEDC
Jay D. Hunt *In* AGARD Icing Testing for Aircraft Eng. Aug. 1978 15 p refs Sponsored in part by AEDC (For primary document see N79-10002 01-01)
Avail: NTIS HC A10/MF A01

Measurement and control of the principal factors that govern the mechanics and thermodynamics of icing, namely, water droplet size and size distribution, liquid water content, cloud temperature, pressure, and airflow, are discussed. A research program in icing measurements is described, and current results are presented. J.A.M.

N79-10009# General Electric Co., Cincinnati, Ohio. Aircraft Engine Group.
MEASUREMENT AND CONTROL OF SIMULATED ENVIRONMENTAL ICING CONDITIONS IN AN OUTDOOR, FREE JET, ENGINE GROUND TEST FACILITY
R. G. Keller. *In* AGARD Icing Testing for Aircraft Eng. Aug. 1978 13 p refs (For primary document see N79-10002 01-01)
Avail: NTIS HC A10/MF A01

The icing test facility real time control measurement systems are described. Predicted size conditions were compared to measured values obtained from several different measurement systems, including oil slides, rotating cylinders, and laser powered particle counters. J.A.M.

N79-10010# National Research Council of Canada, Ottawa (Ontario). Div. of Mechanical Engineering.
THE DYNAMIC ICE DETECTOR FOR HELICOPTERS
T. R. Ringer and J. R. Stallabrass. *In* AGARD Icing Testing for Aircraft Eng. Aug. 1978 8 p refs (For primary document see N79-10002 01-01)
Avail: NTIS HC A10/MF A01

The development of an icing detector is described, using a dynamic principle that results in ice being detected equally well whether the helicopter is hovering or at flight cruise speed. The response was rapid allowing the pilots of unprotected helicopters sufficient time to evade further icing within the time limitations. In addition to detecting ice the instrument output can be presented in the form of an icing severity indication or a cloud liquid water content measurement. Integration of the instrument output allowed accurate control of a helicopter electrothermal deicing systems. J.A.M.

N79-10011# Pratt and Whitney Aircraft, East Hartford, Conn. Commercial Products Div.
AIRCRAFT ENGINE ICING, TECHNICAL SUMMARY
Gordon D. Pfeifer. *In* AGARD Icing Testing for Aircraft Eng. Aug. 1978 17 p refs (For primary document see N79-10002 01-01)
(Contract DOT-FA76WA-3840)
Avail: NTIS HC A10/MF A01

Aircraft engines ingest supercooled water droplets in concentrations roughly fifty percent greater than cloud concentrations, and the first few stages of the engine compressor are subject to icing. Engine icing can be prevented, or at least kept within tolerable limits, by engine design procedures which utilize: the tendency of the fan to create warmer temperatures by compression effects, the tendency of the rotor to shed ice by centrifugal effects before it get too thick, and various designs of active anti-icing systems. Appropriate background information, equations, and design charts, are summarized, such that a design approach to engine ice prevention can be established. Experimental icing simulation procedures are also presented. J.A.M.

N79-10012# Centre d'Essais de Propulseurs, Saclay (France).
EXPERIMENTAL AND THEORETICAL STUDY OF THE INFLUENCE OF VARIOUS PARAMETERS ON AN ICING SECTION [ETUDE THEORIQUE ET EXPERIMENTALE DE L'INFLUENCE DE DIVERS PARAMETERS SUR LE GIVRAGE D'UN PROFIL]
Jacques Bongrand. *In* AGARD Icing Testing for Aircraft Eng. Aug. 1978 13 p refs In FRENCH (For primary document see N79-10002 01-01)
Avail: NTIS HC A10/MF A01

A theoretical and experimental study to investigate the influence of various parameters on ice formation as an obstacle is presented. The effect of altitude was studied in detail utilizing ground simulation laws. Equally considered were (1) speed, (2) temperature; and (3) water concentration and water drop size. The accumulation of ice deposit under high altitude conditions was observed and interpreted on two test sections (conical and cylindrical cowlings). Results show that under certain conditions it appears possible to simulate the phenomena by increasing the diameter of the water drops. Transl. by B.B.

N79-10013# National Gas Turbine Establishment, Pyestock (England). Engine Test Dept.
ICING TESTS ON TURBOJET AND TURBOFAN ENGINES USING THE NGTE ENGINE TEST FACILITY
R. G. J. Ball and A. G. Prince. *In* AGARD Icing Testing for Aircraft Eng. Aug. 1978 15 p ref (For primary document see N79-10002 01-01)
Avail: NTIS HC A10/MF A01

Tests were made at conditions representing wet icing, that was with the air supply containing a fine dispersion of supercooled water droplets (volumetric mean diameter nominally 20 microns), but facilities also existed for injecting solid ice particles into the airstream thereby enabling a mixed icing environment to be simulated. Wet icing tests were made on the Olympus 593 powerplant (engine intake combination) and on the RB211 high by pass turbofan. J.A.M.

N79-10014# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (West Germany). Helicopter Div.
TESTS UNDER SNOW AND ICING CONDITIONS WITH THE BO 105 ENGINE INSTALLATION
Dieter Bender. *In* AGARD Icing Testing for Aircraft Eng. Aug. 1978 12 p refs (For primary document see N79-10002 01-01)
Avail: NTIS HC A10/MF A01

Corresponding preliminary tests had shown that a snowshield ahead of the main rotor gearbox, in conjunction with the production standard compressor bleed air de-icing, was the most effective form of protection. This snowshield caused the engines to draw their air from a plenum chamber, an arrangement which has resulted in faultless behavior even in extremely heavy snowfall. Proof of operational safety under icing conditions was obtained in a number of steps, beginning with tests in the icing tunnel. Then the helicopter hovered for a total of more than 30 hours, under conditions that were considerably more severe than FAA and CAA requirements. The snowshield and plenum configuration proved itself again in flight trials under natural icing conditions partly under rather severe conditions. In addition, the measurement of atmospheric conditions such as liquid water content, droplet diameter, temperature, and icing severity are briefly discussed. J.A.M.

N79-10015# National Research Council of Canada, Ottawa (Ontario).
ICING TESTS OF A SMALL GAS TURBINE WITH INERTIAL SEPARATION ANTI-ICING SYSTEM
W. Grabe and D. Tedstone (Pratt and Whitney Aircraft of Can. Ltd., Longueuil Quebec). *In* AGARD Icing Testing for Aircraft Eng. Aug. 1978 20 p refs (For primary document see N79-10002 01-01)
Avail: NTIS HC A10/MF A01

Two sea-level icing programs were carried out on a Pratt & Whitney Aircraft of Canada PT6 aero engines, protected by inertial separation anti-icing systems. An air ejector, located downstream of the engine, induced air flows in the test section of up to 210 MPH (340 km/h) in icing conditions, to simulate aircraft forward speed. The anti-icing protected the compressor inlet against supercooled water droplets of various diameters, as well as against natural snow. Ice formation in the cowl inlet and bypass sections never rendered the inertial separator inoperative. Inlet total pressure losses increased with ice buildups on inlet surfaces, but generally did not exceed acceptable limits. J.A.M.

N79-20009# Advisory Group for Aerospace Research and Development, Paris (France).
THE IMPACT OF INTEGRATED GUIDANCE AND CONTROL TECHNOLOGY ON WEAPONS SYSTEMS DESIGN
Dec. 1978 242 p refs Presented at the Guidance and Control Panel Symp., Sandefjord, Norway, 9-12 May 1978
(AGARD-CP-257. ISBN-92-835-1303-7) Avail: NTIS HC A11/MF A01

Rapidly developing sensor technology when combined with advancing technologies in guidance and control, the driving forces of acquisition and life cycle costs, needs for operational tactical flexibility, survivability, vulnerability, and critical volume and weight constraints, dictates the need for integrated guidance and control at a higher functional level than heretofore considered. This higher functional level involves an effective blend of the sensor, vehicle and kill-mechanism that can provide a multirole capability for advanced and present operational vehicles. For individual titles, see N79-20010 through N79-20028.

N79-20010# European Office of Aerospace Research and Development, London (England).

THE IMPACT OF INTEGRATED GUIDANCE AND CONTROL TECHNOLOGY ON WEAPONS SYSTEM DESIGN

Eugene L. DeNezza *In* AGARD The Impact of Integrated Guidance and Control Technol. on Weapons Systems Design Dec. 1978 5 p (For primary document see N79-20009 11-01)
Avail: NTIS HC A11/MF A01

The history of guidance and control technology since the 1950's is summarized with emphasis on the progression from the vehicle to air warfare systems. Potential capabilities of command control and communication are examined in relation to tactical control where substantial dynamic and functional integration are needed to provide the desired operational capability. Benefits from space-time positioning, on-board trajectory control, and six-degree-of-freedom are discussed. Guidance and control have a dominant role in the functional structuring of advanced system because of the closed loop dynamics and the design methods required to blend the sensor-vehicle-kill mechanism in a manner that can effectively use multisensor inputs as well as the vehicle's dynamics capability to achieve the precision night, all-weather delivery capability. This can be physically implemented using digital information processed data systems. A.R.H.

N79-20011# Armament Development and Test Center, Eglin AFB, Fla.

NEW WEAPON CONCEPTS DEVELOPED FROM ADVANCED NAVIGATION GUIDANCE AND TARGETING TECHNOLOGY

H. E. Brown *In* AGARD The Impact of Integrated Guidance and Control Technol. on Weapons Systems Design Dec. 1978 2 p (For primary document see N79-20009 11-01)
Avail: NTIS HC A11/MF A01

A highly integrated 'Smart-Package' concept is presented showing how advanced imaging systems and data processing techniques could be used to develop an automatic system for searching, detecting, identifying and selecting targets, and for controlling the simultaneous attack of a group of weapons. Each individual weapon of the group launched would be directed to a specific target. This approach could lead to multiple kills per weapon launched and greatly reduce the pilot work load. Several weaponization concepts are presented to illustrate optional applications of the smart-package. In each case the smart-package is selecting targets in real time as the weapon system flies over the target area. There are some technology voids in these concepts; namely, the data processing algorithms for false target discrimination are not fully developed A.R.H.

N79-20012# Department of the Navy, Washington, D. C.

COST AND DESIGN ADVANTAGES DERIVED FROM THE STANDARD ELECTRONIC MODULES PROGRAM

David Gold, John M. Kucharski (EG and G Washington Analytical Services Center, Rockville, Md.), and Davis R. Bates (Raytheon Co., Sudbury, Mass.) *In* AGARD The Impact of Integrated Guidance and Control Technol. on Weapons Systems Design Dec. 1978 14 p (For primary document see N79-20009 11-01)
Avail: NTIS HC A11/MF A01

The standard electronic modules program is a highly successful design standardization program that is commanding considerable attention within the U. S. Department of Defense as a result of its achieving significant cost and reliability results. This program establishes a rational discipline for the development process for military electronic systems by providing families of functional electronic modules which are already developed, documented, and qualified, and for which a wide industrial base exists. Although this program has been heavily oriented at resolving system maintenance and logistical support problem areas, it nevertheless constitutes a readily available and highly effective building block approach for accomplishing research and development functions Author

N79-20013# Hughes Aircraft Co., Canoga Park, Calif.

GLOBAL POSITIONING SYSTEM TACTICAL MISSILE GUIDANCE

Frederick W. Hardy and C. David DePriest (Air Force Armament Lab.) *In* AGARD The Impact of Integrated Guidance and Control Technol. on Weapons Systems Design Dec. 1978 12 p refs (For primary document see N79-20009 11-01)
Avail: NTIS HC A11/MF A01

The concept of GPS tactical missile guidance is discussed from the standpoint of advantages gained by high level functional integration between the missile and a GPS-equipped launch aircraft. The conflicting requirements of high performance and low cost are shown to be attained by elimination of missile guidance functions that can be performed by the aircraft GPS system and transferred to the missile immediately prior to launch. The importance of integrating missile GPS receiver and inertial guidance system measurements for achieving maximum performance in a jamming environment is discussed, as well as the filter form employed and resulting performance. The unique operational advantages of this GPS missile guidance system for weapon delivery are described, including those gained by integration with a GPS-equipped aircraft Author

N79-20014# Marconi-Elliott Avionic Systems Ltd., Rochester (England). Airport Works.

DIGITAL FLIGHT CONTROL SYSTEM ARCHITECTURE AND IMPLEMENTATION

G. Belcher, P. A. Daniell, and E. M. Scott *In* AGARD The Impact of Integrated Guidance and Control Technol. on Weapons Systems Design Dec. 1978 6 p (For primary document see N79-20009 11-01)
Avail: NTIS HC A11/MF A01

Digital flight systems must be designed to match their specific functional requirements if they are to satisfy the integrity, performance and cost targets. The architecture must be simple and modular so that it can be readily analyzed. There must be a one to one correspondence between software and hardware to ensure visibility, particularly for the Failure Mode Effect analysis. Modularity enables flexibility to be maintained during development and permits development costs to be shared between projects. A modular system is described and its associated communication and control system, which uses a standard interface, is outlined. The advent of the digital microprocessor has extended the range of viable architecture and has made multiprocessor configurations (particularly dual processor) attractive. In such configurations, 16 bit microprocessors perform auxiliary functions such as data management and/or self test. The degree of self test can extend from preflight testing to full monitoring, in which the microprocessor undertakes a dissimilar check of the main processor, thereby protecting against common mode failures which can occur in a multiple, similar redundant system. Author

N79-20015# Lear Siegler, Inc., Grand Rapids, Mich.

DEVELOPMENT OF THE INTEGRATED FLIGHT TRAJECTORY CONTROL CONCEPT

M. W. Bird, W. L. Young (AFFDL), L. Addis, and G. L. Comegys *In* AGARD The Impact of Integrated Guidance and Control Technol. on Weapons Systems Design Dec. 1978 15 p refs (For primary document see N79-20009 11-01)
Avail: NTIS HC A11/MF A01

Operational missions into heavily defended target zones with the likelihood for deviations from the intended routes and redirections from Command and Control centers will impose heavy workload demands upon the pilot/aircrew. The approach selected by the integrated flight trajectory control (IFTC) program involves: (1) combinating the functions of flight control systems and navigation computers; (2) developing techniques for four dimensional trajectory generation and display; and (3) developing procedures for operating on information received via data link. The system is complementary to the pilot and, by its logical operation, reduces the potential for pilot error in high stress situations. The operational advantages offered by the system and the method of evaluating its performance are discussed. A.R.H.

N79-20016# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (West Germany).

REDUNDANT STRAPDOWN NAVIGATION, GUIDANCE, AND CONTROL OF A CONTROL CONFIGURED VEHICLE

Wolfgang J. Kubbat and George A. Napjus *In* AGARD The Impact of Integrated Guidance and Control Technol. on Weapons Systems Design Dec. 1978 18 p refs Prepared in cooperation with Teledyne Systems Co., Northridge, Calif. (For primary document see N79-20009 11-01)
Avail: NTIS HC A11/MF A01

The hardware and software mechanization of the integrated guidance and control system of the CCV-F104-G is explained

with special focus on the strapdown part. This includes the solution to the redundancy problem. Finally, the next feasible steps in system improvement and minimization of the inertial part are outlined. Author

N79-20017# Air Force Flight Dynamics Lab., Wright-Patterson AFB, Ohio.
PRELIMINARY FEASIBILITY ASSESSMENT OF MULTI-FUNCTION INERTIAL REFERENCE ASSEMBLY (MIRA)

John M. Perdzock and Robert C. Burns *In* AGARD The Impact of Integrated Guidance and Control Technol. on Weapons Systems Design Dec. 1978 16 p ref Prepared in cooperation with McDonnell Douglas Corp., St. Louis, Mo. (For primary document see N79-20009 11-01)
Avail: NTIS HC A11/MF A01

Mission and performance goals established for MIRA feasibility studies covering flight control, navigation and weapon/cargo delivery as applied to the F-15 aircraft and a transport aircraft are discussed. The relationship between the key technical issues of concern and the feasibility criteria and the methodology to perform the trade-offs which impact life cycle costs are described. Functional performance and reliability requirements are shown. Computational requirements for a representative MIRA system are summarized. Computer programs were used to evaluate time histories of sensor and system error propagation and to assess the impact on flight control system control laws as MIRA sensors are installed at various aircraft installation locations. The criteria defined to perform the preliminary feasibility assessment is discussed. Comparative studies of life cycle costs show a saving estimate in excess of 69 million dollars for MIRA application to a quantity of 144 fighters over a 15 year operational life. Cost savings for transport applications are qualitatively significant, particularly for the operations and support cost element. The results of ring laser gyro and tuned rotor gyro studies of performance and reliability improvements required are summarized. A.R.H.

N79-20018# Norwegian Defence Research Establishment, Kjeller.
APPLICATION OF PARALLEL FILTERS FOR MALFUNCTION DETECTION AND ALTERNATIVE MODE CAPABILITY
T. Smestad and O. Orpen *In* AGARD The Impact of Integrated Guidance and Control Technol. on Weapons Systems Design Dec. 1978 8 p refs (For primary document see N79-20009 11-01)
Avail: NTIS HC A11/MF A01

A software method is described for malfunction detection and alternate mode capability in dynamic systems where slowly increased sensors errors may occur. The method is based on *parallel Kalman filters* and tests on the filter outputs. The implementation of this method in the integrated navigation system for the new Norwegian coastguard vessels is discussed. Some preliminary simulation results are presented. A.R.H.

N79-20019# Marconi-Elliott Avionic Systems Ltd., Borehamwood (England). Airborne Display Div.
CONTROL AND DISPLAY CONCEPTS FOR COMBAT AIRCRAFT
R. H. Holmes *In* AGARD The Impact of Integrated Guidance and Control Technol. on Weapons Systems Design Dec. 1978 12 p (For primary document see N79-20009 11-01)
Avail: NTIS HC A11/MF A01

The need for low pilot workload in future combat aircraft equipped with electronic displays is discussed. Means by which this may be achieved through optimization of display functions and rationalization of controls are examined. Current work on head up displays and helmet sighting systems is highlighted. A.R.H.

N79-20020# Ferranti Ltd., Edinburgh (Scotland). Inertial Systems Dept.
AN ADVANCED NAVIGATION DISPLAY AND ITS EFFECT ON SYSTEM DESIGN
W. H. McKinlay *In* AGARD The Impact of Integrated Guidance and Control Technol. on Weapons Systems Design Dec. 1978 4 p (For primary document see N79-20009 11-01)
Avail: NTIS HC A11/MF A01

A display which would normally be located immediately below the head-up display in order to show the horizontal situation was developed. The operational requirements are discussed for the COMED combined display which includes a full color topographical map based on 35 mm film and a multimode electronic display capable of accepting cursive or raster information. A planning aid permitting horizontal flight profiles to be digitized automatically in a briefing room from a conventional paper map is described. Flight plan processing is possible and the resultant data can be loaded into a portable store which is then inserted into the aircraft system so that the planned profile can be superimposed on the topographical map. The display was fully developed and demonstrated in flight and the planning aid completed successful operational trials. A.R.H.

N79-20021# Forschungsinstitut fuer Anthropotechnik, Meckenheim (West Germany).
METHODS FOR THE VALIDATION OF SYNTHESIZED IMAGES IN VISUAL FLIGHT SIMULATION
Gert Doerfel *In* AGARD The Impact of Integrated Guidance and Control Technol. on Weapons Systems Design Dec. 1978 10 p refs (For primary document see N79-20009 11-01)
Avail: NTIS HC A11/MF A01

To validate the information content of synthetic visual flight simulation, objectively based methods and criteria are necessary which can show the influence of a variety of visual cues on pilots' perception. Fifty-six pilots and 28 nonpilot enlisted men made height and distance judgements from landing approach scenes with different levels of detail. Some judgements of height and distance were made in relation to a previously shown standard scene. Other judgements (absolute) were given in ft or m. To evaluate the influence of scene information simplification on subjects' perception of height and distance, a number of measures were made including judgement time, error and the exponent of the stimulus-response relationship. Judgement error and the exponent of fitted power-functions both were significantly influenced by scene stylization. The increase of judgement error and the decrease of power-function exponent respectively are more distinct when making absolute judgement than relative ones. Because results for pilots are quite different, nonpilots should not be used as subjects for visual research work with landing scenes. Author

N79-20022# Air Force Flight Dynamics Lab., Wright-Patterson AFB, Ohio.
DESIGN CONSIDERATIONS FOR IMPLEMENTING INTEGRATED MISSION-TAILORED FLIGHT CONTROL MODES

James K. Ramage and Frank R. Swortzel *In* AGARD The Impact of Integrated Guidance and Control Technol. on Weapons Systems Design Dec. 1978 18 p refs (For primary document see N79-20009 11-01)
Avail: NTIS HC A11/MF A01

Some of the more critical design considerations are discussed for successfully integrating decoupled flight path control, mission-tailored control modes, and fault in a multi-role, high performance fighter aircraft design, to achieve improved overall mission effectiveness and cost of ownership without sacrificing system reliability and safety. The recently completed Fighter Control Configured Vehicles (CCV) Program flight test of the yf-16 aircraft provided valuable insight and substantiating technical data for future design and application of active control technology. This program was primarily concerned with the development and evaulation of decoupled six degrees-of-freedom flight path control techniques. Specific CCV features evaluated during the flight test program included (1) maneuver enhancement/gust alleviation, (2) direct lift and sideforce control, (3) independent fuselage pointing and translation, and (4) variable relaxed static stability. Implementation of these CCV capabilities presents unique pilot interface considerations, which must be addressed in terms of required displays, controllers, vehicle response dynamics and mission segment applications. A.R.H.

N79-20023# Litton Systems, Inc., Woodland Hills, Calif. Guidance and Control Systems Div.
TARGET MARKER PLACEMENT FOR DIVE-TOSS DELIVERIES WITH WINGS NON-LEVEL

J. Stanley Ausman *In* AGARD The Impact of Integrated Guidance and Control Technol. on Weapons Systems Design Dec. 1978 11 p (For primary document see N79-20009 11-01)
Avail: NTIS HC A11/MF A01

In a dive-toss, air-to-ground weapon delivery, the pilot steers a target marker symbol or sight reticle (pipper) so as to overlay the target with that symbol. He then depresses a target designation (pickle) switch which commands the computer to record all available target sensor data. From these data the weapon delivery computer first calculates the location of the target and then generates steering signals to guide the pilot in steering the calculated weapon impact point onto the target whereupon the computer automatically issues the weapon release signal. The motion of the calculated impact point during a banked pullup or climbing turn is analyzed to determine the path followed by the calculated impact point during such a maneuver. Placement of the sight reticle along this path allows the pilot to pull straight back on the stick after designating the target without first unrolling to a wings level attitude. A.R.H.

N79-20024# Hughes Aircraft Co., Canoga Park, Calif. Missiles Systems Group.
EXPENDABLE DIGITAL COMPUTERS IN TACTICAL MISSILE TRENDS AND TRADEOFFS IN SOFTWARE AND HARDWARE
H. A. Maurer and K. S. Kongelbeck *In* AGARD The Impact of Integrated Guidance and Control Technol. on Weapons Systems Design Dec. 1978 9 p (For primary document see N79-20009 11-01)
Avail: NTIS HC A11/MF A01

Computers are shown to be an effective way of achieving lower cost and improved performance in tactical guided missiles. Within the confines of currently available semiconductor technology a tactical missile computer is shown to be best applied in a central processor architecture. In this type of systems, a single computer performs the computational tasks of each of the guidance units' subfunctions and also serves as the overall system integrator. Two examples of this structure are given. The complexity of the required tactical missile computer depends on the complexity of the missile to which it is applied. Three classes of missile complexity and four classes of computers are identified. Which computer is required for each of the missile complexity classes is then demonstrated. Missile computer requirements differ considerably from those of other computer systems. The nature of and reasons for these differences are discussed. Finally, an extrapolation of current technology trends is made and projections as to the effect of these trends on tactical missile computer architecture are presented. Author

N79-20025# Laboratoire d'Automatique et d'Analyse des Systemes, Toulouse (France).
A RELIABLE AND SURVIVABLE DATA TRANSMISSION SYSTEM FOR AVIONICS PROCESSING
D. R. Powell, J. C. Laprie, P. Romand (Societe Crouzet), and G. Alcouffe (Societe Crouzet) *In* AGARD The Impact of Integrated Guidance and Control Technol. on Weapons Systems Design Dec. 1978 12 p (For primary document see N79-20009 11-01)
Avail: NTIS HC A11/MF A01

The interconnection of real-time processing elements is discussed with emphasis on the choice of a two-level structure containing a distributed irregular network and a set of local 'star structures'. The irregular network has active nodes that carry out automatic signal routing whereas the star structure has a passive central node based on a loosely-coupled pulse transformer. Two types of communication control presently under analysis are content control and a decentralized daisy chain. The final choice will be based on security and modularity criteria. A.R.H.

N79-20026# Singer-Kearfott, Wayne, N. J.
DYNAMIC SIMULATION OF A MULTI-SENSOR COMMUNICATION AND NAVIGATION SYSTEM
Joseph N. Frisina, William J. Steele, and Jory I. Schlenger *In* AGARD The Impact of Integrated Guidance and Control Technol. on Weapons Systems Design Dec. 1978 13 p (For primary document see N79-20009 11-01)
Avail: NTIS HC A11/MF A01

Multi-sensor communication and navigation system avionic software is comprised of a real-time airborne operating system (RTAOS), a communication subsystem based on the time division muxiplexed access (TDMA) method, a tactical navigation (TACAN) subsystem, and a relative navigation (REL NAV) subsystem. Because this avionic software was written in assembly language there existed a very stringent requirement for a dynamic simulator for both development and validation of the avionic software. COMMANDS was developed to meet this requirement for an economical tool that would support the test requirements of both the communication (TDMA) subsystem's high data rates, and the complex computational requirement of the relative navigation system. The COMMANDS simulator is resident on a mini-computer, and is physically connected to the JTIDS Class 2 operational flight program terminal through the operational input/output I/O devices. This allows the simulation of the avionic box which is receiving the same inputs in the laboratory test as it will under flight conditions. A.R.H.

N79-20027# Boeing Aerospace Co., Seattle, Wash.
RADIO FREQUENCY (RF) HOMING MISSILE GUIDANCE AND CONTROL SIMULATION TECHNIQUES, FACILITIES, AND EXPERIENCES
G. D. Swetnam and F. M. Belrose (Redstone Arsenal, Huntsville, Ala.) *In* AGARD The Impact of Integrated Guidance and Control Technol. on Weapons Systems Design Dec. 1978 32 p refs (For primary document see N79-20009 11-01)
Avail: NTIS HC A11/MF A01

The basic RF homing missile guidance simulation problem is described as well and and solutions that have evolved over the past 20 years. Starting from simple component transfer function measurements in the late 1940's and early 1950's, the evolution of RF homing guidance simulation techniques is followed to present day hardware-in-the-loop facilities at Boeing, the United States Army's Radio Frequency Simulation System (RFSS), and the United States Navy's Central Target Simulator (CTS). A.R.H.

N79-20028# British Aerospace Aircraft Group, Warton (England)
MISSION SIMULATION AS AN AID TO DISPLAY ASSESSMENT
P. Beckett and D. E. A. Houghton *In* AGARD The Impact of Integrated Guidance and Control Technol. on Weapons Systems Design Dec. 1978 12 p (For primary document see N79-20009 11-01)
Avail: NTIS HC A11/MF A01

Advances in computer and display technology make possible drastic changes in aircraft cockpit layout. Investigations involving full mission simulation in an advanced cockpit environment are reported. The philosophies and methods adopted and the hardware required for such simulation are discussed and areas where problems were encountered are indicated. A.R.H.

N79-21996# Advisory Group for Aerospace Research and Development, Paris (France).
HIGH ANGLE OF ATTACK AERODYNAMICS
Jan. 1979 542 p refs In ENGLISH and FRENCH Conf. held at Sandefjord, Norway, 4-6 Oct. 1978
(AGARD-CP-247; ISBN-92-835-0230-2) Avail: NTIS HC A23/MF A01

Reports were presented on (1) studies of configurations of practical application (10 papers); (2) mathematical modelling and supporting investigations (12 papers); (3) design methods (7 papers), and (4) air intakes (2 papers). Eight additional short presentations on these subjects are also documented. For individual titles, see N79-21997 through N79-22034.

N79-21997# National Aeronautical Establishment, Ottawa (Ontario). Unsteady Aerodynamics Lab.
EFFECT OF HIGH ANGLES OF ATTACK ON DYNAMIC STABILITY PARAMETERS
K. J. Orlik-Rueckemann *In* AGARD High Angle of Attack Aerodyn. Jan. 1979 14 p refs (For primary document see N79-21996 13-01)
Avail: NTIS HC A23/MF A01

Effects of flight at high angles of attack are presented for dynamic stability parameters and their significance for the analysis of aircraft motion at those flight conditions. The topics included (1) the strong nonlinear variations of many stability parameters with angle of attack, (2) the emergence of new categories of

parameters such as cross-coupling derivatives that are only of interest for high angle-of-attack or other asymmetrical flight conditions. (3) the significance of time-dependent parameters, such as represented by derivatives due to time rates of change of angles of attack and sideslip, (4) the strong configuration dependence of aerodynamic characteristics, as illustrated by large effects of strakes and of various shapes of aircraft forebody, and (5) the need for establishing and verifying a mathematical model that would satisfactorily describe the motion of an aircraft in the presence of all these high angle-of-attack effects J A M

N79-21998# Messerschmitt-Boelkow-Blohm G m b H , Munich (West Germany)

HIGH ANGLE OF ATTACK CHARACTERISTICS OF DIFFERENT FIGHTER CONFIGURATIONS

H John and W Kraus *In* AGARD High Angle of Attack Aerodyn Jan 1979 15 p refs (For primary document see N79-21996 13-01)

Avail NTIS HC A23/MF A01

Increased maneuverability at the lower end of the flight envelope offers new and attractive possibilities for fighter aircraft To extend the flight regime at low speeds up to high angles of attack beyond maximum lift requires the ability to trim and control the aircraft and by this avoid departure and spin susceptibility at those conditions Basic aerodynamic characteristics of different fighter configurations at separated flow beyond maximum lift are reviewed where the resultant derivatives are completely different from those associated with attached flow The change in trim conditions is primarily dependant on wing planform and overall aircraft configuration Results are shown about the aerodynamic development of aircraft configuration which meet these requirements and, at the same time, minimize the resulting drag penalties in the conventional angle of attack regime J A M

N79-21999# Royal Aircraft Establishment, Farnborough (England)

SOME UK RESEARCH STUDIES OF THE USE OF WING-BODY STRAKES ON COMBAT AIRCRAFT CONFIGURATIONS AT HIGH ANGLES OF ATTACK

G. F. Moss *In* AGARD High Angle of Attack Aerodyn Jan 1979 19 p refs (For primary document see N79-21996 13-01)

Avail. NTIS HC A23/MF A01

Experimental research of interest to design engineers incorporating strakes in combat-aircraft configurations is considered It is likely to be many years before a satisfactory mathematical model is achieved for the detailed flow about such configurations, and there is thus an urgent need to explore the various aerodynamic features of these devices experimentally both to obtain satisfactory solutions to current problems and to guide theoretical work which will form the basis of future design methods Author

N79-22000*# General Dynamics/Fort Worth, Tex.

DESIGN GUIDELINES FOR THE APPLICATION OF FOREBODY AND NOSE STRAKES TO A FIGHTER AIRCRAFT BASED ON F-16 WIND TUNNEL TESTING EXPERIMENT

C. W Smith and C A Anderson *In* AGARD High Angle of Attack Aerodyn Jan. 1979 11 p refs (For primary document see N79-21996 13-01)

(Contract NAS1-15006)

Avail NTIS HC A23/MF A01 CSCL 01C

During the YF-16 and F-16 developmental wind tunnel test program, numerous variations in nose and forebody strakes were investigated These data were reviewed, and the strake aerodynamic characteristics coalesced into design guidelines for the application of strakes to fighter aircraft The design guides take the form of general equations governing the modification of forebody strakes to obtain a linear pitching moment curve and the calculation of the resulting lift and drag increments Additionally, qualitative comments are made concerning the effects of strake geometry on lateral/directional stability It is concluded that the generation of incremental strake lift is primarily dependent upon the area affected by the strake-induced vortex and that strake planform is of secondary importance Forebody strakes have small beneficial effects on lateral/directional stability if properly designed, however, significant gains are easily attained with nose strakes J A M

N79-22001# Northrop Corp., Hawthorne, Calif. Aerodynamics Research Dept

FOREBODY/WING VORTEX INTERACTIONS AND THEIR INFLUENCE ON DEPARTURE AND SPIN RESISTANCE

A M Skow, A Titiriga, Jr., and W A Moore *In* AGARD High Angle of Attack Aerodyn Jan 1979 26 p refs (For primary document see N79-21996 13-01)

Avail NTIS HC A23/MF A01

In-depth studies were conducted to determine the effects of these shed vortices and to isolate parameters which strongly influence them Arising from these studies, methodologies were developed which can be used as general guidelines in the design of both aircraft forebody shapes and hybrid-wing planform shapes such that the interactions between these vortex systems will enhance aircraft stability J A M

N79-22002# Royal Aircraft Establishment, Farnborough (England)

STRAKE-INDUCED SEPARATION FROM THE LEADING EDGES OF WINGS OF MODERATE SWEEP

S P Fiddes and J H B Smith *In* AGARD High Angle of Attack Aerodyn Jan 1979 12 p refs (For primary document see N79-21996 13-01)

Avail NTIS HC A23/MF A01

Mechanisms were proposed to account for the observation that, on a wing of moderate sweep and aspect ratio, leading edge separation occured at a lower incidence when strakes (i e highly swept, forward extensions to the wing root) were attached ahead of it The effect on the main wing of the vortices resulting from the leading edge separation on the strake was considered, and a simplified approach to modelling the flow over strake-wing combinations was introduced J A M

N79-22003# Messerschmitt-Boelkow-Blohm G m b H Munich (West Germany)

AERODYNAMIC CHARACTERISTICS OF A FIGHTER-TYPE CONFIGURATION DURING AND BEYOND STALL

W Staudacher, B Laschka, P Poisson-Quinton (ONERA, Paris France), and J P Ledy (ONERA, Paris, France) *In* AGARD High Angle of Attack Aerodyn Jan 1979 15 p refs (For primary document see N79-21996 13-01)

Avail NTIS HC A23/MF A01

Low speed wind tunnel tests were conducted with a MBB pilot model Angle of attack regime investigated comprised alpha 0 divided by 90 deg Emphasis was directed towards the stability and/or *control contributions* of configurational items such as strakes, canards, tails, rudders and controls and maneuver flap systems as well as the technique of concentrated, spanwise blowing Isolated and combined effects of those devices and systems are demonstrated, and some unconventional control devices are introduced J A M

N79-22004# Lockheed-Georgia Co., Marietta Flight Sciences Div.

THE APPLICATION OF SPANWISE BLOWING FOR HIGH ANGLE OF ATTACK SPIN RECOVERY

J J Cornish, III and M W M Jenkins *In* AGARD High Angle of Attack Aerodyn Jan 1979 12 p (For primary document see N79-21996 13-01)

Avail NTIS HC A23/MF A01

A unique autorotation tunnel test was performed on a 1/30th scaled model of an F-4 fighter configuration During this test, air was blown spanwise over the wing from various nozzle locations and the influence of this blowing on the spinning mode was recorded Over 50 test conditions were evaluated for both flat (alpha - 45 degrees) and steep (alpha 80 degrees) spin modes The wing blowing was very effective in arresting the spin for the steep spin mode and not very effective in stopping the flat spin Nose blowing was also evaluated with only marginal success An optimum wing nozzle location and blowing level was identified These data, when scaled to full-scale values showed that the required nozzle diameter was 1 92 inches located close to the wing root 1/4 chord point and 18 lb/sec of air was required to affect recovery More efficient and effective recovery is possible in the tunnel with an additional degree of freedom and with empennage blowing Further, larger scale testing is urged G Y

N79-22005# Societe Nationale Industrielle Aerospatiale Toulouse (France)

BEHAVIOR OF A TRANSPORT AIRCRAFT WITH A HIGH ASPECT RATIO WING AT A HIGH ANGLE OF INCIDENCE [COMPORTEMENT A HAUTE INCIDENCE U'UN AVION DE TRANSPORT A AILE A GRAND ELANCEMENT]

D Collard *In* AGARD High Angle of Attack Aerodyn Jan 1979 12 p In FRENCH (For primary document see N79-21996 13-01)
Avail NTIS HC A23/MF A01

Results of wind tunnel test on a model of a Concorde supersonic transport aircraft with a high aspect ration wing at a high angle of incidence are reported Graphs, and especially flow visualization charts of the air flow over the top of the airfoil, are presented *Transl by G Y*

N79-22006*# Rockwell International Corp Downey, Calif Space Systems Group
AERODYNAMIC DESIGN OF THE SPACE SHUTTLE ORBITER
W E Bornemann and T E Surber *In* AGARD High Angle of Attack Aerodyn Jan 1979 24 p refs (For primary document see N79-21996 13-01)
(Contract NAS9-14000)
Avail NTIS HC A23/MF A01 CSCL 22B

An overview of the wind tunnel program is given and aerodynamic characteristics of the final configuration are described Aerodynamic parameters critical to definition of Orbiter entry control and performance are identified Trim capability and stability and control characteristics are discussed at critical regions in the entry trajectory Methods are described to *define reaction* control rocket effectiveness and aerodynamic interactions during the initial portion of entry At hypersonic speeds, wind tunnel results of viscous interaction effects at high angles of attack are discussed In the supersonic region, critical stability and control *parameters and wind tunnel results are* described At subsonic speeds, comparisons are shown between predicted aerodynamic characteristics and data from the approach and landing flight test program G Y

N79-22007# Office National d'Etudes et de Recherches Aerospatiales, Paris (France)
VORTEX PATTERN DEVELOPING ON THE UPPER SURFACE OF A SWEPT WING AT HIGH ANGLE OF ATTACK
Jean Mirande, Volker Schmitt, and Henri Werle *In* AGARD High Angle of Attack Aerodyn Jan 1979 18 p refs In *FRENCH, ENGLISH summary (For primary document see* N79-21996 13-01)
Avail NTIS HC A23/MF A01

An experimental study, based on a swept wing, was undertaken in a water tunnel and a wind tunnel at low speeds (V sub o less than or equal to 90 m/s) The vortex flow effects on this wing are illustrated from global effort measurements and static pressure distributions The domain of vortex appearance was deduced as a function of both sweep angle and angle of attack An attempt is made to describe the physical pattern of the vortex flow, from its formation near the apex to its breakdown *at the trailing edge By means of a directional probe, the flow* over the wing was determined G Y

N79-22008# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Goettingen (West Germany) Inst fuer Stroemungsmechanik
STABLE AND UNSTABLE VORTEX SEPARATION
Erich H Wedemeyer *In* AGARD High Angle of Attack Aerodyn Jan 1979 10 p refs (For primary document see N79-21996 13-01)
Avail NTIS HC A23/MF A01

A theoretical study of the stability of leading edge separation on delta wings is presented The theory explains the change from steady vortex type separation to flow with unsteady separation bubble Calculations show that solutions of the vortex-sheet model of leading edge separation can become unstable if the angle of attack is sufficiently high The critical angle of attack decreases with decreasing sweepback angle The calculated stability boundary is in good agreement with the boundary for observed leading edge vortices The findings suggest that the change from vortex type to bubble type separation is due to the change from stable to unstable leading edge vortices The theory explains the effect of a strake on a wing of moderate sweep and aspect ratio the strong leading edge vortices generated by the strake induce an outboard flow on the main wing and thereby increase the effective sweep of the leading edge The higher effective sweep stabilizes the leading edge separation on *the main wing* G Y

N79-22009# Office National d'Etudes et de Recherches Aerospatiales, Paris (France)
UNSTEADY CALCULATION OF VORTEX SHEETS EMITTED BY HIGHLY LOADED LIFTING SURFACES
Colmar Rehback *In* AGARD High Angle of Attack Aerodyn Jan 1979 9 p refs In FRENCH, ENGLISH summary (For primary document see N79-21996 13-01)
Avail NTIS HC A23/MF A01

The vortex sheets that form at the trailing edge and tips and, for higher angles of attack, from the leading edge of lifting surfaces, tend towards well organized and stable shapes only for specific configurations (e g high sweep angles) and within a well-defined range of angles of attack The method used is intended for three-dimensional incompressible flows It is based on an application of the Lagrangian variables to the integro-differential system made of the Green identity and the Helmholtz equation, discretized in the form of point vortex singularities During this numerical study of the influence of the obstacle geometry and incidence on the time evolution and stability of the vortex sheet, the sudden setting in motion of two simple configurations is dealt with a plane rectangular wing and a plane delta wing, both of unity aspect ratio Two problems are especially dealt with that of the vortex core formation and that of the gradual appearance, highly influenced by geometry and angle of attack, of the sheet instabilities G Y

N79-22010# Technische Universitaet, Brunswick (West Germany) Inst fuer Stroemungsmechanik
ON THE VORTEX FORMATION OVER A SLENDER WING AT LARGE ANGLES OF INCIDENCE
Dietrich Humnel *In* AGARD High Angle of Attack Aerodyn Jan 1979 17 p refs (For primary document see N79-21996 13-01)
Avail NTIS HC A23/MF A01

An *experimental study of the flow field around an* A = 1 delta wing at an angle of attack of alpha = 20 5 degrees is presented The effect of Reynolds number on the formation of the secondary vortex is studied in detail Boundary layer measurements were carried out for laminar and turbulent boundary layers and the bound vortex lines in the lifting surface were determined for both cases The flow field was measured in four planes perpendicular to the free stream direction and located in different positions downstream of the wing trailing edge The magnitude and the direction of the local velocity vector were determined by means of a 5-hole probe The results are *given for each plane by lines of constant total pressure, static* pressure, dynamic pressure and by a presentation of the local flow directions The interference between leading-edge vortex, secondary vortex and trailing edge-vortex is studied in detail G Y

N79-22011*# National Aeronautics and Space *Administration* Ames Research Center, Moffett Field, Calif
SYMMETRICAL AND ASYMMETRICAL SEPARATIONS ABOUT A YAWED CONE
David J Peake, F Kevin Owen (Owen Intern, Inc, Palo Alto, Calif), and Hiroshi Higuchi (Dyn Technol, Inc, Torrance, Calif) *In* AGARD High Angle of Attack Aerodyn Jan 1979 27 p refs (For primary document see N79-21996 13-01)
(Contract NAS2-9663)
Avail NTIS HC A23/MF A01 CSCL 01A

Three-dimensional flow separations about a 5 degree (semispex angle, theta sub C), 1 4 m long, circular cone up to moderately high relative incidence, alpha/theta sub C approximately 5, were studied in the Mach number range 0 3 < M sub infinity < 1 8 The cone was tested in the Ames 1 8 by 1 8 m wind tunnel at Reynolds numbers, R sub L infinity, based on the cone length, L, from 4 5 times 10 to the 6th power to 13 5 times 10 to the 6th power, under nominally zero heat transfer conditions Overall forces and mean surface pressures were compared with earlier measurements Supportive three-dimensional laser velocimeter measurements of mean and fluctuating velocity in a slightly asymmetric vortex wake about a slender tangent ogive cylinder at incidence having respective nose and overall body fineness ratios of 3 5 and 12, are included G Y

N79-22012# Bristol Univ (England) Dept of Aeronautical Engineering
PRESSURES ON A SLENDER BODY AT HIGH ANGLE OF ATTACK IN A VERY LOW TURBULENCE LEVEL AIR STREAM
B L Hunt and P C Dexter *In* AGARD High Angle of Attack Aerodyn Jan 1979 14 p refs (For primary document see N79-21996 13-01)
Avail NTIS HC A23/MF A01

Experimentally measured transient pressures at low speeds on a model consisting of a circular cylinder with a tangent ogive

nose in the angle of attack range from 30 deg to 90 deg are reported. Great care was taken to eliminate extraneous disturbances: a wind tunnel with an extremely low level of free stream turbulence (approx. 0.01%) was used, the model was rigidly mounted and efforts were made to ensure laminar separation without turbulent re-attachment. By comparing the result with those obtained previously on the same model in similar tests at a higher level of free stream turbulence (approx. 0.7%) it is shown that there is a dramatic reduction in unsteadiness in the low turbulence level air stream and switching of the flow pattern is virtually eliminated. It is found that the mean unswitched level is dependent on the roll angle of the model, and hence, that strict control of the free stream conditions is not sufficient to guarantee results which are independent of the experimental equipment. The inherent unsteadiness present in the flow pattern is presented. S.E.S.

N79-22013# British Aerospace Dynamics Group, Bristol (England). Aerodynamics Research Group.

WIND AND WATER TUNNEL INVESTIGATIONS OF THE INTERACTION OF BODY VORTICES AND THE WING PANELS OF A MISSILE CONFIGURATION

J. R. Deane. *In* AGARD. High Angle of Attack Aerodyn. Jan. 1979. 18 p. refs. (For primary document see N79-21996 13-01)

Avail: NTIS. HC A23/MF A01.

The interaction with wing panels of vortices formed by flow separation on the leeside of the forebody of an inclined, cruciform wing-body combination was studied. A low-speed flow visualization experiment was conducted using the dye line technique in a water tunnel, where the generation of the symmetric body vortex pair in the incidence angle range was 15 deg to 35 deg. The phenomenon of breakdown of the ordered vortex structure was observed when the vortices pass in the vicinity of wing panels mounted downstream on the body. A supersonic wind tunnel test in which pressure plotting on a wing panel of a geometrically similar wing-body combination was performed. Incidence angles in the range 15 deg to 25 deg were considered at a Mach number of 2 with the pressure tapped wing panel rolled into the leeside flow field. Integration of the pressure distributions yielded information on panel loads which was compared with estimates available from semi-empirical prediction methods. It is shown that prediction accuracy is low for the loads on panels when they are rolled into the vicinity of the vortices. S.E.S.

N79-22014# S. A. Engins Matra, Velizy (France).

AERODYNAMIC CHARACTERISTICS OF BODIES OF REVOLUTION EQUIPPED WITH WINGS OF VARIOUS ASPECT RATIOS [CHARACTERISTIQUES AERODYNAMICS DES CORPS DE REVOLUTION MUNIS D'AILES D'ALLONGEMENTS DIVERS]

L. Mifsud. *In* AGARD. High Angle of Attack Aerodyn. Jan. 1979. 24 p. refs. In FRENCH, ENGLISH summary (For primary document see N79-21996 13-01)

Avail: NTIS. HC A23/MF A01.

Water tank and wind tunnel tests were made on bodies of revolution and finned bodies of small wing aspect ratio. Results of lift and side force, pitching and yawing moments, and wall pressure distributions are presented for angles of attack between 0 and 45 or 70 deg. The parameters are the Mach number, the wing length, and the wing span. Results show the effects of the wing parameters on high incidence phenomena and especially on lateral forces and moments. Author

N79-22015# Von Karman Inst. for Fluid Dynamics, Rhode-Saint-Genese (Belgium).

AERODYNAMIC CHARACTERISTICS OF A MISSILE FEATURING WING WITH STRAKES AT HIGH ANGLES OF ATTACK

M. Akcay, B. E. Richards (DFVLR, Goettingen, West Ger.), W. Stahl, and A. Zarghami. *In* AGARD. High Angle of Attack Aerodyn. Jan. 1979. 7 p. refs. (For primary document see N79-21996 13-01)

Avail: NTIS. HC A23/MF A01.

The forces and pressure distribution on a typical missile configuration with low aspect ratio trapezoidal wings fitted both with and without triangular strakes at angles of incidence up to 32 deg were studied. Normal force and pitching moment measurements showed that different strakes extending forward from the inboard region of the trapezoidal wings straightened the normal force curve and increased the normal force coefficient considerably and improved the pitching moment variation at incidences above 12 deg. Measurements of pressure over the suction side of the body, wings and one of the configuration of strakes and application of various flow visualization techniques at transonic speeds and water tunnel tests provided some insight into the mechanisms that cause the improvements in force characteristics. The vortices generated by the strakes are shown to interact *favourably not only with the flow over the wing*, to suppress the unfavorable effects of large separation, but also with the flow over the body. The distribution of the increment in normal force on the various parts of the configuration caused by the strakes was analyzed. S.E.S.

N79-22016# Technische Univ., Berlin (West Germany). Inst. fuer Luft- und Raumfahrt.

ON THE LEE-SIDE FLOW OVER DELTA WINGS AT HIGH ANGLE OF ATTACK

Joachim Szodruch and Uwe Ganzer. *In* AGARD. High Angle of Attack Aerodyn. Jan. 1979. 7 p. refs. (For primary document see N79-21996 13-01)

Avail: NTIS. HC A23/MF A01.

A classification of various types of lee-side flow for slender delta wings is presented for a range of supersonic Mach number and angle of attack. Two particular types of flow which occur at high angle of attack are discussed. One type exists when the leading edges are subsonic. A shock wave between the strong conterrotating leading-edge-vortices was determined. The other type of flow occurs for supersonic leading edges in which case a pair of separation bubbles occurs with embedded shock waves on top. Strong non-conical effects were observed. S.E.S.

N79-22017# Technische Hogeschool, Delft (Netherlands). Dept. of Aerospace Engineering.

MEASUREMENTS OF THE SUPERSONIC FLOW FIELD PAST A SLENDER CONE AT HIGH ANGLES OF ATTACK

W. J. Bannink and C. Nebbeling. *In* AGARD. High Angle of Attack Aerodyn. Jan. 1979. 15 p. refs. (For primary document see N79-21996 13-01)

Avail: NTIS. HC A23/MF A01.

The flow field past a 7.5 deg semi-apex angle circular cone at angles of attack was investigated experimentally at a free stream Mach number of 2.94. In a cross-sectional plane the conical flow direction, the conical Mach number and the static pressures were determined, using a conical-head directional probe. Surface pressure distributions and oil flow patterns revealed flow separation at an angle of attack of about the cone half-angle. The separation is coupled with the formation of a vortex system. At values of alpha exceeding 14 deg a double separation type of flow was observed: a primary and a secondary vortex at either side of the leeward symmetry plane. Conical supersonic flows were detected, adjacent to the cone surface. Shock waves were measured inside the conical supersonic region, also the occurrence was verified of a shock wave close to the cone surface and extending slightly across the leeward symmetry plane. At 22 deg. the existence was confirmed of a separated vortical singularity in the leeward symmetry plane. S.E.S.

N79-22018*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

NUMERICAL SIMULATION OF SUPERSONIC CONE FLOW AT HIGH ANGLE OF ATTACK

David S. McRae and M. Y. Hussaini (NASA Langley Res. Center). *In* AGARD. High Angle of Attack Aerodyn. Jan. 1979. 10 p. refs. (For primary document see N79-21996 13-01)

(Contracts NAS1-1410, NAS1-14472)

Avail: NTIS. HC A23/MF A01. CSCL 01A.

A conical symmetry assumption is applied to the full Navier-Stokes equations resulting in an equation set containing time and two coordinate directions as independent variables. The set is integrated by use of a finite difference technique for the particular case of sharp cones at incidence. Solutions are obtained and compared with experiment for auxiliary conditions corresponding to both laminar and turbulent flows. Closure for the turbulent flow case is provided by use of a scalor eddy viscosity model based on the mixing length hypothesis. Modifica-

tions to the eddy viscosity model were found which led to excellent surface pressure and surface flow direction agreement for turbulent flow at low supersonic Mach numbers It is apparent that further work on the turbulence model is necessary for agreement at higher supersonic Mach numbers S E S

N79-22019*# National Aeronautics and Space Administration Langley Research Center, Hampton, Va
RECENT THEORETICAL DEVELOPMENTS AND EXPERIMENTAL STUDIES PERTINENT TO VORTEX FLOW AERODYNAMICS, WITH A VIEW TOWARDS DESIGN
John E Lamar and James M Luckring *In* AGARD High Angle of Attack Aerodyn Jan 1979 31 p refs (For primary document see N79-21996 13-01)
Avail NTIS HC A23/MF A01 CSCL 01A

Recent progress in a research program directed toward an improved vortex flow technology base was reviewed Analysis methods for conical flow and analysis and design methods for nonconical flows are presented Applications are made for a variety of planar, nonplanar, and interferring lifting surfaces. Several methods are shown to provide reasonable estimates of over-all forces and moments for simple wing planforms with the suction analogy method currently offering the most versatility for arbitrary configuration applications For the prediction of surface loadings the free vortex sheet method being developed by Boeing is shown to have considerable promise and further development of this type of method is encouraged A data base for ogee strake-wing configurations is summarized with an emphasis on the requirements for maximizing the interference lift A strake planform design procedure is discussed and a first solution (gothic in planview) is integrated with a wing body. The data show the strake to exhibit expected stable vortex characteristics It was found that, apart from increasing sweep, conically cambered delta wings developed drag levels approaching that of attached flow with increasing either the lift or the wing camber height, lastly, an approximate vortex flow design method, based on the suction analogy is outlined and an example is given S E S

N79-22020# *National Aerospace Lab., Amsterdam (Netherlands).*
A COMPUTATIONAL MODEL FOR THE CALCULATION OF THE FLOW ABOUT WINGS WITH LEADING-EDGE VORTICES
H W M Hoeijmakers and B Bennekers *In* AGARD High Angle of Attack Aerodyn Jan 1979 11 p refs (For primary document see N79-21996 13-01)
Avail NTIS HC A23/MF A01

The mathematical model replaced the spiralling free shear layer springing from the leading edge by a free vortex sheet which is terminated by a combination of a feeding sheet plus a discrete line vortex/sink The strength of the sink is related to the entrainment of the rotational core and derived here from semi-empirical arguments The resulting potential flow problem is solved employing a higher-order panel method which involves some recently developed ideas for obtaining a numerically efficient method with second-order accuracy The method is applied to the calculation of the flow about a delta wing at incidence S E S

N79-22021# Boeing Aerospace Co., Seattle, Wash.
SUBCRITICAL DRAG MINIMIZATION FOR HIGHLY SWEPT WINGS WITH LEADING EDGE VORTICES
E N Tinoco and H Yoshihara *In* AGARD High Angle of Attack Aerodyn Jan 1979 9 p refs (For primary document see N79-21996 13-01)
Avail NTIS HC A23/MF A01

The subsonic lift to drag ratio of supercruiser type wings was studied at sufficiently large lifts for which flow separation cannot be avoided In the presence of the resulting leading edge vortex, minimum drag due to lift is no longer dictated by spanwise load distribution alone but is also a function of the chordwise loading For the resulting nonlinear problem a higher order panel method utilizing a vortex sheet model is used to search for an optimal design A brief outline of the computational method is given fllowed by examples validating the procedures Results of the search for an optimal camber are discussed M M M

N79-22022# Messerschmitt Boelkow Blohm G m b H., Munich (West Germany)
NORMAL FORCE AND PITCHING MOMENT OF WING-BODY COMBINATIONS IN THE NONLINEAR ANGLE-OF-ATTACK RANGE AT SUBSONIC SPEEDS
C P Schneider and D Nikolitsch *In* AGARD High Angle of Attack Aerodyn Jan 1979 10 p refs (For primary document see N79-21996 13-01)
Avail NTIS HC A23/MF A01

Two procedures on the nonlinear lifting surface theory are presented One method for the determination of the factor K sub B(W) represents the effect of the wing on the body-forces and moments due to lift carry-over, and predicts the normal force interference factors The other method determines K sub B(W) It uses the nonlinear lifting surface theory for the calculation of normal force and moment of a slowly pitching wing alone, and to get the same quantities for a substitute wing which represents the original wing plus a rectangular flat middle section in place of the body between the wing root chords The results of the two procedures call for an improved prediction method, as comparable quasi-steady data from experiments, which may serve to confirm the results of one or the other method are not available at present Free vortex tracing of discrete vortices by conventional two-dimensional theory is proposed Viscous vortices with core are assumed M M M

N79-22023*# National Aeronautics and Space Administration Ames Research Center, Moffett Field, Calif
PREDICTION OF AERODYNAMIC CHARACTERISTICS FOR SLENDER BODIES ALONE AND WITH LIFTING SURFACES TO HIGH ANGLES OF ATTACK
Leland H Jorgensen *In* AGARD High Angle of Attack Aerodyn Jan 1979 40 p refs (For primary document see N79-21996 13-01)
Avail NTIS HC A23/MF A01 CSCL 01A

A method is presented for computing normal force and pitching moment coefficients for slender bodies of circular and noncircular cross section alone and with lifting surfaces A semiempirical term representing viscous-separation crossflow is added to a term representing potential-theory crossflow For bodies of revolution, computed aerodynamic characteristics agree with measured results for investigated free-stream Mach numbers from 0.6 to 2.9 and for angles of attack from 0 deg to 180 deg For bodies of elliptic cross section, measured results are predicted well over the investigated Mach number range from 0.6 to 2.0 and the angle range from 0 deg to 60 deg For all bodies the predictions are best at supersonic Mach numbers For body-wing and body-wing-tail configurations, measured normal force coefficients and centers are predicted at the upper test Mach number of 2.0 As the Mach number is decreased to 0.6, the agreement for the normal-force coefficients rapidly deteriorates When model flow-separation and vortex patterns are asymmetric, undesirable side forces are usually measured on the models at subsonic Mach numbers and zero sideslip angle Generally, the side-force coefficients decrease or vanish with increase in Mach number, decrease in nose fineness ratio, nose blunting, and flattening of body cross section M M M

N79-22024# Nielsen Engineering and Research, Inc., Mountain View, Calif.
PREDICTION OF LATERAL AERODYNAMIC LOADS ON AIRCRAFT AT HIGH ANGLES OF ATTACK
S. B. Spangler, S. C. Perkins, Jr., and M. R Mendenhall *In* AGARD High Angle of Attack Aerodyn Jan 1979 14 p refs (For primary document see N79-21996 13-01)
Avail NTIS HC A23/MF A01

The lateral loads on high speed fighter-bomber configurations at high angles of attack and small angles of sideslip were studied The configurations of interest are characterized by slender pointed noses that generate asymmetric separation vortices at angles of attack in the 25 to 45 degree range The methods consist of a nose vortex shedding flow model, a vortex lattice wing/body/strake flow model, and a tail interference model All are potential flow methods and were applied at incompressible speeds The methods account for noncircular nose cross sections, prediction of separation location on the nose and interaction between nose and strake vortices Calculations were made to compare the predicted results with measurements of vorticity distribution, velocities in the separated region, and forces on noncircular noses and forces and moments on complete aircraft configurations The predicted results agree with the data, show the proper trends, and demonstrate the proper physical characteristics of the flow M M M

N79-22025# Systems Research Labs., Inc., Newport News, Va.

PREDICTION AND MEASUREMENT OF THE AERODYNAMIC FORCES AND PRESSURE DISTRIBUTIONS OF WING-TAIL CONFIGURATIONS AT VERY HIGH ANGLES OF ATTACK

Richard P. White, Jr. *In* AGARD High Angle of Attack Aerodyn. Jan. 1979 16 p refs (For primary document see N79-21996 13-01)

Avail: NTIS HC A23/MF A01

The three dimensional viscous lifting surface theory that developed to predict the distribution of aerodynamic loading on arbitrary planforms having attached vortex flows at high angles of attack is discussed. Comparisons between measured and predicted performance and pressure distribution data for a wing-strake configuration at a high angle of attack are reported. Limitations of the prediction technique as well as the potential of utilizing vortex lift to amplify the performance characteristics of highly maneuverable aircraft is outlined. M.M.M.

N79-22026*# National Aeronautics and Space Administration, Ames Research Center, Moffett Field, Calif.

HIGH ANGLE OF INCIDENCE IMPLICATIONS UPON AIR INTAKE DESIGN AND LOCATION FOR SUPERSONIC CRUISE AIRCRAFT AND HIGHLY MANEUVERABLE TRANSONIC AIRCRAFT

Leroy L. Presley. *In* AGARD High Angle of Attack Aerodyn. Jan. 1979 10 p refs (For primary document see N79-21996 13-01)

Avail: NTIS HC A23/MF A01 CSCL 01C

The effects of angle of attack on supersonic mixed compression inlet performance at four different locations about a hypothetical forebody are given. A computational method to predict optimum inlet location, orientation, and centerbody control schedule for design and off-design performance is described. The effects of inlet location and a forward canard on the angle-of-attack performance of a normal shock inlet at transonic speeds were studied. Proper integration of inlet location and a forward canard can enhance the angle-of-attack performance of a normal shock inlet. Two lower lip treatments for improving the angle-of-attack performance of rectangular inlets at transonic speeds are discussed. M.M.M.

N79-22027# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (West Germany). Military Airplane Div.

INTAKE DESIGN AND INTAKE/AIRFRAME INTEGRATION FOR A POST-STALL FIGHTER AIRCRAFT CONCEPT

K. W. Lotter and J. Malefakis. *In* AGARD High Angle of Attack Aerodyn. Jan. 1979 16 p refs (For primary document see N79-21996 13-01)

Avail: NTIS HC A23/MF A01

Results from subsonic scale model tests carried out for intake geometries especially designed for high angle of attack capability are discussed. A unit-composed intake model representing a twin-engine fighter aircraft was tested with two basic intake positions in a shielded location, one under the fuselage and one under the wing strakes on both sides of the fuselage. Two different axial positions were tested. An external compression, horizontal ramp inlet design was chosen for the tests. Different auxiliary intakes, all fitted to the lower side of the intake were tested. Various rotatable forward cowl lip designs and a cowl slot were included in the investigations. A shielded intake location offers a high potential for improvement in inlet maneuver capability. Sufficient shielding is generally given for the under-fuselage position. For the side-intakes located under the strakes a position as far downstream as possible is desirable. For such shielded intakes only small performance losses occurred at incidences up to 35 deg. Variable cowl lip geometry introduced for subsonic maneuver improvement offers an attractive means for optimum intake/engine mass flow matching at supersonic speeds by varying the intake capture area. M.M.M.

N79-22028# Texas Univ. at Austin. Dept. of Mechanical Engineering

COMPRESSIBILITY EFFECTS ON THE SYMMETRIC BODY VORTEX WAKE OF AN OGIVE NOSE CYLINDER

William L. Oberkampf and Timothy J. Bartel. *In* AGARD High Angle of Attack Aerodyn. Jan. 1979 4 p refs (For primary document see N79-21996 13-01)

(Contract F08635-77-C-0049)

Avail: NTIS HC A23/MF A01

An extensive experimental investigation of the symmetric body vortex wake was conducted. Cone probe measurements were made on the leeside of an ogive nose circular cylinder for three different supersonic freestream conditions. Measurements of total pressure, Mach number, and three orthogonal velocity components were made at four angles of attack of the body at various axial stations. These data were processed to infer the position of the primary body vortex in the cross flow plane, local circulation distribution in the cross flow plane, vortex core size, and total circulation in the cross flow plane. Although limited results are discussed, particular emphasis is placed on the effects of transonic cross flow Mach numbers on the structure of the body vortex wake. J.A.M.

N79-22029# Royal Inst. of Tech., Stockholm (Sweden). Dept. of Aeronautics.

WIND TUNNEL TEST AT LOW SPEEDS OF A DORSAL AIR INTAKE ON A FIGHTER CONFIGURATION

Sven-Olof Ridder. *In* AGARD High Angle of Attack Aerodyn. Jan. 1979 3 p (For primary document see N79-21996 13-01)

Avail: NTIS HC A23/MF A01

A wind tunnel model with a swept wing and a dorsal air intake mounted well aft on the fuselage was investigated in a low speed wind tunnel with respect to the flow quality of the air intake flow. It was found that the air intake flow was satisfactory at zero angle of yaw for angles of attack up to 20 degrees. Even a moderate angle of yaw, however, resulted in a rather high level of intake flow distortion as caused by the ingestion of forebody vortices. A large number of forebody mounted flow control devices were tested and among these only a canopy mounted device was found effective in reducing the intake flow distortion to an acceptable level. J.A.M.

N79-22030# Avions Marcel Dassault-Breguet Aviation, Saint-Cloud (France)

VISUALISATIONS AND CALCULATIONS OF AIR INTAKES AT HIGH ANGLES OF ATTACK AND LOW REYNOLDS NUMBER

P. C. Perrier and J. Periaux. *In* AGARD High Angle of Attack Aerodyn. Jan. 1979 2 p refs In FRENCH (For primary document see N79-21996 13-01)

Avail: NTIS HC A23/MF A01

The operation of compressors can be strongly perturbed at a high angle of incidence by the instability of the flow created by separation at the edges of the air intake. Both flow visualization and the direct solution numerical solution of the Navier-Stokes equation are complementary methods of analyzing the phenomena. To visualize what is intervening at the interior of the air intake, the flow can be studied at very low velocity and at a low Reynolds number by the injection of colored fluid in a two dimensional flow in a hydrodynamic test tunnel so that an ultra ultra-rapid film of the transonic stream lines can be obtained. The instability of the separation of at the air intake can be calculated only by the exact or approximate solution of the Navier-Stokes equation. Results obtained by using a least squares finite element method for the direct solution of the Navier-Stokes instability equation are presented. This method resolves the nonlinearity of the equation by iteration of the Stokes equation which is itself resolved in an original manner. Transl. by A.R.H.

N79-22031# Old Dominion Univ., Norfolk, Va. Dept. of Mechanical Engineering and Mechanics

STATE OF ART OF NONLINEAR, DISCRETE-VORTEX METHODS FOR STEADY AND UNSTEADY HIGH ANGLE OF ATTACK AERODYNAMICS

Osama A. Kandil. *In* AGARD High Angle of Attack Aerodyn. Jan. 1979 5 p refs (For primary document see N79-21996 13-01)

Avail: NTIS HC A23/MF A01

In all the existing inviscid models, the lines of primary separation were assumed to be known a priori and, hence, these models can only treat wings with sharp edges. In this model, the continuous vortex sheets (bound and free) were approximated by a distribution of concentrated vortex lines. The bound sheet is modelled by a bound-vortex lattice, and the free sheet is modelled by segmented free-vortex lines (steady-flow problem) or a growing free-vortex lattice (unsteady-flow problem). With

this three-dimensional model, the boundary conditions were satisfied at certain control points on the bound and free vortex system, the shape of the free-vortex lines was obtained, and the pressure distribution was calculated on the wing surface
J A M

N79-22032# Bristol Univ (England) Dept of Aeronautical Engineering
ON SLENDER WINGS WITH LEADING EDGE CAMBER

R K Nangia *In* AGARD High Angle of Attack Aerodyn Jan 1979 10 p refs (For primary document see N79-21996 13-01)
Avail: NTIS HC A23/MF A01

The presence of leading edge camber on wing or wing body configuration of low aspect ratio is known to improve their aerodynamic efficiency A research program to develop design methods on this subject is reviewed J A M

N79-22033# Technische Hogeschool Delft (Netherlands) Dept of Aerospace Engineering
AN EXPERIMENTAL INVESTIGATION OF THE ENTRAINMENT OF A LEADING-EDGE VORTEX

N G Verhaagen and L vanderSnoek *In* AGARD High Angle of Attack Aerodyn Jan 1979 5 p refs (For primary document see N79-21996 13-01)
Avail NTIS HC A23/MF A01

An experimental investigation of the flow field of a leading edge vortex, produced by a sharp edged unit aspect ratio delta wing at an angle of attack of 20 deg, was carried out at 45 m/sec Velocity and total pressure distributions were obtained by using a fixed-attitude five-hole probe On the basis of the experimental results, a number of control volumes of different cross sectional dimensions enclosing the rotational vortex core were chosen. For each of the control volumes the entrainment was estimated J A M

N79-22034# Aeritalia S p A , Torino (Italy) Combat Aircraft Div
A SURVEY OF RECENT HIGH ANGLE OF ATTACK; WIND TUNNEL TESTING AT AERITALIA

G Bucciantini, R DeSilvestro, and L Tornaster *In* AGARD High Angle of Attack Aerodyn Jan 1979 4 p refs (For primary document see N79-21996 13-01)
Avail NTIS HC A23/MF A01

The present status of investigation on wind tunnel testing techniques at high angles of attack and on stall/post stall characteristics of configurations typical of modern combat aircraft is illustrated Author

N79-31136*# National Aeronautics and Space Administration, Washington, D C
A COMPARISON OF PREDICTIONS OBTAINED FROM WIND TUNNEL TESTS AND THE RESULTS FROM CRUISING FLIGHT: AIRBUS AND CONCORDE

J Berger Aug 1979 71 p refs Transl into ENGLISH of "Comparison entre les resultats de vol en croisiere Airbus et Concorde", AGARD-CP-242, Rept-20 Presented at Flight Mechanics Panel Specialists Meeting on Performance Prediction Methods, Paris, France, 11-13 Oct 1977 Original language document was announced as N78-26074 Transl by Kanner (Leo) Associates, Redwood City, Calif Original doc prep by Aerospatiale (France)
(Contract NASw-3199)
(NASA-TM-75238 AGARD-CP-242 Rept 20) Avail NTIS HC A04/MF A01 CSCL 02A

Following a summary of the methods used to establish aerodynamic data and propulsion data, a comparison was made in the form of the drag (or thrust) difference between flight results and predictions made on the basis of these data Certain hypothesis and improvements on aerodynamic data were presented in order to explain the slight deficit found on Airbus and Concorde M M M

N80-14017# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France)
ADVANCES IN GUIDANCE AND CONTROL SYSTEMS USING DIGITAL TECHNIQUES

Aug 1979 357 p refs In ENGLISH and FRENCH Presented at the Guidance and Control Panel Symp , Ottawa, 8-11 May 1979
(AGARD-CP-272, ISBN-92-835-0247-7) Avail NTIS HC A16/MF A01

The application of digital methods to guidance and control systems is considered Functional design concepts, trends, and requirements, advances in analytical and design techniques, and advances in digital system design and architecture to assure high integrity are among the topics covered Data processing and computation techniques, software design validation techniques, including simulation, and operational and system development experience are included For individual titles, see N80-14018 through N80-14043

N80-14018*# Milco International, Inc , Huntington Beach, Calif
STATE OF THE ART FOR DIGITAL AVIONICS AND CONTROLS, 1978

Richard K Smyth *In* AGARD Advan in Guidance and Control Systems Using Digital Tech Aug 1979 20 p refs (For primary document see N80-14017 05-01)
(Contract NASw-2691)
Avail NTIS HC A16/MF A01 CSCL 02A

A brief summary of a comprehensive state of the art survey is presented The survey includes five broadly applicable technology areas flight path management, aircraft control systems, crew station & human factors, integration & interfacing technology, and fundamental technology In addition the survey included military technologies which have a technology transfer potential to the five broadly applicable technology areas J M S

N80-14019# Air Force Flight Dynamics Lab , Wright-Patterson AFB, Ohio Flight Control Div
A FLIGHT CONTROL SYSTEM USING THE DAIS ARCHITECTURE

A P DeThomas and R A Hendrix *In* AGARD Advan in Guidance and Control Systems Using Digital Tech Aug 1979 9 p refs (For primary document see N80-14017 05-01)
Avail NTIS HC A16/MF A01

The development of a digital flight control system simulation capability to examine advanced integrated control architectures, in order to increase system performance and availability, is described Near term issues, such as multiplexing interfaces with other avionics functions and structuring of software, are covered J M S

N80-14020# Royal Aircraft Establishment, Farnborough (England) Flight Systems Dept
TRENDS IN DIGITAL DATA PROCESSING AND SYSTEM ARCHITECTURE

A A Callaway *In* AGARD Advan in Guidance and Control Systems Using Digital Tech Aug 1979 5 p (For primary document see N80-14017 05-01)
Avail NTIS HC A16/MF A01

The utilization of airborne digital computers and methods *for their integration into digital avionic systems are discussed* The architecture of two aircraft systems, one designed in the 1960s and one in the 1970s is described The growth in complexity is discussed in terms of two factors the total flow of data between the subsystems which form the elements of the system, and the total volume of the computing task in terms of the number of words of program required Techniques which may assist in alleviating the growing complexity are then considered These include design management aids, such as requirement statement languages, architectural considerations, such as multiplex data busses and distributed processing, and software techniques, such as high level languages, MASCOT, and structured programming J M S

N80-14021# Societe Crouzet, Valence (France)
A METHOD FOR DESIGNING MULTIPROCESSOR ARCHITECTURES FOR AVIONICS FUNCTIONS [METHODOLOGIE DE CONCEPTION D'ARCHITECTURES MULTIPROCESSEURS POUR DES FONCTIONS D'AVIONIQUE]

C Aleonard, A Demoment, P Romand, J Gillon (CERT, Toulouse, France), and J F LeMaitre (CERT, Toulouse, France) *In* AGARD Advan in Guidance and Control Systems Using Digital Tech Aug 1979 7 p In FRENCH (For primary document see N80-14017 05-01)
Avail NTIS HC A16/MF A01

A digital technique is given for the design of high performance automatic systems The evolution of digital techniques presents the automatist with the problem of the total design of

a control system It means going beyond algorithmic synthesis from the beginning, to take into account all the functional and operational aspects Thus, it is possible to optimize the control system according to three important criteria regard for the desired operating performances the total cost and the very important matter of operational safety (reliability, security, maintainability, and availability) Transl by A R H

N80-14022# Singer-Kearfott, Wayne N J
FORTRAN FOR AVIONICS
Austin J Maher *In* AGARD Advan in Guidance and Control Systems Using Digital Tech Aug 1979 8 p refs (For primary document see N80-14017 05-01)
Avail NTIS HC A16/MF A01

The approach taken to address the use of high order languages (HOL) is described A review is presented of the interim languages stipulated by the DOD and the reasons for selecting FORTRAN as the basis of a compiler activity to provide competitive HOL capability The rationale for selecting the oldest and least modern of the six interim languages, and the design approach to select a suitable language dialect for efficient implementation of avionic software without violating the stipulations of the ANSI Standard for FORTRAN are included The success is described of the effort to develop a low cost compiler for the FORTRAN dialect which generates a highly efficient object code in the tradition of the many highly efficient FORTRAN compilers which have been developed for commercial computers F O S

N80-14023# Deutsche Forschungs und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick (West Germany) Inst fuer Flugfuehrung
AN OBSERVER SYSTEM FOR SENSOR FAILURE DETECTION AND ISOLATION IN DIGITAL FLIGHT CONTROL SYSTEMS
Norbert Stuckenberg *In* AGARD Advan in Guidance and Control Systems Using Digital Tech Aug 1979 11 p refs (For primary document see N80-14017 05-01)
Avail NTIS HC A16/MF A01

For the sensor part of a flight control system a sensor failure detection and isolation concept is presented based on analytic redundancy A conventional triplex sensor system is replaced by a duplex sensor system without loss of the fail-operational property In the case of a sensor failure, deterministic Luenberger observers provide the information about which of the two sensors of the duplex system actually failed The proposed concept is applied to a command and stability system of a flight control system Author

N80-14024# Office National d'Etudes et de Recherches Aerospatiales, Toulouse (France)
AUTOMATIC RECOVERY AFTER SENSOR FAILURE ONBOARD
Marc Labarrere, Marc Pelegrin, and Marc Pircher *In* AGARD Advan in Guidance and Control Systems Using Digital Tech Aug 1979 12 p refs (For primary document see N80-14017 05-01)
Avail NTIS HC A16/MF A01

Two techniques are developed which provide reliable failure detection and isolation for a dual-redundant subset of sensors A global procedure using a bank of stationary Kalman filters is described Some difficulties of this technique lead to a sub-optimal procedure which is developed in order to give all the dynamic and static relationships between the measured outputs on the aircraft These techniques are sucessfully applied to simulated sensor failure on a six degree of freedom aircraft simulation and are applying to sensor failures injected on flight data from the N262 aircraft F O S

N80-14025# Marconi Avionics Ltd Rochester (England) Flight Automation Research Lab
RECENT ADVANCES IN FIBRE OPTICS FOR HIGH INTEGRITY DIGITAL CONTROL SYSTEMS
R P G Collinson *In* AGARD Advan in Guidance and Control Systems Using Digital Tech Aug 1979 16 p (For primary document see N80-14017 05-01)
Avail NTIS HC A16/MF A01

The methods for using fiber optic cables for interconnecting the elements of an active control system, and the advantages and disadvantages are discussed The major factors in the use of fiber optics are practical ones connectors terminations ruggedness and environmental capability of cables The techniques are described which were developed to make a fiber bundle a practical cable link The use of multi access optical highways particularly for interfacing other systems with the flight control system (e g Air Data and IN systems) is reviewed and principles of the candidate networks outlined Finally a new concept for a fiber optic multi access network is presented which is fully compatible with the new data transmission specification F O S

N80-14026# General Dynamics/Fort Worth Tex
REDUNDANCY MANAGEMENT CONSIDERATIONS FOR A CONTROL-CONFIGURED FIGHTER AIRCRAFT TRIPLEX DIGITAL FLY-BY-WIRE FLIGHT CONTROL SYSTEM
John H Watson, William J Yousey, and James M Railey *In* AGARD Advan In Guidance and Control Systems Using Digital Tech Aug 1979 23 p ref (For primary document see N80-14017 05 01)
(Contract F33615 77 C 3036)
Avail NTIS HC A16/MF A01

To preclude the shut down of the flight control computers for control configured fighter aircraft redundant (parallel) processing is used in conjunction with redundancy management concepts Using reliability requirements and goals as expressed in loss-of-control per flight hour, a digital flight control system architecture is evolved with specific emphasis placed on the input, processor and output subsystems The incorporation of an analog cross strapping of lower reliability sensors is shown to be an effective means of increasing system reliability by retaining sensor redundancy after a computer failure A technique called control law reconfiguration is developed which insures system survival after a second like sensor failure Computer contribution to loss-of-control is reduced by the addition of system monitors which increase the computer self-test confidence level The resultant architecture is shown to have an inherent reliability which is relatively insensitive to the configuration of the actuator interface, thus allowing this interface to be designed based on *hardware/software complexity tradeoffs*. A R H

N80-14027# Messerschmitt-Boelkow-Blohm G m b H, Munich (West Germany) Aircraft Div
FAILURE DETECTION, ISOLATION AND INDICATION IN HIGHLY INTEGRATED DIGITAL GUIDANCE AND CONTROL SYSTEM
Wolfgang J Kubbat *In* AGARD Advan in Guidance and Control Systems Using Digital Tech Aug 1979 17 p (For primary document see N80-14017 05-01)
Avail NTIS HC A16/MF A01

A broad spectrum of modern failure detection and isolation techniques is discussed and it is shown that the failure problem can be significantly reduced with technology and design Several advanced methods such as vector redundancy, dissimilar redundancy, and methods applied to computers are described and some are backed up by practical examples Data bus orientated guidance and control systems are considered Based upon a practical realization example, guidelines are given for the use of MIL STD 1553 B in redundant applications A R H

N80-14028# Electronique Marcel Dassault, St Cloud (France)
THE INTEGRITY OF ONBOARD COMPUTER PROGRAMS: A SOLUTION [L'INTEGRITE DES LOGICIELS EMBARQUES: UNE SOLUTION]
G Germain *In* AGARD Advan in Guidance and Control Systems Using Digital Tech Aug 1979 8 p refs In FRENCH (For primary document see N80-14017 05-01)
Avail NTIS HC A16/MF A01

A solution is provided for insuring the integrity of the operating system onboard aircraft and engines The principle effect is to increase the security of the system so as to make it homogeneous with that of the material, which in the case considered is very high Interesting consequences are found in the level of reliability and maintainability of the system as well as the costs of validation The means used are the simplest and most economical possible They are applied to the structure of the operating system and hardware of a computer well adapted for onboard applications Emphasis is placed on mechanisms for controlling address, which prevents all untimely destruction of the software Transl by A R H

N80-14029# Hamilton Standard, Farmington, Conn
A REDUNDANT INERTIAL NAVIGATION SYSTEM FOR IUS
R. A. Baum, G. E. S. Morrison (Boeing Aerospace Co., Seattle, Wash.), and R. C. Peters (Aerospace Corp., Los Angeles, Calif.) *In* AGARD Advan. in Guidance and Control Systems Using Digital Tech. Aug. 1979 11 p refs (For primary document see N80-14017 05-01)
Avail: NTIS HC A16/MF A01

A high-performance strapdown redundant inertial navigation system (RINS) being developed for the space transportation system inertial upper stage (IUS) is described and an overview of the test results obtained to date is presented. The IUS RINS is the first navigation system specifically designed to provide a fully redundant configuration with self-contained redundancy management algorithms which will permit the system to experience an in-flight failure and then automatically detect, isolate, and eliminate the field element and continue the mission without loss or out-of-specification degradation of the guidance function. A.R.H.

N80-14030# Centre National de la Recherche Scientifique, Toulouse (France). Lab. d'Automatique et d'Analyse de Systemes.
DEFINITION OF THE HIERARCHICAL NETWORK FOR AGGRESSIVE ENVIRONMENTS (RHEA)
M. Buis, J. C. Laprie, J. Marco, and D. R. Powell *In* AGARD Advan. in Guidance and Control Systems Using Digital Tech. Aug. 1979 15 p refs (For primary document see N80-14017 05-01)
Avail: NTIS HC A16/MF A01

The transmission level of a dependable data communication support system intended for the reliable and survivable interconnection of data processing units (subscribers) in an aggressive environment is described. The functional and dependability specifications of this system lead to the definition of a hierarchical architecture using a network-structured, damage and fault-tolerant global transmission medium and star-structured, fault-tolerant local transmission media. The contention method is used for control of access to the transmission media. A standard transmission-medium/subscriber interface is defined that implements an associative addressing scheme in order to cater for data broadcasting modes and facilitated dynamic system reconfiguration. Throughout the design, a top-down approach was adopted with the use of qualitative and quantitative evaluations at each level in order to make motivated choices among the different possible solutions. A.R.H.

N80-14031# Defence Research Establishment, Ottawa. (Ontario).
DEVELOPMENT OF AIDING GPS/STRAPDOWN INERTIAL NAVIGATION SYSTEM
D. F. Liang, D. B. Reid (Lapp (Philip A.) Ltd., Toronto), R. H. Johnson (S and S Software Ltd., Ottawa), and B. G. Fletcher *In* AGARD Advan. in Guidance and Control Systems Using Digital Tech. Aug. 1979 15 p refs (For primary document see N80-14017 05-01)
Avail: NTIS HC A16/MF A01

An overview is presented of the design and development of an integrated multisensor navigation system comprised of a NAVSTAR GPS receiver, an aiding strapdown inertial navigation system (ASIN) and a number of auxiliary sensors, namely, air data and strapdown magnetic sensors. In the present phase, comprehensive software packages were developed to simulate all the subsystems used. A modular and computationally efficient Kalman filtering algorithm was designed and implemented for the integration of the GPS and ASIN. During the course of the development, two techniques were developed. An exact algorithm was derived to transform inertially referenced data into geographic coordinates. Also, a dual channel attitude algorithm was formulated which increases the bandwidth of the attitude computation in the strapdown navigator. Other routines developed include the baro-damping algorithm, auxiliary sensor processing and calibration routines. To provide a baseline level of performance, simulation results were obtained for future flight testing of the hardware. M.M.M.

N80-14032# Standard Elektrik Lorenz A.G., Stuttgart (West Germany)
DIGITAL ARRAY SIGNAL PROCESSING TECHNIQUES APPLIED TO GUIDANCE AND NAVIGATION
S. Bloch *In* AGARD Advan. in Guidance and Control Systems Using Digital Tech. Aug. 1979 13 p (For primary document see N80-14017 05-01)
Avail: NTIS HC A16/MF A01

Spatial filtering, in particular virtual beam forming techniques, appropriate for guidance and precision landing operations, is discussed. Systems operating at L-Band are described demonstrating that when appropriate digital signal processing is applied, accuracy comparable to that of corresponding C-Band systems is achievable. Thus, the advantages of relatively low L-Band frequencies, may be exploited while maintaining a high degree of precision. M.M.M.

N80-14033# McMaster Univ., Hamilton (Ontario)
MICROCOMPUTER-BASED ON-LINE STATE ESTIMATION WITH APPLICATIONS TO SATELLITES
N. K. Sinha, S. Y. Law (Commun. Res. Centre, Ottawa), and R. Mamen *In* AGARD Advan. in Guidance and Control Systems Using Digital Tech. Aug. 1979 11 p refs (For primary document see N80-14017 05-01)
Avail: NTIS HC A16/MF A01

The use of a Luenberger-type observer with an adaptive filter is discussed for estimating the states of a nonlinear system from the noise-contaminated measurements of the output of the system. The proposed method requires much less computation than the extended Kalman filter and, therefore, can be implemented more easily on a microcomputer. Application to the determination of the orbital states of the unified state model of a satellite is considered. Author

N80-14034# Twente Univ. of Technology, Enschede (Netherlands). Dept. of Electrical Engineering.
METHODS FOR STRAP-DOWN ATTITUDE ESTIMATION AND NAVIGATION WITH ACCELEROMETERS
R. P. Offereins and M. J. L. Tiernego *In* AGARD Advan. in Guidance and Control Systems Using Digital Tech. Aug. 1979 20 p refs (For primary document see N80-14017 05-01)
Avail: NTIS HC A16/MF A01

Methods are presented for calculating the attitude of a vehicle from the signals of three linear and three angular accelerometers which are rigidly attached to the vehicle. Also course, velocity and position measurements relative to some object can be used. Apart from the attitude, the velocity and position, with respect to this object, are also obtained as output signals. In fire control systems, filters for target position prediction and attitude determination can be combined in this way. M.M.M.

N80-14035# Contraves Italiana, Rome
DIGITAL SIGNAL PROCESSING TECHNIQUES IN A MONOPULSE TRACKING RADAR
U. Fazio, F. Ambrosioni, and C. DeBonis *In* AGARD Advan. in Guidance and Control Systems Using Digital Tech. Aug. 1979 12 p refs (For primary document see N80-14017 05-01)
Avail: NTIS HC A16/MF A01

A description of a special-purpose Signal Processor is given. Since the Processor is highly flexible, it can be applied in a wide range of modern ground or ship-borne tracking radars, such as, Fire Control Radar for rockets or for conventional artillery (ground or anti-aircraft), Instrumentation Radar, and Tracking Radar for Command to line-of-sight missile guidance. Illustrated are the three main functions of the processor, considered as being associated to a fully-coherent monopulse radar: signal enhancement based on an FFT (Fast Fourier Transform) algorithm, tracking errors computation and system logic control. A description is given, especially as regards the FFT part, of the practical realization of each block, based on a wide use of the most modern digital techniques and of microprogrammed controls in particular, that have enabled high flexibility and growth potential to be obtained. In the description, it can be seen how the design trade-off costs/performances have led to the predominant use of well-known techniques and widely used electronic circuitry, excluding custom components. M.M.M.

N80-14036# Lockheed-Georgia Co., Marietta
AN ASSESSMENT OF AND APPROACH TO THE VALIDATION OF DIGITAL FLIGHT CONTROL SYSTEMS
D. B. Mulcare and W. G. Ness *In* AGARD Advan. in Guidance and Control Systems Using Digital Tech. Aug. 1979 12 p refs (For primary document see N80-14017 05-01)
Avail: NTIS HC A16/MF A01

Flight-critical digital flight control system functions are evaluated in the context of farther term implementations. The quality and safety associated with fault tolerant, highly integrated, control oriented system implementations are emphasized. Technology needs are addressed so that the verification and validation process for advanced digital flight control systems can be sufficiently developed and purposefully accomodated in system engineering methodologies. K.L.

N80-14037# Electronique Marcel Dassault, St. Cloud (France)
THE AVIONICS COMPUTER PROGRAM: PRACTICAL EXPERIENCES WITH A METHODOLOGY [LOGICIEL AVIONIQUE: EXPERIENCES PRATIQUES D'UNE METHODOLOGIE]
J. Perin *In* AGARD Advan. in Guidance and Control Systems Using Digital Tech. Aug. 1979 17 p *In FRENCH* (For primary document see N80-14017 05-01)
Avail: NTIS HC A16/MF A01

The organization and methodology used in the construction of operating systems in the principle computers of the Mirage F1 and Mirage 200 aircraft are described. Particular emphasis is placed on the definition phases and program validation.
Transl. by A.R.H.

N80-14038# *Westland Helicopters* Ltd., Yeovil (England)
EXPERIENCE IN PRODUCING SOFTWARE FOR THE GROUND STATION OF A REMOTELY PILOTED HELICOPTER SYSTEM
J. P. Webby, P. L. Wescott, M. I. Tucker, and H. M. Smith *In* AGARD Advan. in Guidance and Control Systems Using Digital Tech. Aug. 1979 9 p refs (For primary document see N80-14017 05-01)
Avail: NTIS HC A16/MF A01

A computer system to control the aircraft, produce graphic displays, and handle data received from the aircraft was produced using the Modular Approach to System Construction, Operation, and Test, written in CORAL 66 language. The overall design of the software and the methods used to design, code, and test the software system are described in detail. K.L.

N80-14039*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Center, Edwards, Calif.
SIMULATION USE IN THE DEVELOPMENT AND VALIDATION OF HIMAT FLIGHT SOFTWARE
Albert Myers *In* AGARD Advan. in Guidance and Control Systems Using Digital Tech. Aug. 1979 12 p refs (For primary document see N80-14017 05-01)
Avail: NTIS HC A16/MF A01 CSCL 09B

The use of real time simulation in the development and validation of flight software for the highly maneuverable aircraft technology (HiMAT) remotely piloted research vehicle is described. Four simulations are interfaced with varying amounts of actual flight hardware to produce dynamic system operation. K.L.

N80-14040# Raytheon Co., Bedford, Mass. Missile Systems Div.
FEDERATED MICROCOMPUTER SYSTEMS FOR ONBOARD MISSILE GUIDANCE AND CONTROL
Frank J. Langley, David S. Siegel (ONR, Arlington, Va.), Wayne F. Savage (NSWC), and Rollin E. Wehman *In* AGARD Advan. in Guidance and Control Systems Using Digital Tech. Aug. 1979 15 p refs Sponsored by ONR and NSWC (For primary document see N80-14017 05-01)
Avail: NTIS HC A16/MF A01

Modular digital missile guidance and control systems were analyzed, structured, and built using standard industry microprocessors/microcomputers and associated memory and input/output interface components. The types of missiles considered were air-to-air, ship-to-air, and ship-to-ship, while the guidance and control functions analyzed were target seeker signal processing, seeker head control and stabilization, state estimation, guidance laws, autopilots, ramjet engine throttle control, warhead fuzing, telemetry, and self test. Federal microcomputer systems were found to support hardware modularity at the system level, and a set of 'macrofunction' microcomputer modules provided the desired flexibility at the component level. K.L.

N80-14041# Societe d'Applications Generales d'Electricite et de Mecanique, Paris (France).
COPRA: A NEW LINE OF ULTRARELIABLE RECONFIGURABLE COMPUTERS DESTINED FOR ONBOARD AEROSPACE APPLICATIONS [COPRA: UNE LIGNE NOUVELLE DECALCULAETEURS RECONFIGURABLES ULTRAFIABLES DESTINEE AUX APPLICATIONS AEROSPATIALES EMBARQUEES]
C. Meraud and F. Browaeys *In* AGARD Advan. in Guidance and Control Systems Using Digital Tech. Aug. 1979 23 p In *FRENCH* (For primary document see N80-14017 05-01)
Avail: NTIS HC A16/MF A01

A computer with automatic parallel reconfigurable organization, COPRA covers a gamut going from a redundant monoprocessor (200 kops/sec) to reconfigurable multiprocessors (400, 600, and 800 kops/sec). A model was constructed and a prototype is under development. It corresponds to a double-duplex configuration capable of surviving at least a first complete breakdown, as well as transitory breakdowns of a transparent kind during programming, which considerably simplifies the development of the application operating system. The microprogrammed means for error detection and for automatic recovery and reconfiguration are explained. Some technical aspects, notably the use of CMOS on SOS, are discussed. Some uses are predicted on a supervisory level for facilitating the programming of degradation of the mission. A Markov model permits a precise estimation of reliability which, for the configuration being developed, will be in the neighborhood of 95% over 5 years, with an undetected error rate on the order of 10 to the minus 10 power per hour. Transl. by A.R.H.

N80-14042# Litton Systems (Canada) Ltd., Rexdale, (Ontario)
A HIGH ACCURACY FLIGHT PROFILE DETERMINING SYSTEM
Peter Roy Vousden and Peter Jonathon Gollop *In* AGARD Advan. in Guidance and Control Systems Using Digital Tech. Aug. 1979 16 p (For primary document see N80-14017 05-01)
Avail: NTIS HC A16/MF A01

The characteristics of a system that determines the flight profile of an aircraft in three orthogonal coordinates to an accuracy of a few feet are described. A standard commercial quality inertial navigation system provides the required aircraft dynamic and attitude data while a special infrared sensor provides periodic updates. A digital computer implements an 18 state Kalman filter for estimation of the inertial errors. Filter data is stored on magnetic tape for immediate reprocessing by a fixed interval Bryson-Frazier smoothing algorithm that further refines the system performance. The techniques, applied in real time, are controlled in a multitask environment by a software operating system. Applications for the systems capability are discussed with emphasis on the initial purpose of providing an accurate self contained trajectory measuring system for ILS and MLS flight checking. Other uses such as airborne surveying and weapon release determining systems are examined. A.W.H.

N80-14043# Air Force Flight Dynamics Lab., Wright-Patterson AFB, Ohio.
INTEGRATION OF FLIGHT AND FIRE CONTROL
Robert K. Huber *In* AGARD Advan. in Guidance and Control Systems Using Digital Tech. Aug. 1979 9 p refs (For primary document see N80-14017 05-01)
Avail: NTIS HC A16/MF A01

An evaluation of an integrated flight and fire control (IFFC) system in modern fighter aircraft is described. The IFFC systems for air to air gunnery, air to ground gunnery, and bombing are outlined. The concept involves the coupling of fire control commands into the flight control system. The concept will be tested on a F-15B aircraft. Primary modifications to the F-15B aircraft include the addition of a digital computer for flight control and fire control signal processing, an electro-optical tracker, and a 1553A multiplex bus for communication between the F-15 central computer, the tracker, and the added digital computer. The IFFC concepts, the planned hardware implementation on the F-15B, and safety of flight considerations are discussed. A.W.H.

X80-72047 Advisory Group for Aerospace Research and Development, Paris (France)
***GUIDANCE AND CONTROL DESIGN CONSIDERATIONS* FOR LOW-ALTITUDE AND TERMINAL AREA FLIGHT (U)**
Jun. 1978 14 p This document is not available from the NASA STI Facility. All requests must be directed to AGARD Hq. (AGARD CP-240-Suppl) NATO Confidential report

Twenty-five papers are presented on the following topics: operational problems and considerations, terrain following, terminal area and landing considerations, weapon delivery, and system integration. R.E.S.

X80-72048 Advisory Group for Aerospace Research and Development, Paris (France).
THE IMPACT OF INTEGRATED GUIDANCE AND CONTROL TECHNOLOGY ON WEAPONS SYSTEMS DESIGN (U)
Dec. 1978 68 p This document is not available from the NASA STI Facility. All requests must be directed to AGARD Hq.
(AGARD-CP-257-Suppl) NATO Confidential report

Twenty-seven papers are presented on the following topics: (1) weapon delivery/flight control integration; (2) communications, command, control and sensor data integration; (3) crew station configurations and display concepts; (4) pilot system interaction; (5) data processing and distribution systems; and (6) development and system test experiences. R.E.S.

02 AERODYNAMICS

Includes aerodynamics of bodies, combinations, wings, rotors, and control surfaces; and internal flow in ducts and turbomachinery

For related information see also *34 Fluid Mechanics and Heat Transfer*

N77-32091# Advisory Group for Aerospace Research and Development, Paris (France)
SPECIAL COURSE ON CONCEPTS FOR DRAG REDUCTION
Jun 1977 294 p Presented at an AGARD Special Course at the von Karman Inst., Rhode-St-Genese, Belgium, 28 Mar - 1 Apr 1977
(AGARD-R-654 ISBN-92-835-1247-2) Avail: NTIS HC A13/MF A01

The results of aerodynamic research and development in aircraft design to reduce drag, boundary layer control, and optimization of gas turbine intake system are evaluated in relation with fuel consumption. For individual titles, see N77-32092 through N77-32100

N77-32092*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.
AN OVERVIEW OF CONCEPTS FOR AIRCRAFT DRAG REDUCTIONS
Jerry N. Hefner and Dennis M. Bushnell *In* AGARD Spec. Course on Concepts for Drag Reduction Jun 1977 30 p refs (For primary document see N77-32091 23-02)
Avail: NTIS HC A13/MF A01 CSCL 01A

A current overview of aerodynamic drag reduction concepts which have potential for reducing aircraft fuel consumption is presented. The discussion shows where the greatest percentages of aircraft fuel is burned and what areas have the greatest potential for fuel conservation. The paper deals with aerodynamic improvements and touches only briefly on structural and propulsion improvements. Concepts for reducing pressure drag (i.e., roughness, wave, interference, and separation drag), drag due to lift/induced drag, and skin-friction drag at subsonic and supersonic speeds are emphasized. Author

N77-32093*# *National Aeronautics and Space Administration*, Langley Research Center, Langley Station, Va.
METHODS FOR REDUCING SUBSONIC DRAG DUE TO LIFT
R. T. Whitcomb In AGARD Spec. Course on Concepts for Drag Reduction Jun 1977 17 p refs (For primary document see N77-32091 23-02)
Avail: NTIS HC A13/MF A01 CSCL 01A

The results of repeat experimental research on methods for reducing subsonic drag due to lift are discussed. The NASA supercritical airfoils and their application to structurally practical wings with increased aspect radio are described. A design approach and *experimental results for wing-tip-mounted winglets* are presented. Several methods for utilizing the thrust of jet engines to provide reductions in the drag due to lift are also discussed. Author

N77-32094*# National Aeronautics and Space Administration, Langley Research Center, Langley Station, Va.
LAMINAR FLOW CONTROL *LAMINARIZATION*
Werner Pfenninger *In* AGARD Spec. Course on Concepts for Drag Reduction Jun 1977 75 p refs (For primary document see N77-32091 23-02)
Avail: NTIS HC A13/MF A01 CSCL 01A

A practical aerodynamically and structurally reasonably efficient laminar flow control (LFC) suction method, removing the slowest boundary layer particles through many closed spaced fine slots, was developed and subsequently applied to a second F94 LFC wing glove in flight. 100 percent laminar flow was observed up to the F94 test limit. Laminar flow on LFC wings in flight is thus possible at a much higher Reynolds number than even in the best low turbulence tunnels as a result of the negligible influence of the atmospheric microscale turbulence on transition. The F94 LFC glove comparison experiments, with suction starting at 0.03c and 0.4c, verified the theoretically predicted boundary layer stabilization by suction starting at 0.08c, thus maintaining laminar flow at substantially higher C sub L numbers as compared to boundary layer stabilization by flow acceleration, i.e., geometry alone without suction upstream of 0.4c. Author

N77-32095# Royal Aircraft Establishment, Farnborough (England). Aerodynamics Dept.
LAMINAR FLOW CONTROL: CONCEPTS, EXPERIENCES, SPECULATIONS
Brian Edwards *In* AGARD Spec. Course on Concepts for Drag Reduction Jun 1977 41 p refs (For primary document see N77-32091 23-02)
Avail: NTIS HC A13/MF A01

The twin concepts of laminar flow control by suction, and of propulsion by restoring the momentun of the sucked mass flow are described. An account is given of the progress of some work relating to laminar flow control. Doubts about the practical application of laminar flow control are aired and the reasons why the work was not continued are briefly discussed. The view is expressed that, despite the recent rapid rise in the price of fuel, future prospects for the application of laminar flow control are still uncertain. Author

N77-32096*# National Aeronautics and Space Administration, Langley Research Center, Langley Station, Va.
SLOT INJECTION FOR SKIN-FRICTION DRAG REDUCTION
A. M. Cary, Jr., D. M. Bushnell, and J. N. Hefner *In* AGARD Spec. Course on Concepts for Drag Reduction Jun. 1977 11 p refs (For primary document see N77-32091 23-02)
Avail: NTIS HC A13/MF A01 CSCL 01A

A description and analysis of slot injection in low-speed flow, slot injection in high-speed flow, a discussion of aircraft applications, and possibilities for future improvements of slot drag reduction capability are presented. Author

N77-32097# Cranfield Inst. of Technology (England). School of Mechanical Engineering.
DIFFUSERS AND THEIR PERFORMANCE IMPROVEMENT BY MEANS OF BOUNDARY LAYER CONTROL
R. C. Adkins *In* AGARD Spec. Course on Concepts for Drag Reduction Jun 1977 53 p refs (For primary document see N77-32091 23-02)
Avail: NTIS HC A13/MF A01

Several remedial devices were investigated to optimize diffuser design. At present, the diffuser is too long to fit within gas turbine engines. For this reason the developer has been constrained to use divergence angles significantly greater than the optimum. This system not only impaired engine performance, but also reduced engine life because of the inlet flow distortion. The shortcomings of the intake system design are evaluated. I.M.

N77-32098# Max-Planck-Institut fuer Stroemungsforschung, Goettingen (West Germany).
DRAG REDUCTION BY COMPLIANT WALLS: THEORY
G. Zimmerman *In* AGARD Spec. Course on Concepts for Drag Reduction Jun 1977 14 p refs (For primary document see N77-32091 23-02)
Avail: NTIS HC A13/MF A01

A discussion of general properties of a compliant wall required for drag reduction is given. The difficulties of a theoretical *treatment of the compliant wall problem and the simplifications* and assumptions made to overcome these difficulties are discussed at two exemplary theories: one dealing with the stability of a stationary laminar layer over a compliant wall, the second dealing *with the turbulent boundary layer/compliant wall interaction* problem. Special emphasis is given to the coupling conditions between fluid flow and complient wall. Author

N77-32099# Max-Planck-Institut fuer Stroemungsforschung, Goettingen (West Germany).
ON THE PROGRAM OF DRAG REDUCTION BY MEANS OF COMPLIANT WALLS
A. Dinkelacker *In* AGARD Spec. Course on Concepts for Drag Reduction Jun 1977 21 p *refs (For primary document see* N77-32091 23-02)
Avail: NTIS HC A13/MF A01

Drag reduction with the help of compliant coatings would be of great interest for technical applications as well as for research in turbulence. At present, however there is to the author's knowledge no single experiment on drag reduction by means of compliant walls which has been successfully repeated by a second investigator. Therefore the basic requirement of reproducibility seems to be not yet fulfilled. This does not imply that drag reduction with the help of compliant walls is impossible or that reported results are wrong, it only indicates that the problem has to be regarded as being in an uncertain state. In the present paper some of the difficulties arising from experiments with compliant walls are discussed and recommendations for further studies are given. Investigations of turbulent wall pressure fluctuations are reported which are believed to be helpful for a better understanding of interactions between the flow and compliant walls. Author

N77-32100*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

EFFECT OF COMPLIANT WALL MOTION ON TURBULENT BOUNDARY LAYERS

Dennis M. Bushnell, Jerry N. Hefner, and Robert L. Ash (Old Dominion Univ., Norfolk, Va.) *In* AGARD Spec. Course on Concepts for Drag Reduction Jun. 1977 26 p (For primary document see N77-32091 23-02)

Avail: NTIS HC A13/MF A01 CSCL 01A

A critical analysis of available wall data which indicated drag reduction under turbulent boundary layers. Detailed structural dynamic calculations suggest the surfaces responded in a resonant, rather than compliant, manner. Alternate explanations are given for drag reductions observed in two classes of experiments: flexible pipe flown, and waterbacked membranes in air. Analysis indicates the wall motion for the remaining data is typified by short wave lengths in agreement with the requirement of a possible compliant wall drag reduction mechanism recently suggested by Langley. Author

N78-22033# Advisory Group for Aerospace Research and Development, Paris (France).

UNSTEADY AERODYNAMICS

Feb. 1978 609 p refs In ENGLISH; partly in FRENCH Presented at the Fluid Dyn. Panel Symp., Ottawa, 26-28 Sep. 1977 (AGARD-CP-227; ISBN-92-835-0212-4) Avail: NTIS HC A99/MF A01

The effects of unsteadiness on the aerodynamic characteristics of lifting surfaces and bodies are discussed. Numerical analysis of three dimensional flow is emphasized. For individual titles, see N78-22034 through N78-22067.

N78-22034# Stanford Univ., Calif. Dept. of Aeronautics and Astronautics.

UNSTEADY SUBSONIC AND SUPERSONIC INVISCID-FLOW

Holt Ashley In AGARD Unsteady Aerodyn. Feb. 1978 32 p refs (For availability see N78-22033 13-02) (Grant AF-AFOSR-2712-74)

Avail: NTIS HC A99/MF A01

Circumstances under which the neglect of viscosity still yields useful results in the analysis of time-dependent airflows external to shapes of aeronautical interest are discussed. The corresponding physical laws are reduced to a single differential equation which governs the velocity potential. Determinate mathematical problem statements capable of predicting aerodynamic loads to first or second order in small disturbances superimposed upon a uniform airstream are summarized. Arbitrary small motions are emphasized. From fully linearized potential theory, information is reviewed on isolated lifting surfaces, slender bodies, and interfering configurations in flight below and above the ambient speed of sound. The sonic limit of linearized theory is assessed. The findings of comparative studies on selected wing planforms and on interfering systems are recalled. A brief discussion is presented on the progress of second-order approximations, such as local linearization and numerical solution of the field differential equations. Finally, speculations are offered about the increasing significance of numerical fluid dynamics as a practical approach to unsteady flow phenomena. Author

N78-22035*# Virginia Polytechnic Inst. and State Univ., Blacksburg. Dept. of Engineering Science and Mechanics.

THREE DIMENSIONAL STEADY AND UNSTEADY ASYMMETRIC FLOW PAST WINGS OF ARBITRARY PLANFORMS

O. A. Kandil, E. H. Atta, and A. H. Nayfeh In AGARD Unsteady Aerodyn. Feb. 1978 19 p refs (For availability see N78-22033 13-02) (Grant NGR-47-004-090)

Avail: NTIS HC A99/MF A01

The nonlinear discrete vortex method is extended to treat the problem of asymmetric flows past a wing with leading edge separation, including steady and unsteady flows. The problem is formulated in terms of a body fixed frame of reference and the nonlinear-discrete vortex method is modified accordingly. Although the method is general, only examples of flows past delta wings are presented due to the availability of experimental data as well as approximate theories. Comparison of results with experimental results for a delta wing undergoing a steady rolling motion at zero angle of attack demonstrate the superiority of the present method over existing approximate theories in obtaining highly accurate loads. Numerical results for yawed wings at large angles of attack are also presented. In all cases, total load coefficients, pressure distributions, and shapes of the free vortex sheets are shown. Author

N78-22036*# Boston Univ., Mass. Dept. of Aerospace and Mechanical Engineering.

STEADY, OSCILLATORY AND UNSTEADY, SUBSONIC AND SUPERSONIC AERODYNAMICS (SOUSSA) FOR COMPLEX AIRCRAFT CONFIGURATIONS

Luigi Morino and Kadin Tseng *In* AGARD Unsteady Aerodyn. Feb. 1978 14 p refs (For availability see N78-22033 13-02) (Grant NGR-22-004-030)

Avail: NTIS HC A99/MF A01

The Green's function method and the computer program SOUSSA (Steady Oscillatory and Unsteady Subsonic and Supersonic Aerodynamics) are reviewed. The Green's function method is applied to the fully unsteady potential equation yielding an integro-differential-delay equation. This equation is approximated by a set of differential-delay equations in time using the finite element method. The Laplace transform is used to yield a matrix relating the velocity potential to the normal wash. The matrix of the generalized aerodynamic forces is obtained by premultiplying and postmultiplying the matrices relating generalized forces to the potential and the normal wash by the generalized coordinates. The program SOUSSA is compared with existing numerical results. Results indicate that the program is not only general, flexible, and easy to use, but also accurate and fast. Author

N78-22037# University Coll., London (England). Dept. of Mechanical Engineering.

FORCE MEASUREMENTS ON FINITE WINGS IN OSCILLATORY VERTICAL GUSTS

M. H. Patel *In* AGARD Unsteady Aerodyn. Feb. 1978 16 p refs (For availability see N78-22033 13-02)

Avail: NTIS HC A99/MF A01

Aerodynamic lift and pitching moment measurements on two finite wings in harmonic vertical oscillatory gusts of varying frequency parameter and gust amplitude are described. The variation of aerodynamic force per unit gust amplitude with frequency parameter is shown to be independent of freestream velocity, wing incidence, and gust amplitude, but is strongly influenced by wing sweep. The tests on both wings are extended to the determination of aerodynamic force response to periodic vertical gusts which incorporate a combination of two harmonic frequency components. The validity of the superposition concept for unsteady attached flow over finite wings is demonstrated by comparing the components of force response at each of the two forcing frequencies to the corresponding response at the single harmonic frequency. Further measurements of lift, pitching moment, and rolling moment are presented for both wings at various attitudes of skew (in yaw) to a harmonic oscillatory gust front. The effects of the resultant asymmetric lift distribution on the two wings halves are identified in the results with particular reference to the amplitudes and phases of oscillating rolling moments that are generated. Author

N78-22038# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Goettingen (West Germany). Inst. fuer Aeroelastik

CALCULATION OF UNSTEADY AIRLOADS ON OSCILLATING THREE-DIMENSIONAL WINGS AND BODIES

Wolfgang Geissler *In* AGARD Unsteady Aerodyn. Feb. 1978 13 p refs (For availability see N78-22033 13-02)

Avail: NTIS HC A99/MF A01

A numerical method developed to calculate the steady and unsteady pressure distributions on harmonically oscillating three dimensional wings and bodies in subsonic flow is described.

The method is based on a complex velocity potential represented by appropriate singularity distributions on the real oscillating surfaces. The exact geometric boundary condition on the arbitrary body surface is considered. Oscillating three dimensional thin wings, oscillating bodies at incidence, and oscillating three dimensional wings with finite thickness and incidence were investigated intensively. Numerical results for a variety of problems were compared to other analytical methods as well as experimental data. Agreement was found to be satisfactory. Author

N78-22039# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick (West Germany). Inst. fuer Aerodynamik

SOME BASIC AND NEW ASPECTS ON THE DISTURBANCE FIELDS OF UNSTEADY SINGULARITIES IN UNIFORM MOTION

Arabindo Das *In* AGARD Unsteady Aerodyn. Feb 1978 31 p refs (For availability see N78-22033 13-02)
Avail: NTIS HC A99/MF A01

The influence factors arising from the motion of unsteady singularities and generally valid expressions for these effects are considered. In the linearized theory the aerodynamic and aeroacoustic problem are dealt with by means of a unified treatment. The derived expressions for the influence factors are given general forms which are uniformly valid for subsonic and supersonic velocities of the singularities. The unsteady singularities which are commonly encountered in the field of aerodynamics and aeroacoustics are represented as sources, dipoles, and quadrupoles. The expressions for the near field and far field disturbances of the various moving singularities are presented. The resulting changes in the disturbance fields of moving singularities compared to those of space fixed singularities in an unbounded medium at rest may be denoted as Mach number effect. The usual global notation of this effect as compressibility effect is neither true nor applicable, when linearized theory of disturbance fields is considered. Finally, the problem of disturbance propagation from singularities in motion is treated in a moving reference frame by applying the Lorentz transformation in a nondimensional form, which preserves the physical quantities defined in the medium fixed system, much as singularity strength, phase relations, etc. The significance of the Lorentz transformation is elucidated by presenting the field of a moving source in the space-time continuum. Author

N78-22040# Fuehrungsakademie der Bundeswehr, Hamburg (West Germany)

INTERFERING AIRFOILS IN TWO-DIMENSIONAL UNSTEADY INCOMPRESSIBLE FLOW

Helmut Bosch *In* AGARD Unsteady Aerodyn. Feb 1978 15 p refs (For availability see N78-22033 13-02)
Avail: NTIS HC A99/MF A01

The interference of two or more lifting surfaces in two dimensional unsteady incompressible flow is considered. The integral relations relating the unsteady flow components around a harmonically oscillating airfoil to the pressure distribution are presented. These relations are then applied to treat two problems: first, calculation of the flow field around a single airfoil for a given pressure distribution and, second, calculation of the aerodynamic forces acting on the lifting surfaces. Special consideration is given to the longitudinal force component, i.e. drag or propulsion, acting on the lifting surfaces, and to the propulsion efficiency. The results show that for both the plunging motion and the pitching motion, a lifting surface at rest located behind an oscillating airfoil considerably improves the propulsion efficiency. For the plunging motion the propulsion efficiency is very close to 100%, almost independent of the reduced frequency and the backward position of the aft surface. Author

N78-22041# Office National d'Etudes et de Recherches Aerospatiales, Paris (France)

STUDY OF A SUPERCRITICAL PROFILE WITH OSCILLATING CONTROL SURFACE IN SUB- AND TRANSONIC FLOWS

Richard Grenon and Jean Thers *In* AGARD Unsteady Aerodyn. Feb 1978 10 p refs In FRENCH, ENGLISH summary (For availability see N78-22033 13-02)
Avail: NTIS HC A99/MF A01

Results of unsteady pressure measurements performed on a supercritical profile equipped with a 25% chord trailing edge control surface in harmonic motion, in two dimensional sub- and transonic flows are presented. Important differences appeared between the subcritical regime without shock, and the supercritical regime with shock. In both cases, the influence of the unsteady parameters, such as oscillation frequency and amplitude, and that of steady ones, such as mean flap setting and wing angle of attack is considered. The importance of viscous and shock related phenomena, and the necessity to develop calculation methods taking these phenomena into account is emphasized. Author

N78-22042# National Aerospace Lab., Amsterdam (Netherlands)

INVESTIGATION OF THE UNSTEADY AIRLOADS ON WING-STORE CONFIGURATIONS IN SUBSONIC FLOW

J. W. G. VanNunen, R. Roos, and J. J. Meijer *In* AGARD Unsteady Aerodyn. Feb 1978 10 p refs (For availability see N78-22033 13-02)
Avail: NTIS HC A99/MF A01

The unsteady aerodynamic loading on oscillating wing-store configurations is considered. Accurate prediction of the unsteady airforces introduced by wing mounted stores is emphasized. Author

N78-22043# Arizona Univ., Tucson. Dept. of Aerospace and Mechanical Engineering

UNSTEADY TRANSONIC FLOW COMPUTATIONS

A. R. Seebass, N. J. Yu, and K. Y. Fung *In* AGARD Unsteady Aerodyn. Feb 1978 17 p refs (For availability see N78-22033 13-02)
(Grant NsG-2112, Contract N00014-76-C-0182, Grant AF-AFOSR-2954B-76)
Avail: NTIS HC A99/MF A01

The effects of unsteady modes of motion on two dimensional transonic flows are described. The alternating direction implicit procedure is employed. Shock waves are treated as moving discontinuities. Results of nonlinear and time linearized calculations of the transonic flow past an NACA 64A006 airfoil experiencing harmonic motions in several of its modes are presented and discussed. Author

N78-22044# Northrop Corp., Hawthorne, Calif. Aircraft Div.

TOWARDS A MIXED KERNEL FUNCTION APPROACH FOR UNSTEADY TRANSONIC FLOW ANALYSIS

D. D. Liu and B. A. Winther *In* AGARD Unsteady Aerodyn. Feb 1978 17 p refs (For availability see N78-22033 13-02)
Avail: NTIS HC A99/MF A01

A new formulation in adopting multikernel functions, according to the mixed flow structure, for three dimensional analyses of the oscillatory transonic flow problems is proposed. It was aiming at a unified approach that would bridge the previous subsonic and supersonic lifting surface methods through the regime of linearized transonic flow. The analysis attempted to include the effect of the transonic shock wave, a mildly oscillatory shock-jump condition was derived and its compatible boundary condition considered. The only provision of the present approach was that the nonlinear mean flow distribution must be supplied by other experimental or theoretical means. Author

N78-22045# McDonnell-Douglas Research Labs., St. Louis, Mo.

UNSTEADY TRANSONIC FLOW IN A TWO-DIMENSIONAL DIFFUSER

M. Sajben, J. C. Kroutil, and C. P. Chen *In* AGARD Unsteady Aerodyn. Feb 1978 14 p refs (For availability see N78-22033 13-02)
Avail: NTIS HC A99/MF A01

Two dimensional diffuser flows, including a normal shock near the throat, were investigated using a model with a 2.36 exit to throat area ratio. Reynolds numbers based on the 48 mm throat height ranged to 100,000, the largest time-mean shock Mach number was 1.45. Extensive sidewall and corner boundary layer control produced reasonable two dimensionality of the time mean flow. The flow was separated at all transonic conditions. Observation and subsequent quantitative analysis of high speed schlieren films showed that the system exhibited low frequency fluctuations, highly correlated over the entire diffuser length. Author

N78-22046# Informatics, Inc., Palo Alto, Calif.

UNSTEADY FORCE AND MOMENT ALLEVIATION IN TRANSONIC FLOW

W. Ballhaus (Ames Directorate, US Army AMRDL, Moffett Field, Calif.), P. Goorjian, and H. Ulshimra (Boeing Aerospace Co., Seattle) *In* AGARD Unsteady Aerodyn. Feb 1978 10 p refs (For availability see N78-22033 13-02)
Avail: NTIS HC A99/MF A01

In flutter suppression, controlled stability, and gust alleviation in a transonic regime, an understanding of how the unsteady

lift and moment were generated is essential. Finite difference calculations based on 2D unsteady, small disturbance equations were first used to demonstrate the essential flow adjusting mechanisms. Based on this background, control devices situated in the sensitive parts of the airfoil were next investigated to moderate the chances in the lift and moment arising in the pitching oscillation of a NACA 64A-006 airfoil at M = 0.85. Author

N78-22047# Office National d'Etudes et de Recherches Aerospatiales, Paris (France).
INFLUENCE OF THE NOISE LEVEL IN A TRANSONIC WIND TUNNEL TEST SECTION ON THE AERODYNAMIC CHARACTERISTICS OF MODELS
Xavier Vaucheret *In* AGARD Unsteady Aerodyn. Feb. 1978 15 p refs In FRENCH; ENGLISH summary (For availability see N78-22033 13-02)
Avail: NTIS HC A99/MF A01

This study was carried out with standard models. Except for a shift in the pitching moment, the noise does not affect the overall steady characteristics. Shock locations were strongly modified by the noise, but only when the separation occurs at the shock foot. Without separation, the edge tones were heard clearly by the pressure transducers, and even more so, as the lift decreases. With separation and suppression of wall noise, the transducers reveal wing vibrations on their natural modes. Author

N78-22048# Virginia Polytechnic Inst. and State Univ., Blacksburg.
UNSTEADY BOUNDARY LAYERS, SEPARATED AND ATTACHED
Demetri P. Telionis *In* AGARD Unsteady Aerodyn. Feb. 1978 21 p refs (For availability see N78-22033 13-02)
(Contract DAHC04-75-G-0067)
Avail: NTIS HC A99/MF A01

Ongoing research into unsteady boundary layers is reviewed, including laminar and turbulent fluctuating boundary layers. Unsteady separation and separated flows are also considered, along with the moving wall case. J.A.M.

N78-22049# Centre d'Etudes et de Recherches, Toulouse (France).
EXPERIMENTAL RESULTS AND CALCULATING METHODS CONCERNING TRANSITIONAL AND TURBULENT BOUNDARY LAYERS IN UNSTEADY FLOW
Jean Cousteix, Robert Houdeville, and Andre Desopper *In* AGARD Unsteady Aerodyn. Feb. 1978 16 p refs In FRENCH; ENGLISH summary (For availability see N78-22033 13-02)
Avail: NTIS HC A99/MF A01

A turbulent boundary layer developing in an oscillating external flow was studied experimentally. The periodic component and the turbulent fluctuation of the velocity were analyzed separately with statistical treatment of data from hot wire anemometers. A numerical method is presented for solving the local equations by using a mixing length scheme or a transport equation model. Author

N78-22050# Sybucon, Inc., Atlanta, Ga.
UNSTEADY BOUNDARY LAYERS WITH REVERSAL AND SEPARATION
John F. Nash and Roy M. Scruggs *In* AGARD Unsteady Aerodyn. Feb 1978 12 p (For availability see N78-22033 13-02)
(Contract DAAG29-76-C-0045)
Avail: NTIS HC A99/MF A01

An appropriate computation scheme was developed for both laminar and turbulent flows, exploiting the validity of the first order theory. The effect of time dependence on flow reversal, the nature of unsteady reversal and separation, and the relevance of engineering results (notably to the dynamic stall problem) are discussed. Author

N78-22051# Southern Methodist Univ., Dallas, Tex. Dept. of Civil and Mechanical Engineering.
FEATURES OF UNSTEADY TURBULENT BOUNDARY LAYERS AS REVEALED FROM EXPERIMENTS
R. L. Simpson *In* AGARD Unsteady Aerodyn. Feb. 1978 10 p refs (For availability see N78-22033 13-02)
Avail: NTIS HC A99/MF A01

The first results from an experimental research program on unsteady turbulent boundary layers near separation are presented. The test flow is a periodic, nominally two dimensional, incompressible turbulent boundary layer on a flat surface. A programmable flow damper was used to produce the almost single harmonic velocity variation. It was found that the periodic flow in the viscous sublayer of the boundary is strongly influenced by the oscillating pressure gradient. Within the semilogarithmic velocity profile region there is no phase variation. Since the characteristic frequencies of the turbulence decrease markedly near preparation, there is much more interaction between the periodic oscillation and the turbulence in this region. Author

N78-22052# Queen Mary Coll., London (England). Dept. of Aeronautical Engineering.
AN EXPERIMENTAL STUDY OF THE EFFECT OF OSCILLATORY FLOW ON THE SEPARATION REGION IN A TURBULENT BOUNDARY LAYER
R. C. Kenison *In* AGARD Unsteady Aerodyn. Feb. 1978 12 p refs (For availability see N78-22033 13-02)
Avail: NTIS HC A99/MF A01

A separated turbulent boundary layer on a plate was subjected to harmonic oscillations superimposed on the mean adverse freestream velocity distribution. The resulting effects were investigated over a range of frequencies up to 6 Hz and amplitudes up to 13 per cent of the mean freestream velocity. Measurements were made of boundary velocity profiles, turbulence components, static pressures and skin friction at various points along the plate surface before and immediately after the separation point. For the range of frequencies and amplitudes examined, the oscillating freestream had a negligible effect on the mean distributions of skin friction, static pressures, turbulence intensities, and the mean separation position. The variation of velocity amplitudes in the boundary layer, which exceeded the free stream amplitude at certain positions, was dependent on frequency and distance from the leading edge. Author

N78-22053# Office National d'Etudes et de Recherches Aerospatiales, Paris (France).
DYNAMIC STALL: AN EXAMPLE OF STRONG INTERACTION BETWEEN VISCOUS AND INVISCID FLOWS
Jean-Jacques Philippe *In* AGARD Unsteady Aerodyn. Feb 1978 21 p refs In FRENCH; ENGLISH summary (For availability see N78-22033 13-02)
Avail: NTIS HC A99/MF A01

The phenomena concerning profiles in dynamic stall configuration was surveyed, and more specifically those related to pitch oscillations. The most characteristic experimental results on flow separation with a vortex character, and their repercussions on local pressures and total forces were analyzed. Some aspects of the methods for predicting flows with the presence (or not) of boundary layer separation were examined, as well as the main simplified methods available to date for the calculation of total forces in such configurations. Author

N78-22054# Illinois Inst. of Tech., Chicago. Dept. of Mechanics, Mechanical and Aerospace Engineering.
FEATURES OF UNSTEADY FLOWS OVER AIRFOILS
L. S. Gazana, A. A. Rejer, and M. V. Morkovin *In* AGARD Unsteady Aerodyn. Feb. 1978 11 p refs (For availability see N78-22033 13-02)
Avail: NTIS HC A99/MF A01

Sinusoidally oscillating flows over stationary NACA 0012 airfoils were studied at angles of attack close to the angle of stall in steady flow by means of hot wire surveys of the velocity field, surface pressure measurements and diagnostics with surface film gages and tufts. At the moderate amplitude of these tests stall occurred at subcritical angle of attack and the flow was quasisteady below and above the angle when the frequency was low. At higher frequencies this quasisteady behavior persisted below subcritical angle of attack but the unsteadiness did alter some of the details of the flow Author

N78-22055*# National Aeronautics and Space Administration Ames Research Center, Moffett Field, Calif.
DYNAMIC STALL OF AN OSCILLATING AIRFOIL
Unmeel B. Mehta (Stanford Univ., Calif.) *In* AGARD Unsteady Aerodyn. Feb. 1978 32 p refs Sponsored in part by ARMDL (For availability see N78-22033 13-02)
(Contract NCA2-or745-602, Grant NSG-2253)
Avail: NTIS HC A99/MF A01 CSCL 01A

Unsteady separated boundary layers and wakes were studied by investigating flow past an oscillating airfoil which in part models the retreating blade stall on the helicopters. The Navier-Stokes equations in terms of the vorticity and stream function for laminar flow were solved to determine the flow field around a modified NACA 0012 airfoil. After a fully developed

flow was determined at zero incidence, the airfoil was oscillated in pitch through an angle of attack range from 0 deg to 20 deg. The computed streamlines during this pitch-up motion are in qualitative agreement with the trajectories of air bubbles observed in water tunnel experiments conducted with a NACA 0012 airfoil under the same conditions. During the pitch-down motion of the airfoil, the computed flow patterns cannot be compared with the experiments because the trajectories of air bubbles intersect. Author

N78-22066# Georgia Inst of Tech., Atlanta. School of Aerospace Engineering.
A NUMERICAL STUDY OF UNSTEADY VISCOUS FLOWS AROUND AIRFOILS
J. C. Wu, S. Sampath, and N. L. Senkar. *In* AGARD Unsteady Aerodyn. Feb. 1978. 18 p. refs. (For availability see N78-22033 13-02)
Avail: NTIS HC A99/MF A01

The application of an integro-differential approach in the numerical study of unsteady viscous flow about airfoils is described. Two different procedures are presented. A procedure based on a stream function vorticity formulation and on a transformation technique was in a study of flow about an impulsively started 9% thick Joukowaki airfoil at an angle of attack of 15 deg and a Reynolds number of 1000. Numerical results are presented and compared with available finite difference results. A second procedure based on a velocity vorticity formulation and on a hybrid finite difference-finite element technique is used in a study of flow about an oscillating 12% thick Joukowaki airfoil at a Reynolds number of 1000. With either procedure, the ability of the integro-differential approach to confine the solution field to the vertical region of the flow was utilized. It is shown that this ability offers great computational advantage. Author

N78-22067*# Lockheed Missiles and Space Co., Sunnyvale, Calif.
SCALING PROBLEMS IN DYNAMIC TESTS OF AIRCRAFT-LIKE CONFIGURATIONS
Lars E. Ericson and J. Peter Reding. *In* AGARD Unsteady Aerodyn. Feb. 1978. 11 p. refs. (For availability see N78-22033 13-02)
(Contracts NAS8-28130, NAS8-30652)
Avail: NTIS HC A99/MF A01; CSCL 01C

To extrapolate from subscale wind tunnel tests to full scale flight is a well recognized problem. It is especially critical for present day high performance aircraft and the space shuttle orbiter which operate under flight conditions where separated flow effects often dominate the vehicle aerodynamics. In the case of dynamic tests it may not be possible to simulate flight conditions at subscale Reynolds number. This is illustrated by example from two dimensional dynamic stall tests at low speeds and dynamic tests of fully three dimensional configurations at transonic speeds, such as the space shuttle orbiter. It is shown how analytical means can be developed establishing theoretical relationships between dynamic and static aerodynamic characteristics and how such means make it possible to extrapolate analytically from subscale tests to full scale flight. The role of future high Reynolds number facilities in establishing such analytic extrapolation tools is discussed. Author

N78-22068# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Goettingen (West Germany).
TWO-DIMENSIONAL VISCOUS FLOW PAST AN AIRFOIL IN AN UNSTEADY AIRSTREAM
Robert B. Kinney (Arizona Univ., Tucson). *In* AGARD Unsteady Aerodyn. Feb. 1978. 14 p. refs. Sponsored in part by the Alexander von Humboldt Foundation. (For availability see N78-22033 13-02)
Avail: NTIS HC A99/MF A01

Numerical predictions are made for the viscous flow field near an airfoil in an unsteady airstream of infinite extent. Using an extension of techniques familiar to ideal fluid aerodynamic analyses, the body is represented by bound vortex singularities. These coexist with the free vorticity, which forms the boundary layer and wakes. Application of the no-slip condition at the airfoil surface plus the law of conservation of total vorticity, allows the production of true vorticity at the airfoil surface to be modeled. The velocity field is calculated using the law of induced velocities. Results are presented for a symmetrical Joukowski airfoil of 9% thickness. The airfoil is held fixed, and initially the fluid is at rest. At some instant, the fluid is set into motion. Two cases are treated: the impulsive gust, and the periodic gust. Author

N78-22069# Office National d'Etudes et de Recherches Aerospatiales, Paris (France).
DIFFICULTIES ENCOUNTERED BY AEROELASTICIANS OF UNSTEADY AERODYNAMICS
Rolland Dat and Jean-Jacques Angelini. *In* AGARD Unsteady Aerodyn. Feb. 1978. 12 p. refs. In FRENCH, ENGLISH summary (For availability see N78-22033 13-02)
Avail: NTIS HC A99/MF A01

The aeroelasticians have a real need of flexible and fast methods for calculating unsteady aerodynamic forces. The classical formulation based on the linear lifting surface theory is presented as an example of a method satisfactory as regards its domain of validity. The problems of supercritical flow and separation, which are much outside that domain, are unfortunately the most significant as far as flutter is concerned. Several experimental results are presented to show the phenomena particular to these flows. The approaches used to develop new methods are shown at the end. They extend from strict resolutions of the Mulerian equations to the development of corrections or phenomenological models. Author

N78-22070# Institut de Mecanique des Fluides de Lille (France).
THE STUDY OF SUBSONIC AND SUPERCRITICAL TURBULENT FLOWS BY ULTRA-SHORT DURATION VISUALIZATION [ETUDE D'ECOULEMENTS TURBULENTS SUBSONIQUES ET SUPERCRITIQUES PAR VISUALISATION ULTRA-RAPIDE]
A. Dyment and P. Gryson. *In* AGARD Unsteady Aerodyn. Feb. 1978. 29 p. refs. In FRENCH, ENGLISH summary (For availability see N78-22033 13-02)
Avail: NTIS HC A99/MF A01

The instability of the free boundary which follows separation is at the origin of large eddies existing downstream of a body in a flow. A general law is given which expresses the Strouhal number of eddies generated at a separation point as a function of the Reynolds number. The eddies undergo successive coalescences whose process is explained by a simplified theory. To form a vortex street whose Strouhal number is much lower than the emission one, the eddies of both sides have to coalesce again. The fact that the vortex street does appear immediately behind the body only at moderate Reynolds numbers can be explained in considering a relaxation time necessary for coalescing. Ultra-short duration shadowgraph and Schlieren visualizations were done with spark light sources. They give new information on the structure of the wake near the body in subsonic and supercritical flows. Author

N78-22071# Institut de Mecanique des Fluides de Marseille (France).
THE DYNAMIC FLOW ON A WING PROFILE IN THE MOVEMENT OF A SCREEN. THE INFLUENCE OF OSCILLATION PARAMETERS [RECOLLEMENT DYNAMIQUE SUR UN PROFIL D'AILE EN MOUVEMENT DE TAMIS INFLUENCE DES PARAMETRES D'OSCILLATION]
J. Rebont (CNRS, Marseilles (France)), C. Maresca (CNRS, Marseilles (France)), D. Favier (CNRS, Marseilles (France)), and J. Valensi (Aix-Marseilles Univ. (France)). *In* AGARD Unsteady Aerodyn. Feb. 1978. 28 p. refs. In FRENCH (For availability see N78-22033 13-02)
Avail: NTIS HC A99/MF A01

The mechanics of dynamic flow were studied qualitatively and quantitatively on a wing profile of a NACA 0012 airfoil. The wing, placed at a fixed incidence, is moved by harmonic oscillations parallel to the uniform nonperturbated flow. Flow characteristics were analyzed by comparing the vector development of total aerodynamic forces, static pressure distributions, and shear stress at the side of the profile, as well as the instantaneous flow visualizations at different phases in time.
Transl. by B.B.

N78-22072# Hellenic Air Force Technology Research Center, Athens (Greece). Aerodynamics Section.
DESIGN CRITERIA FOR THE NON-OCCURRENCE OF HIGH SPEED UNSTEADY SEPARATION ABOUT CONCAVE BODIES
A. G. Panaras. *In* AGARD Unsteady Aerodyn. Feb. 1978. 13 p. refs. (For availability see N78-22033 13-02)
Avail: NTIS HC A99/MF A01

Two modes of instability were observed in the unsteady separated flow about some families of axisymmetric concave bodies. In the pulsation mode the conical separation bubble periodically inflates and expands radially. In the oscillation mode the conical foreshock and the accompanying shear layer oscillate laterally and their shape changes periodically from concave to

convex. By means of theoretical arguments and an interpretation of the experimental data it was shown that the pulsation mode is caused by the formation of an annular supersonic jet at the intersection point of two shock envelopes evident during a brief part of the cycle. Additionally, it was found that the oscillation mode is most probably due to the non-satisfaction of the reattachment mechanism in a manner securing equilibrium of the pressure. Author

N78-22083# Air Force Flight Dynamics Lab., Wright-Patterson AFB, Ohio.
A RESUME OF AGARD SMP MEETING ON TRANSONIC UNSTEADY AERODYNAMICS
W. J. Mykytow and J. J. Olsen. *In* AGARD Unsteady Aerodyn. Feb. 1978 20 p refs. Summaries of papers presented at AGARD meeting, Unsteady Airloads in separated and Transonic Flow, Lisbon, Apr. 1977 (For availability see N78-22033 13-02)
Avail: NTIS HC A99/MF A01

Progress in transonic unsteady aerodynamics and the state-of-the-art are summarized. The need to estimate reliable transonic unsteady airloads required for load, deflection, stress, stability, flutter, and gust analyses in this critical speed region is emphasized. Author

N78-22084# Westland Helicopters Ltd., Yeovil (England).
THE IMPORTANCE OF UNSTEADY AERODYNAMICS IN ROTOR CALCULATIONS
G. H. Byham and T. S. Beddoes. *In* AGARD Unsteady Aerodyn. Feb. 1978 23 p refs (For availability see N78-22033 13-02)
Avail: NTIS HC A99/MF A01

The aerodynamic model required for rotor calculation methods is described. The impact of compressibility and dynamic stall on the limiting behavior of the rotor is discussed and it is shown, particularly for the condition of stall flutter, that the interaction of blades with discrete tip vortices is a major factor in controlling the blade torsional motion. It is indicated that wake distortion, particularly in the vertical plane, is necessary for detailed calculation of stall flutter. Author

N78-22085# Naval Postgraduate School, Monterey, Calif.
UNSTEADY FLOWS IN TURBOMACHINES: A REVIEW OF CURRENT DEVELOPMENTS
M. F. Platzer. *In* AGARD Unsteady Aerodyn. Feb. 1978 28 p refs (For availability see N78-22033 13-02)
(WR02403001)
Avail: NTIS HC A99/MF A01

The state-of-the-art of turbomachinery unsteady aerodynamics is reviewed with emphasis on theoretical prediction techniques. Author

N78-22086# Detroit Diesel Allison, Indianapolis, Ind.
AERODYNAMIC PHENOMENA IN AN OSCILLATING TRANSONIC MCA AIRFOIL CASCADE INCLUDING LOADING EFFECTS
Sanford Fleeter and Ronald E. Riffel. *In* AGARD Unsteady Aerodyn. Feb. 1978 16 p refs (For availability see N78-22033 13-02)
(Contract N00014-72-C-0351)
Avail: NTIS HC A99/MF A01

The steady, quasi-steady, and unsteady aerodynamics were determined for a multiple circular arc (MCA) airfoil cascade which modeled the tip section of an advanced design fan blade. The steady airfoil surface aerodynamic performance of the cascade was measured at two levels of aerodynamic loading and correlated with the predictions from a time-marching, steady, transonic flow analysis. The chordwise distribution of the quasi-static unsteady pressure coefficient for a 0 deg interblade phase angle was determined and correlated with two appropriate predictions: one based on the steady transonic analysis and the other on steady inviscid supersonic flat plate theory. Finally, the MCA cascade was harmonically oscillated in the torsional mode at a reduced frequency value of 0.14. The fundamental unsteady aerodynamic data was obtained at a Mach number equal to 1.55 over a range of interblade phase angles for two values of the cascade static pressure ratio. Results were correlated with the predictions from state-of-the-art unsteady flat plate cascade analyses. Author

N78-22087# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Goettingen (West Germany).
DETERMINATION OF THE VORTEX SHEDDING FREQUENCY OF CASCADE WITH DIFFERENT TRAILING EDGE THICKNESS
Hans-J. Heinemann and Karl A. Buetefisch. *In* AGARD Unsteady Aerodyn. Feb. 1978 11 p refs (For availability see N78-22033 13-02)
Avail: NTIS HC A99/MF A01

An electro-optical method developed to determine the shedding frequency of the vortices in the wakes flow is used in testing the flow through various hub-, mid-, and tip-section turbine cascade for various downstream Mach numbers in the sub-and transonic flow regimes. The trailing edge thickness of the blades vary from 0.8 to 5 percent of the blade chord length. These trailing edges lead to higher frequencies than thicker ones at constant Mach numbers. Author

N78-26115# Advisory Group for Aerospace Research and Development, Paris (France).
TECHNICAL EVALUATION REPORT OF THE SPECIALISTS' MEETING ON UNSTEADY AIRLOADS IN SEPARATED AND TRANSONIC FLOW
W. J. Mykytow (AFFDL, Wright-Patterson AFB, Ohio), B. Laschka (Messerchmitt-Boelkow-Blohm GmbH, Munich), and J. J. Olsen (AFFDL, Wright-Patterson AFB, Ohio). Apr. 1978 80 p refs Meeting held in Lisbon, 19-20 Apr. 1977
(AGARD-AR-108, ISBN-92-835-1279-0) Avail: NTIS HC A05/MF A01

The prediction and description of the separated flow environment and the essential effects of airframe response on individual aircraft components are discussed. Flutter, aeroelastic instabilities involving coupling with active control systems and other static and dynamic aeroelastic problems, with specific reference to the transonic speed range, are also presented. For individual titles, see N78-26116 through N78-26118.

N78-26116# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (West Germany).
AIRFRAME RESPONSE TO SEPARATED FLOW
B. Laschka and W. J. Mykytow (AFFDL, Wright-Patterson AFB, Ohio). *In* AGARD Tech. Evaluation Rept. of the Specialist Meeting on the Unsteady Airloads in Separated and Transonic Flow Apr. 1978 p 3-40 refs (For availability see N78-26115 17-02)
Avail: NTIS HC A05/MF A01

The effects of separated or unsteady flow on military aircraft may lead to failures of primary or secondary structures when exceeding design stress limits or design fatigue loads. The separated and unsteady flow environment is described, and its unsteady pressures and forces were determined by wind tunnel and flight test techniques. A description and discussion of the analytical approaches used for the prediction of the essential airframe response effects are given. M.V.

N78-26117# Air Force Flight Dynamics Lab., Wright-Patterson AFB, Ohio.
TRANSONIC UNSTEADY AEROELASTIC PHENOMENA
W. J. Mykytow and J. J. Olsen. *In* AGARD Tech. Evaluation Rept. of the Specialist Meeting on the Unsteady Airloads in Separated and Transonic Flow Apr. 1978 p 42-76 refs (For availability see N78-26115 17-02)
Avail: NTIS HC A05/MF A01

The development of two dimensional non-viscous methods for predicting unsteady airloads up to M = 0.9 are discussed. Methods and measurements of airloads on an oscillating, thick supercritical airfoil were evaluated. These papers and their references set the state-of-the-art and provide a groundwork for some judgments concerning the development of three dimensional engineering methods, and will help to define standard configurations and parameters to be used in formal and informal joint experimental and analytical programs. M.V.

N78-26118# Advisory Group for Aerospace Research and Development, Paris (France).
COMMENTS ON THE STATE OF THE ART OF TRANSONIC UNSTEADY AERODYNAMICS
H. C. Garner. *In its* Tech. Evaluation Rept. of the Specialist Meeting on the Unsteady Airloads in Separated and Transonic Flow Apr. 1978 p 77-78 (For availability see N78-26115 17-02)
Avail: NTIS HC A05/MF A01

A Venn diagram concerning the state-of-the-art with respect to aerodynamic loading on wings in supercritical flow is presented. It was suggested that military applications demand attention to realistic methods for low-supersonic flutter aerodynamics. M.V.

N78-32074# Advisory Group for Aerospace Research and Development, Paris (France)

TECHNICAL EVALUATION REPORT ON THE FLUID DYNAMICS PANEL SYMPOSIUM ON PREDICTION OF AERODYNAMIC LOADING

Rimantas Liaugminas (Dept of AF, Wright Patterson AFB, Ohio) Sep 1978 18 p refs Symp held at Moffett Field, Calif., 27-29 Sep 1976

(AGARD-AR-125 ISBN 92-835-1296-0) Avail NTIS HC A02/MF A01

The fluid dynamic aspects of predicting aerodynamic loads that represent difficult design and operating problems are examined with emphasis on theoretical and semi-empirical methods for determining the level and distribution of the expected loading and on assessing and evaluating the accuracy of the predicted values through comparison with available experimental data from windtunnels and flight tests. Advances in the state-of-art of aerodynamic load prediction are summarized and problem areas for further research effort are indicated. Topics cover: test techniques; stores; high angle of attack; high lift and drag; viscous/inviscid interactions in transonic flow; maneuvering aircraft; unsteady loads on arbitrary bodies in supersonic flow; flow with separation; dynamic stall; buffeting; and special problem areas. A.R.H.

N79-12028# Advisory Group for Aerospace Research and Development, Paris (France)

TECHNICAL EVALUATION REPORT ON THE FLUID DYNAMICS PANEL SYMPOSIUM ON UNSTEADY AERODYNAMICS

H. Bergh (Natl. Aerospace Lab., Amsterdam) Oct 1978 8 p Symp. held at Ottawa, 26-28 Sep. 1977

(AGARD-AR-128. ISBN-92-835-1300-2) Avail NTIS HC A02/MF A01

The proceedings of a symposium on unsteady aerodynamics are presented and the following topics are discussed: (1) unsteady subsonic and supersonic flow, (2) unsteady transonic flow, (3) unsteady nonseparated and separated boundary layers; (4) viscous-inviscid interactions, dynamic stall, and (5) unsteady flows associated with rotors, cascades, and turbomachinery. B.B.

N79-20067# Advisory Group for Aerospace Research and Development, Paris (France).

UNSTEADY VISCOUS THIN AIRFOIL THEORY

John E. Yates (Aeronautical Res. Associates of Princeton, Inc., N. J.) Jan. 1979 24 p refs Presented at 47th Structures and Mater. Panel Meeting, Florence, Sep. 1978

(AGARD-R-671; ISBN-92-835-1306-1) Avail: NTIS HC A02/MF A01

The concept of viscous thin airfoil theory introduced is formulated for unsteady incompressible flow. The theory is developed for a flat plate airfoil with no thickness boundary layer. Results indicate that the viscous pressure-downwash kernel function has a logarithmic singularity in contrast to the Cauchy singularity of inviscid theory. It is shown by direct numerical solution that for Reynolds number greater than 1000 the viscous and inviscid results are virtually the same except in the immediate vicinity of the trailing edge. The pressure loading is greater than inviscid theory would indicate and the phase of the complex loading is less than inviscid theory. The effect of edge bluntness is demonstrated for the case of steady flow. S.E.S.

N79-20088# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).

A COMPARISON OF PANEL METHODS FOR SUBSONIC FLOW COMPUTATION

H. S. Sytsma (National Aerospace Lab., Amsterdam), B. L. Hewitt (British Aerospace, Lancaster, United Kingdom), and P. E. Rubbert (Boeing Military Airplane Development, Seattle) Feb. 1979 89 p refs

(AGARD-AG-241. ISBN-92-835-1312-6) Avail: NTIS HC A05/MF A01

A data base for a number of relatively simple wing configurations and nacelle configurations is presented. The data results were obtained from the Roberts (BAe) Spline-Neumann Program and a pilot version of the Boeing Advanced Panel-Type Influence Coefficient Method. In addition, results from the practical, engineering type application of several methods are compared with the data solutions. These comparisons suggest that of the methods considered the Boeing Advanced Panel-Type Influence Coefficient Method is the most efficient, in terms of accuracy/computation time ratio. J.M.S.

N79-23050# Advisory Group for Aerospace Research and Development, Paris (France)

MISSILE AERODYNAMICS

Feb 1979 385 p refs In ENGLISH, partly in FRENCH Lecture series held in Ankara, 5-6 Mar.; Rome, 8-9 Mar.; and Rhode-Saint-Genese, Belgium, 12-16 Mar

(AGARD-LS-98) Avail: NTIS HC A17/MF A01

The differences in flight conditions and geometric configurations between aircraft and missiles mean that aerodynamic techniques for missile applications frequently differ from those used for aircraft. The aim of the lecture series was to emphasize these differences in the aerodynamic design features of both guided and unguided weapons. In addition to treating the component parts of the weapons themselves (e.g. wings, bodies, controls, propulsion units) and particular aspects of complete weapons (e.g. kinetic heating, high incidence effects), the course also dealt with the effects of air-breathing engines on the aerodynamics and vice versa, the interactions between aircraft and the weapons they carry, stores separation, and model test techniques. For individual titles see N79-23051 through N79-23059.

N79-23051# Royal Aircraft Establishment, Farnborough (England) Aerodynamics Dept

A BRIEF REVIEW OF AIR FLIGHT WEAPONS

George G. Brebner *In* AGARD Missile Aerodynamics Feb 1979 12 p (For primary document see N79-23050 14-02) Avail: NTIS HC A17/MF A01

The differences in design objectives and, consequently, in geometry between aircraft and weapons, and the aerodynamic repercussions, are described. Various general categories of air flight weapons are listed, propelled and unpropelled, guided and unguided, and in the particular category of propelled guided weapons different classes are identified. The following components of a guided weapon are described briefly: warhead, propulsive unit, safety and arming mechanism, fuze, guidance system and control system. Their functions and their effects on the aerodynamic design are described. The place of the aerodynamicist in the design of a guided weapon is discussed, and related to the various stages of the design and development process. G.Y.

N79-23052# Royal Aircraft Establishment, Farnborough (England) Aerodynamics Dept

GENERAL MISSILE AERODYNAMICS

George G. Brebner *In* AGARD Missile Aerodynamics Feb. 1979 16 p refs (For primary document see N79-23050 14-02) Avail: NTIS HC A17/MF A01

The six components of aerodynamic force and moment acting on an air flight missile are taken in turn, their importance discussed and their various characteristics described, along with some comments on methods of estimating them. The nondimensional forms of these forces and moments are functions of the components of linear and angular velocities, and their derivatives with respect to these velocities are listed and the more important ones defined. Brief descriptions are given of the origins and significance of Nagmus effects and cross-coupling effects. G.Y.

N79-23053# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Goettingen (West Germany) Inst. fuer *Theoretische Stroemungsmechanik*.

AERODYNAMICS OF LOW ASPECT RATIO WINGS

W. H. Stahl *In* AGARD Missile Aerodynamics Feb. 1979 64 p refs (For primary document see N79-23050 14-02) Avail: NTIS HC A17/MF A01

The types of wings are discussed which generally find application on missiles, that is with wings having delta, rectangular, trapezoidal, or other, planform, of more or less small aspect ratio. An overview over the available experimental evidence for the flow fields of such wings is given, as well as a discussion of measured pressure distributions, forces, and moments at low and high speeds, also the influence of Reynolds number is considered. Various methods to predict the aerodynamic characteristics of such wings are reviewed and comparisons are made between theoretical and experimental results. An extensive list of references is provided. G.Y.

N79-23054# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Cologne (West Germany)

BODIES

H. Esch *In* AGARD Missile Aerodynamics Feb. 1979 29 p refs (For primary document see N79-23050 14-02) Avail: NTIS HC A17/MF A01

The determination of the static aerodynamic coefficients of axisymmetric bodies is addressed. According to physical aspects the forces are decomposed into potential flow, friction, and separated flow. For each of these three types of flow, different computational methods must be applied. Only relatively simple methods are discussed which allow a quick estimation of the aerodynamics for slender shapes. The problem which arises from the bluntness is therefore discussed in every chapter. The Reynolds number is also discussed in every chapter. The discussion of the aerodynamics of bodies is not complete within the frame of this lecture. Only some aspects of static coefficients are treated. G.Y.

N79-23055# Naval Surface Weapons Center, White Oak, Md.
HIGH-ANGLE-OF-ATTACK MISSILE AERODYNAMICS
Andrew B. Wardlaw, Jr. *In* AGARD, Missile Aerodynamics, Feb. 1979, 53 p, refs (For primary document see N79-23050 14-02)
Avail: NTIS, HC A17/MF A01

Experimental data on and predictive methods for bodies, fins and complete missile configurations are reviewed. An outline and description is provided of the various vortex regimes that exist on a missile and its conponents at high angles of attack. Data is examined to determine quantitative trends in surface pressure distributions and loads. Available analytic, semi-empirical and empirical predictive methods are reviewed. G.Y.

N79-23056# Office National d'Etudes et de Recherches Aerospatiales, Paris (France).
BASE FLOWS BEHIND MISSILES
Jean Delery and Maurice Sirieix. *In* AGARD, Missile Aerodynamics, Feb. 1979, 78 p, refs. In FRENCH, ENGLISH summary (For primary document see N79-23050 14-02)
Avail: NTIS, HC A17/MF A01

The practicle implications of the base flow phenomena in the realistic case of turbulent boundary layers and in a Mach range up to, but excluding, hypersonics are addressed. The paper is divided into two main parts. The first part is devoted to a phenomenological analysis of the base flow with or without propulsive jet, at subsonic and supersonic velocities. The effects of the main factors of influence are surveyed and empirical correlation methods are presented. The second part concerns the presently available theories for the practical treatment of base flow problems. The basic principles of these theories are first presented in the fundamental and simplest case of reattachment on a wall. The extensions to base problems for axisymmetrical flows are then presented. The validity of the methods is discussed by comparison with available experimental results. G.Y.

N79-23057# Royal Aircraft Establishment, Farnborough (England). Aerodynamics Dept.
THE CONTROL OF GUIDED WEAPONS
G. G. Brebner. *In* AGARD, Missile Aerodynamics, Feb. 1979, 29 p, refs (For primary document see N79-23050 14-02)
Avail: NTIS, HC A17/MF A01

The most common form of control is the deflected aerodynamic surface, which may be placed at the rear of the missile (tail control), at the nose (canard control) or near the center of gravity (moving wing). The characteristics of these types are described, with examples of tail and canard controls and particular reference to interference effects. The origins and effects of cross-coupling are briefly described. The possibility of constructing monoplane and cruciform tail control characteristics from single panel measurements, thereby saving wind tunnel test time, is illustrated by an example. Other types of control considered are mechanical spoilers, jet reaction controls and thrust vector controls. Examples are given of typical characteristics of these three systems. G.Y.

N79-23058# Air Force Armament Lab., Eglin AFB, Fla. Aircraft Compatibility Branch.
STORE SEPARATION
Charles B. Mathews. *In* AGARD, Missile Aerodynamics, Feb. 1979, 76 p, refs (For primary document see N79-23050 14-02)
Avail: NTIS, HC A17/MF A01

Comments are made on the significant parameters affecting store trajectories. Some of the analytical and experimental techniques used to predict store separation trajectories are described. Examples are given of previous problems and their solutions. Methods for improving store separation and jettison characteristics are suggested. The relationship of store separation perturbations to weapon delivery accuracy is discussed. Attractive areas for additional research are recommended. G.Y.

N79-23059# Von Karman Inst. for Fluid Dynamics, Rhode Saint Genese (Belgium). Dept. of Aeronautics/Aerospace.
KINETIC HEATING OF HIGH SPEED MISSILES
Bryan E. Richards. *In* AGARD, Missile Aerodynamics, Feb. 1979, 21 p, refs (For primary document see N79-23050 14-02)
Avail: NTIS, HC A17/MF A01

The aspects considered are: the design problem, areas in which kinetic heating is important; the prediction of heating in attached and separated flows; measurements on configurations in flight and in wind tunnels; ground simulation of flows over models, and the measurement of kinetic heating. The experience is generally obtained from studies in related areas such as high speed aircraft, reentry vehicles, etc. rather than on tactical missiles since little information appears to be available on this application due to it being a fairly recently confronted problem area. Because of the wide coverage of the field, a generous list of references is provided to guide the reader to papers giving more refined details. G.Y.

N79-31159# Advisory Group for Aerospace Research and Development, Neuilly Sur Seine (France).
EXPERIMENTAL DATA BASE FOR COMPUTER PROGRAM ASSESSMENT. REPORT OF THE FLUID DYNAMICS PANEL WORKING GROUP 04
May 1979, 609 p, refs
(AGARD-AR-138, ISBN 92-835-1323-1) Avail: NTIS, HC A99/MF A01

The acquisition of highly reliable wind tunnel test data for aircraft design was investigated. For individual titles see N79-31160 through N79-31162.

N79-31160# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Goettingen (West Germany).
INTRODUCTION AND OVERVIEW OF CONFIGURATIONS
Juergen Barche. *In* AGARD, Exptl. Data Base for Computer Program Assessment, May 1979, 5 p (For primary document see N79-31159 22-02)
Avail: NTIS, HC A99/MF A01

An overview of the application of two- and three-dimensional transonic flows to aircraft design is presented. The criteria for two-dimensional, three-dimensional, and body alone configurations are tabulated. F.O.S.

N79-31161# ARO, Inc., Arnold Air Force Station, Tenn.
LIMITATIONS OF AVAILABLE DATA
Travis W. Binion. *In* AGARD, Exptl. Data Base for Computer Program Assessment, May 1979, 8 p, refs (For primary document see N79-31159 22-02)
Avail: NTIS, HC A99/MF A01

The factors affecting wind tunnel test results are discussed. These include: flow nonuniformity, three dimensional effects in two dimensional tests, support interference, aeroelastic effects, flow unsteadiness, wall interference, wave reflections, and boundary conditions. F.O.S.

N79-31162# Royal Aircraft Establishment, Bedford (England).
RECOMMENDATIONS FOR FUTURE TESTING
K. G. Winter and L. H. Ohman (NAE, Ottawa, Ont.). *In* AGARD, Exptl. Data Base for Computer Program Assessment, May 1979, 3 p, refs (For primary document see N79-31159 22-02)
Avail: NTIS, HC A99/MF A01

Recommendations for improvements in tunnel techniques to achieve highly reliable data for aircraft design are presented. Interferences and disturbances for two- and three-dimensional flows are discussed. F.O.S.

N80-10147# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
TECHNICAL EVALUATION REPORT ON THE FLUID DYNAMICS PANEL SYMPOSIUM ON HIGH ANGLE OF ATTACK AERODYNAMICS
Edward C. Polhamus, Aug. 1979, 20 p, refs. Symp. held at Sandefjord, Norway, 4-6 Oct. 1978. Prepared in cooperation with NASA, Langley Res. Center
(AGARD-AR-145, ISBN-92-835-1334-7) Avail: NTIS, HC A02/MF A01

An overview is presented of 32 formal papers and 7 open session papers. Topics covered include: (1) studies of configurations of practical interest, (2) mathematical modelling and supporting investigations of slender wings, bodies of revolution and body-wing configurations, (3) design methods, and (4) air intakes. A.R.H.

X80-72049# Advisory Group for Aerospace Research and Development, Paris (France)

DRAG AND OTHER AERODYNAMIC EFFECTS OF EXTERNAL STORES (U)

Nov. 1977 304 p This document is not available from the NASA STI Facility All requests must be directed to AGARD Hq

(AGARD-AR-107) NATO Restricted report

An assessment of future prospects and possibilities, and an identification of promising areas for research and development in connection with external stores are presented. M.M.M.

03 AIR TRANSPORTATION AND SAFETY

Includes passenger and cargo air transport operations, and aircraft accidents

For related information see also *16 Space Transportation* and *85 Urban Technology and Transportation*

N77-19031# Advisory Group for Aerospace Research and Development, Paris (France).
AIRCRAFT OPERATIONAL EXPERIENCE AND ITS IMPACT ON SAFETY AND SURVIVABILITY
Jan 1977 329 p Presented at the Flight Mech Panel Symp., Sandefjord, Norway, 31 May - 3 Jun 1976
(AGARD-CP-212) Avail NTIS HC A15/MF A01

Aircraft safety and survivability are discussed for accident prevention and aircraft reliability. Safety management and accident investigations are described for improving pilot and aircraft performance. For individual titles, see N77-19032 through N77-19055

N77-19032# Army Air Mobility Research and Development Lab., Fort Eustis, Va.
U.S. ARMY HELICOPTER ACCIDENT EXPERIENCE
George T. Singley, III and Laurel D. Sand (Army Agency for Aviation Safety, Ft. Rucker, Ala.) In AGARD Aircraft Operation Experience and its Impact on Safety and Survivability, Jan. 1977 6 p (For primary document see N77-19031 10-03)
Avail NTIS HC A15/MF A01

U.S. Army helicopter accident experience for the period FY68 through FY75 is examined. Helicopter operational trends such as the declining accident rate, fatality rate, and hours flown are discussed. Helicopter accident causes, conditions, and casualties are discussed. Data for crashes resulting from enemy combat actions are not included. A summary of recent advances in helicopter crashworthiness which promise to reduce future material and human losses due to helicopter accidents is included.
Author

N77-19033# Air Force Inspection and Safety Center, Norton AFB, Calif.
USAF ACCIDENT PREVENTION PROGRAM
Alfred C. Baker, Jr. *In* AGARD Aircraft Operation Experience and its Impact on Safety and Survivability, Jan. 1977 5 p (For primary document see N77-19031 10-03)
Avail NTIS HC A15/MF A01

A number of the systematic approaches which are aimed at isolating and quantifying hazards during the conceptual stage are discussed. It is anticipated that they will contribute substantially to a still further reduction in the rate of accidents experienced.
Author

N77-19034# National Research Council of Canada, Ottawa (Ontario)
THE RECOVERY AND ANALYSIS OF ACCIDENT DATA FROM FLIGHT RECORDERS IN CANADIAN TRANSPORT AIRCRAFT
B. Caiger *In* AGARD Aircraft Operation Experience and its Impact on Safety and Survivability, Jan. 1977 23 p refs (For primary document see N77-19031 10-03)
Avail NTIS HC A15/MF A01

A Playback Center was established that is acquiring unique experience in recovering and analyzing information from a wide range of aircraft audio and data recorders. In particular, the Center was designed to handle all cockpit voice recorders and flight data recorders fitted to Canadian civil and military transport aircraft. Recorders are forwarded to the Center whenever incidents or accidents warrant investigation by the authorities concerned. The playback facilities were designed with special emphasis on the problems that might be encountered in these cases. Routine monitoring is also conducted on the military systems for maintenance purposes. Current and future capabilities of the Center are summarized and examples are given of some of the work that was undertaken.
Author

N77-19035# Department of Trade and Industry, London (England)
THE FLIGHT RECORDER AND ACCIDENT INVESTIGATION
Geoffrey C. Wilkinson *In* AGARD Aircraft Operation Experience and its Impact on Safety and Survivability, Jan. 1977 20 p (For primary document see N77-19031 10-03)
Avail NTIS HC A15/MF A01

An attempt to give perspective to the introduction of the flight data recorders (FDR) in civil aviation is presented. The dangers inherent in a proliferation of different FDR equipment should be fully appreciated. Civil aviation learned from bitter experience the cost of noncompatible FDR equipment. A detailed analysis of a FDR record from an actual accident is presented, demonstrating some of the techniques used in FDR data analysis.
Author

N77-19036# Royal Netherlands Air Force, The Hague
AN ACCIDENT ANALYSIS OF FIGHTER AIRCRAFT IN RELATION TO MODIFICATIONS INTRODUCED AND NEW DEVELOPMENTS
A. P. Okkelman *In* AGARD Aircraft Operation Experience and its Impact on Safety and Survivability, Jan. 1977 4 p (For primary document see N77-19031 10-03)
Avail NTIS HC A15/MF A01

Fighter aircraft accidents are discussed for aircraft survivability from takeoff to landing. The analysis of some typical accidents is presented for accident prevention.
M.C.F.

N77-19037# National Transportation Safety Board, Washington, D.C. Bureau of Aviation Safety
CIVIL AIRCRAFT ACCIDENT ANALYSIS IN THE UNITED STATES-THE JET AGE
Coe M. Anderson *In* AGARD Aircraft Operation Experience and its Impact on Safety and Survivability, Jan. 1977 6 p (For primary document see N77-19031 10-03)
Avail NTIS HC A15/MF A01

The investigations and investigative techniques are presented for the total fatal U.S. air carrier turbojet accident experience from 1958 through 1975. Early series of 707 and DC-8 accidents are examined and analyzed along with certain recent wind shear accidents.
Author

N77-19038# Societe Nationale Industrielle Aerospatiale, Blagnac (France)
FORECAST ASSESSMENT OF THE TOTAL LEVEL OF SAFETY FOR A CIVIL AVIATION TRANSPORT AIRCRAFT [EVALUATION PREVISIONNELLE DU NIVEAU GLOBAL DE SECURITE D'UN AVION DE TRANSPORT CIVIL]
C. Lenseigne In AGARD Aircraft Operation Experience and its Impact on Safety and Survivability, Jan. 1977 7 p In FRENCH (For primary document see N77-19031 10-03)
Avail NTIS HC A15/MF A01

A method is described for assuring total safety for aircraft with large integrated systems. Because certain elementary failures of equipment have the same consequences as failure of other equipment in the same system, it is possible to group them into a failure resume for the system. The group remains unchanged in all systems studies and is considered an independent factor in all probabilities. All failure resumes are combined for total safety evaluation.
Trans. by A.R.H.

N77-19039# Avions Marcel Dassault-Breguet Aviation, Saint-Cloud (France)
SAFETY ANALYSIS OF THE FLIGHT CONTROL OF MERCURE AIRCRAFT [ANALYSE DE SECURITE DES COMMANDES DE VOL DU MERCURE]
J. F. Georges *In* AGARD Aircraft Operation Experience and its Impact on Safety and Survivability, Jan. 1977 5 p In FRENCH (For primary document see N77-19031 10-03)
Avail NTIS HC A15/MF A01

Certification of the Mercure was conducted in collaboration with French Official Services, using a method based on characterization of all systems' components and the analysis of all imaginable simple and multiple failures.
Trans. by A.R.H.

N77-19040# Hawker Siddeley Aviation Ltd., Kingston upon Thames (England)
FAILURE MODE ANALYSIS IN THE LIGHT OF EXPERIENCE
H. A. G. Waugh and M. R. Dawn *In* AGARD Aircraft Operation Experience and its Impact on Safety and Survivability, Jan. 1977 13 p (For primary document see N77-19031 10-03)
Avail NTIS HC A15/MF A01

Aircraft equipment failure and the cost of maintenance are discussed for accident prevention. Aircraft reliability and mission effectiveness are described for aircraft survivability.
M.C.F.

N77-19041*# National Aeronautics and Space Administration, Washington, D.C. Aviation Safety Technology Branch
AVIATION SAFETY AND OPERATION PROBLEMS RESEARCH AND TECHNOLOGY

John H Enders and Joseph W Strickle (NASA Langley Research Center) *In* AGARD Aircraft Operation Experience and its Impact on Safety and Survivability Jan 1977 30 p refs (For primary document see N77-19031 10-03)
Avail NTIS HC A15/MF A01 CSCL 01C

Aircraft operating problems are described for aviation safety It is shown that as aircraft technology improves the knowledge and understanding of operating problems must also improve for economics, reliability and safety M C F

N77-19042# Boeing Commercial Airplane Co Seattle, Wash Flight Deck Development Group
FLIGHT DECK TECHNIQUES: A NEW APPROACH TO SAFETY
Hartwell G Stoll *In* AGARD Aircraft Operation Experience and its Impact on Safety and Survivability Jan 1977 11 p (For primary document see N77-19031 10-03)
Avail NTIS HC A15/MF A01

The present commercial aircraft operational experience shows that the percent of accidents that is crew related has remained almost constant over the last few years Since the future airline operational environment is expected to increase in complexity, some new types of techniques for flight deck design will be required if a significant reduction in crew caused accident rate is to be achieved There are several new techniques and technological advances in flight deck designs that can contribute to improvement of commercial aircraft operational safety The digital computer technology alone allows a degree of flexibility in both design techniques and controls and displays that was not possible a few years ago Improved engine control energy management, systems, improved caution and warning systems, windshields designed for better collision avoidance capability, and overall simplification of the flight deck are some of the improvements that this new technology can provide Author

N77-19043# Dornier Werke G m b H , Friedrichshafen (West Germany)
STUDY (SAFETY ANALYSIS) OF AIRCRAFT SYSTEMS DURING TAKE-OFF AND LANDING
R Keppeler *In* AGARD Aircraft Operation Experience and its Impact on Safety and Survivability Jan 1977 19 p refs (For primary document see N77-19031 10-03)
Avail NTIS HC A15/MF A01

A general survey of accident statistics and the results of the evaluation of accident reports which were carried out to define, in a quantitative way, the causes of accidents and critical flight phases are presented The results show that, besides the technical safety, human behavior in interaction with technology is of special importance This should be taken into account to a greater extent with regard to future developments A possible method for a treatment on a systems analysis basis is demonstrated by means of typical examples In this context, procedures (e g for approach and departure) and activity analyses for a selected aircraft type are presented, on the basis of which a digital simulation for the approach procedure, for example, can be established, as shown As a result, unsatisfactory design, especially for the cockpit may be identified, and recommendations for training and decision aids for the operation can be derived. Author

N77-19044*# National Aeronautics and Space Administration Ames Research Center, Moffett Field, Calif
THE INFLUENCE OF HANDLING QUALITIES ON SAFETY AND SURVIVABILITY
Seth B Anderson *In* AGARD Aircraft Operation Experience and its Impact on Safety and Survivability Jan 1977 10 p refs (For primary document see N77-19031 10-03)
Avail NTIS HC A15/MF A01 CSCL 01C

The relationship of handling qualities to safety and survivability of military aircraft is examined which includes the following (1) a brief discussion of the philosophy used in the military specifications for treatment of degraded handling qualities, (2) an examination of several example handling qualities problem areas which influence safety and survivability and (3) a movie illustrating the potential dangers of inadequate handling qualities features Author

N77-19045# Army Air Mobility Research and Development Lab Fort Eustis, Va
DESIGN OF HELICOPTERS FOR SURVIVABILITY
George T McAllister *In* AGARD Aircraft Operation Experience and its Impact on Safety and Survivability Jan 1977 22 p refs (For primary document see N77-19031 10-03)
Avail NTIS HC A15/MF A01

A review of the design features criteria and experience that the U S Army has had with designing helicopters for survivability is presented Specific areas covered are infrared radiation, radar cross section, aural detectability, ballistic damage tolerance, and crashworthiness A few of the more interesting areas of work are highlighted as well as improvements in aircraft survivability planned for the future Author

N77-19046# Vereinigte Flugtechnische Werke Fokker G m b H Bremen (West Germany)
DESIGNING THE SURVIVABILITY OF FLYING WEAPON SYSTEM
H Schmidtlein, K Belsomherz, and M Mohring *In* AGARD Aircraft Operation Experience and its Impact on Safety and Survivability Jan 1977 11 p (For primary document see N77-19031 10-03)
Avail NTIS HC A15/MF A01

Based on investigations of remotely piloted vehicles systems the importance of survivability and the possible threat of enemy ground-to-air defense systems to RPV's are illustrated Five principles to increase the survivability of RPV weapon systems are described which can be evaluated mainly with respect to cost effectiveness and mission effectiveness Test and simulation results for the various principles are discussed Author

N77-19047# Institut de Mecanique des Fluides de Lille (France)
BEHAVIORAL PREDICTION OF WATER AND EMERGENCY LANDINGS [PREVISION DU COMPORTEMENT A L'AMERRISSAGE ET A L'ATTERRISSAGE FORCE]
Francis Dupriez *In* AGARD Aircraft Operation Experience and its Impact on Safety and Survivability Jan 1977 6 p refs In FRENCH ENGLISH summary (For primary document see N77-19031 10-03)
Avail NTIS HC A15/MF A01

Catapulted free-flight models of aircraft used at the design phase of a project as a prediction tool of the crash and ditching behavior of the full scale aircraft are investigated Similarity laws used for the dynamics of the airframe and the structural representation are given A typical ditching test model is described A review of current ditching test procedures is given Recent improvements of the methods allowing a better simulation of the full-scale phenomena and a better analysis of the local structural behavior are presented and compared to global behavior methods used in the past years Aircraft ditching test results are presented with emphasis on the influence of the main parameters Application to helicopter testing is briefly mentioned The description of a newly operated multipurpose facility based on the catapult technique which can also be used for cross-wind landing studies is also included Author

N77-19048# McDonnell-Douglas Corp , Long Beach, Calif
REDUCING FIRE HAZARDS IN COMMERCIAL TRANSPORT AIRCRAFT
Roger D Schaufele *In* AGARD Aircraft Operation Experience and its Impact on Safety and Survivability, Jan 1977 16 p refs (For primary document see N77-19031 10-03)
Avail NTIS HC A15/MF A01

The status of fire prevention design practices for current commercial transport aircraft is surveyed, and research and development activities aimed at providing additional fire prevention design criteria are reviewed To enable treatment of such a broad subject in a somewhat orderly manner, this paper is arranged to cover the development of fire preventing design concepts, a review of actual fire incidents, and an overview of related research and development activities Author

N77-19049# Federal Aviation Administration Washington D C
THE FEDERAL AVIATION ADMINISTRATION AND AVIATION SAFETY
David J Sheftel *In* AGARD Aircraft Operation Experience and its Impact on Safety and Survivability Jan 1977 8 p (For primary document see N77-19031 10-03)
Avail NTIS HC A15/MF A01

The Federal Aviation Administration's safety systems are analyzed together with the programs and projects to achieve an ultimate goal of zero accidents I M

N77-19050# Naval Air Systems Command, Washington, D C
DESIGN FOR REDUCTION OF AIRCRAFT VULNERABILITY
R T Remers *In* AGARD Aircraft Operation Experience and its Impact on Safety and Survivability, Jan 1977 23 p (For primary document see N77-19031 10-03)

Avail: NTIS HC A15/MF A01

A discussion of aircraft survivability in a nonnuclear threat environment and, in particular, that part of the total survivability discipline that encompasses the application of engineering design concepts and techniques to reduce the vulnerability of aircraft components and systems to the physical damage effects of projectiles and fragmenting warheads is presented. A brief overview of the aircraft survivability discipline to better define the roll of vulnerability reduction in the solution of the total aircraft survivability enhancement problem is given. The report then goes on to describe: (1) the results of analyses of fixed-wing aircraft combat losses in the Southeast Asia conflict, (2) the identification of the suspected aircraft system damage and failure modes that resulted in the loss of aircraft, (3) the verification by ballistic testing of many of these failure modes, (4) the vulnerability reduction features that have been developed and tested to protect aircraft systems, (5) design guidance that has been developed to aid in mission oriented aircraft configuration and systems location, and (6) examples of application of this design guidance to new aircraft. Author

N77-19051# Civil Aviation Authority, Redhill (England).
THE CAA MANDATORY OCCURRENCE REPORTING SYSTEM
Peter Meiklem *In* AGARD Aircraft Operation Experience and its Impact on Safety and Survivability. Jan 1977 18 p (For primary document see N77-19031 10-03)
Avail: NTIS HC A15/MF A01

This committee had been instructed by the government of the day to examine the economic and regulatory conditions in the UK air transport industry, and had recommended a merger of the bodies then separately responsible for the control of route licences, operational and airworthiness regulation, and air traffic control services. Mandatory incident and defect reporting was introduced. Author

N77-19052# Service Technique de l'Aeronautique, Paris (France).
PILOTING A PATH IN 1976 [PILOTAGE DE LA TRAJECTOIRE EN 1976]
Gilbert Klopfstein *In* AGARD Aircraft Operation Experience and its Impact on Safety and Survivability. Jan 1977 3 p In FRENCH (For primary document see N77-19031 10-03)
Avail: NTIS HC A15/MF A01

Aircraft accidents during landing approaches are due to errors in judgment which are tied to the poor quality of information given, and not to the performance of the pilot. The condemnation of manual control during this phase of flight was hasty. With adequate information, based on six paremeters abstracted from routine experience, the simplification of piloting systems can be achieved. Trans. by A.H.

N77-19053# Aerospace Medical Research Labs., Wright-Patterson AFB, Ohio. Biodynamics Div.
PHYSIOLOGICAL AND PSYCHOLOGICAL FACTORS IN AIRCRAFT OPERATIONS: AN OVERVIEW
Henning E. VonGierke *In* AGARD Aircraft Operation Experience and its Impact on Safety and Survivability. Jan 1977 14 p refs (For primary document see N77-19031 10-03)
Avail: NTIS HC A15/MF A01

New technologies evolving in the form of more sophisticated physiological, behavioral and human operator man-in-the-loop models mark progress in these areas. However, laboratory data and models based on them are always open to criticism, since, in spite of efforts to stimulate the real situation, the lack of realism with respect to environment, task, motivation and equipment remains. This criticism is still more justified with respect to extrapolation to combat conditions. The collection and evaluation of operational experiences including combat data collection have probably not progressed as much as laboratory research and simulation. Even if complexity and cost of field studies explain this state of affairs, it is nonetheless important to realize this deficiency. A final contribution to the analysis of pilot/aircrew, as well as systems performance, is provided by accident analysis and interpretation. Author

N77-19054# KLM Royal Dutch Airlines, Amsterdam (Netherlands). Head Flight Safety Dept.
ALERT FOR SAFETY - AN AIRLINE APPROACH
G. C. Wansbeek *In* AGARD Aircraft Operation Experience and its Impact on Safety and Survivability. Jan 1977 5 p (For primary document see N77-19031 10-03)
Avail: NTIS HC A15/MF A01

Safetywise the ultimate goal of any airline is no accidents and no important incidents. When this ideal situation is achieved the operator must be on the alert to prevent any development of self-confidence, and he must take the necessary steps to achieve this. Although this activity certainly may not be limited to cockpit personnel it is evident that the position of these crew members in the total operational loop is such that they have a primary responsibility to operate safely. The way in which pilots and flight-engineers are approached, however, must be carefully planned, and the best approach will differ from airline to airline. The method KLN Royal Dutch Airlines has chosen is described. Author

N77-19055# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick (West Germany).
RECENT RESEARCH IN COMBAT AIRCRAFT AND *HELICOPTER RESCUE SYSTEMS*
U. Schmidt *In* AGARD Aircraft Operation Experience and its Impact on Safety and Survivability. Jan 1977 16 p refs (For primary document see N77-19031 10-03)
Avail: NTIS HC A15/MF A01

Actual accidents of combat fighters as well as changes in their mission profiles have raised problems which require rescue systems improvements, some of which are discussed herein. Measuring methods and correlations between theory and test results are presented. Some observations that affect theoretical predictions during the ejection phases are discussed in detail. Furthermore, a survey is given of rescue concepts for helicopter crews. Two concepts, bailout during autorotation and, as a most likely system, the upward extraction after rotor blade separation, are discussed in depth. For the latter, emphasis is placed on basic research through use of wind tunnel and free flight models. Author

N78-13032# *Advisory Group for Aerospace Research and Development, Paris (France).*
THE PRINCIPLES OF UNDERWATER ESCAPE FROM AIRCRAFT
A. F. Davidson. Nov. 1977 31 p refs
(AGARD-AG-230) Avail: NTIS HC A03/MF A01

The physical, mechanical, and physiological factors involved in escape from aircraft following ditching are reviewed. Some mechanical devices which can be used to assist the aircrew to reach the surface safely were described. Comments on the conduct of trials and the training of personnel in the techniques of underwater escape from aircraft are also included. Author

N80-12079# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
PROPULSION AND ENERGETICS PANEL WORKING GROUP 2 ON AIRCRAFT FIRE SAFETY. VOLUME 1: EXECUTIVE SUMMARY
B. P. Botteri (AFSC). Sep. 1979 17 p
(AGARD-AR-132-Vol-1, ISBN-92-835-0246-9) Avail: NTIS HC A02/MF A01

The fire experience, areas in which fire protection enhancement is needed, technological advances in the areas of safety and personnel survivability for a civilian turbine engine transport aircraft are presented. M.M.M.

X80-72055# Advisory Group for Aerospace Research and Development, Paris (France).
AIRCRAFT OPERATIONAL EXPERIENCE AND ITS IMPACT ON SAFETY AND SURVIVABILITY (U)
Feb. 1977 24 p Symp. held at Sandefjord, Norway, 31 May - 3 Jun. 1976
This document is not available from the NASA STI Facility. All requests must be directed to AGARD Hq.
(AGARD-CP-212-Suppl) NATO Confidential report

An overview of the international state of the art in aircraft safety and survivability is given. Areas covered include: (1) accident statistics and analysis, (2) design practices for aircraft safety, (3) design for aircraft vulnerability and survivability, (4) operational experience and safety considerations, and (5) aircrew considerations. J.M.S.

04 AIRCRAFT COMMUNICATIONS AND NAVIGATION

Includes digital and voice communication with aircraft, air navigation systems (satellite and ground based); and air traffic control

For related information see also *17 Spacecraft Communications, Command, and Tracking* and *32 Communications*

N77-22068# Advisory Group for Aerospace Research and Development, Paris (France)
PROPAGATION LIMITATIONS OF NAVIGATION AND POSITIONING SYSTEMS
Feb. 1977 340 p refs In ENGLISH; partly in FRENCH Conf. Proc. of the Electromagnetic Wave Propagation Panel Specialists' Meeting, Istanbul, 20-22 Oct. 1976
(AGARD-CP-209; ISBN-92-835-0189-6) Avail: NTIS HC A15/MF A01

The limitations that the propagation medium places on sea, air and ground navigation systems are discussed. For individual titles, see N77-22069 through N77-22094.

N77-22069# Aerospace Corp., El Segundo, Calif.
IONSPHERIC EFFECTS IN NAVSTAR GPS
Bradford W. Parkinson (SAMSO, El Segundo, Calif.), Edward M. Lassiter, and C. K. Cretcher *In* AGARD Propagation Limitations of Navigation and Positioning Systems Feb. 1977 12 p refs (For primary document see N77-22068 13-04)
Avail: NTIS HC A15/MF A01

The impact of ionospheric effects upon user system performance in the positioning process is reviewed. System performance of ionospheric delay corrections in terms of ionospheric modeling and in terms of dual frequency receiver calibration are discussed. The effects of signal degradation by phase and amplitude scintillation are reviewed. Author

N77-22070# Army Electronics Command, Fort Monmouth, N.J. Communications/Automatic Data Processing Lab
PLASMASPHERIC SIGNAL TIME-DELAY EFFECTS IN SATELLITE NAVIGATION SYSTEMS
H. Soicher *In* AGARD Propagation Limitations of Navigation and Positioning Systems Feb. 1977 9 p refs (For primary document see N77-22068 13-04)
Avail: NTIS HC A15/MF A01

Since delay time modeling efforts to date have been based on total electron count obtained by the Faraday rotation technique, the plasmaspheric delay is not compensated for and thus comprises a source of error. In an effort to determine the magnitude of this error, observations of plasmaspheric content were performed at a midlatitude station, an auroral station and a station in the vicinity of the geomagnetic equatorial anomaly. Diurnal, day-to-day, and latitudinal variations of the contents were observed. The ratio of the plasmaspheric-to-ionospheric contents varied substantially from day to night. Author

N77-22071# Air Force Geophysics Lab., Hanscom AFB, Mass.
IONOSPHERIC TIME DELAY CORRECTIONS FOR ADVANCED SATELLITE RANGING SYSTEMS
J. A. Klobuchar *In* AGARD Propagation Limitations of Navigation and Positioning Systems Feb. 1977 13 p refs (For primary document see N77-22068 13-04)
Avail: NTIS HC A15/MF A01

Some general comments are made concerning ionospheric time delay models, and a specific algorithm designed for the single frequency user of the NAVSTAR-Global Positioning System (GPS) is described in detail. Author

N77-22072# General Electric Co., Syracuse, N.Y.
TRANSIT SATELLITE OBSERVATIONS OF IONOSPHERIC IRREGULARITIES
George H. Millman and Roy E. Anderson (GE Co., Schenectady, N.Y.) *In* AGARD Propagation Limitations of Navigation and Positioning Systems Feb. 1977 13 p refs (For primary document see N77-22068 13-04)
Avail: NTIS HC A15/MF A01

The characteristics of the phase fluctuations imposed by ionospheric irregularities on the 150- and 400-MHz coherent frequencies emanating from the polar orbiting U.S. Navy Navigation Satellites (TRANSIT) are evaluated in terms of the phase coherence of ionospheric propagation. In addition to the differential phase measurements, the two signal amplitudes were also recorded throughout the orbital passes. From the second derivative with respect to time of the differential phase fluctuations, an estimate is made of the nonlinear phase shift introduced by the ionosphere. For an assumed altitude of the irregularities, estimates are made of the overall spatial extent of the inhomogeneities producing the phase and amplitude fluctuations. By correlating radio optical observatory data with the differential phase and 150-MHz amplitude measurements recorded simultaneously, the two-dimensional spatial configurations of the irregularities responsible for the perturbations are deduced. From the differential phase data, the characteristics of the equatorward edge of the midlatitude trough are evaluated. A correlation is made of the equatorward edge of the trough with the equatorward edge of the phase and amplitude scintillation regions. Author

N77-22073# Naval Research Lab., Washington, D. C. Space Systems Div.
PROPAGATION EFFECTS OBSERVED IN CONNECTION WITH NTS-1 OBSERVATIONS NEAR THE MAGNETIC EQUATOR
Rudolph R. Zirm and John M. Goodman *In* AGARD Propagation Limitations of Navigation and Positioning Systems Feb. 1977 19 p refs (For primary document see N77-22068 13-04)
Avail: NTIS HC A15/MF A01

Amplitude and differential propagation delay scintillation of the 335 and 1,580 MHz transmissions from NTS-1 satellite were measured. The results obtained through analysis of amplitude and differential propagation delay data at 335 and 1,580 MHz are discussed. Several conclusions have been reached on the basis of analysis: (1) Severe scintillation activity was observed at 335 MHz for approximately four days out of a two week interval and varied from a few db to over 30 db; (2) no apparent scintillation was observed at 1,580 MHz; and (3) the differential delay scintillation was not observed to exceed two nanoseconds peak-to-peak. The smoothed differential delay information suggests the existence of an anomaly in the total electron content as the satellite passed over the magnetic equator. This feature is not inconsistent with currently accepted models of electron redistribution near the equator. Author

N77-22074# Air Force Geophysics Lab., Hanscom AFB, Mass.
IONOSPHERIC RANGE ERROR CORRECTION IN PRECISION RADAR SYSTEMS BY ADAPTIVE PROBING OF THE PROPAGATION MEDIUM
R. S. Allen, D. D. DuLong (Regis College, Weston, Mass.), M. D. Grossi (Raytheon Co., Sudbury, Mass.) and A. H. Katz (Raytheon Co., Sudbury, Mass.) *In* AGARD Propagation Limitations of Navigation and Positioning Systems Feb. 1977 16 p refs (For primary document see N77-22068 13-04)
(Contract F19628-76-C-0094)
Avail: NTIS HC A15/MF A01

A real time adaptive scheme for ionospheric range error correction in precision UHF radars is based on the use of a model of the monthly median ionosphere constructed from existing worldwide climatology and on updating and correcting this model with real-time dual frequency measurements of the columnar electron content. The space-time cell in which the dual frequency correction maintains its validity is so large that a single dual frequency sample taken along a direction that cuts across the volume monitored by the radar as rarely as once every half hour still suffices. This requires that the adopted ionospheric model, while the solar cycle progresses, correspondingly becomes more and more sophisticated in such features as its reproduction of horizontal gradients. Author

N77-22075# Queensland Univ., St. Lucia (Australia). Dept. of Physics
THE EFFECT OF RADIO LENSES IN THE IONOSPHERE ON THE SCINTILLATION OF SATELLITE-TO-GROUND RADIO SIGNALS
Kenneth Davies and J. D. Whithead *In* AGARD Propagation Limitations of Navigation and Positioning Systems Feb. 1977 10 p refs Prepared in cooperation with NOAA, Boulder, Colo. (For primary document see N77-22068 13-04)
Avail: NTIS HC A15/MF A01

The radio beacon on board the geostationary satellite ATS6 emits phase coherent signals on frequencies near 40, 140, and 360 MHz. A particularly interesting phenomenon was observed characterized by the following features. (1) An almost total fade out of the amplitudes of the 40, 140 and 360 MHz signals, (2) asymmetric Fresnel-type fading of the signals on both sides of the deep fades, with periods of the order of 1 sec; and (3) a distinctive modulation of the diffraction (fading) pattern. The peculiar diffraction patterns have been simulated by the use of cylindrical lenses in the ionosphere which give Gaussian distributions of phase advance. The asymmetric fading pattern may be caused by one of two effects. An asymmetric cross section, or a cylinder expanding in time. Author

N77-22076# Max-Planck-Institut fuer Aeronomie, Lindau Uber Northeim (West Germany)

LOW ANGLE EFFECTS ON VHF AND UHF PROPAGATION DUE TO IONOSPHERE AND TROPOSPHERE (A REVIEW)

G. K. Hartmann. *In* AGARD Propagation Limitations of Navigation and Positioning Systems. Feb. 1977. 7 p. refs. (For primary document see N77-22068 13-04)

Avail: NTIS. HC A15/MF A01

A literature survey is reported for low angle effects on VHF and UHF propagation due to ionosphere and troposphere. Main emphasis is given to effects which occur for satellite elevation angles of less than 30 deg. The most important effect is due to scintillation. The effects due to antenna beamwidth and due to small changes of the medium within that 3 db cone are also discussed. Author

N77-22077# Royal Aircraft Establishment, Farnborough (England).

A REVIEW OF LF/VLF RADIO NAVIGATION SYSTEMS AND SOME RELATED PROPAGATION INFLUENCES

B. Burgess. *In* AGARD Propagation Limitations of Navigation and Positioning Systems. Feb. 1977. 5 p. refs. (For primary document see N77-22068 13-04)

Avail: NTIS. HC A15/MF A01

Radio navigational aids are reviewed that have been developed in the LF/VLF bands since the 1940s. Attention is paid to the operational requirement that is met by this type of aid and the effects that the propagation characteristics of the radio waves at these frequencies have on the performance of the aids. Author

N77-22078# Nebraska Univ., Lincoln. Dept. of Electrical Engineering.

EFFECTS OF IRREGULAR MEDIA ON NAVIGATION AND POSITIONING SYSTEMS: FULL WAVE SOLUTIONS

E. Bahar. *In* AGARD Propagation Limitations of Navigation and Positioning Systems. Feb. 1977. 15 p. refs. (For primary document see N77-22068 13-04)

(Grant DAHC04-74-G-0074)

Avail: NTIS. HC A15/MF A01

Radio wave propagation over several irregular propagation paths is examined in detail. The phase anomalies, the delays and the distortions for pulsed radio signals transmitted across hills or valleys on the earth's surface are determined using a full wave approach. Author

N77-22079# Colorado Research and Prediction Lab., Boulder.

DISCUSSION OF REAL AND APPARENT LORAN-C PROPAGATION LIMITATIONS

R. H. Doherty. *In* AGARD Propagation Limitations of Navigation and Positioning Systems. Feb. 1977. 5 p. refs. (For primary document see N77-22068 13-04)

Avail: NTIS. HC A15/MF A01

Loran-C propagation limitations derived from measured data are related to the prediction model against which the data are analyzed. After measuring and analyzing Loran-C data throughout the world over a period of 20 years, it has become possible to recognize these analysis problems. Some examples of real versus apparent propagation type errors are presented to show the problems associated with certain analysis techniques. Also, an example of an unfounded assumption is used to show how errors in basic assumptions can affect the evaluation of the entire system's capability. Author

N77-22080# Colorado Research and Prediction Lab., Boulder.

PREDICTION OF GROUND WAVE PROPAGATION TIME ANOMALIES IN THE LORAN-C SIGNAL TRANSMISSIONS OVER LAND

J. Ralph Johler. *In* AGARD Propagation Limitations of Navigation and Positioning Systems. Feb. 1977. 7 p. refs. (For primary document see N77-22068 13-04)

Avail: NTIS. HC A15/MF A01

The ultimate accuracy to which Loran-C can be predicted is dependent firstly upon the Loran chain grid including the measuring equipment and secondly upon the predictability. Prediction of the signal propagation time to full accuracy over land or over seawater involving land masses in the propagation paths to each of the transmitters requires special considerations. This means that spatial perturbations of the signal propagation time limit the prediction accuracy of the Loran coordinates (time differences). This limitation arises from the physical nature of the ground and its effect on wave propagation--land is nonhomogeneous and irregular. It is argued that such anomalous propagation is a unique function of the geographic location of the propagation path and requires the introduction of terrain, soil and basement rock electrical properties and features along the propagation path. Such detail is readily introduced into the modern solution of the ground wave propagation problem using an integral equation and computer data handling capabilities. Author

N77-22081# Air Force Geophysics Lab., Hanscom AFB, Mass. Electromagnetic Sciences Div.

LORAN C/D COORDINATE PREDICTION DEPENDENCE ON GROUND ELECTRICAL PROPERTIES

S. Horowitz and J. R. Johler (Colo. Res. and Prediction Lab., Boulder). *In* AGARD Propagation Limitations of Navigation and Positioning Systems. Feb. 1977. 9 p. refs. (For primary document see N77-22068 13-04)

Avail: NTIS. HC A15/MF A01

The time of arrival of a Loran pulse depends on the electrical properties of the earth's surface over which these signals propagate. These electrical properties include the impedance or conductivity of the ground, the roughness or terrain variations of the surface, the refractive index of the atmosphere at the surface, and the lapse rate or rate of change of refractive index with altitude above the surface. Spatial variations of the transmitted Loran signal are primarily influenced by the nonhomogeneous surface impedance and by variations in the terrain. Loran ground wave time of arrival calculations have been made in the presence of irregular and nonhomogeneous ground. The irregularities are represented by elevation data as a function of range from the ground transmitters to the receiver. The ultimate limitation in the reduction of the propagation error as a function of quality of data for different types of land paths is illustrated. Author

N77-22082# Norwegian Defence Research Establishment, Kjeller.

IONOSPHERIC EFFECTS ON LORAN-C IN POLAR REGIONS

T. R. Larsen and E. V. Thrane. *In* AGARD Propagation Limitations of Navigation and Positioning Systems. Feb. 1977. 8 p. refs. (For primary document see N77-22068 13-04)

Avail: NTIS. HC A15/MF A01

Loran-C is a radio navigation system using pulsed signals at 100 kHz. Interference between ground wave and waves reflected from the ionosphere can reduce the accuracy of this system. The reflecting properties of the ionosphere are variable, and irregular disturbances affecting these properties are particularly frequent in polar regions. Amplitude and time delay of a 100 kHz radio wave that is reflected from different ionospheric models are computed. These models simulate day and night conditions and conditions during a severe ionospheric disturbance. The computations indicate at which distance from a Loran-C transmitter the skywave interferes with the ground wave. Author

N77-22083# Naval Electronics Lab. Center, San Diego, Calif.

PROPAGATION EFFECTS ON OMEGA

E. R. Swanson. *In* AGARD Propagation Limitations of Navigation and Positioning Systems. Feb. 1977. 20 p. refs. (For primary document see N77-22068 13-04)

Avail: NTIS. HC A15/MF A01

Special propagational effects including Sudden Phase Anomalies (SPA's) associated with Sudden Ionospheric Disturbances (SID's) and Polar Cap Absorptions (PCA's) are defined. Normal propagational conditions are emphasized, especially typical repeatability and typical diurnal behavior. Factors affecting the prediction of phase include characteristic velocity and phase variation with excitation of the waveguide mode, ground conductivity over a propagation path, variations with geomagnetic dip angle and path azimuth, effects of the aural zone and polar cap regions, and solar cycle variation of velocity. The zenith angle effect is shown to explain seasonal variations as well as most diurnal change. General propagational considerations are shown to represent the received OMEGA phase over 95% of

the time. A few percent of the time, however, phase is shown to be abnormally perturbed due to SPA's on sunlit paths or PCA's on arctic paths. Note is made of the importance of single mode propagation by the same dominant mode throughout the day. Author

N77-22084# Services Technique des Phares et Balises, Bonneuil-sur-Marne (France).
DIFFERENTIAL OMEGA: TESTS AND DEVELOPMENT IN FRANCE
D. Abadie and P. Laurent (SERCEL, Nantes, France). *In* AGARD Propagation Limitations of Navigation and Positioning Systems Feb. 1977 13 p. refs (For primary document see N77-22068 13-04)
Avail: NTIS HC A15/MF A01

The operation of OMEGA radio navigation system worldwide coverage is locally improved as far as accuracy and reliability are concerned, by taking into account corrections by a fixed shore station called differential Omega station. The telemetering format used in France is described, and some experimental results obtained at the differential OMEGA stations on French coasts are given. Author

N77-22085# Leicester Univ. (England)
A COMPARISON OF THE CALCULATED AND MEASURED DAYTIME PROPAGATION CHARACTERISTICS OF THE OMEGA TRINIDAD TRANSMISSIONS
G. Foley, T. B. Jones, and B. Burgess (RAE, Farnbourough, Engl.) IN AGARD Propagation Limitations of Navigation and Positioning Systems Feb. 1977 8 p. refs (For primary document see N77-22068 13-04)
Avail: NTIS HC A15/MF A01

Phase and amplitude of the 10.2 and 13.6 kHz transmissions from Omega Trinidad were measured in an aircraft flying radially away from, and then towards, the transmitter. Data were obtained during daytime for propagation in three azimuthal directions E-W, W-E and S-N. The variations of the phase and amplitude of both frequencies has been calculated for the three azimuthal directions, using a number of D-region models. The calculated variations are compared with the measured changes of phase and amplitude in order to assess the accuracy of the analysis procedure. Very close agreement is obtained the measured and calculated values of both phase and amplitude when the ionospheric model employed is similar to that suggested by Deeks. Other D-region models yield calculated values which do not show the same degree of agreement with those measured. It is possible to calculate accurately the phase and amplitude of both the 10.2 and 13.6 kHz transmission at any distance from the low latitude Omega Trinidad transmitter for daytime conditions. Author

N77-22086# Norwegian Defence Research Establishment, Kjeller.
OMEGA ACCURACY IN POLAR REGIONS DURING IONOSPHERIC DISTURBANCES
T. R. Larsen. *In* AGARD Propagation Limitations of Navigation and Positioning Systems Feb. 1977 16 p. (For primary document see N77-22068 13-04)
Avail: NTIS HC A15/MF A01

Omega propagation variability studies at high latitudes show typically an r.m.s. variability of 4 to 9 centicycles at 10.2 kHz for hourly standard deviations grouped into 24-hour periods on a monthly basis. Highest variability was obtained during winter months. Phase difference observations during solar X-ray flares have been analyzed for the pair A-C received at Ny Alesund. The mean value of the phase offset (at 10.2 kHz) was 38 sec with a standard deviation of 11 sec. Offset in excess of 60 sec was recorded during initial hours of the event. Author

N77-22087# Transportation Systems Center, Cambridge, Mass.
SHORT RANGE NAVIGATION REQUIREMENTS FOR TRANSPORT SYSTEMS
Louis W. Roberts and George G. Haroules. *In* AGARD Propagation Limitations of Navigation and Positioning Systems Feb. 1977 31 p. refs (For primary document see N77-22068 13-04)
Avail: NTIS HC A15/MF A01

The overall errors affecting the accuracy of radio navigation systems are discussed in terms of their impact on the requirement. Several scenarios typical of transport problems with their inherent accuracy requirements are also presented to emphasize the propagation problems that need to be satisfied as a function of frequency. A recently discovered principle of interferometry is submitted as a solution to solve the transport requirements. Author

N77-22088# Service Hydrographique et Oceanographique de la Marine, Paris (France)
LONG AND SHORT RANGE NAVIGATION SYSTEM REQUIREMENTS FOR CIVILIAN AND MILITARY SHIPS
A. M. Roubertou. *In* AGARD Propagation Limitations of Navigation and Positioning Systems Feb. 1977 10 p. refs In FRENCH (For primary document see N77-22068 13-04)
Avail: NTIS HC A15/MF A01

A sophisticated system such as in the American project NAVSTAR could supply most basic navigation requirements if the short range factor were eliminated. An analysis of civilian and military needs shows that a unique system is not possible for short range navigation because of precision requirements and national preoccupations. Existing short range systems are classed and analyzed from the point of view of adaptation to recognized needs, and the various categories of users. Trans. by A.R.H.

N77-22089# SERCEL, Nantes (France)
SYLEDIS, A RADIOPOSITIONING SYSTEM
P. Laurent and G. Nard. *In* AGARD Propagation Limitations of Navigation and Positioning Systems Feb. 1977 10 p. refs (For primary document see N77-22068 13-04)
Avail: NTIS HC A15/MF A01

A pulse system has been developed, named SYLEDIS, which does not rely on radar techniques. The use of compression of long pulses by correlation methods, and of a carrier wave in the 420-450 MHz band, has resulted in a highly accurate system, insensitive to soil conductivity, exhibiting no ambiguity problem, capable of ranges of 2 or 3 times the line of sight and not limited by obstacles of reasonable size. Author

N77-22090# Leicester Univ. (England). Dept. of Physics
APPLICATIONS OF THE DOPPLER TECHNIQUE AS AN AID TO BEARING MEASUREMENT
T. B. Jones and C. T. Spracklen. *In* AGARD Propagation Limitations of Navigation and Positioning Systems Feb. 1977 10 p. refs (For primary document see N77-22068 13-04)
Avail: NTIS HC A15/MF A01

A Doppler system is described which provides an indication of the presence, or absence, of TID's even when a short-duration nonfrequency stable transmission is monitored. Thus, a good/bad bearing indication can be given and some assessment of the likely variances in the measured bearing predicted. When more than one propagation mode is present multiple frequency shifts are observed in the received signal. These are easily identified and the system is an efficient monitor of multimode conditions. The application of this Doppler technique has led to an improvement in the performance of a wide aperture direction finder, moreover, it is possible to estimate the expected variances from the Doppler observations. Author

N77-22091# Max-Planck-Institut fuer Aeronomie, Lindau Uber Northeim (West Germany)
POSITION FINDING OF FIXED HF-TRANSMITTERS BY MEANS OF TRAVELING IONOSPHERIC STRUCTURES
J. Roettger. *In* AGARD Propagation Limitations of Navigation and Positioning Systems Feb. 1977 12 p. refs (For primary document see N77-22068 13-04)
Avail: NTIS HC A15/MF A01

It is assumed that the parameters of a traveling ionospheric structure or disturbance, like velocity and azimuth of propagation, are deduced by a measurement of the Doppler shift using a known array of three transmitters and one common receiver. The cross-correlation of the signals of the known array with the unknown signal yields the position of the unknown transmitter by applying some geometrical calculations. The basic method to evaluate the signal variations by means of the cross-correlation and cross-spectrum technique is described. Calculations based on appropriate models of traveling ionospheric structures are carried out to prove the applicability of the introduced method. Some implications on the accuracy and reliability of the position determination are considered. Author

N77-22092# Standard Electrik Lorenz A.G., Stuttgart (West Germany)
A SIMPLE MULTIPATH ERROR REDUCTION METHOD FOR SINGLE SITE DF SYSTEMS
M. Boehm. *In* AGARD Propagation Limitations of Navigation and Positioning Systems Feb. 1977 12 p. refs (For primary document see N77-22068 13-04)
Avail: NTIS HC A15/MF A01

Multipath error reduction by aperture sampling uses at least three antenna elements. This method is derived from a simple

error model that is independent from frequency. At each of the three elements phase and amplitude of the electromagnetic field are sampled simultaneously by providing each antenna element with its own receiver. The phase/amplitude pairs are digitized and fed into a computer for processing. The basic method is applicable to linear as well as circular arrays. In order to evaluate the method an L-band test system was built, featuring a five lambda linear array. Author

N77-22093# National Committee for Space Research, Haifa (Israel).
SINGLE FREQUENCY USE OF THE NAVY NAVIGATIONAL SATELLITE SYSTEM
Abraham Shuval and Jonathan Mass. *In* AGARD Propagation Limitations of Navigation and Positioning Systems. Feb. 1977 10 p refs (For primary document see N77-22068 13-04)
Avail: NTIS HC A15/MF A01

In the Navy Navigational Satellite System (NNSS), simultaneous transmission and reception on two frequencies are normally used in order to overcome the navigation error caused by the ionosphere. The navigation error caused by the ionosphere while using one frequency only is investigated. Several ways to reduce the navigation errors, while receiving on one frequency only, are discussed. It is shown that one frequency only (400 MHz) could be used if a small increase in average time between navigation fixes and an accuracy of about 200 m are tolerable. Author

N77-22094# Decca Navigator Co. Ltd., Surrey (England). Dept. of Operational Research and Computer Systems.
A STUDY OF SUDDEN IONOSPHERIC DISTURBANCES AND THEIR EFFECT ON VLF POSITION FIXING ACCURACY
M. E. Perry. *In* AGARD Propagation Limitations of Navigation and Positioning Systems. Feb. 1977 12 p refs (For primary document see N77-22068 13-04)
Avail: NTIS HC A15/MF A01

With the concentration of air traffic over the North Atlantic organized track structure area it has become necessary to ensure that aircraft do not stray from the specified track by more than given amounts. The positional errors that may be encountered by an aircraft using the Omega system in this area during periods of high solar activity are determined. Omega phase records from many sources have been analyzed to give an approximate frequency and propagation path dependence. These dependencies have been used to convert the collected data to a normalized form to determine the approximate errors observed at any point in the North Atlantic Area. Author

N78-21071# Advisory Group for Aerospace Research and Development, Paris (France).
APPLICATIONS OF ADVANCES IN NAVIGATION TO GUIDANCE AND CONTROL
Feb. 1978 279 p refs. Partly in ENGLISH and FRENCH. Presented at the 24th Technical Meeting of the Guidance and Control Panel, Stuttgart, 10-13 May 1977
(AGARD-CP-220. ISBN-92-835-0211-6) Avail: NTIS HC A13/MF A01

Conference proceedings on the application of advances in navigation to guidance and control are reported. Topics discussed include: (1) improvements in inertial navigation systems and their applications; (2) improvements in radar and radio navigation aids and their applications; (3) specific functions and system concepts; (4) new major systems; and (5) system improvements and concepts. For individual titles, see N78-21072 through N78-21091.

N78-21072# Raytheon Co., Sudbury, Mass.
FUTURE APPLICATIONS OF LOW COST STRAPDOWN LASER INERTIAL NAVIGATION SYSTEMS
James B. Matthews and Davis R. Bates, Jr. (SSD Marketing). *In* AGARD Appl. of Advan. in Navigation to Guidance and Control. Feb. 1978 13 p refs (For availability see N78-21071 12-04)
Avail: NTIS HC A13/MF A01

Fundamental principles of the laser gyro are reviewed to identify characteristics of this new means of measuring direction. The review of the development progression from Sagnac's ring interferometer through multibeam ring resonator to regenerative ring resonator is concise in order to emphasize considerations important in the comparison of the various laser gyro mechanization approaches. The treatment is intended to be augmented by reference material carefully selected and recommended for deeper study. Laser gyros based on dithered approaches to lock in circumvention are compared to the Raytheon multi-oscillator laser gyro in terms of performance requirements for precision pointing and high bandwidth versus navigation applications. A description of the Raytheon multioscillator approach is presented together with performance and physical data on current instruments. Author

N78-21073# Singer Co., Little Falls, N. J. Kearfott Div.
NEW TECHNIQUES FOR LOW COST STRAPDOWN INERTIAL SYSTEMS
P. M. Brodie and C. R. Giardina. *In* AGARD Appl. of Advan. in Navigation to Guidance and Control. Feb. 1978 13 p refs (For availability see N78-21071 12-04)
Avail: NTIS HC A13/MF A01

A number of techniques which can be employed to make a redundant strapdown configuration feasible is addressed. The major topics discussed are: concept of self contained redundancy, and modular reliability comparisons. J.C.S.

N78-21074# Societe Nationale Industrielle Aerospatiale, Toulouse (France).
INERTIAL SMOOTHING AND EXTRAPOLATION OF ILS BEAMS: APPLICATION TO THE AIRBUS A 300 B
J. Irvoas, D. Buisson, P. Lloret (SAGEM, Paris), and X. Lagarde (SAGEM, Paris). *In* AGARD Appl. of Advan. in Navigation to Guidance and Control. Feb. 1978 49 p refs In ENGLISH and FRENCH (For availability see N78-21071 12-04)
Avail: NTIS HC A13/MF A01

The hybrid radio inertial guidance system described in this report performs the following functions: (1) smoothing of the aircraft's flight path during an ILS automatic approach; (2) a very marked reduction in the lateral movements of the aircraft around its center of gravity and in the deflection of the control surface due to LOC beam noise; (3) the continuance of guidance in the event of failure of the LOC receiver; (4) in the event of serious or sudden failures which interfere with guidance of the aircraft, the LISS system dispenses with the need for LOC signals and reduces any deviation movements of the aircraft. The system requires only a relatively low performance inertial unit, although one with a higher performance would improve the overall system. Author

N78-21075# Ferranti Ltd., Edinburgh (Scotland).
RECENT ADVANCES IN HIGH RESOLUTION INERTIAL NAVIGATION
K. R. Brown and R. A. R. Tait. *In* AGARD Appl. of Advan. in Navigation to Guidance and Control. Feb. 1978 10 p ref (For availability see N78-21071 12-04)
Avail: NTIS HC A13/MF A01

An inertial navigator can survey to great accuracy and resolution if its self-generated velocity errors are determined by stopping and comparing the indicated velocity with the zero velocity at standstill. Three examples of the uses of this technology are described to demonstrate the performance that is possible. The relationship between survey and accuracy is examined and an estimate of the inertial instrument performance is made. It is found that the instruments are capable of far higher resolution than previously considered and to realize the benefit requires higher resolution interface units and a flexible computing system. Author

N78-21076# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick (West Germany).
CALIBRATION OF AN INS BASED ON FLIGHT DATA
B. Stieler and W. Lechner. *In* AGARD Appl. of Advan. in Navigation to Guidance and Control. Feb. 1978 13 p refs (For availability see N78-21071 12-04)
Avail: NTIS HC A13/MF A01

The results presented in this paper are based on an off line evaluation of flight data using optimal smoothing algorithms. This is an effective way to be followed for flight testing an INS and getting an insight into the sensor and system errors under flight conditions. The user of an INS, especially in the military field, is in general more interested in the in flight alignment and calibration of an INS, than in the on line evaluation of the data on board the aircraft for which optimal filtering algorithms are at hand. This opens the way for the fast take off of an aircraft with a coarse aligned platform. Corresponding simulation results are discussed. Author

N78-21077# Rohde and Schwartz, Munich (West Germany).
UHF DF TRIANGULATION SYSTEM FOR CONTROL AND GUIDANCE OF MILITARY AIRCRAFT

Bernhard F Ernst *In* AGARD Appl of Advan in Navigation to Guidance and Control Feb 1978 7 p (For availability see N78-21071 12-04)
Avail NTIS HC A13/MF A01

A system for the guidance of aircraft from ground stations is discussed The system consists essentially of a network of direction finders and is intended to complement, rather than replace, conventional radars and other landing aids normally installed at airports As a guidance technique a network of direction finders offers the advantage of surface coverage or it permits a form of surface navigation The system has a further advantage of particular significance in emergency situations such as may follow an error in navigation or a loss of fuel nothing more than an operational radio set need be available on board the aircraft before use can be made of the DF guidance network This feature can also be useful in the guidance of military aircraft since, as practice has shown, maneuvers at low level can often take the aircraft outside the airspace covered by ground-based radars Author

N78-21078# Standard Electrik Lorenz A G , Stuttgart (West Germany)
PRECISE ENROUTE NAVIGATION BASED ON GROUND-DERIVED TECHNIQUES
G Blaschke and G Peuker *In* AGARD Appl of Advan in Navigation to Guidance and Control Feb 1978 13 p refs (For availability see N78-21071 12-04)
Avail NTIS HC A13/MF A01

A solution is offered by a ground-derived concept for azimuth measurement It is based on the standard L-band DME, using also the existing airborne DME set The DME interrogation pulses of the aircraft are received at the ground via a special antenna array by DF equipment that allows immediate determination of angle of incidence This angle is sent back to the aircraft by a third pulse synchronized with the according DME reply In the aircraft a search and track system extracts the 'angle reply', the time delay of which, relative to the DME reply, represents angle information The signal format is the key element of the system, allowing for simplicity of airborne equipment and flexibility of ground stations Basic error considerations show that errors due to airborne signal processing can be neglected and that the ground system can be adapted to a large extent to the special multipath environment This allows the deployment of ground stations tailored to a special site leading to very economic solutions also on the ground Implementation of airborne equipment is described followed by a more detailed presentation of ground station design (DME transponder, antenna array, receiver multiple, processing method, transmitter and data encoder, calibration and monitoring) Author

N78-21079# Standard Electrik Lorenz A G , Stuttgart (West Germany)
ONE-WAY RANGING WITH TACAN
M Boehm *In* AGARD Appl of Advan in Navigation to Guidance and Control Feb 1978 15 p refs (For availability see N78-21071 12-04)
Avail NTIS HC A13/MF A01

Principles of TACAN, one-way and pseudo one-way ranging, and their possible application to TACAN, ground and airborne are discussed and described Particular emphasis is put on synchronization techniques The paper concludes with an outlook on some new operational applications which would be made possible by one-way ranging with TACAN Author

N78-21080# Siemens A G , Munich (West Germany) Central Telecommunications Labs
AN ECM-RESISTANT COMMUNICATION AND RANGING SYSTEM FOR REMOTELY PILOTED VEHICLES
Hermann Sapp *In* AGARD Appl of Advan in Navigation to Guidance and Control Feb 1978 8 p refs (For availability see N78-21071 12-04)
Avail NTIS HC A13/MF A01

A jam resistant communication and ranging system designated SIECON (Siemens ECM Resistant Communication and Navigation) is described Accurate ECM resistant navigation and two way ECM resistant data transmission are significant requirements in remotely piloted vehicle systems Both problems can be solved simultaneously by the SIECON system which achieves its high ECM resistance with the aid of pseudo noise phase shift keying modulation The design fabrication, and testing of various prototypes are discussed The tests included flight tests with ECM resistant TV transmission equipment in order to demonstrate the negligible influence of multipath propagation on the communication system J C S

N78-21081# Deutsche Forschungs und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick (West Germany) Inst fuer Flugfuehrung
ACCURACY CONSIDERATIONS ON NEW MICROWAVE LANDING SYSTEMS (MLS) FROM AN OPERATIONAL POINT OF VIEW
Alfred Becker *In* AGARD Appl of Advan in Navigation to Guidance and Control Feb 1978 15 p refs (For availability see N78-21071 12-04)
Avail NTIS HC A13/MF A01

Some selected problems are dealt with related to the accuracy of the different systems from an operational point of view Some general remarks to the International Civil Aviation Organization (ICAO) Microwave Landing Systems (MLS) competition are presented, along with ICAO Accuracy Requirements on the new MLS Also presented are discussions on the performance of the system and flare guidance problems Some perspective considerations are given as an indication of possible future performance improvements Author

N78-21082# Lear Siegler, Inc , Grand Rapids, Mich Instrument Div
A MULTI-SENSOR IMPLEMENTATION FOR NAVIGATION, POSITION LOCATION, POSITION UPDATE, RECONNAISSANCE, AND WEAPON DELIVERY: AN/ARN-101(V)
F E Pickel *In* AGARD Appl of Advan in Navigation to Guidance and Control Feb 1978 9 p (For availability see N78-21071 12-04)
Avail NTIS HC A13/MF A01

The AN/ARN-101(V) is a digital system developed to replace and/or functionally improve the present avionics in the USAF F-4E and RF-4C aircraft It upgrades the operational capability of the total weapon system through a multi-sensor implementation for navigation, offset aim point and target location, weapon delivery, and reconnaissance The navigation, position locating, and position updating capabilities utilize a digital Inertial Measurement Unit (IMU), loran, fire control or mapping radar, Pave Tack, TISEO (Electro-Optical Target Identification System), and Lead Computing Optical Sight System (LCOSS) interfaces Performance features include long-range and tactical navigation, all-weather blind bombing, adverse weather landing approach, uncanned weapon delivery profiles, and automatic reconnaissance steering Author

N78-21083# Rockwell International Corp , Cedar Rapids, Iowa Collins Avionics Div
A 4D APPROACH CONTROL USING VOR/DME/ILS GUIDANCE
Juergen M H Bruckner and Thomas G Sharpe *In* AGARD Appl of Advan in Navigation to Guidance and Control Feb 1978 15 p (For availability see N78-21071 12-04)
Avail NTIS HC A13/MF A01

A study is presented to design, develop, and implement a 4D approach control system using conventional aircraft sensors and displays augmented with area navigation capability The goal was to arrive at a system capable of retrofit with most air transport aircraft Multifunction CRT (MAP) displays and inertial complementation were to be avoided The only equipment item required in the final design is a Mark 2 type RNAV system capability used specifically to automatically define the nominal multiple-ordered-leg 4D RNAV approach path The capability for close-in ILS captures (including those from above) was also included to allow for diverse aircraft separation and noise abatement requirements Author

N78-21084# Technische Hogeschool, Delft (Netherlands) Dept of Aerospace Engineering
THE CALCULATION OF RMS VALUES OF DEVIATIONS OF AIRCRAFT CONTROLLED TO FLY ALONG A DESIRED FLIGHT PATH
J C VanDerVaart, H L Jonkers, and F K Kappetijn *In* AGARD Appl of Advan in Navigation to Guidance and Control Feb 1978 22 p refs (For availability see N78-21071 12-04)
Avail NTIS HC A13/MF A01

A description is given for a method to calculate the covariance matrix, as a function of time, of a linear system perturbed by a number of random noise signals Using basic principles of modern system theory it allows the computation of variance or r m s values of aircraft variables in the case where system dynamics and statistical properties of the disturbing noise signals are a function of time Results are shown of a numerical example of the symmetric motions of a present day jet transport in a coupled

approach followed by an automatic landing, the random disturbing signals being Gaussian atmospheric turbulence and ILS electronic noise The problem of wind shear is briefly touched upon and an analytical approach to worst case wind time histories is presented Author

N78-21085# Space and Missile Systems Organization, El Segundo, Calif

APPLICATIONS OF THE NAVSTAR GLOBAL POSITIONING SYSTEM TO MILITARY GUIDANCE AND CONTROL

Bradford W Parkinson *In* AGARD Appl of Advan in Navigation to Guidance and Control Feb 1978 7 p (For availability see N78-21071 12-04)

Avail NTIS HC A13/MF A01

The NAVSTAR Global Positioning System (GPS) is a satellite-based navigation system that will provide extremely accurate timing and three-dimensional position and velocity information to properly equipped users anywhere on or near the earth The system will be available continuously, worldwide, regardless of weather conditions, and will find extensive utilization in improved weapons delivery accuracies, range instrumentation, etc Furthermore, it will provide an ultimate savings in the number and cost of navigation and position-fixing systems currently employed or projected NAVSTAR GPS is a Joint Service Program with the Air Force as the executive service The system concept evolved from Air Force and Navy programs which were initiated in the mid-1960's The program is now in Phase 1 of three phases. Phase 1 (concept validation) calls for the deployment of six satellites in 1977-1978 which will permit demonstration and evaluation tests The system will then be expanded in Phases 2 and 3 through deployment of additional satellites until the full-up operational 24 satellite configuration is achieved This paper presents several applications of GPS and its potential impact on military guidance and control Author

N78-21086# JTIDS Program Office, Hanscom AFB, Mass

THE JOINT TACTICAL INFORMATION DISTRIBUTION SYSTEM (JTIDS)

B. Brentnall *In* AGARD Appl of Advan in Navigation to Guidance and Control Feb 1978 12 p (For availability see N78-21071 12-04)

Avail NTIS HC A13/MF A01

JTIDS is a radio Communication Navigation Identification (CNI) system providing tactical elements for a broad range of services. Receiver-transmitter terminals are being developed for a range of applications including airborne, ground-based, and seaborne communications, command and control; CNI for tactical vehicles; data links for unmanned systems; and C(3) relay through unmanned stations and platforms. The system provides for jamming resistant digital data exchange, precision relative ranging between units, and positive identification and position correlation of users. Design of the system is based on a pseudo-noise modulated, frequency hopped signal characteristic which provides for jam-resistant, secure, data communication on a rigidly structured time division access basis The various relative navigation techniques are described, and the relation to other navigation devices is discussed Author

N78-21087# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick (West Germany) Inst fuer Flugfuehrung

IMPROVED AIRCRAFT TRACKING USING MANEUVER STATISTICS ENROUTE AND IN THE TERMINAL AREA

Ulrich Brokof *In* AGARD Appl of Advan in Navigation to Guidance and Control Feb 1978 9 p refs (For availability see N78-21071 12-04)

Avail NTIS HC A13/MF A01

By means of radar tracking it is possible to estimate continuously the dynamic state of an aircraft from discrete radar data This is necessary, for instance, when investigating collision risks In this paper autocorrelation functions have been computed from acceleration data The autocorrelation function could be approximated by a model which corresponds to a periodic random variable The model itself as well as the model parameters gives an indication of how to improve radar tracking algorithm (additional parameters) A simple and an extended model are practically tested in view of predicting properties The same example is used to show how it is possible to improve radar tracking by aiding lateral acceleration with the roll angle information of the aircraft via a data link between the control centre and the aircraft Author

N78-21088# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick (West Germany) Inst fuer Flugfuehrung

A HYBRID GUIDANCE SYSTEM FOR ALL-WEATHER APPROACH AND LANDING

Karlheinz Hurras *In* AGARD Appl of Advan in Navigation to Guidance and Control Feb 1978 9 p refs (For availability see N78-21071 12-04)

Avail NTIS HC A13/MF A01

The micro-wave landing system (DLS) has been tested in Braunschweig Apart from the DLS on-board equipment an inertial navigation system had been installed in a test aircraft for this purpose One of the aims of these tests was to find out, to what degree the accuracy of the landing system could be improved by integrating this inertial navigation system Both systems were combined by means of a Kalman filter In this study, the way in which the filter operates during an approach is described The errors of the DLS trial system set up at Braunschweig airport, could be reduced to about 20 percent by using the inertial navigation system Author

N78-21089# Messerschmitt-Boelkow-Blohm G m b H., Munich (West Germany)

DEVELOPMENT OF THE INTEGRATED ALL-WEATHER NAVIGATION SYSTEM FOR TORNADO (MRCA)

H F Schwegler *In* AGARD Appl of Advan in Navigation to Guidance and Control Feb 1978 8 p refs (For availability see N78-21071 12-04)

Avail NTIS HC A13/MF A01

A short rundown of the various development stages is given together with methods used and pitfalls encountered From the experience gained in this project it seems that for the design of similar Kalman type navigation filters the most important tool is a data bank derived from flight tests together with well tested flexible evaluation software which allows the investigation of filter variants in a very short time on a ground based general purpose computer Author

N78-21090# Ferranti Ltd., Edinburgh (Scotland)

NAVIGATION, GUIDANCE AND CONTROL FOR HIGH PERFORMANCE MILITARY AIRCRAFT

W H McKinlay *In* AGARD Appl of Advan in Navigation to Guidance and Control Feb 1978 12 p refs (For availability see N78-21071 12-04)

Avail NTIS HC A13/MF A01

The paper discusses some of the factors involved in applying advanced navigation to an aircraft operating at low altitude for reconnaissance or to locate and attack ground targets It considers the distinctions between navigation accuracy and the accuracy with which a pilot can follow a given flight profile There are references to target acquisition and the need to pre-plan the profile Recent Ferranti developments in the display of navigation information coupled with a level of automatic pre-planning are discussed Author

N78-21091# Systems Control, Inc., West Palm Beach, Fla

AREA NAVIGATION SYSTEMS AND PROCEDURES

Donald W Richardson and James S Tyler *In* AGARD Appl of Advan. in Navigation to Guidance and Control Feb 1978 9 p refs (For availability see N78-21071 12-04)

Avail NTIS HC A13/MF A01

An attempt to identify, in pragmatic user-related terms, the operational significance of the overall concept of area navigation (RNAV) is presented Its purpose is to explore, over a range of users and missions, the spectrum of functions and capabilities that this generic navigation technique offers Starting with a summary of the correlation between current navigation systems both civilian and military and the concept of area navigation, the main content of the paper deals with two major issues, the current status of RNAV research, and future applications of RNAV The current status is reviewed in the light of the results of extensive operational and cost benefit studies Two illustrative examples of RNAV operational applications are discussed, namely the use of RNAV to facilitate complex noise abatement profiles, and the application of RNAV techniques to improve the efficiency of airborne search and rescue operations Author

N78-26124# Advisory Group for Aerospace Research and Development, Paris (France)

STRAP-DOWN INERTIAL SYSTEMS

May 1978 276 p refs Partly in ENGLISH and FRENCH Lecture ser held at London 6-7 Jun 1978 Copenhagen 9 Jun

1978, Bokesjo, Norway, 12-13 Jun 1978, Cologne, 15-16 Jun 1978, Rome, 19-20 1978
Avail: NTIS HC A13/MF A01

A detailed tutorial to strapdown inertial sensors, algorithms and systems is presented. Actual system applications using all of the different types of inertial sensors was emphasized. For individual titles, see N78-26125 through N78-26132

N78-26125# Draper (Charles Stark) Lab., Inc., Cambridge, Mass. Advanced Systems Dept.
STRAPDOWN INERTIAL SYSTEMS: THEORY AND APPLICATIONS. INTRODUCTION AND OVERVIEW
George T. Schmidt *In* AGARD Strap-Down Inertial Systems May 1978 10 p refs (For availability see N78-26124 17-04)
Avail: NTIS HC A13/MF A01

Comparisons between conventional gimbal inertial systems and strapdown inertial systems are presented in terms of implementation requirements and performance differences. A generalized approach to inertial system analysis that can determine the performance of different inertial mechanizations is described. Author

N78-26126# Honeywell, Inc., Minneapolis, Minn. Avionics Div.
STRAPDOWN SENSORS
Payl G. Savage *In* AGARD Strap-Down Inertial Systems May 1978 46 p refs (For availability see N78-26124 17-04)
Avail: NTIS HC A03/MF A01

Gyros and accelerometers available for strapdown digital system application are described and compared. Instruments described are the following: (1) single degree of freedom floated rate integrating gyro; (2) tuned rotor gyro; (3) electrostatic gyro, (4) laser gyro; and (5) pendulous accelerometer. For each sensor the theory of operation and mechanization approach was studied and an analytical error model was developed. Performance characteristics were analyzed. Advantages and limitations were examined and application areas were identified. Torque loop electronic design approaches that were utilized with the torque rebalance strapdown sensors were reviewed. B.B.

N78-26127# Lear Siegler, Inc., Grand Rapids, Mich. Instrument Div.
STRAPDOWN SYSTEM ALGORITHMS
Alan VanBronkhorst *In* AGARD Strap-Down Inertial Systems May 1978 22 p refs (For availability see N78-26124 17-04)
Avail: NTIS HC A13/MF A01

Strapdown system algorithms are the mathematical definition of processes which convert the measured outputs of inertial sensors that are fixed to a vehicle body axis into quantities which can be used to control the vehicle. The outputs of body-fixed inertial sensors are angular rates and linear velocities along orthogonal axes. The measured angular rates are converted into changes in attitude of the vehicle with respect to its initial orientation. The resulting attitude transformation matrix is used to convert the measured velocities from body axes to reference coordinates. The essential algorithms are described in terms of analytic equations and procedures for optimizing the critical algorithms. B.B.

N78-26128# Lear Siegler, Inc., Grand Rapids, Mich. Instrument Div.
STRAPDOWN SYSTEM SYNTHESIS
Alan VanBronkhorst *In* AGARD Strap-Down Inertial Systems May 1978 14 p refs (For availability see N78-26124 17-04)
Avail: NTIS HC A13/MF A01

Strapdown system synthesis is the process of developing a cost/performance optimized assembly for application in a particular weapon system. The procedure is a two way process of definition and demonstration. Definition begins with the weapon system requirements and generates the specifications in a top down process, of the system, subassemblies, and elements. Demonstration begins with the physical elements and their defined specifications and, in a step by step bottom-up integration process, completes the synthesis of the system. The major factors and tasks which characterize the process of strapdown system synthesis are discussed. B.B.

N78-26129# Marconi-Elliott Avionic Systems Ltd., Rochester (England).
APPLICATION OF STRAPDOWN INERTIAL SYSTEMS WITH PARTICULAR REFERENCE TO UNDERWATER VEHICLES
J. R. Catford *In* AGARD Strap-Down Inertial Systems May 1978 17 p (For availability see N78-26124 17-04)
Avail: NTIS HC A13/MF A01

An application of strapdown inertial techniques is presented. The theory of the strapdown attitude sensing mechanization was explained and the experience gained from various trails was illustrated. Digital mechanization of the attitude sensing function is described. A brief examination is made of the way in which the techniques developed for the underwater weapon environment can be extended for other relatively low accuracy strapdown inertial mechanizations. B.B.

N78-26130# Sperry Rand Corp., Great Neck, N. Y. Gyroscope Div.
LASER-GYRO STRAPDOWN INERTIAL SYSTEM APPLICATIONS
Emanuel Levinson *In* AGARD Strap-Down Inertial Systems May 1978 48 p refs (For availability see N78-26124 17-04)
Avail: NTIS HC A13/MF A01

The following laser gyro strapdown inertial systems are described: (1) tactical air to surface missile midcourse guidance, (2) shipboard fire control, attitude reference; and (3) aircraft inertial navigation. Mission requirements system configuration, alignment techniques, and existing hardware and software are delineated for each application. Error analysis simulation and test data are presented which demonstrate the capacity of the laser gyro system to meet the specific application requirements. B.B.

N78-26131# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (West Germany). Aircraft Div.
APPLICATION OF STRAPDOWN INERTIAL NAVIGATION TO HIGH PERFORMANCE FIGHTER AIRCRAFT
Wolfgang J. Kubbat *In* AGARD Strap-Down Inertial Systems May 1978 16 p refs (For availability see N78-26124 17-04)
Avail: NTIS HC A13/MF A01

A experimental strapdown inertial navigation system which is part of an integrated guidance and control system was examined. Based upon technical requirements and a general comparison between a gimballed solution vs a strapdown solution, a description of the major elements of the redundant inertial information and computation system was given. The redundant inertial information and computation system was given. The redundancy management problem was addressed as well as software timing and memory occupation. Various aspects of advanced configurations such as sensor skewing and data bus application were also included. B.B.

N78-26132# Societe de Fabrication d'Instruments de Mesure SFIM, Massy (France).
SIL 3 STRAP-DOWN INERTIAL GUIDANCE SYSTEM FOR TACTICAL MISSILES
G. Cattan and J. Michelin *In* AGARD Strap-Down Inertial Systems May 1978 53 p In ENGLISH and FRENCH (For availability see N78-26124 17-04)
Avail: NTIS HC A13/MF A01

A detailed tutorial to strapdown inertial sensors, algorithms and systems is presented. Actual system applications using all of the different types of inertial sensors was emphasized. B.B.

N78-27109# Advisory Group for Aerospace Research and Development, Paris (France)
TECHNICAL EVALUATION REPORT ON THE 24TH GUIDANCE AND CONTROL PANEL TECHNICAL MEETING: SYMPOSIUM ON APPLICATIONS OF ADVANCES IN NAVIGATION TO GUIDANCE AND CONTROL
Jun 1978 11 p ref. Symp. held at Stuttgart, 10-13 May 1977
(AGARD-AR-115) Avail: NTIS HC A02/MF A01

A symposium was held to study advances in navigational techniques with relation to guidance and control. Specific topics of discussion were some of the following: (1) improvements in inertial navigation systems and their applications, (2) improvements in radar and radio navigation aids, and (3) major systems specific functions and concepts. B.B.

N79-23946# Advisory Group for Aerospace Research and Development, Paris (France)
TECHNICAL EVALUATION REPORT ON THE 27TH GUIDANCE AND CONTROL PANEL SYMPOSIUM ON THE V/STOL AIRCRAFT AT NIGHT AND IN POOR VISIBILITY
G. C. Howell (RAE, Bedford, Engl.) May 1979 13 p
(AGARD-AR-142 ISBN 92-835-1319-3) Avail: NTIS HC A02/MF A01

The desire of operators of all three services of the NATO nations to extend the use of helicopters and V/STOL aircraft

into night and conditions of poor visibility has caused an expansion of activity in various technological fields, but most particularly in the electro-optical and radar sensors of various kinds The integration of these new sensors into modern navigation, flight control and display systems is an important aspect - particularly in helicopters where space and weight are at a premium Also, the pilot workload is already high in helicopters and V/STOL aircraft near the ground and any new technology must be introduced in a manner to keep the workload within bounds so as not to lose the benefits of the new sensors Author

N80-10154# Advisory Group for Aerospace Research and Development, Paris (France)
PRINCIPLES AND OPERATIONAL ASPECTS OF PRECISION POSITION DETERMINATION SYSTEMS
Cornelius T Leondes, ed (Calif Univ., Los Angeles.) Jul 1979 472 p refs
(AGARD-AG-245, ISBN 92-835-1330-4) Avail NTIS HC A20/MF A01

Reports are presented concerning the current status of radio navigation, the Global Positioning System, and the Joint Tactical Information Distribution System For individual titles, see N80-10155 through N80-10191

N80-10155# Systems Control, Inc., Palo Alto, Calif
RADIO NAVIGATION SYSTEMS: CURRENT STATUS
James S Tyler and Fred G Karkalik *In* AGARD Principles and Operational Aspects of Precision Position Determination Systems Jul 1979 35 p refs (For primary document see N80-10154 01-04)
Avail NTIS HC A20/MF A01

The life-cycle costs, user requirements, and current system capabilities of radio navigation systems are addressed The life-cycle costs of several system scenarios are first presented for a limited segment of civil air users in order to illustrate the large magnitude of the costs involved Current user requirements are summarized for air and marine civil users Finally, the technical characteristics and operational status of several current systems are presented, namely, Loran-A, Loran-C, Omega, Decca, *VOR/DME, and TACAN* F O S

N80-10156# Magnavox Government and Industrial Electronics Co., Torrance, Calif Advanced Products Div
TRANSIT: THE CURRENT SATELLITE NAVIGATION SYSTEM
Thomas A Stansell, Jr *In* AGARD Principles and Operational Aspects of Precision Position Determination Systems Jul 1979 41 p refs (For primary document see N80-10154 01-04)
Avail NTIS HC A20/MF A01

An in-depth review is provided of Transit, the Navy Navigation Satellite System, from the user's point of view After a brief system description, a spectrum of diverse applications is described, ranging from the navigation of fishing boats to guiding submarines Next, the Transit system status and its vitality are discussed It becomes clear that the system is exceptionally reliable and trustworthy, that the use of and the investment in Transit equipment is growing at a remarkable rate, and that the basic system is about to be improved by the addition of a new generation of NOVA satellites A technical description is presented of the position fix process and of the factors which influence accuracy The satellite signal structure, the meaning of the navigation message, and the interpretation of the Doppler measurements are covered in detail, followed by an overview of the fix calculation process Finally, a thorough review of the system accuracy potential and of the factors which determine accuracy performance is given F O S

N80-10157# Naval Research Lab., Washington, D C Space Applications Branch
THE TIMATION NAVIGATION SATELLITES
Roger L Easton *In* AGARD Principles and Operational Aspects of Precision Position Determination Systems Jul 1979 3 p (For primary document see N80-10154 01-04)
Avail NTIS HC A20/MF A01

The development of stable RF oscillators in the two post World War II decades was essential to the design of passive ranging navigation systems Early involvement of the U S Naval Research Laboratory in this method of time synchronized navigation is outlined The first NRL satellite used to validate the concept was launched in 1967 Both, it and the second satellite used quartz crystal oscillators The two following satellites use rubidium and cesium standards, respectively The lessons learned from the early satellites are summarized, and the merger of TIMATION into the NAVSTAR Global Positioning System Program is described Selected experimental results from NTS-1 and 2 are analyzed and the plans for NTS 3 are outlined Author

N80-10158# Rockwell International Corp., Downey, Calif Space Div
PRINCIPLE OF OPERATION OF NAVSTAR AND SYSTEM CHARACTERISTICS
Robert J Milliken and Curt J Zoller *In* AGARD Principles and Operational Aspects of Precision Position Determination Systems Jul 1979 12 p ref (For primary document see N80-10154 01-04)
Avail NTIS HC A20/MF A01

The NAVSTAR/Global Positioning System (GPS) will provide extremely accurate three-dimensional position and velocity information to users anywhere in the world The position determinations are based on the measurement of the transit time of RF signals from four satellites of a total constellation of 24 Accuracies on the order of 10 meters may be anticipated The basic technique by which the system operates, the navigation signal, the measurement of the transit time error sources, accuracies, and other characteristics of the system are discussed F O S

N80-10159# Stanford Telecommunications, Inc., Sunnyvale, Calif
GLOBAL POSITIONING SYSTEM: SIGNAL STRUCTURE AND PERFORMANCE CHARACTERISTICS
James J Spilker, Jr *In* AGARD Principles and Operational Aspects of Precision Position Determination Systems Jul 1979 35 p refs (For primary document see N80-10154 01-04)
Avail NTIS HC A20/MF A01

Details of the Global Positioning System (GPS) signal structure are discussed in relation to the signal generation and the performance of the navigation system The GPS performance objectives, orbit geometry, and propagation effects are summarized in order to gain better understanding of the signal and what characteristics it must provide With these performance objectives as a preface, the details of the signal are described, showing the details of the dual frequency transmission and both the precise (P) and clear/acquisition (C/A) codes and their characteristics Finally, the basic performance of simplified receivers operating on this received signal is discussed in order to show compatibility with the original performance objectives and typical receiver operation It is shown that an rms position error of less than 10 meters is well within the achievable performance bounds of the system J M S

N80-10160# ADVAND Systems Engineering, San Diego, Calif
THE GPS NAVIGATION MESSAGE
A J VanDierendonck, S S Russell (Gen. Dyn./Electron., San Diego, Calif.), and E R Kopitske (Magnavox Res Labs., Torrance, Calif.) *In* AGARD Principles and Operational Aspects of Precision Position Determination Systems Jul 1979 21 p refs (For primary document see N80-10154 01-04)
Avail NTIS HC A20/MF A01

The Global Positioning System (GPS) navigation message design process included numerous trade studies which weighed various representations and algorithms against variables such as message size, accuracy, update frequency, user computational requirements, and legacy for the operational GPS Other factors such as graceful degradation and future user requirements were also considered Finally, upon selecting the appropriate design structure, the design was fine tuned to its final form and user algorithm implementation trade-offs were performed The representational algorithms and user algorithms were jointly tested using a simulated space vehicle ephemeris trajectory and space vehicle clock The results of these tests demonstrate that the user models represent the simulated ephemeris and clock to within 0 01 meters with precise parameters, and to within 0 1 meters with truncated parameters J M S

N80-10161# Naval Research Lab., Washington, D C Space Systems Div
CLOCKS: EVOLUTION OF FREQUENCY STANDARDS
C A Bartholomev *In* AGARD Principles and Operational Aspects of Precision Position Determination Systems Jul 1979 11 p refs (For primary document see N80-10154 01-04)
Avail NTIS HC A20/MF A01

The development of clock technology to meet the changing requirements of satellite navigation systems is discussed The sequence of flight experiments from Timation 1 launched in 1967 to the multihundred watt Navigation Technology Satellites 1, 2 and 3 of the Global Positioning System is traced J M S

N80-10162# ADVAND Systems Engineering, San Diego, Calif.
GPS TIME
A. J. VanDierendonck. *In* AGARD Principles and Operational Aspects of Precision Position Determination Systems, Jul. 1979, 10 p, refs (For primary document see N80-10154 01-04)
Avail: NTIS HC A20/MF A01

The control and distribution of Global Positioning System (GPS) time measurements is discussed. Compatibility with other timing and navigation systems, 'fast' user acquisition of GPS 'P' signals, and continuous user navigation accuracy are among the factors included. J.M.S.

N80-10163# General Dynamics/Electronics, San Diego, Calif.
MASTER CONTROL STATION
M. J. Hurley, J. L. Kramer, and D. D. Thornburg. *In* AGARD Principles and Operational Aspects of Precision Position Determination Systems, Jul. 1979, 8 p (For primary document see N80-10154 01-04)
Avail: NTIS HC A20/MF A01

Phase 1 of the GPS navigation satellite effort is described. The control segment generates the data required by the user to obtain a navigation solution, uploads this data into the satellite processor for transmission to the user, and collects the satellite ranging data required to determine the satellite ephemeris and clock performance parameters. The control segment software mechanization to perform these functions is a file-based, multi-tasked architecture. This architecture and its legacy to future phases of GPS are described. J.M.S.

N80-10164# General Dynamics/Electronics, San Diego, Calif.
GPS MASTER CONTROL STATION OPERATIONS
H. C. Johnson. *In* AGARD Principles and Operational Aspects of Precision Position Determination Systems, Jul. 1979, 3 p (For primary document see N80-10154 01-04)
Avail: NTIS HC A20/MF A01

The operation and function of the control segment of the Global Positioning System is discussed. Satellite tracking, range measurements, estimates of the satellite's ephemerides, and periodic uploads of current data and downlink-formatting instructions to the satellite's onboard computer are among the factors covered. Performance of the computer system is evaluated. J.M.S.

N80-10165# General Dynamics/Electronics, San Diego, Calif.
MONITOR STATIONS
R. L. Harrington, W. A. Fabrizio, and E. Salinas. *In* AGARD Principles and Operational Aspects of Precision Position Determination Systems, Jul. 1979, 9 p (For primary document see N80-10154 01-04)
Avail: NTIS HC A20/MF A01

Monitor stations (MS) which are fixed tracking stations in the GPS control segment are described. Monitor stations collect space vehicle (SV) tracking data, downlink navigation message data, and station health and status. The functional relationship of the monitor stations to other parts of the system is discussed. GPS concept validation monitor stations are located at Vandenburg Air Force Base, Hawaii, Guam, and Alaska. R.E.S.

N80-10166# General Dynamics/Electronics, Vandenburg AFB, Calif.
THE GPS UPLOAD STATION
W. H. Harbour and M. Rochette. *In* AGARD Principles and Operational Aspects of Precision Position Determination Systems, Jul. 1979, 5 p (For primary document see N80-10154 01-04)
Avail: NTIS HC A20/MF A01

The GPS Upload Station (ULS) which provides the master control station (MCS) space uplink for the transmission of the navigation data payload to the GPS navigation satellites, is described. The ULS receives upload data messages from the MCS as well as additional data necessary to point the ULS antenna properly at the space vehicle selected for upload. The ULS computer hardware and software are described. R.E.S.

N80-10167# Stanford Telecommunications, Inc., Sunnyvale, Calif.
A TIME TRANSFER UNIT FOR GPS
Jackson T. Witherspoon and Leonard Schuchman. *In* AGARD Principles and Operational Aspects of Precision Position Determination Systems, Jul. 1979, 6 p, refs (For primary document see N80-10154 01-04)
Avail: NTIS HC A20/MF A01

A time transfer unit for use with NAVSTAR satellites of the global positioning system (GPS) is described. This unit can provide worldwide time transfer with an accuracy of better than 100 nanoseconds relative to GPS system time. Techniques used for GPS signal processing and data reduction are summarized, and potential applications are discussed. R.E.S.

N80-10168# General Dynamics/Electronics, San Diego, Calif.
EPHEMERIS AND CLOCK DETERMINATION IN GPS
J. H. Schaibly and E. L. Lasley. *In* AGARD Principles and Operational Aspects of Precision Position Determination Systems, Jul. 1979, 7 p, refs (For primary document see N80-10154 01-04)
Avail: NTIS HC A20/MF A01

The data processing performed at the GPS 'master control station' is described. Estimation/prediction techniques are given for determining satellite ephemeris and clock behavior. The evaluation of the techniques is also described. R.E.S.

N80-10169# Texas Instruments, Inc., Dallas
TEXAS INSTRUMENTS PHASE 1 GPS USER EQUIPMENT
M. J. Borel, J. N. Damoulakis, D. R. Delzer, T. D. Fuchser, J. H. Hinderer, C. R. Johnson, and D. J. Pinkos. *In* AGARD Principles and Operational Aspects of Precision Position Determination Systems, Jul. 1979, 15 p, refs (For primary document see N80-10154 01-04)
Avail: NTIS HC A20/MF A01

The design and fabrication of the Global Positioning System user equipment sets is described. The system concept and design permits maximum commonality between various system designs through the use of different quantities of common modules to satisfy specific performance requirements. Also, because of the functional nature of the modules, improvements to accommodate performance requirements were incorporated with minimum impact. Global positioning system user equipment consists of three different system types: the high dynamic user equipment used in high performance aircraft; the missile-borne receiver set used in the Minuteman missile test program; and the manpack/vehicular user equipment used in manned vehicles such as trucks, tanks, and jeeps. A comparison of the major performance requirements of these systems is presented. Additional information regarding the three systems is presented following a discussion of the receiver, the processor, and the navigation filter. R.E.S.

N80-10170# Magnavox Government and Industrial Electronics Co., Torrance, Calif. Advanced Products Div.
GPS RECEIVER OPERATION
Burton G. Glazer. *In* AGARD Principles and Operational Aspects of Precision Position Determination Systems, Jul. 1979, 5 p (For primary document see N80-10154 01-04)
Avail: NTIS HC A20/MF A01

Different receiver configurations which are suitable for applications having differing levels of dynamics of the most vehicle and interference environments, are described. All configurations are capable of accomplishing certain fundamental operations: satellite selection, signal acquisition, tracking and measurement and data recovery. After correction for propagation effects, signal time-of-arrival measurements are used to obtain the navigation solution. The limits of the performance of the receivers are described. R.E.S.

N80-10171# Aerospace Corp., Los Angeles, Calif.
PHASE 2 GPS RECEIVER DESIGN PHILOSOPHY
Frank E. Butterfield and Robert E. Sung. *In* AGARD Principles and Operational Aspects of Precision Position Determination Systems, Jul. 1979, 9 p, ref (For primary document see N80-10154 01-04)
Avail: NTIS HC A20/MF A01

The development of the Global Positioning System (GPS) User System Segment is discussed as well as the development objectives, program plan and a brief review of development activities. A discussion of user requirements, host vehicle interfaces and integration, definition of user equipment set configurations and the elements of a Design to Cost (DTC)/Life Cycle Cost (LCC) program is presented. The GPS Phase 2 User Equipment (UE) DTC/LCC program objectives and tasks required to accomplish these objectives are described. The modular design concept, which embraces the use of a limited inventory of standard function replaceable hardware and computer program or software modules to implement specific operational building blocks, to be uniquely arranged for the synthesis of differing UE sets, is presented along with the flexible interface module concept and the form, fit and function approach to integration. M.M.M.

N80-10172# Lincoln Lab Mass Inst of Tech Lexington
PERFORMANCE ENHANCEMENT OF THE GPS RECEIVER BY DATA-FREE OPERATION
J R Sklar and L L Horowitz *In* AGARD Principles and Operational Aspects of Precision Position Determination Systems Jul 1979 6 p refs Sponsored by AF (For primary document see N80-10154 01-04)
Avail NTIS HC A20/MF A01

The operation of a receiver designed to receive the signal transmitted by a Global Positioning System (GPS) satellite in the dynamic environment experienced by a high-performance tactical aircraft is presented Because the GPS signal is modulated with system data the signal energy is spread over a 50 Hz band as a result there is a limit to the noise filtering that can be performed If this data were removed or (equivalently) stored in the receiver additional filtering could be employed and other changes made in the receiver to improve the noise (and/or jamming) immunity The quantitative effects of these changes are derived M M M

N80-10173# Draper (Charles Stark) Lab Inc Cambridge, Mass
INTEGRATION OF GPS WITH INERTIAL NAVIGATION SYSTEMS
Duncan B Cox, Jr *In* AGARD Principles and Operational Aspects of Precision Position Determination Systems 1979 10 p refs (For primary document see N80-10154 01-04)
Avail NTIS HC A20/MF A01

Benefits and means of integrating GPS and inertial systems are described Emphasis was placed on the data to be transferred and the operations to be performed in attaining varying degrees of integration An understanding of the mechanisms and degrees of complexities involved was given, as well as a perspective on the technical issues that are involved in the integration problem It was concluded that very substantial performance improvements can be obtained through integration of GPS and inertial systems in comparison to what can be achieved by either system alone Some of the improvements are only achieved through substantial increases in system complexity M M M

N80-10174# Teledyne Systems Co Northridge Calif
APPLICATION OF GPS TO LOW COST TACTICAL WEAPONS
A F Schmitt and J J Bowden *In* AGARD Principles and Operational Aspects of Precision Position Determinational Systems 1979 10 p refs (For primary document see N80-10154 01-04) (Contract F08635-76-C-0343)
Avail NTIS HC A20/MF A01

A navigation receiver employing the Global Positioning System (GPS) navigation satellites signals is described which capitalizes upon initialization at the launch point so as to achieve considerable simplification, and hence low unit cost An excellent application of such a 'mother-daughter' design is to the guidance of tactical weapons wherein the launch facility (ground launcher or aircraft) is presumed equipped with a full-capability GPS navigation set suitable for the initialization of the simplified receiver Once initialized with GPS data (satellite orbital parameters and clock corrections) and synchronized to track the received signals, this receiver is thereafter fully capable of autonomous navigation including signal reacquisition following any signal outage periods Mission time following launch must be limited to no more than an hour or so to minimize degradations in accuracy a constraint of little concern in most tactical applications M M M

N80-10175# Gilbert (Glen A) and Associates, Washington, D C
CIVIL APPLICATIONS OF NAVSTAR GPS
Glen A Gilbert, E H Martin (Magnavox Government and Industrial Electronics Co Silver Spring, Md), Denis Symes (Urban Mass Transportation Adminstration), and Carl Matthews (Maritime Administration) *In* AGARD Principles and Operational Aspects of Precision Position Determination Systems 1979 26 p refs (For primary document see N80-10154 01-04)
Avail NTIS HC A20/MF A01

Various aspects of potential civil applications of the U S Department of Defense satellite based NAVSTAR Global Positioning System (GPS) are discussed Land, sea and air applications are covered It was concluded that the GPS offers many promising potential civil applications However certain questions need to be resolved before international civil application of GPS can be implemented M M M

N80-10176# Rockwell International Corp Downey Calif Space Div
LAUNCH VEHICLES
William Nissim and Curt J Zoller *In* AGARD Principles and Operational Aspects of Precision Position Determination Systems 1979 15 p (For primary document see N80-10154 01-04)
Avail NTIS HC A20/MF A01

The launch vehicles and upper stages are described The physical and performance characteristics and the expected operational procedure based on data obtained from various Rockwell International publications (for shuttle) and from representatives of General Dynamics (for Atlas) and Fairchild (for the stage vehicle) are included Potential system improvements for the operational phase which are expected to result in satellite weight growth can be accommodated by launch and stage vehicle growth options M M M

N80-10177# California Univ Los Angeles School of Engineering and Applied Science
ALTERNATE CONSTELLATIONS FOR THE GLOBAL POSITIONING SYSTEM
Hosam E Emara Shabaik *In* AGARD Principles and Operational Aspects of Precision Position Determination Systems 1979 37 p refs (For primary document see N80-10154 01-04)
Avail NTIS HC A20/MF A01

Different satellite constellations were studied comparatively with the base line constellation considering both coverage and precision requirements Increasing the orbital period provided better satellite visibility and higher accuracy of navigation Higher orbital inclination angles moved the better covered areas to higher latitudes Increasing the number of orbital planes is thought to be more effective in gaining better performance than increasing the number of satellites per plane General directions and guidelines to be followed for designing constellations for the Global Positioning System are presented K L

N80-10178# California Univ Los Angeles School of Engineering and Applied Science
ON THE OPTIMAL SELECTION OF SATELLITES IN GPS
Katsumi Ohnishi *In* AGARD Principles and Operational Aspects of Precision Position Determination Systems 1979 5 p refs (For primary document see N80-10154 01-04)
Avail NTIS HC A20/MF A01

An analytical method is given for the optimal selection of four satellites for estimation of the user's position in global positioning systems (GPS) The problem is discussed completely within the framework of linear estimation theory which converts the optimal selection of satellites into the optimal orientation of four antennas An estimator equation is presented which is shown to give good estimation results The four satellites to be selected are obtained by directly minimizing the determinant of the covariance of the estimation error K L

N80-10179# Naval Air Development Center, Warminster Pa Sensors and Avionics Technology Directorate
THE EVOLUTION OF JTIDS
Ronald S Vaugh *In* AGARD Principles and Operational Aspects of Precision Position Determination Systems 1979 3 p (For primary document see N80-10154 01-04)
Avail NTIS HC A20/MF A01

The genesis of predecessor programs to the Joint Tactical Information Distribution System (JTIDS) is traced and the reasons for merging them into a joint services development program are given. In addition, the major technology evolution affecting the JTIDS engineering approach is discussed K L

N80-10180# JTIDS Program Office, Hanscom AFB Mass Engineering Div
JTIDS SYSTEM OVERVIEW
Roy L Eisenberg *In* AGARD Principles and Operational Aspects of Precision Position Determination Systems 1979 6 p (For primary document see N80-10154 01-04)
Avail NTIS HC A20/MF A01

The navigation, communications, and identification functions of JTIDS are described The JTIDS development program and implementation concepts are discussed and operational requirements are summarized K L

N80-10181# Naval Air Development Center, Warminster Pa Communications and Navigation Technology Directorate
NAVIGATION ARCHITECTURE
Lawrence Newman, ed *In* AGARD Principles and Operational Aspects of Precision Position Determination Systems 1979 17 p refs (For primary document see N80-10154 01-04)
Avail NTIS HC A20/MF A01

The JTIDS relative navigation capability is discussed. The relative navigation system establishes the tactical grid, resolves the grid lock problem, improves on board system accuracy, and shares community navigation resources. Potential applications of the advanced development model system and technological issues of JTIDS architecture are explored. K L

N80 10182# Naval Air Development Center, Warminster, Pa.
INTEGRATED TACTICAL NAVIGATION SYSTEMS (ITNS)
Edward Dinter and James D. Bivin. *In* AGARD, Principles and Operational Aspects of Precision Position Determination Systems, 1979, 7 p. (For primary document see N80-10154 01-04)
Avail: NTIS, HC A20/MF A01

An integrated tactical navigation systems (ITNS) which combines range measurements between vehicles with self contained dead reckoning to achieve accurate tactical navigation in spite of geographic navigation error is examined. The five demonstration tests performed and their associated results are discussed. The feasibility of the ITNS concept, the operational performance and tactical utility of the ITNS concept, and the benefits of the ITNS to the sea control ships and flight control operations are determined. A.W.H.

N80-10183# ITT Avionics, Nutley, N.J. CNI Systems Dept.
JTIDS: THE ISSUE OF FREQUENCY SELECTION
Jack Rubin and Sven H. Dodington. *In* AGARD, Principles and Operational Aspects of Precision Position Determination Systems, 1979, 5 p. (For primary document see N80-10154 01-04)
Avail: NTIS, HC A20/MF A01

The joint tactical information distribution system (JTIDS) which features spread spectrum, frequency hopping, high performance digital communications is discussed in relation to the electromagnetic spectrum (960 to 1215 MHz) proposed for its operation. The compatibility of the JTIDS with existing navigation services in this frequency band is examined. The interference effects of existing Tacan, DME, and IFF/ATCRBS signals on JTIDS operations is studied. A.W.H.

N80-10184# Naval Air Development Center, Warminster, Pa. Communication Navigation Technology Directorate.
JTIDS SIGNAL STRUCTURE
Gerald J. Palatucci. *In* AGARD, Principles and Operational Aspects of Precision Position Determination Systems, 1979, 3 p. (For primary document see N80-10154 01-04)
Avail: NTIS, HC A20/MF A01

The joint tactical information distribution systems (JTIDS) signal structure is described in terms of a hybrid frequency hopping, time hopping, and direct sequence pseudo noise spread spectrum system for communication, navigation, and identification applications. The primary design constraints, classified as either fundamental bounds or requirements bounds, on the system at the outset of the waveform design are described. The characteristics of the signal structure, such as channel coding, data modulation, and RF modulation are discussed. A.W.H.

N80-10185# Hughes Aircraft Co., Fullerton, Calif.
COMMAND AND CONTROL TERMINALS
Ara N. Boyajian. *In* AGARD, Principles and Operational Aspects of Precision Position Determination Systems, 1979, 4 p. (For primary document see N80-10154 01-04)
Avail: NTIS, HC A20/MF A01

The systems configuration of the command and control terminals in the joint tactical information distribution system (JTIDS) is discussed. The units that comprise the JTIDS system and the interrelationship between the units are described. The units include the digital computer, the radio set control, the signal data converter, the antenna coupler, and the high power amplifier. Technology improvements in the JTIDS system are discussed including areas of error detection and correction, surface acoustic wave devices, and L band power amplifiers. A.W.H.

N80-10186# Singer-Kearfott, Wayne, N.J.
AN/URQ-28 JTIDS CLASS 2 TACTICAL TERMINAL
R. Aughey and G. Solowey. *In* AGARD, Principles and Operational Aspects of Precision Position Determination Systems, 1979, 13 p. (For primary document see N80-10154 01-04)
Avail: NTIS, HC A20/MF A01

The performance characteristics of the JTIDS tactical aircraft terminal AN/URQ-28, a low detectability, cryptographically secure, antijam, integrated communication and relative navigation system are described. The time division multiple access processing function and the TACAN processing functions are examined. The navigation processing and capability of the AN/URQ-28 is discussed. The mechanical design and the application of each unit in the AN/URQ-28 is reported. A.W.H.

N80-10187# IBM Federal Systems Div., Owego, N.Y.
JTIDS EXPENDABLE LOW COST TERMINAL DEVELOPMENT
P. D. Danker, R. J. Giannini, and I. S. Glickstein. *In* AGARD, Principles and Operational Aspects of Precision Position Determination Systems, 1979, 13 p. (For primary document see N80-10154 01-04)
Avail: NTIS, HC A20/MF A01

Applications for low cost, expendable JTIDS compatible terminals are discussed. These include weapon and RPV guidance and control, remote sensors and beacons, and range instrumentation. Expendable terminals are examined as extensions for the other JTIDS class terminals where expendability and unmanned operations are required, and system communications control resides with the JTIDS Class 1, 2, or 3 terminal. A.W.H.

N80-10188# Naval Ocean Systems Center, San Diego, Calif.
INTEGRATION DEVELOPMENTS
Albert Wunsch. *In* AGARD, Principles and Operational Aspects of Precision Position Determination Systems, 1979, 9 p. refs (For primary document see N80-10154 01-04)
Avail: NTIS, HC A20/MF A01

The integration of JTIDS into a platform is described. The nature and scope of the interface required between JTIDS and the system(s) it must service on various platforms is defined. Aspects of system integration with the tactical data system are discussed. A.W.H.

N80-10189# ITT Avionics, Nutley, N.J. CNI Systems Dept.
DISTRIBUTED TDMA - AN APPROACH TO JTIDS PHASE 2
Jack Rubin. *In* AGARD, Principles and Operational Aspects of Precision Position Determination Systems, 1979, 14 p. refs (For primary document see N80-10154 01-04)
(Contract N62269-76-C-0105)
Avail: NTIS, HC A20/MF A01

The joint tactical information distribution system (JTIDS), a triservice, multichannel, multifunction system is reviewed. A time division multiple access (TDMA) channel (JTIDS 1) is introduced to handle total connectivity information distribution for digital communications and relative navigation. The development of a channel architecture by DTAMA to permit a single terminal to participate concurrently in multiple independent functions or network, which have the flexibility to be structured and organized in a manner to efficiently meet the broad spectrum of tactical information distribution operational requirements, is examined. A.W.H.

N80-10190# ITT Avionics, Nutley, N.J. CNI Systems Dept.
JTIDS II/DTDMA - COMMAND AND CONTROL TERMINALS
Jack Rubin and Joseph Heinen. *In* AGARD, Principles and Operational Aspects of Precision Position Determination Systems, 1979, 7 p. (For primary document see N80-10154 01-04)
Avail: NTIS, HC A20/MF A01

The development of a command and control terminal employing the JTIDS 2/DTDMA architecture is described. The functions of the power amplifier unit, the receiver/transmitter unit, the signal processor unit, and the terminal processor unit are examined. The grouping of the time scheduling, pseudo-random control, and transmission/reception control are presented. A.W.H.

N80-10191# ITT Avionics, Nutley, N.J. CNI Systems Dept.
JTIDS II/DTDMA TACTICAL TERMINAL
Joseph Heinen and Jack Rubin. *In* AGARD, Principles and Operational Aspects of Precision Position Determination Systems, 1979, 6 p. ref. (For primary document see N80-10154 01-04)
(Contract N62269-76-C-0105)
Avail: NTIS, HC A20/MF A01

The JTIDS 2 tactical terminal which provides antijam, digital data/voice communications, and relative navigation in the DTDMA and TDMA architectures, is examined. The functions and capabilities, the overall design, the integration and installation into airborne platforms, and the projected production configuration of the terminal are described. A.W.H.

N80-12082# Advisory Group for Aerospace Research and Development, Neuilly Sur-Seine (France).

THE IMPACT OF GLOBAL POSITIONING SYSTEM ON GUIDANCE AND CONTROLS SYSTEMS DESIGN OF MILITARY AIRCRAFT, VOLUME 1

G C Howell ed (Royal Aircraft Establishment) Sep 1979 43 p refs 2 Vol

(AGARD AR-147 Vol 1 ISBN 92-835-1339-8) Avail NTIS HC A03/MF A01

Contents (1) to study the application of GPS to interdiction, ground attack, interception and close combat aircraft, (2) to determine the extent which improved performance or new capabilities are made possible, (3) to study the integration of GPS into guidance and control systems, determine the impact on system design, and indicate where simplification and cost savings may be brought about, and (4) to make recommendations for further and more detailed study of the most promising applications M M M

X80-72056# Advisory Group for Aerospace Research and Development, Paris (France)

USE OF PRECISION POSITIONING SYSTEMS BY NATO, VOLUME 2 (U)

Jan 1977 82 p This document is not available from the NASA STI Facility All requests must be directed to AGARD Hq

(AGARD-AR-88-Vol-2) NATO Secret report

The potential applications within NATO of a precision positioning system, as exemplified by the US NAVSTAR Global Positioning System are considered Emphasis is placed on a qualitative and quantitative evaluation of the impact of increased position information accuracy on the tactical air attack capability of NATO in Europe in the 1980's and beyond J M S

X80-72057 # Advisory Group for Aerospace Research and Development, Paris (France)

USE OF PRECISION POSITIONING SYSTEMS BY NATO, VOLUME 3 (U)

Nov 1977 106 p This document is not available from the NASA STI Facility All requests must be directed to AGARD Hq

(AGARD-AR-88-Vol-3) NATO Secret report

The feasibility of a secure and very precise precision positioning system (PPS) is examined Emphasis is placed on the all weather attack capability on quasi-stationary targets Application of PPS to manned and unmanned aircraft, as well as stand-off missiles is considered The need for a unified command, control, and communications system is identified J M S

05 AIRCRAFT DESIGN, TESTING AND PERFORMANCE

Includes aircraft simulation technology

For related information see also *18 Spacecraft Design, Testing and Performance* and *39 Structural Mechanics*

N77-24107# Advisory Group for Aerospace Research and Development, Paris (France)

FLIGHT TEST TECHNIQUES

Apr 1977 415 p In ENGLISH, partly in FRENCH Conf Proc. of the Flight Mechanics Panel Symp., Porz Wahn, W Germany, 11-14 Oct. 1976

(AGARD-CP-223, ISBN-92-835-0194-2) Avail: NTIS HC A18/MF A01

Techniques used in flight clearance of the basic air vehicles including flight control systems, engines, engine-inlet systems, etc., and the externally carried weapons are described along with techniques used in weapon system development. Instrumentation systems and components, data transmission, data processing, airborne displays and computers, and real time flight test analysis and monitoring are among the topics discussed. For individual titles, see N77-24108 through N77-24132.

N77-24108# Air Force Flight Test Center, Edwards AFB, Calif.

FLIGHT CONTROL SYSTEM STRUCTURAL RESONANCE AND LIMIT CYCLE RESULTS

Paul W. Kirsten *In* AGARD Flight Test Tech. Apr 1977 17 p (For primary document see N77-24107 15-05)

Avail: NTIS HC A18/MF A01

Theory, testing, and results pertaining to limit cycle and structural resonance characteristics of aircraft flight control are presented. Methods for insuring that limit cycling and structural resonance do not occur unexpectedly during flight are suggested. Ground tests and inflight envelope expansion tests were used with success in the past to determine limit cycle and structural resonance characteristics. Data obtained from these tests are presented for several aircraft. Also, control system modifications made on several aircraft to eliminate control system instabilities which were uncovered through ground testing are included. Additional topics are discussed which include digital sampling effects on limit cycle characteristics, large amplitude saturation limit cycles, and pilot-in-the-loop instabilities. Author

N77-24109# Hawker Siddeley Aviation Ltd., Dunsfold (England)

FLIGHT TESTING TECHNIQUES, AUTUMN 1976

R. J. Poole *In* AGARD Flight Test Tech. Apr 1977 17 p (For primary document see N77-24107 15-05)

Avail: NTIS HC A18/MF A01

A test program to demonstrate the aircraft's controllability in, and the recovery procedure from a spin formulated with reference to spinning tunnel tests is described. Data presented are gathered using the aircraft's PCM recording equipment and telemetered records observed by flight test engineers, together with the safety ground pilot, while the spins were being executed. This instrumentation together with the pilot displays and warnings in the cockpit are described. The recovery procedures to be adopted and the pilots' qualitative assessment of their effectiveness are included. Author

N77-24110# Office National d'Etudes et de Recherches Aerospatiales, Paris (France).

METHODS AND TECHNIQUES OF GROUND VIBRATION TESTING

Gerard Piazzoli *In* AGARD Flight Test Tech. Apr 1977 9 p refs In FRENCH, ENGLISH summary (For primary document see N77-24107 15-05)

Avail: NTIS HC A18/MF A01

Flight vibration tests, an important and sophisticated part of the aeroelastic research carried out for prototype clearance and certification of production aircraft, are described along with methods used for dynamic investigations of structural stability. The different techniques for delivering excitation forces, the special equipment of measurement and conditioning, and present methods of data processing and analysis are illustrated. Typical installations on aircraft of various types are described. Author

N77-24111# British Aircraft Corp., Preston (England). Military Aircraft Div.

TORNADO FLIGHT LOADS SURVEY

D. W. Altham, D. K. Potter, J. Nuscheler (Messerschmitt-Boelkow-Blohm GmbH, Munich), and W. Seidel (Messerschmitt-Boelkow-Blohm GmbH, Munich) *In* AGARD Flight Test Tech. Apr 1977 16 p refs (For primary document see N77-24107 15-05)

Avail: NTIS HC A18/MF A01

Flight loads survey instrumentation and its calibration, data acquisition and analysis techniques, and a flight test program for the TORNADO aircraft are described. Several examples of test results are given and discussed. Author

N77-24112# British Aircraft Corp., Preston (England). Military Aircraft Div.

THE EFFECT OF A COMMAND AND STABILITY AUGMENTATION SYSTEM ON FLIGHT TESTING

T. B. Saunders *In* AGARD Flight Test Tech. Apr 1977 16 p refs (For primary document see N77-24107 15-05)

Avail: NTIS HC A18/MF A01

The influence of a CSAS on flight test procedures, analysis techniques and instrumentation requirements is discussed and is shown to be a significant factor in promoting developments in these three areas. Current handling qualities criteria are considered in relation to the CSAS. Some handling qualities requirements are written in terms that cover the introduction of major new concepts like the CSAS. Author

N77-24113# Aeronautical Systems Div., Wright Patterson AFB, Ohio

DEVELOPMENT FLIGHT TEST TECHNIQUES FOR DIGITAL MULTIMODE FLIGHT CONTROL SYSTEMS

David L. Carleton *In* AGARD Flight Test Tech. Apr 1977 14 p refs (For primary document see N77-24107 15-05)

Avail: NTIS HC A18/MF A01

A technique that assesses the aircrafts ability to allow the pilot to perform precision tracking tasks, such as air to air gunnery and air to ground weapon delivery is described. Data requirements, evaluation criteria, and examples of how the technique is used in flight test programs are included along with a discussion of merits and limitations of the technique. Author

N77-24114# British Aircraft Corp. (Operating) Ltd., Bristol (England). Commercial Aircraft Div.

FLIGHT ASSESSMENT AND DEVELOPMENT OF THE CONCORDE INTAKE SYSTEM

D. P. Morriss *In* AGARD Flight Test Tech. Apr 1977 42 p (For primary document see N77-24107 15-05)

Avail: NTIS HC A18/MF A01

The rapid exposure and resolution of problems were the prime objectives of the flight investigation program, devised to exploit fully the advantage of preflight prediction of potential problem areas. An account of the flight investigation, including a description of the test techniques employed, is placed in perspective by a brief recapitulation of the design of the engine air inlet system and the associated fundamental control concepts. The impact of flight investigation on the evolution of the certification standard aircraft is apparent, e.g. modification of the prototype standard wing leading edge to improve surge free negative incremental normal acceleration capability, and suppression of local reference pressure sensing for automatic air inlet control in favor of computed reference signals derived from central air data sources. In similar contex the clear emergence of the necessity to place reliance on flight test data as the basis of formulation of the production standard air inlet control system functional laws is of paramount significance. Flight determination of the sensitivity of engine surge thresholds and hence the effective maneuver Mach Number, and throttling limits, to systematic variation of inlet geometry proved to be essential. The delicate balance between the requirements of performance, inlet/engine compatibility, and simplicity of crew management, dictated by considerations of commercial viability, was achieved by the air inlet control system laws so derived. Author

N77-24115# Royal Aircraft Establishment, Farnborough (England).

WEAPONS TESTING TECHNIQUES

F. J. Bigg, N. Tait (Cape Engineering Ltd., Warwick, Eng.), and D. A. Williams (Cranfield Inst. of Technology) *In* AGARD Flight Test Tech. Apr 1977 13 p refs (For primary document see N77-24107 15-05)

Avail: NTIS HC A18/MF A01

The philosophy adopted by the Directorate of Air Armament MOD (PE) United Kingdom and the Air Armaments Department, Royal Aircraft Establishment, Farnborough in obtaining experimen-

tal information relevant to the design and clearance of free fall weapons and associated carriage equipment is described. A number of instrumented stores which were developed as a result are described in some detail, and the conclusions are presented. Author

N77-24116# National Gas Turbine Establishment, Pyestock (England).
SUPERSONIC POWERPLANT TESTING FOR PREFLIGHT PERFORMANCE EVALUATION
G. G. Annear. *In* AGARD Flight Test Tech. Apr. 1977 12 p refs (For primary document see N77-24107 15-05)
Avail: NTIS HC A18/MF A01

The facilities used to evaluate the performance at supersonic speeds of complete propulsion units, (inlet, engine and exhaust system) is described. The way in which ground level test bed data are used to predict flight performance, and how the prediction may be refined by the use of altitude Cell data are discussed. Author

N77-24117# National Gas Turbine Establishment, Pyestock (England).
PROCEDURES FOR THE MEASUREMENT OF ENGINE THRUST IN FLIGHT
J. C. Ascough. *In* AGARD Flight Test Tech. Apr. 1977 19 p refs (For primary document see N77-24107 15-05)
Avail: NTIS HC A18/MF A01

General principles of thrust and drag accounting are discussed, the essential fluid flow relationships on which measurements are based are presented, and the necessary testing of model components and full scale engine is indicated. A strong emphasis in placed upon error estimation and thrust option management. Author

N77-24118# Technische Hogeschool, Delft (Netherlands). Dept. of Aerospace Engineering
ESTIMATION OF DRAG AND THRUST OF JET-PROPELLED AIRCRAFT BY NON-STEADY FLIGHT TEST MANEUVERS
J. A. Mulder and J. M. VanSliedregt. *In* AGARD Flight Test Tech. Apr. 1977 30 p refs (For primary document see N77-24107 15-05)
Avail: NTIS HC A18/MF A01

When measuring aircraft performance or lift-drag characteristics in steady or nonsteady flight numerical apriori information is required from engine (altitude) test facilities for an accurate determination of engine thrust. It is shown that this need for apriori information may be eliminated by an inflight calibration of the measuring probes for engines gross thrust and mass flow simultaneously with the measurement of the aircraft lift-drag characteristics. Results are presented of 9 nonsteady flight test maneuvers with a Hawker Hunter mk VII jet aircraft at 10,000, 20,000, and 30,000 ft nominal flight altitude. Besides lift-drag characteristics and engine gross thrust and mass flow calibration factors, several alternative performance characteristics as excess thrust in horizontal flight and also stability and control characteristics may be deduced from the measurements. The validity of the flight test results, in particular with respect to the inflight calibration of the gross thrust and mass flow measuring probes is, because of the particular aircraft exploited for the flight tests, restricted to the case of a socalled straight jet engine configuration and a non-flexible aircraft. Author

N77-24119# Dornier-Werke G.m.b.H., Friedrichshafen (West Germany).
FLIGHT TESTING AND EVALUATION TECHNIQUES FOR THE DETERMINATION OF HANDLING QUALITIES
Horst Wuennenberg and Ulrich VonMeier. *In* AGARD Flight Test Tech. Apr. 1977 13 p refs (For primary document see N77-24107 15-05)
Avail: NTIS HC A18/MF A01

The techniques of handling qualities determination in flight testing are discussed. The main targets for flight testing are described and examples from the Alpha Jet flight testing are presented. It is proposed to present the necessary information for flight manual and certification documentation (pilot comments, flight test evaluation, and theoretical calculations) in table form. Author

N77-24120# Air Force Flight Test Center, Edwards AFB, Calif.
A MISSION ORIENTED FLIGHT TEST TECHNIQUE FOR IDENTIFYING AIRCRAFT AND FLIGHT CONTROL SYSTEM TRANSFER FUNCTIONS
Thomas R. Twisdale, Gerald L. Jones, and Tice A. Ashurst. *In* AGARD Flight Test Tech. Apr. 1977 14 p refs (For primary document see N77-24107 15-05)
Avail: NTIS HC A18/MF A01

Data analysis techniques were developed at the Air Force Flight Test Center (AFFTC) which offer unique and quantitative insights into pilot-in-the-loop handling qualities. These data analysis techniques, called System Identification From Tracking (SIFT), are based on time series analysis procedures. These procedures are used to perform a frequency domain evaluation of data obtained during closed-loop, mission oriented precision tracking maneuvers. Normal stability and control test parameters are measured and recorded in the time domain during the maneuver. As many as four of these parameters are selected as multiple inputs to the system being evaluated and one parameter is selected as the system response. These time domain data are Fourier transformed into the frequency domain, where spectral content, multiple frequency response transfer functions, and coherence functions are estimated and plotted. Depending on the parameters selected for analysis, either the flight control system (or its components), or the airframe aerodynamics, or the total system characteristics (control system plus aerodynamics) may be identified. Interim results show that, for the aircraft being analyzed, lateral-directional coupling into the pitch axis has an unexpected and apparently significant impact on longitudinal handling qualities, even for small angles of attack and sideslip. Author

N77-24121# Air Force Flight Test Center, Edwards AFB, Calif. Systems Engineering Branch
OVERALL AIRCRAFT SYSTEMS EVALUATION
Frank N. Lucero and Charles E. Adolph. *In* AGARD Flight Test Tech. Apr. 1977 13 p (For primary document see N77-24107 15-05)
Avail: NTIS HC A18/MF A01

The managerial and test procedures used by personnel at the Air Force Flight Test Center to plan, conduct, and report on overall aircraft systems test programs are described. Author

N77-24122# National Aerospace Lab., Amsterdam (Netherlands).
DETERMINATION OF ANTENNA RADIATION PATTERNS, RADAR CROSS SECTIONS AND JAM-TO-SIGNAL RATIOS BY FLIGHT TESTS
O. B. M. Pietersen, G. J. Alders, and R. B. A. Wasch. *In* AGARD Flight Test Tech. Apr. 1977 6 p (For primary document see N77-24107 15-05)
Avail: NTIS HC A18/MF A01

A data acquisition and processing method, aimed at the determination of radiation patterns of airborne equipment is described. The data acquisition procedure and, more specific, the data processing and presentation schemes used are emphasized. Author

N77-24123# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick (West Germany). Inst. Fuer Flugfuehrung.
REAL TIME DATA TRANSMISSION AND PROCESSING FOR THE DETERMINATION OF AIRCRAFT ANTENNA RADIATION PATTERNS
Helmut Bothe. *In* AGARD Flight Test Tech. Apr. 1977 11 p refs (For primary document see N77-24107 15-05)
Avail: NTIS HC A18/MF A01

A measuring system determining aircraft antenna radiation patterns in flight is described. Measuring system requirements and configuration are outlined. Real time data processing and quick-look monitoring during flight tests are enabled by a telemetry system, the state of which is described. Author

N77-24124# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick (West Germany). Inst. fuer Flugfuehrung.
HYBRID REFERENCE SYSTEMS FOR FLIGHT TESTING
Heinz Winter and Ulrich Brokof. *In* AGARD Flight Test Tech. Apr. 1977 15 p refs (For primary document see N77-24107 15-05)
Avail: NTIS HC A18/MF A01

Hybrid reference systems consisting of ground-based measuring equipment (tracking radar, long sitance radar) and on-board sensors (Doppler or inertial navigation systems) were analyzed with respect to the accuracy of position, velocity, and attitude measurement. Flight experiments demonstrated that the high accuracies required for weapon guidance systems testing can be obtained with such systems. Author

N77-24125# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick (West Germany) Inst. fuer Flugfuehrung.

FLIGHT TESTING OF DISPLAYS IN A HELICOPTER

R. Beyer *In* AGARD Flight Test Tech. Apr. 1977 11 p refs (For primary document see N77-24107 15-05)

Avail: NTIS HC A18/MF A01

Electro-optical sensors and electronic displays for a future helicopter avionics system may extend the flexibility of helicopter operation at night and in bad weather. Flight tests were made with a simulated system which presented a combination of flight instruments and an image of the terrain to the pilot. Means were developed to assess flight performance and pilot strain in flights with the system and some of the measures and the results obtained are discussed. Author

N77-24126# Royal Aircraft Establishment, Farnborough (England). Dept. of Instrumentation and Trials.

ANGULAR MOTION SENSING WITH GAS ROTORS

W. R. MacDonald *In* AGARD Flight Test Tech. Apr. 1977 26 p refs (For primary document see N77-24107 15-05)

Avail: NTIS HC A18/MF A01

Angular motion transducers based on a gas rotor are discussed. These exploit the fact that when a coil of tube containing gas experiences angular acceleration, a pressure proportional to the acceleration is generated. The pressure is measured by a capacitive membrane sensor and depending on the design characteristics, outputs representing angular acceleration, vibratory angular displacement, or vibratory angular velocity may be obtained. The design and performance of these three types of transducer are discussed in detail and examples of practical instruments are given. Gas rotor transducers display characteristics similar to those of rotary spring-mass systems, but they are effectively devoid of moving parts and in principle are perfectly balanced. They are therefore potentially cheap and very robust. Moreover, since the rotor can be of any convenient shape, optimum use can be made of available space and multi-axis instruments of similar size to their single-axis counterparts are feasible. Author

N77-24127# Centre d'Essais en Vol, Istres (France).

EXAMPLES OF LASER UTILIZATION IN CIVIL AIRCRAFT CERTIFICATION TESTS

Nicolas Lapchine *In* AGARD Flight Test Tech. Apr. 1977 20 p refs In FRENCH (For primary document see N77-24107 15-05)

Avail: NTIS HC A18/MF A01

The STRADA system installed at the Brittany Flight Test Center was used in flight certification tests of the Concorde and Mercure 100 aircraft. The system uses optical radar (LIDAR) mounted on a turret, consisting of a yttrium-aluminum yag laser transmitting in the infrared at a frequency of 3200 impulses per second. The luminous energy received by passive retroreflectors mounted on the aircraft is received in an optical reception system linked to two receivers which measure distance and angle variations. A computer is used for real time calculation of the trajectory of the reflectors mounted on the aircraft. Tests for both the Concorde and the Mercure flights are described. Transl. by A.R.H.

N77-24128*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.

TELEMETRY AND DATA RELAY FOR MANNED SPACE PROGRAMS

Kim W. Anson *In* AGARD Flight Test Tech. Apr. 1977 14 p (For primary document see N77-24107 15-05)

Avail: NTIS HC A18/MF A01

Previously and currently planned methods of transferring or relaying telemetered information from a remote receiving station to the Mission Control Center, at the National Aeronautics and Space Administration Lyndon B. Johnson Space Center, are discussed. The data flow techniques of the Apollo Program (fixed formats), the Skylab Program (data compression), and the Space Shuttle Program (data throughput) are defined and analyzed according to their advantages and deficiencies from an operations viewpoint. Excluded from the data flow technique discussions are command data, tracking data, television data, and Teletype and Datafax messages. Voice transmissions are addressed in the Space Shuttle Program discussion because they form a part of the telemetry data stream. The tradeoffs between actual data flow requirements and existing communications limitations are addressed for each of these programs. Finally, a short discussion of current problem areas in the planned ground data transmission system for the Space Shuttle Program is presented. Author

N77-24129# Boeing Aerospace Co., Seattle, Wash.

RESORS: A SYSTEM FOR ON-LINE, ON-BOARD DATA REDUCTION AND PERFORMANCE ANALYSIS DEVELOPED ESPECIALLY FOR E-3A FLIGHT TESTS

H. A. Williams *In* AGARD Flight Test Tech. Apr. 1977 13 p (For primary document see N77-24107 15-05)

Avail: NTIS HC A18/MF A01

A system of computer programs (RESORS) to analyze radar report data using an interactive graphics terminal is described. Developed for E-3A test flights, RESORS permits on-board, on-line engineering judgemental decisions in data reduction and analysis. With RESORS, complex multi-dimensioned data can be displayed and sorted in any pair of twenty or so dimensions assisting in immediate decisions affecting test conduct and control. Primary functions include a quick look at flight results, isolation of identifiable radar reports such as tracks, detection of radar anomalies, and determination of false alarm rates. The program flexibility provides both detailed analysis capability, and a big picture overview of flight test data. Author

N77-24130*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Center, Edwards, Calif.

AN ADVANCED AIRBORNE DATA ACQUISITION SYSTEM

Febo Bartoli *In* AGARD Flight Test Tech. Apr. 1977 12 p refs (For primary document see N77-24107 15-05)

Avail: NTIS HC A18/MF A01

The development and features of and user experience with an advanced airborne data acquisition system are described. The system consists of as many as 16 high speed pulse code modulation data acquisition units which are integrated with an airborne computer and a cockpit display unit. The data acquisition units may be operated without the computer. Operation without the computer is termed stand-alone operation. Computer integrated operation is intended for large-scale projects, and stand-alone operation is designed for small-scale projects. The cockpit display unit, which is part of the computer operated system, displays computed real time data in engineering units. An example of the cost reduction experienced by a major aircraft company by using the advanced data acquisition system is given. Author

N77-24131# Boeing Commercial Airplane Co., Seattle, Wash.

USE OF ONBOARD REAL-TIME FLIGHT TEST ANALYSIS AND MONITOR SYSTEMS Progress Report

William S. Lieberman *In* AGARD Flight Test Tech. Apr. 1977 10 p (For primary document see N77-24107 15-05)

Avail: NTIS HC A18/MF A01

The actual usage of onboard real time computer controlled data analysis systems during the recent flight test programs for two different Boeing model aircraft, and the plans for use in future application are described. The results of such usage have been the shortening in schedule flow time and cost of the programs, as well as the increased accuracy of results and reduction in post-flight batch data processing. They have also reduced the dependency on geographical location of the test area since down link telemetry systems are not required. Author

N77-24132# Air Force Flight Test Center, Edwards AFB, Calif.

THE AUTOMATED FLIGHT TEST DATA SYSTEM

Charles O. Johnson and Paul J. Sehnert *In* AGARD Flight Test Tech. Apr. 1977 17 p (For primary document see N77-24107 15-05)

Avail: NTIS HC A18/MF A01

The United States Air Force, Air Force Flight Test Center Automated Flight Test Data System (AFTDS), a derivative of the Grumman real time system, was extensively used by the B-1 development test program, was used to a lesser degree for the F-5E spin evaluation, and has considerable use planned during the F-16 full scale development tests. The applications range from simple real time validation of instrumentation system health to presentation of engineering data such as drag polars, load analysis, and terrain following/terrain avoidance system information. A system that employs on-line computation to generate real time engineering data is also described. Interfaces with the onboard instrumentation system, the planning activity required to effectively apply this data system, description and presentation of typical data analyses packages, consideration of the limitations, benefits, and indication of future plans are covered in greater detail. Author

N78-17048# Advisory Group for Aerospace Research and Development, Paris (France)

APPLICATIONS OF STRUCTURAL OPTIMIZATION FOR STRENGTH AND AEROELASTIC DESIGN REQUIREMENTS

Warner Lansing (Grumman Aerospace Corp., Bethpage, N. Y.), Edwin Lerner, and Ronald F. Taylor (AFFDL) Jan. 1978 25 p refs Presented at the 45th Struct. and Mater. Panel Meeting, Voss, Norway, Sep. 1977

(AGARD-R-664, ISBN-92-835-1269-3) Avail: NTIS HC A02/MF A01

The need to design airframe components of minimum weight, while taking into account both strength and aeroelastic requirements, has been recognized for some time. An historical review is presented of optimization technology development and a state of the art survey of methods in use by the U.S. industry that indicate considerable progress was made in automating this aspect of the airframe design process. It is concluded that algorithms for addressing strength and flutter are now sufficiently developed for practical use at all levels of design, and for addressing other aeroelastic design objectives in the preliminary design stage. It is recommended that airframe designers utilize these methods more extensively in future aircraft development programs. Additional effort is needed to extend some of the finite element resizing techniques so that static aeroelastic design objectives can be treated as effectively as flutter-speed requirements, and additional computer software development is always desirable to upgrade analysis and data management capabilities. Author

N78-17049# Advisory Group for Aerospace Research and Development, Paris (France)

TECHNICAL EVALUATION REPORT ON THE FLIGHT MECHANICS PANEL SYMPOSIUM ON ROTORCRAFT DESIGN

H. R. Velkoff (Ohio State Univ., Columbus) Jan. 1978 14 p refs Symp. held at NASA Ames Research Center, Moffett Field, Calif., 16-19 May 1977

(AGARD-AR-114 ISBN-92-835-1273-1) Avail: NTIS HC A02/MF A01

The status of rotorcraft design and development, the possible divergence of the development pattern of military and civil helicopters, and the possibilites for greater coordination in the development of future rotary wing aircraft are considered. Specific topics discussed include: (1) military requirements and new military rotorcraft; (2) civil operations and new civil helicopters; (3) rotary wing aircraft research vehicles; (4) wind tunnel and flight research; (5) common ground for military and civil cooperation in the development of rotary wing aircraft; and (6) coordination of military and civil requirements and specifications. It is recommended to seek out ways to maximize common mission and design features to reduce overlapping costs and increase production. J.M.S.

N78-18046# Advisory Group for Aerospace Research and Development, Paris (France).

FATIGUE DESIGN OF FIGHTERS: GUIDELINES FOR OBTAINING AND MAINTAINING ADEQUATE FATIGUE PERFORMANCE OF TACTICAL AIRCRAFT

Jan. 1978 138 p refs

(AGARD-AG-231; ISBN-92-835-1271-5) Avail: NTIS HC A07/MF A01

Guidelines are presented to establish recommended procedures for fatigue conscious design of aircraft, with special reference to tactical aircraft. Steps of the design process are outlined and for each step, based on current knowledge, those procedures most likely to provide adequate fatigue performance are given. For individual titles, see N78-18047 through N78-18052

N78-18047# National Aerospace Lab., Amsterdam (Netherlands).

FATIGUE DESIGN OF FIGHTERS: GUIDELINES FOR OBTAINING AND MAINTAINING ADEQUATE FATIGUE PERFORMANCE OF TACTICAL AIRCRAFT: GENERAL SURVEY

J. B. deJonge *In* AGARD. Fatigue Design of Fighters: Guidelines for Obtaining and Maintaining Adequate Fatigue Performance of Tactical Aircraft Jan. 1978 p 6-11 refs (For availability see N78-18046 09-05)

Avail: NTIS HC A07/MF A01

In the structural design process of a new aircraft, a number of successive stages can be defined. Four successive phases are distinguished here; (a) The definition phase. In this phase, the basic structural lay-out, including the type of structure and materials to be used is determined. (b) The development phase. In this phase the detail design of the structure takes place. (c) The prototype and production phase. This phase is characterised by the assessment of the performance of the new aircraft and its certification. (d) The service phase. The aircraft has entered service and is being subjected to its actual operational environment. The impact of fatigue on the structural design and the considerations with regard to the fatigue phenomenon in each of these successive phases are discussed. Author

N78-18048# Air Force Systems Command, Wright-Patterson AFB, Ohio. Structures Div.

THE DEVELOPMENT OF FATIGUE/CRACK GROWTH ANALYSIS LOADING SPECTRA

J. E. Holpp and M. A. Landy *In* AGARD. Fatigue Design of Fighters: Guidelines for Obtaining and Maintaining Adequate Fatigue Performance of Tactical Aircraft Jan. 1978 p 13-41 refs (For availability see N78-18046 09-05)

Avail: NTIS HC A07/MF A01

The processes involved in developing a realistic loading spectrum are described. The purpose of developing a realistic loading spectrum is to define a stress-time history that is representative of those stresses encountered by a component during actual usage. The discussion centers around developing load and stress spectrum for aircraft structural (airframe) components, particularly fighter or strike aircraft. The realism of the spectrum is determined by the accuracy of the input from the different disciplines and the degree of complexity that the analyst is willing, or able, to go to. There are many external factors to be considered in the spectrum development process. Among these are time and money considerations, available data, degree of accuracy required, etc. These factors may require the use of simpler, less time consuming techniques than one would prefer to use for realism's sake. The steps involved in the processes include: (1) Mission profile definition, (2) Loading environment, (3) Loading conditions, (4) Structural loads analysis, (5) Stress analysis, and (6) Stress sequencing. Author

N78-18049# Industrieanlagen-Betriebsgesellschaft m.b.H., Ottobrunn (West Germany).

CALCULATION METHODS FOR FATIGUE LIFE AND CRACK PROPAGATION

Walter Schutz *In* AGARD. Fatigue Design of Fighters: Guidelines for Obtaining and Maintaining Adequate Fatigue Performance of Tactical Aircraft Jan. 1978 p 45-76 refs (For availability see N78-18046 09-05)

Avail: NTIS HC A07/MF A01

A number of more or less well known methods to calculate fatigue life in the crack initiation and crack propagation phases are discussed. Each section is divided into two sub-sections: present status and potential improvements. Methods are classified as present status when they are used widely in industry, examined by systematical test programs or are simply outgrowths of older methods and no improvement can be expected for fundamental reasons. They are classified as potential improvements when they offer some hope for improvement compared to the present status but this has not been conclusively proved. Thus a method will be in the potential improvements section when it has not been thouroughly examined experimentally, although it may have been around for many years. Author

N78-18050# Industrieanlagen-Betriebsgesellschaft m.b.H., Ottobrunn (West Germany)

TESTS ON DETAILS AND COMPONENTS

K. Ahrensdorf *In* AGARD. Fatigue Design of Fighters: Guidelines for Obtaining and Maintaining Adequate Fatigue Performance of Tactical Aircraft. Jan. 1978 p 77-106 refs (For availability see N78-18046 09-05)

Avail: NTIS HC A07/MF A01

The fatigue life of critical components and/or the reaction of their structures to cracks must be determined to serve as a basis for fatigue life calculation and the final layout of fatigue-critical components. Such fatigue tests are often combined with detailed stress analyses. Also carried out are specimen tests to determine the crack propagation rates for the materials used and the crack growth in critical areas. Specimen tests are employed to complement the component tests because even in this early phase, it is not only interesting to find out how the structure will react to a mission mix used for fatigue verification, but it is also necessary to investigate the influence of variations of mission mix. These trade-off studies give information about the limitations in life associated with different usage. A seemingly more severe load spectrum may yield a longer life. Author

N78-18051# Royal Aircraft Establishment, Farnborough (England).
CURRENT STANDARDS OF FATIGUE TEST ON STRIKE AIRCRAFT
R. D. J. Maxwell *In* AGARD Fatigue Design of Fighters: Guidelines for Obtaining and Maintaining Adequate Fatigue Performance of Tactical Aircraft Jan. 1978 p 107-116 refs (For availability see N78-18046 09-05)
(AGARD-AR-92) Avail: NTIS HC A07/MF A01

Many types of aircraft are operated by countries other than those in which the aircraft were designed and tested. It is important, therefore, that sufficient information on major tests is made available to enable the airworthiness authorities of all user countries to interpret the tests in terms of their own requirements and monitoring systems. The discussion outlines in an advisory manner a list of the steps necessary to achieve the above objectives and to recommend those procedures, based on current knowledge, most likely to produce acceptable outputs at each step. The presentation is divided into three sections: (1) a brief statement of the objectives of a fatigue test and a list of the essential steps needed to achieve those objectives, (2) a summary of the recommendations of the way in which each of the steps should be carried out, and (3) a review of the background philosophy associated with the recommendations. Author

N78-18052# National Aerospace Lab., Amsterdam (Netherlands).
FATIGUE LOAD MONITORING
J. B. DeJonge *In* AGARD Fatigue Design of Fighters: Guidelines for Obtaining and Maintaining Adequate Fatigue Performance of Tactical Aircraft Jan. 1978 p 117-134 refs (For availability see N78-18046 09-05)
Avail: NTIS HC A07/MF A01

For modern fighter aircraft with their usage versatility and desired long operational lives on the one hand and their finite fatigue endurance on the other, monitoring of operational load experience has become indispensable. Monitored loads are used for re-assessing the service life under operational conditions and the inspection intervals for fail-safe structures which are based on crack growth rates in conjunction with loading severity. Methods available for such re-assessment are discussed. Various load monitoring techniques are described and general aspects of fatigue load monitoring are discussed. Author

N78-19126# Advisory Group for Aerospace Research and Development, Paris (France).
ROTORCRAFT DESIGN
Jan. 1978 342 p refs Proceedings of the Flight Mechanics Panel Symp., Moffett Field, Calif., 16-19 May 1977
(AGARD-CP-233; ISBN-92-835-1272-3) Avail: NTIS HC A15/MF A01

Military and civilian rotorcraft designers are provided with exchanges concerning common problems and grounds for civil/military cooperation. Sessions included military requirements and new rotorcraft systems; civil operations and new helicopter designs; and research vehicles. Rotor wind tunnel and flight research are also reviewed, and opportunities for coordinating military and civil requirements and specifications are discussed. For individual titles, see N78-19127 through N78-19151

N78-19127# Army Aviation Systems Command, St. Louis, Mo.
PROJECTED NEEDS OF US ARMY AVIATION
Story C. Stevens *In* AGARD Rotorcraft Design Jan. 1978 22 p refs (For availability see N78-19126 10-05)
Avail: NTIS HC A15/MF A01

The projected needs of U.S. Army air mobility as they are seen today within the U.S. Army Aviation Systems Command are reviewed. The U.S. Army's envisioned future aviation requirements are discussed and their relation to research and development needs is summarized. Special emphasis is given to those aspects of the military requirements which seem to offer the best opportunities for coordination with civil developments. Both the short term needs, as exemplified by the currently developing systems, and the long term requirements, which may be represented by conceptual studies only, are addressed. Author

N78-19128# Bundesministerium der Verteidigung, Bonn (West Germany).
GERMAN ARMY HELICOPTER DEVELOPMENT AND PROSPECTS FOR THE FUTURE
K. W. Mack and H. Jakob *In* AGARD Rotorcraft Design Jan. 1978 22 p (For availability see N78-19126 10-05)
Avail: NTIS HC A15/MF A01

The present German army helicopter development is concentrated on a light antitank helicopter (ATH) and a liasion-and-observation helicopter (LOH), based on the civilian BO 105 helicopter of Messerschmitt-Bolkow-Blohm. The outstanding characteristics of these two systems is a high degree of commonality that is promising considerable advantages for cost effectiveness, maintenance, overhaul and other logistic aspects. Guidelines for the future German military helicopter development are among others: night- and bad-weather capability; increased maneuverability; improved survivability and crashworthiness; improved maintenance, overhaul and repair; reduction of the number of types; and consideration of standardization and interoperability requirements. Author

N78-19129# Canadian Forces Base, Shearwater (Nova Scotia).
CANADIAN NAVY EXPERIENCE WITH SMALL SHIP HELICOPTER OPERATIONS
N. H. J. Browne *In* AGARD Rotorcraft Design Jan. 1978 4 p (For availability see N78-19126 10-05)
Avail: NTIS HC A15/MF A01

A short summary is presented of the development of the Canadian Navy's approach and solution to operating medium size helicopters from small ships in the North Atlantic. This is followed by a general description of the Helicopter Hauldown Rapid Securing Device - the main item of equipment which enabled successful open sea operations with the available equipment. An overview of the operating capabilities of the Destroyer/Helicopter system, the lessons learned from its development and a subjective assessment of future helicopter requirements for the Canadian Navy are also offered. Author

N78-19130# Ministry of Defence, London (England). Directorate of Naval Air Warfare.
BRITISH MILITARY HELICOPTER PROGRAMMES
J. D. W. Husband *In* AGARD Rotorcraft Design Jan. 1978 7 p (For availability see N78-19126 10-05)
Avail: NTIS HC A15/MF A01

The range of helicopters in current use within the UK armed services is described and the broad requirements for the future are examined. It is recognized that, because of the spiralling cost of development of new helicopters, every effort will have to be made to reduce the through life costs by improving the life, reliability and maintainability of components. Survivability, both in crash resistance and in reduced vulnerability to hostile fire are of particular importance in the battlefield environment, while increased speed and endurance are sought in naval helicopters. Author

N78-19131# Army Aviation Systems Command, St. Louis, Mo. Research, Development and Engineering Directorate.
THE US ARMY UTTAS AND AAH PROGRAMS
Ronald F. Gormont and Robert A. Wolfe *In* AGARD Rotorcraft Design Jan. 1978 18 p refs (For availability see N78-19126 10-05)
Avail: NTIS HC A15/MF A01

The U. S. Army's latest developed utility and attack helicopters with contracts recently awarded to Sikorsky Aircraft for the utility tactical transport aircraft system (UTTAS) and Hughes Aircraft for the advanced attack helicopter (AAH) are addressed. A brief history into the background of the Army's requirement for a UTTAS and AAH is provided along with a history of the development, a general description of the aircraft with intended missions, planned activities, significant capabilities, and potential alternate uses of the resulting designs. The capabilities and potential alternate uses consider the implication of the stringent military requirements in adapting the UTTAS and AAH to other nonmilitary or noncombat missions. Both development programs have concentrated efforts on reliability and maintainability characteristics which provide enhanced operational capability on the modern day battlefield at an affordable cost. Author

N78-19132# Department of the Navy, Washington, D. C.
US NAVY/MARINE CORPS ROTARY WING REQUIREMENTS
J. A. Purtell *In* AGARD Rotorcraft Design Jan. 1978 4 p (For availability see N78-19126 10-05)
Avail: NTIS HC A15/MF A01

Points addressed include how rotorcraft fit into a Navy committed to a future VTOL force, current helicopter developments in Naval aviation with emphasis upon characteristics and capabilities of CH-53E Super Stallion, LAMPS MK III, and the AH-1T improved Sea Cobra, and finally, what current trends are underway in navalized helicopters to applications. Author

N78-19133# British Airways Helicopters Ltd., Horley (England)
BRITISH AIRWAYS HELICOPTER OPERATIONS
J. A. Cameron *In* AGARD Rotorcraft Design Jan. 1978 4 p (For availability see N78-19126 10-05)
Avail: NTIS HC A15/MF A01

The helicopter's role in civil aviation in the United Kingdom is assessed. The main operation considered is a helicopter passenger service from Penzance on Britain's south west coast to the Isles of Sicily. A comparison is made between fixed wing aircraft and rotary wing aircraft in regard to operating costs and flight time reduction. Other aspects of operations economics are examined, including helicopter design, fleet maintenance and overhaul life. B.L.P.

N78-19134# Squadron 330/B-Wing, Banak AFB, Laksalv (Norway).
AIR-SEA RESCUE OPERATIONS. SEARCH AND RESCUE EXPERIENCE
Tore Skaar *In* AGARD Rotorcraft Design Jan. 1978 8 p (For availability see N78-19126 10-05)
Avail: NTIS HC A15/MF A01

The 330th squadron operates Sea King helicopters for air-sea rescue missions all along the Norwegian coast. The operational environment is one of the most demanding in the world. The shortcomings of the present generation of helicopters are discussed, the most serious being the lack of in flight icing protection of the rotor systems. Author

N78-19135# KLM North Sea Helicopters, Amsterdam (Netherlands)
SOME ASPECTS OF OFFSHORE OPERATIONS IN THE NETHERLANDS
R. J. VanDerHarten *In* AGARD Rotorcraft Design Jan. 1978 7 p refs (For availability see N78-19126 10-05)
Avail: NTIS HC A15/MF A01

The sound film 'Bridging the Troubled Waters' (Sikorsky Aircraft), which gives a general impression of helicopter operations between mainland and naval destinations, is summarized. Problems which had to be solved in order to realize the required services on a 24-hour basis are reviewed. One of these problems was the certification of helicopter weather minima for IFR-flight. This involved the development and evaluation of instrument procedures and the proper choice of instruments and panel layout, the navigational aids and the communication system. Special attention was paid to the radar system, which provides not only weather detection but is also used during the approach to the targets at sea, as well as to the recent evaluation of an integrated pilot display system, which has a great potential for very low weather minima without the use of automatic guidance. Author

N78-19136# Hughes Helicopters, Culver City, Calif.
COMBINED MILITARY AND COMMERCIAL APPLICATION OF LIGHT HELICOPTERS
E. E. Cohen, K. B. Amer, and R. E. Moore *In* AGARD Rotorcraft Design Jan. 1978 21 p (For availability see N78-19126 10-05)
Avail: NTIS HC A15/MF A01

An overview is presented of light helicopters of less than 4000 pounds gross weight used by both military and commercial aviation. Hughes Helicopters background in light helicopters, the design considerations and criteria used in the development of these helicopters, and the Army's entry into light helicopter development are considered as well. Some conjecture is offered on the design considerations and criteria which might be used to develop a next generation lightweight, multipurpose helicopter which could be used suitably by both military and commercial aviation. Author

N78-19137# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (West Germany)
LONG TERM EXPERIENCE WITH A HINGELESS/ COMPOSITE ROTOR
G. Reichert and E. Weiland *In* AGARD Rotorcraft Design Jan. 1978 14 p refs (For availability see N78-19126 10-05)
Avail: NTIS HC A15/MF A01

The Messerschmitt-Bolkow-Blohm Company has gained good experience with its light helicopter MBB - BO 105, which is engaged in civilian as well as in military operations. Up to now, more than 300 BO 105 helicopters have been delivered to customers, and some 250,000 hours of flight time have been accumulated. The first helicopters have about 5,000 flight hours. This experience is especially valuable because the BO 105 is the first production helicopter with a hingeless rotor and fiberglass rotorblades which has been able to prove its ability in practical operation consistently over a long period of time. The broad spectrum of operation and experience includes the following types of missions in civilian operation: utility, executive, rescue, police, offshore, lighthouse supply as well as LOH, scout and antitank-missions in military operation. Besides the problems resulting from this broad field of operations, which are typical for many light helicopters, additional questions associated with the new technology were specially considered, for example the changed handling characteristics and the different loading situation of the hingeless rotor, and the behavior of the fatigue loaded fiberglass blades. Author

N78-19138# Textron Bell Helicopter, Ft. Worth, Tex.
THE BELL MODEL 222
James R. Garrison *In* AGARD Rotorcraft Design Jan. 1978 16 p (For availability see N78-19126 10-05)
Avail: NTIS HC A15/MF A01

The design objectives, features and performance of the recently developed Bell Model 222 helicopter are described. The Model 222 was designed to meet the needs of the worldwide commercial market. Primary design objectives were safety, efficiency, reduced cost of ownership, and superior handling qualities. From the test results, the Model 222 is a fuel conservative, productive aircraft with excellent flying qualities. The 222 far exceeds the FAA requirements for fail-safe design and crashworthiness. Redundancy, 8g seats, crash resistant fuel tanks, and real twin-engine safety are examples. The latter refers to the fact that for any altitude at which the helicopter can hover OGE, it can continue to cruise if one engine fails. Author

N78-19139# Sikorsky Aircraft, Stratford, Conn.
THE SIKORSKY S-76 PROGRAM
R. F. Donovan *In* AGARD Rotorcraft Design Jan. 1978 14 p (For availability see N78-19126 10-05)
Avail: NTIS HC A15/MF A01

The Sikorsky S-76 helicopter was designed for the commercial market in general, and in particular, was designed to serve the off-shore oil market and meet its requirements to carry 12 passengers and a crew of two on a 400 nautical mile radius mission with flotation equipment. Author

N78-19140# Societe Nationale Industrielle Aerospatiale, Paris (France).
THE AS 350 LIGHT HELICOPTER
Rene Mouille *In* AGARD Rotorcraft Design Jan. 1978 18 p (For availability see N78-19126 10-05)
Avail: NTIS HC A15/MF A01

The AS-350 was designed especially for civil operators, with cost effectiveness a major concern. Overall architectural design reduced the number of engine components, resulting in a lightweight (4200 lb), single-engined helicopter capable of carrying a crew of six. M.V.

N78-19141# Dornier-Werke G.m.b.H., Friedrichshafen (West Germany).
TETHERED RPV-ROTORCRAFT
G. Kannamueller and W. Goeller *In* AGARD Rotorcraft Design Jan. 1978 7 p (For availability see N78-19126 10-05)
Avail: NTIS HC A15/MF A01

A tethered rotor platform was designed for the stabilization of transmitters and receivers of electromagnetic waves at an adequate altitude over a ground control station for military and civil purposes. The complete system consisted of rotor platform, tethering cable, and ground control station. Apart from the transmission of command and information data the tethering cable was also used for the power supply. Tethered rotor platforms were used primarily in the military field for electronic warfare, fire control, communication, and surveillance of battlefield, sea surface and air space. Author

N78-19142*# National Aeronautics and Space Administration Ames Research Center, Moffett Field, Calif.
EVALUATION OF THE TILT ROTOR CONCEPT: THE XV-15'S ROLE
James H. Brown, Jr., H. Kipling Edenborough (Textron Bell Helicopter, Fort Worth, Tex.), and Kenneth G. Wernicke *In* AGARD Rotorcraft Design Jan. 1978 9 p. Prepared in cooperation with Army Air Mobility Res. and Develop. Lab., Moffett Field, Calif. (For availability see N78-19126 10-05)
Avail: NTIS HC A15/MF A01 CSCL 01C

The need for an aircraft combining the efficient vertical takeoff and landing capability of a helicopter with the efficient high speed characteristics of a fixed wing turboprop is examined. The ability of the tilt rotor concept to fill this requirement and

examples as to its potential usefulness in both military and civil missions are discussed. Author

N78-19143# Army Air Mobility Research and Development Lab., Fort Eustis, Va
THE ADVANCING BLADE CONCEPT (ABC) ROTOR PROGRAM
Harvey R. Young and Duane R. Simon *In* AGARD *Rotorcraft Design* Jan. 1978 23 p refs (For availability see N78-19126 10-05)
Avail: NTIS HC A15/MF A01

The advancing blade concept, a coaxial counterrotating hingeless helicopter rotor system, was flight tested. Flight results in a basic helicopter configuration confirmed several important advantages of the concept and identified some shortcomings. The background and current status of the program are presented, and rotor and test aircraft features are briefly described. Author

N78-19144*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.
THE ROTOR SYSTEMS RESEARCH AIRCRAFT: A NEW STEP IN THE TECHNOLOGY AND ROTOR SYSTEM VERIFICATION CYCLE
Robert J. Houston, Julian L. Jenkins, Jr., and John L. Shipley (Army Air Mobility Res. and Develop. Lab., Hampton, Va.) *In* AGARD Rotorcraft Design Jan. 1978 24 p refs (For availability see N78-19126 10-05)
Avail: NTIS HC A15/MF A01; CSCL 01C

Rotor systems research aircraft vehicles, (RSRA), were developed specifically to provide the capabilities necessary for the effective and efficient in-flight test and verification of promising new rotor concepts and supporting technology developments. The capabilities of the RSRA aircraft for potential research programs are discussed. Author

N78-19145# National Aeronautical Establishment, Ottawa (Ontario).
THE NAE AIRBORNE V/STOL SIMULATOR
S. R. M. Sinclair, W. E. B. Roderick, and K. Lum *In* AGARD *Rotorcraft Design* Jan. 1978 12 p refs (For availability see N78-19126 10-05)
Avail: NTIS HC A15/MF A01

Specialized facilities for investigating the problems associated with high-lift, low-speed flight were established. The airborne simulator's four major areas of systems development are discussed: installation of an electrohydraulic actuator system to interface with the basic helicopter controls, development and integration of a hybrid computing system, implementation of a model-following autopilot, and development of a broadband motion sensing system. A short description of each of these systems is given. Author

N78-19146# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick (West Germany). Inst. fuer Flugmechanik.
DFVLR ROTORCRAFT RESEARCH
B. Gmelin, H. J. Langer, and P. Hamel *In* AGARD Rotorcraft Design Jan. 1978 17 p refs (For availability see N78-19126 10-05)
Avail: NTIS HC A15/MF A01

Selected activities in the field of rotorcraft research and development are presented and discussed: helicopter wind tunnel test stands, active vibration control, crew escape systems, and helicopter system identification. Author

N78-19147# Westland Helicopters Ltd., Yeovil (England).
RESEARCH REQUIREMENTS FOR THE IMPROVEMENT OF HELICOPTER OPERATIONS
Martin V. Lowson *In* AGARD Rotorcraft Design Jan. 1978 13 p refs (For availability see N78-19126 10-05)
Avail: NTIS HC A15/MF A01

Principal difficulties in helicopter performance engineering were studied. Problems in the areas of noise, both external and internal, and ice formation were examined. Reduction of rotor speed as a noise control method was suggested, and ice formation was attributed to meteorological uncertainties. Author

N78-19148# Office National d'Etudes et de Recherches Aerospatiales, Paris (France).
ONERA AERODYNAMIC RESEARCH WORK ON HELICOPTERS
Jean-Jacques Philippe and Claude Armand *In* AGARD Rotorcraft Design Jan. 1978 19 p refs (For availability see N78-19126 10-05)
Avail: NTIS HC A15/MF A01

Aerodynamic research on helicopters included basic research in two or three-dimensional flows and studies on rotors. The study of steady and unsteady characteristics of airfoils and of problems pertaining to blade tips and to vortex interactions is discussed. For the rotors, a computing program for the forces on the blades, based on the acceleration potential method was developed. The problems of unsteady transonic aerodynamics related to high speed flight are also discussed. In order to perform wind tunnel tests for helicopter companies and for research purposes two rotor test rigs were developed. Measuring techniques which were used and the more characteristic results for total forces on helicopter or convertible, for absolute pressure on the blades, for identification of the boundary layers, for smoke visualizations, and for rotating blade deformations are described. Author

N78-19149# Westland Helicopters Ltd., Yeovil (England).
WESTLAND WISP
M. J. Breward *In* AGARD Rotorcraft Design Jan. 1978 14 p ref (For availability see N78-19126 10-05)
Avail: NTIS HC A15/MF A01

Feasibility studies for a surveillance and target acquisition system led to a proposal for a remotely piloted helicopter with co-axial twin rotors having symmetry about the rotor axis. One project which has proceeded into hardware status and which has commenced flight trials, carries a trainable television camera and gyro based automatic stabilization equipment. It is operable by two persons, one of which performs all piloting functions. Author

N78-19150# Societe Nationale Industrielle Aerospatiale, La Courneuve (France).
TECHNICAL AND FINANCIAL FALL-OUT ON ARMED FORCES FROM COMMERCIAL AND EXPORT HELICOPTER PROGRAMMES
Andre L. Renaud *In* AGARD Rotorcraft Design Jan. 1978 4 p (For availability see N78-19126 10-05)
Avail: NTIS HC A15/MF A01

An attempt was made to highlight the drawbacks for industry, and advantages for armed forces, when launching a helicopter program as a private venture. The drawbacks for the industry lie in the investments, the lack of operational and technical specifications, and of official crew's judgement on the aircraft. The advantages for military operators were the deferred and lower non-recurring cost outlay if a helicopter was developed as a private venture. Author

N78-19151# Boeing Vertol Co., Philadelphia, Pa.
CIVIL AND MILITARY DESIGN REQUIREMENTS AND THEIR INFLUENCE ON THE PRODUCT
David G. Harding and John P. Walsh *In* AGARD Rotorcraft Design Jan. 1978 9 p refs (For availability see N78-19126 10-05)
Avail: NTIS HC A15/MF A01

Differences in airworthiness requirements were found to cause substantial cost increases, particularly for civil application of military helicopters. The effects of these differences are discussed by examing the civil certification programs of various military helicopters. Author

N78-22093# Advisory Group for Aerospace Research and Development, Paris (France).
TECHNICAL EVALUATION REPORT ON THE MULTI-PANEL SYMPOSIUM ON FIGHTER AIRCRAFT DESIGN
H. Andrews (Dept. of the Navy, Washington, D.C.) and R. J. Balmer (British Aerospace Aircraft Group, Kingston-Upon-Thames (England)) Feb. 1978 14 p Symp. held at Florence, 3-6 Oct. 1977
(AGARD-AR-119; ISBN-92-835-1275-8) Avail: NTIS HC A02/MF A01

The proceedings of a symposium on fighter aircraft design were evaluated. The primary conclusions of the report are that technology is available, in all areas of fighter design, to meet the military requirements for the 80's. However, the cost of using the most advanced technology to meet every conceivable requirement can be exorbitant. Cost-effectiveness is of vital importance. Operational requirements must be carefully developed

and clearly defined so as to ensure the most economical solution. Fighter aircraft must be designed with sufficient flexibility to meet the changing needs during their service life. Research and development should be directed towards those areas offering the most cost-effective solutions. Author

N78-28088# Advisory Group for Aerospace Research and Development, Paris (France).
COMBAT DAMAGE TOLERANCE AND REPAIR OF AIRCRAFT STRUCTURES
Jun. 1978 33 p refs Presented at the 46th Struct. and Mater. Panel Meeting, Aalborg, Denmark, Apr. 1978
(AGARD-R-667, ISBN-92-835-1286-3) Avail: NTIS HC A03/MF A01

The following topics are discussed: (1) approaches to combat damage repair, (2) considerations of the likely tolerance to, and repair of battle damage in aircraft structures; and (3) aims and progress of a battle damage repair capability in the Royal Air Force. For individual titles, see N78-28089 through N78-28091.

N78-28089# Army Research and Technology Labs., Fort Eustis, Va. Applied Technology Lab.
APPROACHES TO COMBAT DAMAGE REPAIR
Thomas L. House and John Ariano *In* AGARD Combat Damage Tolerance and Repair of Aircraft Struct. Jun. 1978 p 1-10 ref (For primary document see N78-28088 19-05)
Avail: NTIS HC A03/MF A01

Issues of maintaining helicopters under mid-intensity combat conditions are discussed. The need to defer all but essential scheduled and unscheduled maintenance was addressed with specific interest directed toward minimizing aircraft downtime for combat damage repair. It is apparent that the application of interim, quick-fix approached for certain combat damage repair is needed to achieve an optimum combat maintenance capability. Selected damage repair techniques are discussed, requirements for further development in this area are also reviewed. B.B.

N78-28090# British Aircraft Corp., Warton (England).
SOME CONSIDERATIONS OF THE LIKELY TOLERANCE TO, AND REPAIR OF, BATTLE DAMAGE IN COMBAT AIRCRAFT STRUCTURES
T. Sharples *In* AGARD Combat Damage Tolerance and Repair of Aircraft Struct. Jun. 1978 p 11-24 (For primary document see N78-28088 19-05)
Avail: NTIS HC A03/MF A01

Design cases and likely margins of strength on the major structural components of typical combat aircraft were outlined. Levels of allowable damage which may be expected for both sharp-edged and cleaned out holes caused by projectile damage to structural skins were examined. Simple skin repairs are then discussed followed by a suggested format for a structural Battle Damage Manual. B.B.

N78-28091# Royal Air Force, London (England).
AIMS AND PROGRESS OF A BATTLE DAMAGE REPAIR CAPABILITY IN THE ROYAL AIR FORCE
C. M. Harris *In* AGARD Combat Damage Tolerance and Repair of Aircraft Struct. Jun. 1978 p 25-28 ref (For primary document see N78-28088 19-05)
Avail: NTIS HC A03/MF A01

The background to the RAF's decision to develop a capability to rapidly repair aircraft that were damaged in combat is discussed, and features of aircraft design which would simplify battle damage repair were studied. B.B.

N78-30099# Advisory Group for Aerospace Research and Development, Paris (France).
FIGHTER AIRCRAFT DESIGN
Jun. 1978 292 p refs Partly in ENGLISH and FRENCH Presented at the Multi-Panel Symp. on Fighter Aircraft Design, Florence, 3-6 Oct. 1977
(AGARD-CP-241, ISBN-92-835-0215-9) Avail: NTIS HC A13/MF A01

The state of technology as related to future fighter aircraft design' is assessed in terms of military requirements for the 80's. System design approach, aerodynamics and aircraft configurations, propulsion, structures design, avionics/guidance, and human factors are among to topics covered. For individual titles, see N78-30100 through N78-30118.

N78-30100# Hawker Siddeley Aviation Ltd., Kingston upon Thames (England).
TECHNOLOGY DEVELOPMENT TO MEET THE MILITARY REQUIREMENTS
R. S. Hooper *In* AGARD Fighter Aircraft Design Jun. 1978 12 p (For primary document see N78-30099 21-05)
Avail: NTIS HC A13/MF A01

Various factors characterizing fighter aircraft are considered with emphasis on airborne agility and survivability. Types of fighter aircraft identified include: interceptor, air combat, and ground attack. Wing and span loading and engine characteristics are also discussed. J.M.S.

N78-30101# Aeronautical Systems Div., Wright-Patterson AFB, Ohio.
ASSURING COMBAT PILOT EFFECTIVENESS
David L. Carleton *In* AGARD Fighter Aircraft Design Jun. 1978 8 p refs (For primary document see N78-30099 21-05)
Avail: NTIS HC A13/MF A01

Pilot selection and training concepts are discussed. Maintaining a high level of proficiency during peacetime is emphasized. Specific programs cited include: fighter lead-in training, graduated combat capability; red flag program; and mission simulator. These programs provide for basic tactics training as well as specific mission capabilities and monitoring and assessing the pilot's performance. The impact of specialized training philosophy on the design criteria for specialized airframes is considered. J.M.S.

N78-30102# Breguet-Aviation, Saint Cloud (France).
PERFECTING ARMAMENTS IN THE FAMILY OF MIRAGE AIRCRAFT [LA MISE AU POINT DES ARMEMENTS DANS LA FAMILLE DES MIRAGE]
M. B. Revellin-Palcoz *In* AGARD Fighter Aircraft Design Jun. 1978 2 p In FRENCH (For primary document see N78-30099 21-05)
Avail: NTIS HC A13/MF A01

The different versions of the Mirage aircraft such as the Mirage 3, Mirage 4, Mirage 5, F1 Mirage and the Mirage 2000 are capable of carrying a large variety of amaments such as bombs, rockets, and air-to-air missiles or air-to-ground missiles. Methods of perfecting and testing these armaments were developed from the initial stage of study, to the drawing stage and including the final stage of flight operations. Various characteristic aspects of these successive stages are reported in detail. Trans. by B.B.

N78-30103# Preyss (Scott) Associates, Los Angeles, Calif.
AIR COMBAT
Albert E. Preyss *In* AGARD Fighter Aircraft Design Jun. 1978 16 p refs (For primary document see N78-30099 21-05)
Avail: NTIS HC A13/MF A01

A solution to the generalized multiple component engagement of opposing military forces is presented. The results provide detailed insights through the use of asymptotic models, human interactive analysis, and topological arguments. The technique is demonstrated by example, using the fighter escort problem. Application to any air combat problem of reasonable dimension is possible. Aircraft performance, avionics, and weaponry are considered. The results can be used to guide the allocation of research and development resources, to evaluate the force mix problem related to new weapon system purchases, and to advise operational commands of deployment and tactics for known forces. J.M.S.

N78-30104# Dornier-Werke G.m.b.H., Friedrichshafen (West Germany)
ADVANCED CONTROL CONCEPTS FOR FUTURE FIGHTER AIRCRAFT
Horst Wunnenberg and Wolfgang J. Kubbat (Messerschmitt-Boelkow-Blohm G.m.b.H., Ottobrunn, West Ger.) *In* AGARD Fighter Aircraft Design Jun. 1978 15 p refs (For primary document see N78-30099 21-05)
Avail: NTIS HC A13/MF A01

In detail the possibilities and limits of new control concepts such as active control technology and reduced static stability and the criteria for the corresponding control surface layout are discussed. Requirements and the technical realization methods for a modern fly by wire digital control technology are presented. Comments on current research programs and future prospects are given. J.M.S.

N78-30105# McDonnell Aircraft Co., St. Louis, Mo.
FIGHTER SUPERIORITY BY DESIGN
W. P. Murden, H. D. Altis, and M. L. Ramey *In* AGARD Fighter Aircraft Design Jun. 1978 16 p (For primary document see N78-30099 21-05)
Avail: NTIS HC A13/MF A01

Aspects of the F-18 program are discussed in terms of increasing combat effectiveness and decreasing combat costs. Combat performance, firepower and weapon system capability, multimission versatility, increased reliability and maintainability, and combat survivability are among the factors considered.
J.M.S.

N78-30106# Avions Marcel Dassault-Breguet Aviation, Saint-Cloud (France). Div. des Etudes Avancees.
AERODYNAMICS OF THE NEW GENERATION OF COMBAT AIRCRAFT WITH DELTA WINGS [AERODYNAMIQUE DE LA NOUVELLE GENERATION D'AVIONS DE COMBAT A AILE DELTA]
M. Pierre Bohn. *In* AGARD, Fighter Aircraft Design, Jun. 1978, 13 p. In FRENCH (For primary document see N78-30099 21-05)
Avail: NTIS HC A13/MF A01

Utilization of various aerodynamic configurations for modern delta wing combat aircraft is discussed in relation to approach speeds and reducing impact damage at Supersonic speeds. Mission requirements such as maneuverability were examined in detail, and principle reasons for the discontinuation of fixed winged aircraft for combat were illustrated. Transl. by B.B.

N78-30107# Air Force Flight Dynamics Lab., Wright-Patterson AFB, Ohio.
SUPERCRUISER FIGHTER ANALYSIS
L. Earl Miller and Valentine Dahlem, III. *In* AGARD, Fighter Aircraft Design, Jun. 1978, 16 p. (For primary document see N78-30099 21-05)
Avail: NTIS HC A13/MF A01

A fighter aircraft that cruises efficiently at supersonic speeds and is effective in air to air combat is considered. Supersonic cruise performance and transonic maneuvering requirements are emphasized. Speed advantage, ability to engage or disengage at will, maintaining control over the combat arena, and target acquisition are among the factors analyzed. From differential game technology, supercruiser maneuvering requirements are determined as a function of the threat's maneuvering capability. Wind tunnel results indicate that a small single aircraft can be configured to produce the level of efficiency necessary for supersonic cruise.
J.M.S.

N78-30108# *Naval Air Systems Command*, Washington, D. C.
ANALYSIS OF ADVANCED VARIABLE CAMBER CONCEPTS
R. F. Stewert and R. E. Whitehead (ONR, Arlington, Va.). *In* AGARD, Fighter Aircraft Design, Jun. 1978, 21 p. refs (For primary document see N78-30099 21-05)
Avail: NTIS HC A13/MF A01

A survey of variable camber devices used on contemporary fighter aircraft to improve maneuverability in the air combat flight regime is presented. Variable camber concepts which offer potential for even greater benefits on future fighter aircraft designs are discussed. Finally, some analysis is presented which provides insight into the advantages that are achieved in various off-design conditions with the use of these variable camber concepts.
J.M.S.

N78-30109# Motoren- und Turbinen-Union Muenchen G.m.b.H. (West Germany).
VARIABLE-CYCLE ENGINE FIGHTER AIRCRAFT: ADVANCE IN PERFORMANCE AND DEVELOPMENT PROBLEMS
H. Grieb, W. Weiler, and G. Weist. *In* AGARD, Fighter Aircraft Design, Jun. 1978, 16 p. refs. Sponsored by Min. of Defence of Federal Rep. of Ger. (For primary document see N78-30099 21-05)
Avail: NTIS HC A13/MF A01

The requirements on engines for civil and military supersonic aircraft and the interest in variable cycle engines are explained. In addition, the variable cycle engine concepts and their function are described briefly. For two concepts of variable cycle engines for fighter aircraft, the operating characteristics, performance data, and leading design features are discussed. These examples are used to contrast the advances offered by such engines against the problems to be overcome. It is shown that, whereas the desired flexibility in operating characteristic and performance is feasible, the extra engine weight and complexity compared with conventional engines is very substantial. For a fighter aircraft, a simplified comparison of effectivity is made between the installation of variable cycle engine concepts and two types of conventional engines with different bypass ratio. It is shown that the extra weight to be expected with variable cycle engines investigated so far, does not justify their future application.
J.M.S.

N78-30110# National Gas Turbine Establishment, Farnborough (England).
INTAKE DESIGN FOR FIGHTER AIRCRAFT
J. Dunham. *In* AGARD, Fighter Aircraft Design, Jun. 1978, 15 p. refs. Sponsored in part by RAE (For primary document see N78-30099 21-05)
Avail: NTIS HC A13/MF A01

An outline is given of the requirements placed upon the intake designer. Low external drag, high intake pressure recovery and low distortion of the engine face flow are demanded, over a wide range of aircraft maneuvers at subsonic speeds as well as through the transonic and supersonic speed ranges. All this is to be accomplished at minimum cost, weight, and complexity. Some of the factors involved in the design are discussed. These include intake location, blunt cowl lips and their influence on incidence range, matching of engine flow demand with intake capacity, dynamic distortion measurement, and the control system for a variable intake. An assessment of the state of the art, research requirements, and possible technological advances is given.
J.M.S.

N78-30111# Air Force Aero Propulsion Lab., Wright-Patterson AFB, Ohio. Turbine Engine Div.
ADVANCE NOZZLE TECHNOLOGY
Lawrence D. Wolfe and Arthur E. Fanning. *In* AGARD, Fighter Aircraft Design, Jun. 1978, 31 p. (For primary document see N78-30099 21-05)
Avail: NTIS HC A13/MF A01

The exhaust concepts developed as design options for use on turbine engines which are to power advanced fighter aircraft are discussed with emphasis on nonaxisymmetric nozzle configurations. Nozzle performance, cooling effectiveness, and structural integrity at minimum weight are among the topics studied. Variations in thrust vector schedule, aircraft wing loading, and thrust loading are included. An example is used to illustrate the point that certain nonaxisymmetric nozzle and thrust vectoring schemes introduce an additional degree of complexity into the procedures necessary to properly account for the applied forces.
J.M.S.

N78-30112# Societe Nationale d'Etudes et de Construction de Moteurs d'Aviation, Moissy-Cramayel (France).
STUDY OF A COMPROMISE BETWEEN THE COMPLEXITY OF A ROCKET ENGINE AND ITS COST [LA RECHERCHE D'UN COMPROMIS ENTRE LA COMPLEXITE D'UN MOTEUR DE CHASSEUR ET SON COUT]
J. F. Chevalier. *In* AGARD, Fighter Aircraft Design, Jun. 1978, 8 p. In FRENCH (For primary document see N78-30099 21-05)
Avail: NTIS HC A13/MF A01

The cost of an aircraft is often related to takeoff weight or the complexity of the engine. The performance of the engine can reduce the weight of the aircraft and also the cost of the entire aircraft. These two aspects are discussed in detail. Aircraft weight and costs were calculated and the following missions were analyzed: (1) low altitude penetration, (2) tactical support, (3) aerial superiority; and (4) interception. Transl. by B.B.

N78-30113# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (West Germany).
IMPACT OF ACTIVE CONTROL ON STRUCTURES DESIGN
O. Sensburg and H. Zimmermann (Vereinigte Flugtechn. Werke-Fokker G.m.b.H., Bremen, West Ger.). *In* AGARD, Fighter Aircraft Design, Jun. 1978, 26 p. refs (For primary document see N78-30099 21-05)
Avail: NTIS HC A13/MF A01

A review of active control technologies is given with emphasis on fighter aircraft structures design. Artificial lateral stability, longitudinal stability, maneuver load control, and gust load alleviation are considered along with fatigue reduction, ride quality improvement, and active flutter suppression.
J.M.S.

N78-30114# Departement Structures B. E. Aerospatiale, Toulouse (France).
NEW STRUCTURES MADE OF COMPOSITE MATERIALS FOR HIGH PERFORMANCE COMBAT AIRCRAFT [STRUCTURES NOUVELLES EN MATERIAUX COMPOSITES A HAUTES PERFORMANCES POUR AVIONS DE COMBAT]
Gilbert Correge. *In* AGARD, Fighter Aircraft Design, Jun. 1978, 18 p. In FRENCH (For primary document see N78-30099 21-05)
Avail: NTIS HC A13/MF A01

Composite materials utilized in aircraft construction are described. Other areas of study are the following: (1) Types of composite structures utilized; (2) Materials; (3) Principles of

local reinforcement, and (4) Protection against lightning strike
Transl by B B

N78-30115# Hawker Siddeley Aviation Ltd., Kingston upon Thames (England)
METAL TECHNOLOGY FOR FUTURE AIRCRAFT DESIGN
Roger S Dabbs *In* AGARD Fighter Aircraft Design Jun 1978 16 p (For primary document see N78-30099 21-05)
Avail NTIS HC A13/MF A01

Requirements of a material to be used for aircraft structures are discussed These include strength and stiffness, service life, vulnerability, repairability, inspectability, and cost effectiveness Aluminum alloys, titanium alloys, and steels are among the metallic materials considered for application to future aircraft structures The performance of metallic materials and graphite composites is compared J M S

N78-30116# Messerschmitt-Boelkow-Blohm G m b H., Munich (West Germany) Dept of Human Engineering
DISPLAY SYSTEMS AND COCKPIT DESIGN
Ruediger Seifert and Hans Denkscherz *In* AGARD Fighter Aircraft Design Jun 1978 11 p (For primary document see N78-30099 21-05)
Avail NTIS HC A13/MF A01

A concept for a new cockpit design technology is presented The need for a technology is dictated by the technical requirement for saving cockpit weight and space, resulting from the high g operations requirements, and from the operational requirement for limiting the quantitative personnel requirements The basis for the technology is given by the present knowledge concerning the information processing capabilities of man, and by the empirical results of measurements of the time budget of man in man machine operations From this the display and control modalities are derived, which ensure better utilization of the pilot's capabilities in the future fighter aircraft This concept is considered to increase the system capacity of manned fighter aircraft, compared with the equipment overloaded aircraft of today The principle allocation of the display and control function to the equipment and an example for the required characteristic for the functions in accordance to the time budget considerations are given J M S

N78-30117# Boeing Co., Seattle, Wash
APPLICATION TECHNIQUES FOR DIGITAL FLIGHT CONTROL SYSTEMS
Donald L Martin *In* AGARD Fighter Aircraft Design Jun 1978 12 p refs (For primary document see N78-30099 21-05)
Avail NTIS HC A13/MF A01

System design and implementation considerations in application of digital processing and signal transmission techniques to flight control systems are discussed The digital flight control design cycle and both the overall similarity with analog implementation and the differences associated with software requirements specification are covered Design problems that result from the digital processing are reviewed along with software development and testing at both the software and system development levels The three channel redundant flight control computer used on the Boeing YC-14 advanced medium STOL transport is described along with advantages of digital applications J M S

N78-30118# British Aircraft Corp., Warton (England) Military Aircraft Div
THE DESIGN OF A HIGH g COCKPIT
A G Barnes *In* AGARD Fighter Aircraft Design Jun 1978 12 p refs (For primary document see N78-30099 21-05)
Avail NTIS HC A13/MF A01

The physiological factors of operating under high g are discussed The geometric aspects of reclining the pilot's seat, in order to achieve a measure of g alleviation, are illustrated The implications of such a change with respect to displays and controls are considered along with techniques which offer solutions to the problems associated with displays and controls Radical changes in cockpit layout are implied J M S

N79-12080# Advisory Group for Aerospace Research and Development, Paris (France)
TECHNICAL EVALUATION REPORT ON THE SPECIALISTS' MEETING OF THE FLIGHT MECHANICS PANEL ON PILOTED AIRCRAFT ENVIRONMENT SIMULATION TECHNIQUES
K J Staples (RAE, Bedford, England) Oct 1978 18 p Meeting held at Brussels, 24-27 Apr 1978
(AGARD-AR-126, ISBN-92-835-1299-5) Avail NTIS HC A02/MF A01

The proceedings of a meeting concerning the flight mechanics of and simulation techniques of piloted aircraft environments are presented Some of the following topics are discussed (1) requirements on simulation of the environment, (2) simulation of the atmospheric environment, and (3) out of the cockpit visual scenes B B

N79-15036# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France)
AIRCRAFT ICING
Nov 1978 136 p refs Presented at an AGARD Fluid Dyn Panel Round-Table Discussion on Aircraft Icing, Ottawa, 30 Sep 1977
(AGARD-AR-127, ISBN-92-835-1302-9) Avail NTIS HC A07/MF A01

Icing of unprotected components is one of the major problems engineers are faced with during the development phase of an aircraft The Fluid Dynamics Panel of AGARD held a round-table discussion of the fluid dynamic aspect of icing This took place following the FDP Symposium on Unsteady Aerodynamics in Ottawa, Canada on the 30th of September, 1977. Papers are presented on the following topics: (1) recent results on icing parameters, (2) helicopter ice detection, icing severity and liquid water content measurement; (3) icing trails on the front fuselage and engine intake of helicopters at conditions simulating forward flight; (4) ice accretion and its effects on aerodynamics of unprotected aircraft components; (5) a theoretical and experimental means to predict ice accretion shapes for evaluating aircraft handling and performance characteristics; and (6) icing test facilities and techniques in Europe For individual titles, see N79-15037 through N79-15043

N79-15037# Messerschmitt-Boelkow-Blohm G m b H., Hamburg (West Germany)
SOME RESULTS ON ICING PARAMETERS
W Kleuters and G Woelfer *In* AGARD Aircraft Icing Nov 1978 18 p refs (For primary document see N79-15036 06-05)
Avail: NTIS HC A07/MF A01

Meteorological icing data on forty-seven encounters in cumulus clouds over western central Europe are analyzed statistically, and compared with similar data quoted in FAR 25 Appendix C The data for FAR 25 Appendix were obtained by the Rotating Cylinder method, a measuring device with a capacity limited to relatively low liquid content and/or low temperatures. To overcome these limitations, the liquid water content was measured in these tests by employing a liquid-nitrogen-cooled Test Rod, enabling measurements of liquid water content up to 3 g/cu m G Y

N79-15038# National Research Council of Canada, Ottawa (Ontario). Div. of Mechanical Engineering
HELICOPTER ICE DETECTION, ICING SEVERITY AND LIQUID WATER CONTENT MEASUREMENTS
J. R. Stallabrass *In* AGARD Aircraft Icing Nov 1978 7 p refs (For primary document see N79-15036 06-05)
Avail NTIS HC A07/MF A01

Icing detection on a helicopter presents difficulties because of the wide relative speed range from hover to maximum cruise. High detection sensitivity is necessary at any flight speed because of the high susceptability of the rotor blades to the effects of even quite small ice accretion An icing detector is described that largely overcomes the problem of speed dependence and thus permits the determination of icing rate and cloud liquid water content with reasonable accuracy G Y

N79-15039# National Gas Turbine Establishment, Pyestock (England). Engine Test Dept
ICING TRIALS ON THE FRONT FUSELAGE AND ENGINE INTAKES OF HELICOPTERS AT CONDITIONS SIMULATING FORWARD FLIGHT
P. F Ashwood and R D Swift *In* AGARD Aircraft Icing Nov 1978 16 p refs (For primary document see N79-15036 06-05)
Avail NTIS HC A07/MF A01

One of the large test chambers of the Altitude Test Facility at the NGTE was successfully used for full-scale trials on the front fuselage and engine intakes of the Westland Sea King and the Westland/Aerospatiale Lynx helicopters under simulated wet icing conditions The paper describes tests made to examine the effects of air temperature, air speed, water concentration and aircraft attitude on the extent of ice accretion The possibility of ice ingestion by the engines during melt-off was also studied using high-speed videotape recordings Data are also presented

from non-rotating tests on full scale sections of main rotor blade made to examine the effects on accretion of bladespeed, pitch angle, air temperature and water concentration. The effects of cyclic pitch change have also been examined and typical results are presented. The paper includes general comments on the use of an altitude cell for helicopter icing investigations and the accumulation of data leading to clearance for flight in icing conditions. Author

N79-15040# Messerschmidt-Boelkow-Blohm G.m.b.H., Ottobrunn (West Germany).

ICE ACCRETION AND ITS EFFECTS ON AERODYNAMICS OF UNPROTECTED AIRCRAFT COMPONENTS

Boris Laschka and Rudolf E. Jesse. *In* AGARD Aircraft Icing Nov. 1978 22 p refs (For primary document see N79-15036 06-05)

Avail: NTIS HC A07/MF A01

A survey is given on theoretical and experimental methods applied to determine the ice accretion and its effects on the respective aerodynamics on unprotected components of a modern jet transport aircraft. Together with an introductory outline of the mechanism and the basic mathematical equations and correlations ruling ice generation, the experience obtained for the European Airbus A300 is used to describe these methods. In addition, an example for the prediction of trajectories of shedding ice particles as applied for the German jet transport aircraft VFW 614 is given. Author

N79-15041# Boeing Co., Seattle, Wash.

A THEORETICAL AND EXPERIMENTAL MEANS TO PREDICT ICE ACCRETION SHAPES FOR EVALUATING AIRCRAFT HANDLING AND PERFORMANCE CHARACTERISTICS

Ramon W. Wilder. *In* AGARD Aircraft Icing Nov. 1978 20 p refs (For primary document see N79-15036 06-05)

Avail: NTIS HC A07/MF A01

To determine the need for airfoil ice protection systems and the effects of large ice shapes on airplane performance, a research program was initiated to obtain basic ice accretion and ice shedding data on typical jet transport airfoils. An empirical relationship derived from basic airfoil water catch parameters was used to correlate measured ice accretion rates with theoretical water impingement parameters. This correlation used glaze ice heights and angles measured from the plaster casts of the actual ice shapes as taken from the two swept airfoil test models. Results of this correlation show that ice accretion characteristics are dependent on airfoil shape, particularly leading edge radius, camber and angle of attack. Complex trends of the data obtained in this test program precluded a general ice accretion relationship with other airfoils. Additional testing of other airfoil shapes and angle of attack would provide for broader application of the ice cap calculation procedures developed herein. Airplane performance penalties associated with icing in terms of landing weight penalties, and when these penalties are assessed, are also discussed. Destination airport temperatures and ice shedding characteristics are shown to be significant in determining the frequency of aerodynamic penalties due to ice. Author

N79-15042# Office National d'Etudes et de Recherches Aerospatiales, Paris (France).

ICING TEST FACILITIES AND TEST TECHNIQUES IN EUROPE

Marcel Pierre and Xavier Vaucheret. *In* AGARD Aircraft Icing Nov. 1978 23 p refs (For primary document see N79-15036 06-05)

Avail: NTIS HC A07/MF A01

Icing techniques performed at various test facilities in Europe are described. The locations of the facilities are given with special emphasis on the Onera Modane center for icing tests. Problems encountered in performing artificial icing tests in wind tunnels are discussed. L.S.

N79-15043# National Research Council of Canada, Ottawa (Ontario). Div. of Mechanical Engineering.

ICING TEST FACILITIES IN CANADA

T. R. Ringer. *In* AGARD Aircraft Icing Nov. 1978 12 p refs (For primary document see N79-15036 06-05)

Avail: NTIS HC A07/MF A01

The icing simulation facilities for research, development and testing at the National Research Council of Canada are described. The major facilities include a low speed icing wind tunnel, a high speed variable density tunnel, a refrigerated jet engine test cell and a helicopter icing spray rig. An Appendix is included that lists reports and papers published on icing since 1935. Author

N79-23074# Advisory Group for Aerospace Research and Development, Paris (France).

HELICOPTER FATIGUE. A REVIEW OF CURRENT REQUIREMENTS AND SUBSTANTIATION PROCEDURES

Feb. 1979 74 p refs In ENGLISH, partly in FRENCH Presented at the 47th Meeting of the Struct. and Mater. Panel, Florence, 25-29 Sep. 1978

(AGARD-R-674, ISBN-92-835-0232-9) Avail: NTIS HC A04/MF A01

A detailed review of current fatigue requirements and substantiation procedures in the United States, United Kingdom, Germany, Italy, and France in the field of helicopter fatigue is presented. Although general requirements and specifications seem to be very similar, approved procedures applied by manufacturers may sometimes appear to be rather arbitrary or, in some cases, to differ significantly from one firm to another. For individual titles, see N79-23075 through N79-23079.

N79-23075# Army Aviation Research and Development Command, St. Louis, Mo. Structures and Aeromechanics Branch.

US ARMY HELICOPTER FATIGUE REQUIREMENTS AND SUBSTANTIATION PROCEDURES

Robert A. Wolfe and Robert W. Arden. *In* AGARD Helicopter Fatigue Feb. 1979 p 1-12 refs (For primary document see N79-23074 14-05)

Avail: NTIS HC A04/MF A01

The current fatigue criteria and testing requirements are provided for U.S. Army helicopter structures with primary emphasis on dynamic components. The comparative industry applications of the requirements were brought to light as a result of the Army's latest major helicopter competitions for the Utility Tactical Transport Aircraft System, recently designated BLACK HAWK, and the Advanced Attack Helicopter. These competitions resulted in evaluations by the Army of four major helicopter companies (two competitors for each program) and provided significant lessons learned in future Army fatigue requirements primarily because of differences in loads application, S/N curves shape criteria, working level curve deviations and component testing techniques applied by each contractor. These differences and how they relate to the current Army requirements were addressed. As a result of these lessons learned, the Army is in the process of specifying new fatigue requirements for future helicopter procurements. J.A.M.

N79-23076# Westland Helicopters Ltd., Yeovil (England).

HELICOPTER FATIGUE EVALUATION. THE UK APPROACH

A. D. Hall. *In* AGARD Helicopter Fatigue Feb. 1979 p 13-20 (For primary document see N79-23074 14-05)

Avail: NTIS HC A04/MF A01

The philosophies of fatigue substantiation were used satisfactorily for the Lynx and it is considered that the practicability of the approach has been well established. The main concern was with the safe fatigue life substantiation of the vital components of a helicopter and consideration is given to three phases in the life cycle, i.e. design, development, and production. It is shown how the prototype aircraft is defined from the fatigue strength point of view and how flight testing and development testing of the prototype leads in turn to the production definition. J.A.M.

N79-23077# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (West Germany).

FATIGUE LIFE ESTIMATION METHODS FOR HELICOPTER STRUCTURAL PARTS

F. Och. *In* AGARD Helicopter Fatigue Feb. 1979 p 21-27 refs (For primary document see N79-23074 14-05)

Avail: NTIS HC A04/MF A01

Analytical fatigue life estimation mainly consisted of three steps: prediction of loads, determination of fatigue strength, and application of a damage hypothesis linking these two aspects. Following the above mentioned three steps of fatigue life investigation, methods for the prediction of loads were dealt with according to the available amount of information. Similarly, it then investigated methods describing the fatigue strength of components, taking into account the influence of steady loads and the reduction of a mean S/N curve to a working level curve. J.A.M.

N79-23078# Costruzioni Aeronautiche Giovanni Agusta S.p.A., Gallarate (Italy).

PRESENT FATIGUE ANALYSIS AND DESIGN OF HELICOP-

TERS REQUIREMENTS AND QUALIFICATION PROCEDURES
Pietro Alli *In* AGARD Helicopter Fatigue Feb 1979 p 29-46 refs (For primary document see N79-23074 14-05)
Avail *NTIS HC A04/MF A01*

The state-of the-art in AGUSTA in the area of structural fatigue and fail-safe strength evaluation is reported The need of general regulations and procedures was pointed out The convenience of automatic procedures was underlined. J A M

N79-23079# Societe Nationale Industrielle Aerospatiale, Paris (France) Helicopter Div
FATIGUE OF HELICOPTERS: SERVICE LIFE EVALUATION METHOD
F Liard *In* AGARD Helicopter Fatigue Feb 1979 p 47-69 In ENGLISH and FRENCH (For primary document see N79-23074 14-05)
Avail NTIS HC A04/MF A01

The general principle of fatigue substantiation for helicopter components consists in evaluating the fatigue strength of the component, determining the value and frequency of the loads to which it will be subjected during normal operation, and then deriving from these data the steps to be taken to make the possible occurrence of serious accidents due to the failure of the component extremely remote The method differs for the parts mainly di uensioned by high cycle fatigue (rotors and gearboxes) and for those subjected to low cycle fatigue (e.g *fuselage). Safety is determined from the stress* in the 1st case and the number of cycles in the 2d case Where both types of fatigue are encountered, various methods allow taking into account their superimposition, but each of them leads to practical problems These two modes of fatigue being two aspects of a same phenomenon, it seems realistic to use a single approach and select the acceptable total risk, whether the damage is calculated for each load level or the tests are conducted under programmed loads In both cases, it would be necessary to have the equal probability-of-failure curves between a few cycles and the infinite, which has not been achieved to date. Composite materials could be given the same treatment as metals as reqards fatigue strength and that their fail safety could be taken into account when the first deteriorate appear on external surfaces. A.R.H

N79-23957# Advisory Group for Aerospace Research and Development, Paris (France)
TECHNICAL EVALUATION REPORT ON THE 26TH GUIDANCE AND CONTROL PANEL SYMPOSIUM ON THE IMPACT OF INTEGRATED GUIDANCE AND CONTROL TECHNOLOGY ON WEAPONS SYSTEMS DESIGN
Morris A. Ostgaard Mar 1979 13 p refs Symp held in Sandefjord, Norway, 9-12 May 1978
(AGARD-AR-140, ISBN-92-835-1317-7) Avail NTIS HC A02/MF A01

The significant conclusions and recommendations resulting from the technical evaluation are (1) there appears to be heavy reliance on well-defined requirements and operational concepts before technology innovations are stimulated. (2) technology will support increased functional integration and standardization for interoperability as evidenced by the use of a common Kalman filter for several positioning systems and multiple use of the horizontal station display for both command and control and map display purposes, *(3) mission tailored control* laws properly supported by mission display information can reduce pilot workload. (4) missile systems are critically dependent upon positioning systems and functional integration to satisfy critical performance cost, weight, and volume constraints, and (5) multiple use of common sensors, particularly for control and positioning, were shown to be technically practical Author

N80-10202# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France)
AGARD TWO-DIMENSIONAL AEROELASTIC CONFIGURATIONS
S R Bland, Comp Aug 1979 16 p refs Submitted for publication Prepared in cooperation with NASA Langley Res Center
(AGARD-AR-156) Avail NTIS HC A02/MF A01

The development of reliable, efficient methods for the calculation of unsteady aerodynamic forces in the frequency-critical transonic speed regime can be enhanced by the availability of a *limited number of test cases for the comparison* of competing methods Seven test cases are presented for airfoils with thickness from 6.0% to 16.5% a biconvex parabolic arc airfoil, three conventional airfoils, and three cambered supercritical airfoils The aerodynamic conditions such as Mach number, mean angle of attack, and oscillation amplitude and frequency *are also given* Recommendations are made for uniformity in definition and reporting to enhance desired comparison for the aeroelastician A R H

N80-10203# *Advisory Group for Aerospace Research* and Development, Neuilly-Sur-Seine (France)
MANOEUVRE LIMITATIONS OF COMBAT AIRCRAFT
Aug 1979 33 p refs
(AGARD AR-155A, ISBN-92-835-1336-3) Avail NTIS HC A03/MF A01

The choice of aircraft detail arrangement and configuration is closely related to desired flight speed, altitude and maneuverability The maneuver limitations that are directly related to configuration, flight speed and attitude are reasonably independent of airplane size and engine thrust These limiting flight characteristics include pitchup, wing rock, wing drop, nose slice, and buffeting These configuration and detail-sensitive limitations and the aircraft characteristics that cause them are discussed for 15 NATO aircraft A R H

N80-19090# Advisory Group for Aerospace Research and Development, Paris (France)
DYNAMIC ENVIRONMENTAL QUALIFICATION TECHNIQUES
Nov 1979 40 p refs Meeting held in Williamsburg, Va., Apr 1979
(AGARD-R-682, ISBN-92-835-1342-8) Avail NTIS HC A03/MF A01

Dynamic qualification test procedures are discussed with emphasis on determining the resistance of equipment to the effects of environments peculiar to military operations and requirements For individual titles, see N80-19091 through N80-19093

N80-19091# Aeronautical Systems Div., Wright-Patterson AFB, Ohio
APPLICATION OF MIL-STD-810C DYNAMIC REQUIREMENTS TO USAF AVIONICS PROCUREMENTS
J H Wafford *In* AGARD Dyn Environ Qualification Tech Nov 1979 11 p refs (For primary document see N80-19090 *10-05)*
Avail NTIS HC A03/MF A01

The vibration requirements and the application of these requirements to the procurement of avionics equipment are discussed. Data obtained from external noise measurements and aerodynamically induced vibration are reported R C T

N80-19092# Messerschmidt-Boelkow G m b H., Munich (West Germany) Unternehmensbereich Flugzeuge
DYNAMIC ENVIRONMENTS AND TEST SIMULATION FOR QUALIFICATION OF AIRCRAFT EQUIPMENT AND EXTERNAL STORES
G Haidl, C Lodge (British Aerospace Aircraft Group, Warton, England), and H Zimmermann (Vereinigte Flugtechnische Werke-Fokker G m b H., Bremen, West Germany) *In* AGARD Dyn Environ Qualification Tech Nov 1979 13 p refs (For primary document see N80-19090 10-05)
Avail NTIS HC A03/MF A01

Equipment within an aircraft was exposed to a wide variety of environments during ground and flight operations in order to determine its reliability and performance under conditions which will be encountered during its service life Test specifications based upon real environments, but simplified for simulation were established Significant observations and results are reported R C T

N80-19093# British Aerospace Aircraft Group, Bristol (England)
CIVIL AIRCRAFT EQUIPMENT ENVIRONMENT QUALIFICATION TECHNIQUES
B W Payne and G H F Nayler *In* AGARD Dyn Environ Qualification Tech Nov 1979 10 p refs (For primary document see N80-19090 10-05)
Avail NTIS HC A03/MF A01

The vibration testing of civil aircraft equipment is discussed The environmental test levels that are existing in international requirements for civil aircraft are presented R C T

N80-19094# Advisory Group for Aerospace Research and Development, Paris (France)
PARAMETER IDENTIFICATION
Nov 1979 353 p refs Lecture held in Delft, Netherlands, 29-30 Oct 1979 and in London, 1-2 Nov 1979

(AGARD-LS-104, ISBN-92-835-1340-1) Avail NTIS HC A16/MF A01

The present state of the art of aircraft parameter identification techniques is reviewed. A critical appraisal of current methods developed and applied to the problems of analysis of flight test data in a number of NATO countries is given. Particular emphasis is placed on the practical aspects of aircraft parameter estimation to generate information useful for the flight test engineer. For individual titles see N80-19095 through N80-19104.

N80-19095# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick (West Germany). Inst. fuer Flugmechanik.

AIRCRAFT PARAMETER IDENTIFICATION METHODS AND THEIR APPLICATIONS: SURVEY AND FUTURE ASPECTS

P. G. Hamel *In* AGARD Parameter Identification Nov. 1979 26 p refs (For primary document see N80-19094 10-05) Avail NTIS HC A16/MF A01

An overall view of the methods for the determination of aircraft flight mechanic parameters from flight tests and the problems associated with them is given. Technologies in the field of instrumentation, data handling, and data processing as well as improved methodologies for optimum control input design are covered. The application spectrum for parameter identification including aircraft handling qualities investigations and acceptance testing is emphasized. J.M.S.

N80-19096*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

IDENTIFICATION EVALUATION METHODS

Vladislav Klein *In* AGARD Parameter Identification Nov. 1979 21 p refs (For primary document see N80-19094 10-05) Avail NTIS HC A16/MF A01 CSCL 01C

Methods for airplane parameter estimation, the equation error method, output error method, and two advanced methods are presented and their basic properties described. The advanced methods include the maximum likelihood and extended Kalman filter method. For a better understanding of the estimation techniques a first-order scalar differential equation is used as a model of the system under test. Application of the methods to a general multivariable linear system is briefly outlined. A note on the parameter estimation in the frequency domain is also presented. Numerical examples along with the comparison of results from various methods are given. J.M.S.

N80-19097# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick (West Germany). Inst. fuer Flugmechanik.

PRACTICAL INPUT SIGNAL DESIGN

E. Plaetschke and G. Schulz (DFVLR, Oberpfaffenhofen, West Germany) *In* AGARD Parameter Identification Nov. 1979 19 p refs (For primary document see N80-19094 10-05) Avail NTIS HC A16/MF A01

The design of optimal inputs for identifying stability and control derivatives of the longitudinal and lateral motion of an aircraft is considered. First the purpose of input optimization, the constraints, and an overview of the literature is presented. Then two different procedures of input design are treated in more detail. Starting with investigations in the frequency domain the first method yields a multistep input signal, which fulfills specific spectral requirements. The second way of input design is based on the optimization of different measures of the Fisher information matrix, such as determinant or trace. Depending on the measure used, the designed signals differ with respect to their spectral composition. The discussed input signals, which were used in a flight test program, are compared with respect to the achieved accuracy of the identified stability and control derivatives. J.M.S.

N80-19098# National Aerospace Lab., Amsterdam (Netherlands).

ASPECTS OF FLIGHT TEST INSTRUMENTATION

J. H. Breeman, K. vanWoerkom, H. L. Jonkers, and J. A. Mulder *In* AGARD Parameter Identification Nov. 1979 22 p refs Prepared in cooperation with Technische Hogeschool, Delft, Netherlands (For primary document see N80-19094 10-05) Avail NTIS HC A16/MF A01

The design of the instrumentation system for parameter estimation tests is considered. Specifications of instrumentation for nonsteady flight testing are discussed along with general aspects and selection criteria of various transducer types. As practical examples parts of the high accuracy instrumentation systems developed for the determination of performance and stability and control characteristics for dynamic maneuvers are described. Problems of signal conditioning are discussed. J.M.S.

N80-19099# Technische Hogeschool, Delft (Netherlands). Dept. of Aerospace Engineering.

ANALYSIS OF AIRCRAFT PERFORMANCE STABILITY AND CONTROL MEASURES

J. A. MUlder, H. L. Jonkers, J. J. Horsten, J. H. Breeman, and J. L. Simons *In* AGARD Parameter Identification Nov. 1979 87 p refs Prepared in cooperation with National Aerospace Lab., Amsterdam (For primary document see N80-19094 10-05) Avail NTIS HC A16/MF A01

An overview is presented of the nonsteady flight test technique. Principal elements of this technique which is directed towards time efficient and accurate determination of performance characteristics as well as stability and control characteristics from measurements in nonsteady or quasi-steady flight, are application of high quality flight test instrumentation systems, accurate reconstruction of the aircraft's motions, identification of nonlinear aerodynamic models, and calculation of performance, stability and control characteristics by correction of nonsteady or quasi-steady flight conditions towards prespecified nominal conditions. Main emphasis is on a tutorial exposition of the first three of these elements. In addition to the tutorial presentation some experimental results of various flight test programs are presented. J.M.S.

N80-19100*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Center, Edwards, Calif.

AIRCRAFT IDENTIFICATION EXPERIENCE

Kenneth W. Iliff In AGARD Parameter Identification Nov. 1979 35 p refs (For primary document see N80-19094 10-05) Avail NTIS HC A16/MF A01 CSCL 01C

Important aspects of estimating the unknown coefficients of the aircraft equations of motion from dynamic flight data are presented. The primary topic is the application of the maximum likelihood estimation technique. Basic considerations that must be addressed in the estimation of stability and control derivatives from conventional flight maneuvers are discussed. Some complex areas of estimation (such as estimation in the presence of atmospheric turbulence, estimation of acceleration derivatives, and analysis of maneuvers where both kinematic and aerodynamic coupling are present) are also discussed. R.E.S.

N80-19101# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick (West Germany). Inst. fuer Flugmechanik.

ROTORCRAFT IDENTIFICATION EXPERIENCE

J. Kaletka *In* AGARD Parameter Identification Nov. 1979 32 p refs (For primary document see N80-19094 10-05) Avail NTIS HC A16/MF A01

An overview of the identification of stability and control derivatives of the rotorcraft with respect to practical aspects and applications is presented. First an introduction to the basic dynamics and control of helicopters is given. The helicopter characteristics causing difficulties in the identification are discussed. Measurement and sensor problems are also discussed. Approaches to overcome the difficulties are presented. Emphasis is placed on the following two key elements of the identification procedure: (1) the selection of adequate mathematical models and identifiable derivatives of the helicopter to isolate significant model effects, and (2) possibilities of increasing the information content of flight test data by appropriate system excitation and by multiple-run evaluations. Identification results obtained from simulated and flight test data of helicopters by applying different identification methods are presented. R.E.S.

N80-19102# Royal Aircraft Establishment, Farnborough (England). Flight Systems Dept.

IDENTIFICATION EXPERIENCE IN EXTREME FLIGHT REGIMES
A Jean Ross *In* AGARD Parameter Identification Nov 1979 15 p refs (For primary document see N80 19094 10-05)
Avail NTIS HC A16/MF A01

A mathematical model for identifying stability and control derivatives of fighter aircraft is presented The principles of the statistical approach are described The treatment of the nonlinear terms is described and the tests which should be applied to assess the validity of the results are discussed Selected results from investigations of manoeuvres at high angles of attack are presented to show the types of problems which can be solved, and to illustrate some effects of nonlinearities R E S

N80-19103# Institut de Mecanique des Fluides de Lille (France)
WIND TUNNEL AND FREE FLIGHT MODEL IDENTIFICATION EXPERIENCE
R A Verbrugge, W Charon, and M Marchand (DFVLR, Brunswick) *In* AGARD Parameter Identification Nov 1979 33 p refs (For primary document see N80-19094 10-05)
Avail NTIS HC A16/MF A01

An overview of different experimental techniques used for parameter identification based on dynamic model tests in wind tunnel or in free flight is presented The specific domain of application is defined for each test technique Particular aspects of semi-free and free model tests techniques in wind tunnel or laboratory experiences are described Data processing from the collection until the application of identification procedure is discussed in terms of (1) the nature and quality of the information, (2) the data acquisition software, (3) the state vector elaboration, and (4) some specific filter aspects and evaluation methods A set of results illustrate each particular point A review of the present state of these techniques is given and future field of application is discussed R E S

N80-19104# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick (West Germany) Inst fuer Flugmechanik
CLOSED LOOP ASPECTS OF AIRCRAFT IDENTIFICATION
R Koehler and K Wilhelm *In* AGARD Parameter Identification Nov 1979 24 p refs (For primary document see N80-19094 10-05)
Avail NTIS HC A16/MF A01

Specific problems of system identification applied to highly augmented aircraft with respect to flying qualities assessment are discussed An introduction to the influence of augmentation system on dynamic response and flying qualities is given The application of parameter estimation techniques to control loop systems and problems of control loop identification and equivalent system modellization are discussed R E S

X80-72062# Advisory Group for Aerospace Research and Development, Paris (France).
AVIONICS/GUIDANCE AND CONTROL FOR REMOTELY PILOTED VEHICLES (U)
Jun 1977 568 p Joint Symp held at Florence, 4-8 Oct 1976 This document is not available from the NASA STI Facility All requests must be directed to AGARD Hq
(AGARD-CP-213) NATO Secret report

The state of the art in avionics, guidance, and control is surveyed Topics covered include the following operational concepts and requirements; electro-optical sensors, radar and radiometric sensors; communications, guidance and flight control techniques, target acquisition and weapon delivery, command and control J M S

X80-72063 Advisory Group for Aerospace Research and Development, Paris (France).
INTERCEPTION OF MACH 3 AIRCRAFT BY FIGHTERS, VOLUME 1 (U)
Jun 1978 78 p This document is not available from the NASA STI Facility All requests must be directed to AGARD Hq
(AGARD-AR-102-Vol-1) NATO Secret report

An investigation was performed to identify (1) feasible intercept fighter systems (consisting of manned aircraft with their fire control systems and air to air missiles) for the near term (1977-1985) and the long term (1985-2000), (2) tactics for the employment of these fighters, and (3) the most promising areas for research and development On the basis of parametric studies of the most important technical and operational factors, the study concludes that it is possible to propose options for alternate solutions and to identify advantages and drawbacks of each potential solution R E S

X80-72064# Advisory Group for Aerospace Research and Development, Paris (France)
INTERCEPTION OF MACH 3 AIRCRAFT BY FIGHTERS, VOLUME 2 (U)
Jun 1978 56 p This document is not available from the NASA STI Facility All Requests must be directed to AGARD Hq
(AGARD-AR-102-Vol-2) NATO Confidential report

Volume 2 consists of 3 appendices which support respectively chapter 4, chapter 5, and chapter 6 of volume 1 Topics include fire control, air to air missiles, and interception probabilities A W H

X80-72065# Advisory Group for Aerospace Research and Development, Paris (France)
FIGHTER AIRCRAFT DESIGN (U)
Jul 1978 84 p
This document is not available from the NASA STI Facility All requests must be directed to AGARD Hq
(AGARD-CP-241-Suppl) NATO Secret report

Current fighter aircraft designs and the implemented technology in the aircraft's design are reviewed Future design technology for the fighter aircraft is explored in relation to forecasted requirements The defeat of anticipated threats with minimum life cycle cost is emphasized in the design of the future aircraft The aspects of fighter design addressed include systems design; aerodynamics and configurations, propulsion, structures and materials, avionics and guidance; and human factors A W H

X80-72066# Advisory Group for Aerospace Research and Development, Paris (France).
MANOEUVRE LIMITATIONS OF COMBAT AIRCRAFT (U)
Aug 1979 108 p
This document is not available from the NASA STI Facility All requests must be directed to AGARD Hq
(AGARD-AR-155B) NATO Confidential report

The phenomena which limit the maneuverability of combat aircraft and the relationship between these phenomena and the aircraft's physical configuration characteristics are discussed The procedures available to the engineer to determine and optimise the aircraft maneuver boundaries are presented R C T

06 AIRCRAFT INSTRUMENTATION

Includes cockpit and cabin display devices, and flight instruments.

For related information see also *19 Spacecraft Instrumentation* and *35 Instrumentation and Photography*.

N77-18152# Advisory Group for Aerospace Research and Development, Paris (France)

AGARD FLIGHT TEST INSTRUMENTATION SERIES. VOLUME 8. LINEAR AND ANGULAR POSITION MEASUREMENT OF AIRCRAFT COMPONENTS

J. C. VanderLinden (Natl. Aerospace Lab., Amsterdam) and H. A. Mensink (Natl. Aerospace Lab., Amsterdam). Feb. 1977. 47 p. refs.

(AGARD-AG-160-Vol-8; AGARDograph-160-Vol-8; ISBN-92-835-1236-8) Avail: NTIS HC A03/MF A01

Flight test instrumentation for determining the position of movable aircraft components was considered. The components included: rudder, elevator and aileron surfaces, wing flaps, trim tabs, speed brakes, spoilers, power-control levers, elements of hydraulic systems and airconditioning systems, and elements of nosewheel-steering systems and of landing gear mechanisms. Author

N79-24993# Advisory Group for Aerospace Research and Development, Paris (France)

PROCESSING OF AIRBORNE RECONNAISSANCE DATA FOR IN-FLIGHT DISPLAY AND NEAR REAL-TIME TRANSMISSION

G. vanKeuk (Forschungsinst. fuer Funk und Math.). Mar. 1979. 67 p. refs.

(AGARD-AR-135; ISBN-92-835-1310-X) Avail: NTIS HC A04/MF A01

Communication on aircraft beyond the horizon is discussed. The fundamental relationships between several parameters and interactions and between human factors and technology to assist operational and technical users were examined. S.E.S.

07 AIRCRAFT PROPULSION AND POWER

Includes prime propulsion systems and systems components, e.g., gas turbine engines and compressors, and on board auxiliary power plants for aircraft.

For related information see also *20 Spacecraft Propulsion and Power*, *28 Propellants and Fuels*, and *44 Energy Production and Conversion*.

N77-22112# Advisory Group for Aerospace Research and Development, Paris (France)
VARIABLE GEOMETRY AND MULTICYCLE ENGINES
1976 459 p In ENGLISH, partly in FRENCH Presented at the 48th Meeting of the AGARD Propulsion and Energetics Panel held at the Ecole Nationale Superieure des Tech. Avancees, Paris, 6-9 Sep. 1976
(AGARD-CP-205) Avail: NTIS HC A20/MF A01

A broad variety of cycle investigations are presented along with work on geometry variation of individual engine components. Advanced performance for supersonic conventional takeoff and landing aircraft and VTOL aircraft, high speed turboprops, fuel conservation, low noise, low exhaust emission, and integrated control systems are among the topics discussed. For individual titles, see N77-22113 through N77-22145.

N77-22113# Boeing Co., Seattle, Wash.
OPPORTUNITIES FOR VARIABLE GEOMETRY ENGINES IN MILITARY AIRCRAFT
W. C. Swan, A. D. Welliver, G. W. Klees, and S. G. Kyle *In* AGARD Variable Geometry and Multicycle Eng. 1976 9 p refs (For primary document see N77-22112 13-07)
Avail: NTIS HC A20/MF A01

Several concepts for engine development and the apparent opportunities such advancements offer in terms of either vehicle performance or total system cost are discussed. Medium range air to surface attack vehicles and long range supersonic vehicles with high altitude recon/strike capability are included. Author

N77-22114# National Gas Turbine Establishment, Pyestock (England)
SOME ASPECTS OF VARIABLE CYCLE PROPULSION SYSTEMS
F. W. Armstrong and D. R. Eigton *In* AGARD Variable Geometry and Multicycle Eng. 1976 11 p refs (For primary document see N77-22112 13-07)
Avail: NTIS HC A20/MF A01

The incentives which encourage the study of variable cycle gas turbine powerplants are considered. Achieving performance gains at off-design running conditions, increasing safety and flexibility by providing greater operating margins, and control of both exhaust emissions and noise are discussed. The gains potentially available in a number of civil and military aircraft applications are outlined together with the resulting requirements for cycle variation and the implications for the configuration of the gas turbine engine itself and its intake and exhaust systems. The substantial component and system design problems posed by advanced variable cycle powerplants are included. Author

N77-22115# Centre d'Essais de Propulseurs, Saclay (France)
PARAMETERS FOR OPTIMIZING ENGINES AS A FUNCTION OF MISSION [PARAMETRES D'OPTIMISATION DES MOTEURS EN FONCTION DE LA MISSION]
B. Cocheteux, A. Coursimault, and J.-C. G. Ripell *In* AGARD Variable Geometry and Multicycle Eng. 1976 15 p refs (For primary document see N77-22112 13-07)
Avail: NTIS HC A20/MF A01

Conditions under which the choice of cycle for a military engine is determined are investigated. Although elaborated methods for optimization exist, direct reflection is used as the approach to clarify the problem. Constraints imposed on the choice of cycle in combat aircraft are reviewed, and the advantage of variable geometry is assessed. Hypotheses defining a mission are highly influential. In some cases, the choice of characteristics makes compromise easy; in others, contradictions appear. A number of independent variables, some neither technical nor qualifiable, must be taken into consideration when engines are designed. Transl. by A.R.H.

N77-22116# Motoren- und Turbinen-Union Muenchen G.m.b.H. (West Germany)
ADVANCED ENGINE DESIGN CONCEPTS AND THEIR INFLUENCE ON THE PERFORMANCE OF MULTI-ROLE COMBAT AIRCRAFT
H. Grieb and E. Ackermann *In* AGARD Variable Geometry and Multicycle Eng. 1976 15 p refs (For primary document see N77-22112 13-07)
Avail: NTIS HC A20/MF A01

Engine design concepts which combine the advantages of the reheated turbojet with the advantages of the reheated turbofan are considered. Emphasis is placed on the demands placed on the power plant by a multirole weapon system. Variable geometry and the penalty in engine weight and complexity are among the factors discussed. It is shown that the variable cycle engine improves the performance of multirole combat aircraft. Author

N77-22117# Naval Air Propulsion Test Center, Trenton, N.J.
VARIABLE CYCLE ENGINES FOR V/STOL FIGHTERS
John R. Facey and Fred C. Glaser (McDonnell Douglas Corp., St. Louis) *In* AGARD Variable Geometry and Multicycle Eng. 1976 10 p ref. (For primary document see N77-22112 13-07)
Avail: NTIS HC A20/MF A01

The impact of variable cycle engines on advanced V/STOL multimission fighters was studied. A program description is given along with a summary of results and conclusions drawn from the initial phase of the program. Author

N77-22118# Centre de Villaroche, Moissy (France)
VARIABLE CYCLE AND SUPERSONIC TRANSPORT [CYCLE VARIABLE ET TRANSPORT SUPERSONIQUE]
C. Menioux *In* AGARD Variable Geometry and Multicycle Eng. 1976 11 p (For primary document see N77-22112 13-07)
Avail: NTIS HC A20/MF A01

An ideal variable cycle engine adapted for supersonic transport at Mach 2 is described. Its principal characteristics are explored from the point of view of cycle, space occupied, and internal structure. Transl. by A.R.H.

N77-22119*# National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio
VARIABLE-CYCLE ENGINES FOR SUPERSONIC CRUISE AIRCRAFT
Edward Willis *In* AGARD Variable Geometry and Multicycle Eng. 1976 18 p refs (For primary document see N77-22112 13-07)
Avail: NTIS HC A20/MF A01

Variable cycle engine design concepts studied in terms of performance, economic, and environmental requirements that apply to modern supersonic cruise aircraft are described. The dual impact of design simplification and technology advancements is discussed along with advanced technology requirements in air and noise pollution reduction. J.M.S.

N77-22120# Politecnico di Torino (Italy)
NUMERICAL PREDICTION OF THE UNSTEADY FLOW IN VARIABLE GEOMETRY ENGINES - PRELIMINARY INVESTIGATION
Luca Zannetti and Maurizio Pandolfi *In* AGARD Variable Geometry and Multicycle Eng. 1976 7 p refs (For primary document see N77-22112 13-07)
Avail: NTIS HC A20/MF A01

A numerical method is presented which predicts the unsteady flow, through turbojet engines, due to the variation in time of the geometry of some engine component. The approach is based on the idea of replacing the actual bladings with actuator discs, which deflect the gas stream according to the real geometry. Other surfaces of discontinuity simulate the inlet and the exhaust of the engine and the combustion chamber. The computation is carried out by integrating in time the hyperbolic partial differential equations which describe the gas motion, with a second order of accuracy integration scheme. Numerical examples show the

simulated unsteady flow originated by variation in time of stators stagger angles and of exhaust nozzle area Author

N77-22121*# National Aeronautics and Space Administration Langley Research Center, Langley Station, Va
ASSESSMENT OF VARIABLE-CYCLE ENGINES FOR SUPERSONIC TRANSPORTS
E Boxer, S J Morris, and W E Foss, Jr *In* AGARD Variable Geometry and Multicycle Eng 1976 19 p refs (For primary document see N77-22112 13-07)
Avail NTIS HC A20/MF A01

Propulsion systems are evaluated in terms of relative aircraft range for a fixed payload and takeoff gross weight with a design cruise Mach number of 2.7. In order to put the performance of these engines in perspective, a comparison of these engines and the former U S SST engine is made with an idealized variable cycle engine whose performance at all operating points matches that of an optimized point design cycle within specified limits. Range comparisons are made with and without noise level constraints to determine the influence of noise upon cycle selection. The critical areas requiring new or improved technology for each cycle are delineated Author

N77-22122# Rolls-Royce Ltd., Derby (England)
USE OF ENGINE VARIABLES TO IMPROVE MILITARY PERFORMANCE
N G Hatton and B Swann *In* AGARD Variable Geometry and Multicycle Eng 1976 15 p (For primary document see N77-22112 13-07)
Avail NTIS HC A20/MF A01

Variation of engine cycle by geometric changes to allow operation nearer the design point is discussed for a variety of flight conditions. The effect of representative losses due to cycle and geometric changes is illustrated Author

N77-22123# Industrieanlagen-Betriebsgesellschaft m.b.H., Ottobrunn (West Germany)
POSSIBILITIES OF ADAPTING BY-PASS-ENGINES TO THE REQUIREMENTS OF HIGHER SUPERSONIC FLIGHT
H Kuenkler *In* AGARD Variable Geometry and Multicycle Eng 1976 15 p refs (For primary document see N77-22112 13-07)
Avail NTIS HC A20/MF A01

Methods of improving the adaptability of the reheated bypass engine to supersonic flight missions by varying the thermodynamic cycle are investigated. In particular, the following possibilities were studied: (1) fuel-rich primary-flow heating during reheat operation, (2) fuel-rich total-flow reheating during high-thrust mission segments, (3) precooling of turbine coolant by heat exchange with reheat fuel, and (4) intercooling of primary air flow by heat exchange with reheat fuel Author

N77-22124# Naval Air Propulsion Test Center, Trenton, N.J.
AUGMENTED DEFLECTOR EXHAUST NOZZLE (ADEN) DESIGN FOR HIGH PERFORMANCE FIGHTERS
J Lawrence Palcza *In* AGARD Variable Geometry and Multicycle Eng 1976 7 p (For primary document see N77-22112 13-07)
Avail NTIS HC A20/MF A01

A two dimensional augmented deflector exhaust nozzle (ADEN) was designed, fabricated, and tested for use on future advanced multimission V/STOL aircraft. The aerodynamic and mechanical features of the ADEN and the full scale demonstrator program are described Author

N77-22125# General Electric Co., Cincinnati, Ohio. Aircraft Engine Group
VARIABLE CYCLE ENGINE APPLICATIONS AND CONSTRAINTS
Robert J Payzer *In* AGARD Variable Geometry and Multicycle Eng 1976 13 p (For primary document see N77-22112 13-07)
Avail NTIS HC A20/MF A01

The potential applications for variable cycle engines are discussed along with the payoffs for variable cycle engines and the constraints on these engines both from a totally installed aspect, as well as the internal engine restrictions Author

N77-22126# *United Technologies Corp., East Hartford, Conn*
HIGH EFFICIENCY ENGINE CYCLES FOR AIR TRANSPORT FUEL ECONOMY
D E Gray *In* AGARD Variable Geometry and Multicycle Eng 1976 10 p refs (For primary document see N77-22112 13-07)
Avail NTIS HC A20/MF A01

The effects of projected gas turbine technological progress, unconventional thermodynamic processes, and advanced propulsion devices are assessed in terms of their fuel savings potential. The operating characteristics of two selected propulsion systems - an advanced turbofan and a turboprop engine - are projected and compared at points along a transport flight profile. The applicability of engine component geometry variation to improve propulsion system efficiency is also reviewed Author

N77-22127# Hamilton Standard, Windsor Locks, Conn
MULTI-MISSION USES FOR PROP-FAN PROPULSION
A H Jackson and B S Gatzen *In* AGARD Variable Geometry and Multicycle Eng 1976 12 p refs (For primary document see N77-22112 13-07)
Avail NTIS HC A20/MF A01

Advanced turboprops or Prop-Fans are considered in terms of major reductions in fuel consumption. Aerodynamics, noise reduction, and structural design are discussed along with engine design and applications J M S

N77-22128# Rolls-Royce Ltd., Bristol (England) Aero Div
VARIABLE GEOMETRY IN THE GAS TURBINE - THE VARIABLE PITCH FAN ENGINE
R M Denning *In* AGARD Variable Geometry and Multicycle Eng 1976 10 p refs (For primary document see N77-22112 13-07)
Avail NTIS HC A20/MF A01

A specific example of a variable pitch engine, the M45SD-02, is examined. Wide speed range, high relative takeoff thrust, low noise, steep approach path control, fuel efficiency, and reverse thrust capability are among the characteristics discussed. Potential applications for the variable pitch engine are included J M S

N77-22129# Societe Turbomeca Bordes (France)
THE ASTAFAN: DUAL FLOW WITH VARIABLE PITCH AND CONSTANT SPEED [L'ASTAFAN: DOUBLE-FLUX A PAS *VARIABLE ET VITESSE CONSTANTE*]
Joseph Szydlowski *In* AGARD Variable Geometry and Multicycle Eng 1976 5 p In FRENCH; ENGLISH summary (For primary document see N77-22112 13-07)
Avail NTIS HC A20/MF A01

The historical background of the different variable geometry turbofan engines with constant speed operation is discussed. The present formula includes a fan whose rotating blades have a variable pitch, thus permitting a correct adaptation to the different flight configurations. Author

N77-22130# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (West Germany) Aircraft Div.
THE INTERMITTENT JET FOR SUPERSONIC CONDITIONS INCREASED WITH PASSAGE TO OPERATING IN A RAMJET - A LOW COST ENGINE [LE PULSO-REACTEUR POUR REGIME SUBSONIQUE ELEVE AVEC PASSAGE AU FONCTIONNEMENT EN STATO-REACTEUR - UN MOTEUR DE FAIBLE PRIX DE REVIENT]
W K Eick *In* AGARD Variable Geometry and Multicycle Eng 1976 27 p refs In FRENCH (For primary document see N77-22112 13-07)
Avail NTIS HC A20/MF A01

The results of preliminary studies made on a jet engine without a safety-valve are reported. Essential parameters were studied in detail to determine their influence on thrust characteristics and fuel consumption Transl by B B

N77-22131# Pisa Univ. (Italy)
PERFORMANCE CHARACTERISTICS OF TURBO-ROCKETS AND TURBO-RAMJETS USING HIGH ENERGY FUEL
Dino Dini *In* AGARD Variable Geometry and Multicycle Eng. 1976 30 p refs (For primary document see N77-22112 13-07)
Avail NTIS HC A20/MF A01

The aerodynamic and thermodynamic behavior of turborockets and turboramjets is considered. By means of variable engine geometry, multicycle engines meet aircraft requirements for takeoff, climb, cruise, maneuver, loiter, and landing. Performance characteristics are evaluated for these conditions, taking into account variable geometry in some intake and exhaust configura-

tions Problems arising from future high energy fuels, particularly hydrogen, impose changes in interface components, geometry, and control Preliminary designs of turborockets and turboramjets for military and civil applications are discussed Author

N77-22132# Naples Univ (Italy)
RAM-TURBOJET ENGINE FOR LONG RANGE HIGH TERMINAL SPEED MISSIONS
Rodolfo Monti and Attilio Galasso (AERITALIA, Naples, Italy) *In* AGARD Variable Geometry and Multicycle Eng 1976 14 p refs (For primary document see N77-22112 13-07)
Avail NTIS HC A20/MF A01

Preliminary calculations are presented for a combined ramjet-turbofan engine where the long range, low speed, low altitude flight is powered by the turbofan, and the final supersonic approach at low altitude is powered by the ramjet after the turbofan has been jettisoned The system is evaluated, and possible competitive solutions are compared Design criteria are also discussed, and an applicative example is presented Author

N77-22133# Army Air Mobility Research and Development Lab., Fort Eustis, Va Technology Applications Div
CONVERTIBLE FAN SHAFT ENGINE (FOR ROTARY WING AIRCRAFT)
John W White *In* AGARD Variable Geometry and Multicycle Eng 1976 15 p refs (For primary document see N77-22112 13-07)
Avail NTIS HC A20/MF A01

The convertible fan shaft (CFS) engine, utilizing lightweight fan and advanced turboshaft engine technology, is proposed as a propulsion system for a compound helicopter that can potentially double the operating envelope of present rotary wing aircraft The compound helicopter's performance capabilities and propulsion requirements are briefly reviewed The AH-56 Cheyenne aircraft is used as a baseline to evaluate the CFS engine Author

N77-22134# Cranfield Inst of Technology (England). School of Mechanical Engineering
AN APPLICATION FOR VARIABLE INLET GUIDE VANES IN DISTORTION SUPPRESSION
R E Peacock and M A R A El-Attar *In* AGARD Variable Geometry and Multicycle Eng 1976 16 p refs (For primary document see N77-22112 13-07)
Avail: NTIS HC A20/MF A01

The effects of distortion upon compressor performance are considered, and a design technique for inlet guide vanes to decrease the effect of circumferential pressure distortion is discussed A method of selectively varying the stagger of a sector of the guide vane row to minimize the effect of change of rotor incidence created by circumferential distortion is analyzed Design charts for both cases are included Author

N77-22135# Rolls-Royce Ltd., Bristol (England). Aero-Div.
THE PREDICTION AND OPTIMISATION OF VARIABLE GEOMETRY STATORS FROM COMPRESSOR BASIC DATA
P A Whiteman *In* AGARD Variable Geometry and Multicycle Eng 1976 10 p ref (For primary document see N77-22112 13-07)
Avail NTIS HC A20/MF A01

With high performance axial flow compressors, there is a positive requirement for variable geometry The amount of variable geometry required in terms of the number of variable stators rows, the stator travel, and rate of travel are all important parameters The effects of these parameters on compressor performance can be predicted and optimized using the stage stacking method of analysis Author

N77-22136# Office National d'Etudes et de Recherches Aerospatiales, Paris (France)
PREDICTION OF VARIABLE GEOMETRY COMPRESSOR PERFORMANCES (OFF DESIGN)
Pierre Bry and Yves LeBot *In* AGARD Variable Geometry and Multicycle Eng 1976 7 p refs In FRENCH, ENGLISH summary (For primary document see N77-22112 13-07)
Avail: NTIS HC A20/MF A01

The effect of variable geometry on compressor performance was investigated numerically This approach, based on a simplified way of writing derivatives with respect to the axial direction, allows the calculation of trough flow (uniform tangentially) in subsonic, transonic, and supersonic regimes provided no shock waves occur in the calculation planes The overall flow analysis takes into account losses caused by fluid friction, wake mixing angle of attack, and cross section variation Results are compared to experimental data obtained on a low speed compressor with variable blade angle settings Author

N77-22137# Societe Nationale d'Etudes et de Construction de Moteurs d'Aviation Moissy-Cramayel (France)
ANTI-NOx COMBUSTION CHAMBER WITH VARIABLE AERODYNAMIC FLOW FOR A TURBO-JET ENGINE [CHAMBRE DE COMBUSTION ANTI-NOx A ECOULEMENT AERODYNAMIQUE VARIABLE POUR TURBOREACTEUR]
Ph Gastebois and J Caruel *In* AGARD Variable Geometry and Multicycle Eng 1976 11 p In FRENCH (For primary document see N77-22112 13-07)
Avail NTIS HC A20/MF A01

The work of the SNECMA on reducing the NO(2) emissions produced by the combustion chambers of turbojet engines is discussed in detail, and the plan for a chamber with two modules is presented Experimental results are also included
Transl by B B

N77-22138# Laval Univ. (Quebec)
DESIGN FEATURES FOR A PRE-MIXED VARIABLE AREA COMBUSTOR
J Odgers and D Kretachmer *In* AGARD Variable Geometry and Multicycle Eng 1976 7 p refs (For primary document see N77-22112 13-07)
Avail NTIS HC A20/MF A01

Design features of a premixed variable area combustor for pollution control are analyzed, especially with respect to the construction of the primary zone and its ancillary parts. In addition, the practicability of the control of the three major pollutants, oxides of nitrogen, carbon monoxide, and unburnt hydrocarbons, is discussed Author

N77-22139# *Cranfield Inst. of Technology (England)* *School* of Mechanical Engineering
THE VARIABLE GEOMETRY COMBUSTOR
R S Fletcher and R C Adkins *In* AGARD Variable Geometry and Multicycle Eng. 1976 10 p refs (For primary document see N77-22112 13-07)
Avail: NTIS HC A20/MF A01

The concept of variable geometry as it applies to the control of emissions from gas turbine combustors and potential of a novel fluidic device to put the concept into practice are reviewed This method is based upon the use of a bled vortex generated to control and vary the air distribution characteristics within the combustor liner Experimental data are given from the first 'cold' tests carried out with the device. It was concluded that although significant emissions reductions can be achieved by the use of variable geometry, it is unlikely that the level of reduction attained will be sufficient to exceed the appropriate U S Federal Standards for civil aircraft engines Results also indicate that the vortex controlled, variable geometry combustor has potential for further development. Author

N77-22140# Technische Hochschule, Munich (West Germany). Aerospace Inst.
THE PROS AND CONS OF VARIABLE GEOMETRY TURBINES
H. G. Muenzberg and J. Kurzke *In* AGARD Variable Geometry and Multicycle Eng 1976 12 p ref (For primary document see N77-22112 13-07)
Avail: NTIS HC A20/MF A01

Analysis of the advantages of variable geometry turbines indicates that an adjustable stator in the low pressure of a two spool turbojet is of no explicit advantage The shape of the compressor performance map could be so altered that, even in a simple example, a stator adjustment would result in an improvement of fuel consumption In this case, stator adjustment proves to be advantageous Such a result cannot be considered as generally valid, because only the characteristic of one specific engine can be altered, and then only in the form of a remedial measure Variable geometry can be advantageous for flight missions in which the engine is run for long periods of time at a very low partial load Author

N77-22141# Air Force Aero Propulsion Lab., Wright-Patterson AFB, Ohio

POTENTIAL IMPROVEMENTS IN ENGINE PERFORMANCE USING A VARIABLE GEOMETRY TURBINE

Robert J. May, Jr., Wayne A. Tall, and H. Ivan Bush *In* AGARD Variable Geometry and Multicycle Eng. 1976 16 p refs (For primary document see N77-22112 13-07)

Avail: NTIS HC A20/MF A01

Installed performance characteristics of a fixed geometry turbofan, a fixed geometry turbojet, and a variable geometry turbojet are compared for typical subsonic cruise, supersonic cruise and combat flight conditions. Results indicate that for applications where both subsonic and supersonic fuel consumptions are important, a variable geometry turbine turbojet can offer substantial reductions in fuel usage. Author

N77-22142# Rolls-Royce Ltd., Bristol (England). Bristol Engine Group

VARIABLE FLOW TURBINES

R. J. Latimer *In* AGARD Variable Geometry and Multicycle Eng. 1976 6 p (For primary document see N77-22112 13-07)

Avail: NTIS HC A20/MF A01

Varying turbine flow capacity by restaggering the stator blades or by restricting the annulus is considered. A brief survey of research into controlling the turbine flow is given along with conclusions. J.M.S.

N77-22143# Motoren- und Turbinen-Union Muenchen G.m.b.H. (West Germany).

EXPERIENCE WITH A ONE STAGE VARIABLE GEOMETRY AXIAL TURBINE

J. Hourmouziadis, K. Hagemeister, O. Rademacher, and H. Kolben *In* AGARD Variable Geometry and Multicycle Eng. 1976 9 p refs (For primary document see N77-22112 13-07)

Avail: NTIS HC A20/MF A01

Based on steady-state and transient performance characteristics of a two spool turboshaft engine, the possible improvements resulting from a variable geometry power turbine are discussed and the design requirements defined. The aerodynamic design of a turbine fulfilling these requirements is described, and the predicted power turbine characteristic is presented and compared with component test results. The design and development of the hot environment variable stator mechanism is described, including consideration of the vane positioning accuracy and response characteristics. Performance test results and the problems encountered with the turbine operating in a full scale engine are presented. Mechanical aspects such as the long term endurance capability of the variable stator mechanism, as well as vibrational problems of the rotor blading caused by the variable geometry, are discussed. Author

N77-22144# Air Force Aero Propulsion Lab., Wright-Patterson AFB, Ohio.

INTEGRATED PROPULSION CONTROL SYSTEM FOR FIGHTER AIRCRAFT

Joseph J. Batka *In* AGARD Variable Geometry and Multicycle Eng. 1976 10 p refs (For primary document see N77-22112 13-07)

Avail: NTIS HC A20/MF A01

An integrated propulsion control system (IPCS) was designed, fabricated, and flight tested on a F-111 aircraft. The IPCS combined the functions of the traditionally separate inlet and engine controls into one computational unit. This integrated approach was proven to be a most effective way to utilize the full potential of the propulsion components to achieve a high performance aircraft. Author

N77-22145# British Aircraft Corp. (Operating) Ltd., Bristol (England). Electronics and Space Systems Group.

THE BENEFITS OF AN INTEGRATED DIGITAL POWER-PLANT CONTROL SYSTEM

R. S. Dale Afima *In* AGARD Variable Geometry and Multicycle Eng. 1976 11 p (For primary document see N77-22112 13-07)

Avail: NTIS HC A20/MF A01

The flight experience gained on air intake control was applied to a study of the feasibility of integrating the controls of a powerplant (air intake, engine, reheat, and nozzles) into a single digital system. The control system developed and the benefits and problems of integration are described. Author

N77-32165# Advisory Group for Aerospace Research and Development, Paris (France).

LASER OPTICAL MEASUREMENT METHODS FOR AERO-ENGINE RESEARCH AND DEVELOPMENT

Jul. 1977 161 p Lectures held in Trenton, 25-26 Aug. 1977, London, 30-31 Aug. 1977 and Urbino, Italy, 5-6 Sep. 1977 (AGARD-LS-90; ISBN-92-835-1248-0) Avail: NTIS HC A08/MF A01

Lectures are given to inform propulsion specialists of the techniques that are available in the field of optical measurement. Laser-velocimetry is emphasized along with Raman scattering and holography interferometry. For individual titles, see N77-32166 through N77-32171.

N77-32166# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Cologne (West Germany). Inst. fuer Luftstrahlantriebe

REQUIREMENTS OF AERO-ENGINE DEVELOPMENT TO ADVANCED EXPERIMENTAL TECHNIQUES

H. B. Weyer *In* AGARD Laser Opt. Meas. Methods for Aero Engine Res. and Develop. Jul. 1977 17 p refs (For primary document see N77-32165 23-07)

Avail: NTIS HC A08/MF A01

In regards to the aero-engine, an attempt is made to expose the primary problems of the aerothermodynamic design, to outline the requirements to adequate experimental studies and the corresponding testing techniques. L.S.

N77-32167# Office National d'Etudes et de Recherches Aerospatiales, Paris (France).

REVIEW OF OPTICAL TECHNIQUES WITH RESPECT TO AERO-ENGINE APPLICATIONS

Claude Veret *In* AGARD Laser Opt. Meas. Methods for Aero-Engine Res. and Develop. Jul. 1977 17 p refs (For primary document see N77-32165 23-07)

Avail: NTIS HC A08/MF A01

With the exception of laser Doppler velocimeter measurement, the main optical methods providing quantitative information on gas flows are presented. Those methods usable in compressible flow are based on the deformation of a light wave crossing a medium (interferometry) or light rays deviations accompanying these deformations (schlieren technique and shadowgraphy). These methods allow measurement of either snock pattern shape in transonic and supersonic flows or, in some cases, gas density fields. A few examples on stationary or rotating blade cascade flows are given and holography advantages to get interferograms are shown. Spontaneous or stimulated Raman scattering is descussed and it provides original means to determine the concentrations and temperatures of given components within the flame itself. It is difficult to apply most of these methods to the engines themselves. Their use on test rigs simulating the conditions to be encountered in engines is described. Author

N77-32168# ARO, Inc., Arnold Air Force Station, Tenn.

FUNDAMENTALS OF LASER DOPPLER VELOCIMETRY

A. E. Lennert *In* AGARD Laser Opt. Meas. Methods for Aero Engine Res. and Develop. Jul. 1977 41 p refs (For primary document see N77-32165 23-07)

Avail: NTIS HC A08/MF A01

The characteristics of the Bragg cell system, both one- and two-component types, is presented. Several counting techniques are reviewed and a real time processor evaluated. Of the various data acquisition and processing mechanisms only the direct-counting techniques are favorably considered for aircraft engine applications. Included are discussions concerning pertinent parameters affecting LV design for engine application and finally several LV systems used in wind tunnel environments are described. Author

N77-32169# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Cologne (West Germany). Inst. fuer Luftstrahaltriebe

LASER-TWO-FOCUS VELOCIMETRY (L2F) FOR USE IN AERO ENGINES

R. Schodl *In* AGARD Laser Opt. Meas. Methods for Aero-Engine Res. and Develop. Jul. 1977 34 p refs (For primary document see N77-32165 23-07)

Avail: NTIS HC A08/MF A01

The L2F method measures the velocity of a fluid by utilizing the principle of light scattering of small particles entrained in the fluid. However, a much higher laser light concentration is achieved in the probe volume which helps to overcome the difficulty of obtaining measurements in regions of unfavorable signal-to-noise ratio. For this application a concentric backscatter measuring device was considered and compared with an equivalent

LD-system. It can be demonstrated that in principle the L2F-method is less susceptible to the injurious back-ground radiation which is generated from solid surfaces and in the narrow blade channels. A description of an improved L2F-velocimeter suitable for use in strongly turbulent flows such as those found in turbomachines is presented. From a series of probability density distributions taken at each measuring location nearly all two-dimensional information about the flow can be calculated. Measurement errors and their possible correction are discussed and the measuring accuracy is demonstrated in windtunnel tests. Author

N77-32170# General Electric Co., Cincinnati, Ohio. Aircraft Engine Group.

PRACTICAL APPLICATION OF LV SYSTEMS TO AERO ENGINE RESEARCH AND DEVELOPMENT

D. C. Wisler and R. W. Mossey. *In* AGARD Laser Opt. Meas. Methods for Aero-Engine Res. and Develop. Jul. 1977 17 p refs (For primary document see N77-32165 23-07)

Avail: NTIS HC A08/MF A01

Laser velocimeter (LV) measurement technology was applied to aircraft gas turbine research and development. The velocimeter operates by measuring the transit time of a seed particle across interference fringes produced at the intersection of a split and crossed laser beam. The LV system was used to make nondisturbing gas velocity measurements in front of bellmouth inlets, within jet exhausts for acoustic studies and within the rotating bladerows of axial flow compressors, fans and turbines, including the mapping of shock locations. The rotor flowfields were obtained at several radial immersions for operating-line and near-stall throttle settings. The results show the effects of blade loading on the flowfield and, for the supersonic fan, show the change in shock pattern as stall is approached. Analytical predictions of the various flowfields were obtained using potential flow theory, the method of characteristics and a time-dependent, finite difference solution of the fluid dynamic equations of motion. The analytical results and the flowfield measurements are considered to be in good agreement. Author

N77-32171# Rolls-Royce Ltd., Derby (England). Advanced Research Lab.

SPECIAL PROBLEMS OF LASER ANEMOMETRY IN DIFFICULT APPLICATIONS

A. E. Smart. *In* AGARD Laser Opt. Meas. Methods for Aero-Engine Res. and Develop. Jul. 1977 18 p refs (For primary document see N77-32165 23-07)

Avail: NTIS HC A08/MF A01

Many difficulties with this technique of laser anemometry arise from engineering constraints. A few solutions to some of these problem are outlined. Data retrieval from very low signal is possible using photon correlation and this is popular in many engineering applications because of its high efficiency. Good measurements were obtained in aero-engine exhaust and in unsteady combustion systems with this method. For real noise is serious here but may be compensated by separate assessment. Transit anemometry is shown to be superior in conditions of bad flare, such as blade passages, but takes longer to make a given measurement. However, shear stresses may be derived from the same measurement. The disparity between particle and fluid velocity field is related to its practical consequences. More application topics are included such as window installation and cleanliness, vibration and noise, thermal problems, laser safety and finally information presentation. Author

N77-33181# Advisory Group for Aeronautical Research and Development, Paris (France).

POWER PLANT RELIABILITY

Aug. 1977 222 p refs In ENGLISH and FRENCH. Presented at the 49th Meeting of the AGARD Propulsion and Energetics Panel, The Hague, 31 Mar. - 1 Apr. 1977

(AGARD-CP-215; ISBN-92-835-0198-5) Avail: NTIS HC A10/MF A01

The reliability of current civil and military engines is discussed. Plans to improve engine reliability and the role of engine diagnostics and monitoring is explored. For individual titles, see N77-33182 through N77-33199.

N77-33182# Aeronautical Systems Div., Wright-Patterson AFB, Ohio.

ENGINE STRUCTURAL INTEGRITY PROGRAM (ENSIP)

Eric E. Abell and Edward G. Koepnick. *In* AGARD Power Plant Reliability Aug. 1977 4 p (For primary document see N77-33181 24-07)

Avail: NTIS HC A10/MF A01

A new military standard for turbine engines for use by the Air Force is discussed. The standard is aimed at providing overall policy and requirements for turbine engine structural development during the entire system life cycle. A first review of the tasks involved in the standard are outlined. Specific items such as duty cycle and tests concerned with fatigue considerations are noted. Author

N77-33183# Ministero della Difesa Aeronautica, Rome (Italy).

MILITARY ENGINE DETERIORATION IN SERVICE CONNECTED WITH LIFE CYCLE COSTS

G. Facca and L. Giorgieri. *In* AGARD Power Plant Reliability Aug. 1977 18 p refs (For primary document see N77-33181 24-07)

Avail: NTIS HC A10/MF A01

Problems responsible for military jet engine deterioration are identified and cost structure for these problems is analyzed. Since a large amount of labor, skill and costs are involved in maintaining engines in service at an adequate standard of efficiency and safety, several standards must be met. Overall maintenance and repair life cycle costs must be comparable to the new engine cost. Design must pay proper attention to reliability and maintainability concepts from the beginning and trade-offs should be performed in order to optimize the engine overall life cycle costs. Author

N77-33184# Direction Centrale du Materiel de l'Armee de l'Air, Paris (France).

MAINTENANCE METHODS FOR IMPROVING PROPULSION SYSTEM RELIABILITY [METHODES DE MAINTENANCE POUR AMELIORER LA FIABILITE DES PROPULSEURS]

Claude Sprung. *In* AGARD Power Plant Reliability Aug. 1977 9 p In FRENCH (For primary document see N77-33181 24-07)

Avail: NTIS HC A10/MF A01

Preventive measures used by the French Air Force in systematic aircraft engine maintenance procedures are described. Topics discussed include: spectrometry of oils, analysis of metal particles, engine vibration, and the use of endoscopy, ultrasonics, and gammagraphy. Transl. by A.R.H.

N77-33185# Civil Aviation Authority, Redhill (England). Airworthiness Div.

CIVIL AIRWORTHINESS REQUIREMENTS FOR POWER-PLANT RELIABILITY

John Slatford. *In* AGARD Power Plant Reliability Aug. 1977 6 p (For primary document see N77-33181 24-07)

Avail: NTIS HC A10/MF A01

Several aspects of aircraft reliability are discussed. These considerations relating to the safety of the aircraft and its occupants are summarized into three objectives. Any failure of an engine that could hazard the aircraft must be kept to an absolute minimum. Loss of thrust in flight must not reduce the total thrust available to the aircraft to such an extent that the flight cannot be completed safely. A normally operating engine must provide the thrust necessary for the aircraft to meet its scheduled performance and respond quickly and accurately to the demands of the pilot. Author

N77-33186# KLM Royal Dutch Airlines, Amsterdam (Netherlands).

RELIABILITY VERSUS COST IN OPERATING WIDE BODY JET ENGINES

S. K. W. J. Demarteau. *In* AGARD Power Plant Reliability Aug. 1977 7 p (For primary document see N77-33181 24-07)

Avail: NTIS HC A10/MF A01

The high degree of reliability from aircraft and engines required by scheduled international airline operational and maintenance characteristics is discussed. Standards must be met in order to offer a safe but also commercially and economically justified product. A specific cost/reliability level was investigated for the General Electric CF6 engine. Reliability was found to be influenced by inherent design deficiencies, operation environment and maintenance policy. Cost consequences were dependent on airline operation, the way an airline is organized, the scale of operation and airline standards. Author

N77-33187# Service des Etudes de Propulsion, Paris (France).

RISKS AFFECTING THE STRUCTURAL RESISTANCE AND INTEGRITY OF MODERN PROPULSION SYSTEMS [LES RISQUES AFFECTANT LA RESISTANCE STRUCTURALE ET LA SECURITE DES PROPULSEURS MODERNES]

Jean A. Aguer *In* AGARD Power Plant Reliability Aug. 1977 14 p refs In FRENCH (For primary document see N77-33181 24-07)
Avail: NTIS HC A10/MF A01

The performance of modern engines already in service or those which will be in use in the 1980's and thereafter depends on higher temperature levels, greater thermal and kinetic stress and constraints, and new materials technologies for improved efficiency. To maintain the structural integrity of these engines, the effects of thermal and kinetic energies to be used in the future must be determined. Precise examples are given to demonstrate what precautions must be taken. The most important priorities should be given to the use of titanium, engine ingestion, turbine blades, fuels and lubricants, and the thrust/weight ratio. Transl. by A.R.H.

N77-33188# Ministry of Defence, London (England). *Directorate* of Engine Development
DEVELOPMENT PROCEDURES TO PROMOTE RELIABILITY
R. Holl *In* AGARD Power Plant Reliability Aug. 1977 14 p refs (For primary document see N77-33181 24-07)
Avail: NTIS HC A10/MF A01

Reliability attainment so far as the military aircraft gas turbine is concerned was studied. Civil engine development and operational reliability were considered in order to emphasize that the aircraft gas turbine, particularly in a basically non-complete form, provided a step change in reliability when compared with its predecessor, the high powered piston propeller engine. Conclusions indicate that recent concentration on the achievement of performance goals has resulted in increasingly complex and very costly engines as well as a near total lack of attention to design reliability. Author

N77-33189# Societe Nationale d'Etudes et de Construction de Moteurs d'Aviation, Moissy-Cramayel (France).
CFM56 TURBOFAN MAINTAINABILITY AND RELIABILITY-ORIENTED DEVELOPMENT
Jean-Pierre Marechal *In* AGARD Power Plant Reliability Aug. 1977 19 p In ENGLISH and FRENCH (For primary document see N77-33181 24-07)
Avail: NTIS HC A10/MF A01

Reliability and maintainability criteria introduced in the CFM 56 turbofan engine are described. A 7500 operating program will provide methodical accumulation of data so that maintenance costs may be minimized through high repairability, accessibility, modularity, and interchangeable features. Author

N77-33190# General Electric Co., Cincinnati, Ohio. Aircraft Engine Group.
AIRCRAFT ENGINE DESIGN AND DEVELOPMENT THROUGH LESSONS LEARNED
Bernard L. Koff *In* AGARD Power Plant Reliability Aug. 1977 11 p (For primary document see N77-33181 24-07)
Avail: NTIS HC A10/MF A01

Aircraft engine design was examined in terms of performance and reliability. Durability, maintenance, weight, initial cost and timing were also considered. It is stated that design and development are derivatives of a 'lessons learned' approach. Since materials, modern analytical and experimental techniques have progressed, so has our ability to design and develop modern aircraft. Author

N77-33191# Societe Nationale d'Etudes et de Construction de Moteurs d'Aviation, Moissy-Cramayel (France).
SOPHISTICATION AND RELIABILITY [SOPHISTICATION ET FIABILITE]
J. Rennesson *In* AGARD Power Plant Reliability Aug. 1977 4 p refs In FRENCH (For primary document see N77-33181 24-07)
Avail: NTIS HC A10/MF A01

When sophistication is bound to reliability, the compromise to be made rests essentially on the safety, operational, and economic aspects of engine reliability. Differences between the structural parts of an aircraft engine and its systems for regulation and control are discussed. Conceptual differences which usage can impose on single and multi-engined aircraft are examined in several examples. Costs and operational difficulties involving redundancy techniques must be considered when priorities are set. Transl. by A.R.H.

N77-33192# Air Force Aero Propulsion Lab., Wright-Patterson AFB, Ohio.
A PROCEDURE FOR PREDICTING THE LIFE OF TURBINE ENGINE COMPONENTS
R. J. Hill *In* AGARD Power Plant Reliability Aug. 1977 9 p refs (For primary document see N77-33181 24-07)
Avail: NTIS HC A10/MF A01

A procedural method is presented for the creation of a life estimate of aircraft gas turbine engine components. The method consists of three segments -- the calculation of a modulus, the determination of a critical material property, and a comparison of the modulus to the material property with a resulting judgment. Each segment is discussed in qualitative terms and related to required validation and acceptance testing. Author

N77-33193# Direction du Materiel Etudes de Propulsion, Paris (France)
THE EVOLUTION AND CONTROL OF DIFFERENT PERFORMANCE DEGRADATION PROCESSES IN MODERN PROPULSION SYSTEMS [EVOLUTION ET CONTROLE DES DIFFERENTS PROCESSUS DE DEGRADATION DE PERFORMANCE SUR LES PROPULSEURS MODERNES]
P. Chetail *In* AGARD Power Plant Reliability Aug. 1977 17 p refs In FRENCH (For primary document see N77-33181 24-07)
Avail: NTIS HC A10/MF A01

The development of policies for jet engine maintenance and the basic principles for applying monitoring methods are discussed. Processes involved in the degradation of thermodynamic and mechanical performance are examined. A computer program is described for evaluating the efficacy of the monitoring methods from a technical and economic point of view. Transl. by A.R.H.

N77-33194# Pisa Univ. (Italy).
TESTING SIMULATION OF DAMAGES OCCURRED IN SERVICE
D. Dini and L. Giorgieri (Ministero della Difesa Aeronautica) *In* AGARD Power Plant Reliability Aug. 1977 22 p refs (For primary document see N77-33181 24-07)
Avail: NTIS HC A10/MF A01

A basic framework is presented from which further simulation of increased complexity and sophistication can be easily implemented regarding engine failures by an in-flight foreign object, large overpressure signature inlet flow distortion, and icing environment. A general basic engine reliability program is provided, capable of simulating a running turbojet-engine and its air supplying environment as an integrated system. The specific subroutines for the possible damages are to be supplied by the user. Recent advances on testing simulation of flight-incurred power plant damages promise to reduce accidents due to engine operation at low altitudes and in rugged confined terrain. State-of-the-art design techniques are discussed to improve engine reliability, including an analysis of three particular experimental simulations to determine damage causes and effects. Recommendations are put forth that will eliminate or reduce the causes of aviation accidents. Author

N77-33195# Societe Nationale d'Etudes et de Construction de Moteurs d'Aviation, Moissy-Cramayel (France).
PROGRESS IN DETERMINING SERVICE LIFE BY ENDURANCE TESTS [PROGRES DE LA DETERMINATION DE LA VIE EN SERVICE PAR LES ESSAIS D'ENDURANCE]
B. Devoge *In* AGARD Power Plant Reliability Aug. 1977 6 p In FRENCH (For primary document see N77-33181 24-07)
Avail: NTIS HC A10/MF A01

For numerous reasons, aircraft engine builders conduct long endurance tests which are notably distinguished from the usual development and certification tests. Formulas for accelerated cyclic tests were adapted for the Olympus MK 610-14-28 engine used on the Concorde. Topics discussed include a description of the cycle test compared to the flight cycle, the installation of the test equipment, and the precautions that were taken to assure a faithful representation of operational conditions. When commercial Concorde service began, the accumulated cycles represented several years of usage. Transl. by A.R.H.

N77-33196# Pratt and Whitney Aircraft, West Palm Beach, Fla. Government Products Div.
ACCELERATED MISSION TEST: A VITAL RELIABILITY TOOL
B. J. McDonnell *In* AGARD Power Plant Reliability Aug. 1977 6 p (For primary document see N77-33181 24-07)
Avail: NTIS HC A10/MF A01

The Accelerated Mission Test (AMT) has been successfully used in the F100 engine program to anticipate potential future problems. Early identification of service oriented problems has

provided the lead time necessary to take corrective action before the problems occur in operation which decreases engine 'down' time thereby improving life cycle cost. The AMT is a supplemental testing procedure and must be used in conjunction with all of the advanced structural analysis techniques. Plans are now being developed to conduct accelerated mission tests on engines that have completed the overhaul or depot cycle. The purpose of the testing will be to identify potential problem areas associated with engine parts that have been repaired in accordance with the overhaul procedures. Author

N77-33197# Technische Hochschule, Aachen (West Germany) Inst. fuer Strahlantriebe und Turboarbeitsmaschinen.
EXPERIMENTAL INVESTIGATION ON THE INFLUENCE OF COMPONENT FAULTS ON TURBOJET ENGINE PERFORMANCE
H. Toenskoetter *In* AGARD Power Plant Reliability Aug. 1977 12 p refs (For primary document see N77-33181 24-07)
Avail: NTIS HC A10/MF A01

Some results of experimental investigations on the effect of implanted local faults, e.g. turbine guide vane damage, plugged fuel nozzles, and turbine rotor blade damage, on the performance of a single spool turbojet engine are presented. The formation of flow non-uniformities downstream from the faults is especially described. In one-dimensional gas path analysis systems, circumferential-averaged thermodynamic parameters are used for fault detection. The effect of the implanted faults on some of these averaged parameters will be shown in comparison with the local parameter changes in the disturbed sector. The possibilities of using the analysis of flow non-uniformities for the isolation of local faults in the hot section of turbojet engines are discussed and questions of probe position for this diagnostic technique are ventilated. Author

N77-33198# Vereinigte Flugtechnische Werke-Fokker G.m.b.H., Bremen (West Germany).
METHODS OF IMPROVING THE PERFORMANCE RELIABILITY OF ADVANCED MILITARY POWER PLANT SYSTEMS
Richard Smyth *In* AGARD Power Plant Reliability Aug. 1977 23 p refs (For primary document see N77-33181 24-07)
Avail: NTIS HC A10/MF A01

Advanced military propulsion systems will be equipped with multi-parameter control systems based around an electronic computer making use of digital technology. Such control systems have a high degree of flexibility and can be used for a wide range of applications. This offers new possibilities of efficient and accurate monitoring of engine performance in the aircraft and by the flight support organization responsible for reliability and safety of the propulsion system. The possibilities are discussed based on the experience gained with a multi-parameter electronic engine controller of a V/STOL fighter aircraft. Special consideration is given to practical aspects such as handling procedures. Author

N77-33199# Air Force Logistics Command, Wright-Patterson AFB, Ohio.
PRELIMINARY RESULTS OF USAF EXPERIENCE WITH ENGINE MONITORING AND DIAGNOSTICS
A. Bruce Richter and Kenneth E. Eickmann *In* AGARD Power Plant Reliability Aug. 1977 6 p (For primary document see N77-33181 24-07)
Avail: NTIS HC A10/MF A01

A formal flight test evaluation of an engine health monitoring system being used on ten T-38 supersonic aircraft is described. The system consists of engine sensors, an airframe mounted Data Processing Unit (DPU), and a ground based diagnostic display unit. The sensors continuously monitor some 24 parameters including an EGT, RPM, fuel flow, and EPR; however, data is only recorded if the pilot wishes or if a gate in the DPU is triggered. Author

N78-11083# Advisory Group for Aerospace Research and Development, Paris (France)
SECONDARY FLOWS IN TURBOMACHINES
Sep 1977 304 p In ENGLISH and FRENCH Presented at the 49th meeting of the AGARD Propulsion and Energetics Panel held at The Hague, Netherlands, 28-30 Mar 1977
(AGARD-CP-214 ISBN-92-835-0199-3) Avail NTIS HC A14/MF A01

The consensus of research which was presented suggested that (1) simplified secondary vorticity considerations and pseudo-boundary layer approaches seem to be promising for multistage compressor analysis if backed by experimental results, (2) this analysis seems to be inadequate for turbines and fully three dimensional calculation methods must be used These are still time consuming but are certainly less expensive than experiments, and (3) new experimental techniques must be used, in spite of cost and effort, to provide the necessary flow models However, experiments must be carefully planned For individual titles, see N78-11084 through N78-11104

N78-11084 Salford Univ (England)
RECENT DEVELOPMENTS IN SECONDARY FLOW
J H Horlock *In* AGARD Secondary Flows in Turbomachines Sep 1977 18 p refs (For availability see N78-11083 02-07)
Avail NTIS HC A14/MF A01

The 'state-of the art' in secondary flow work was reviewed Major recent developments include (1) clarification of earlier work on the inviscid analysis of secondary flows, (2) a new emphasis on Beltrami flows (flows with uniform stagnation pressure but streamwise vorticity), (3) integration of boundary layer calculations with inviscid secondary flow analyses, (4) full three dimensional flow calculations, both inviscid and viscid, and (5) improvements in correlations of secondary losses Author

N78-11085 Ecole Centrale de Lyon, Ecully (France) Laboratoire de Mecanique des Fluides
CALCULATIONS CONCERNING THE SECONDARY FLOWS IN COMPRESSOR BLADINGS
F Leboeuf, A Comte, and K D Papailiou *In* AGARD Secondary Flows in Turbomachines Sep 1977 9 p refs (For availability see N78-11083 02-07)
Avail NTIS HC A14/MF A01

The behavior of secondary flows in compressors is analyzed using an integral method of calculation based on MELLOR's theory and a radial equilibrium calculation method The comparison of the theory with the experiment is finally discussed Author

N78-11086 Ecole Centrale de Lyon, Ecully (France)
EXPERIMENTAL STUDY OF THE BEHAVIOR OF SECONDARY FLOWS IN A TRANSONIC COMPRESSOR
G Bois, F Leboeuf, A Comte, and K D Papailiou *In* AGARD Secondary Flows in Turbomachines Sep 1977 20 p refs (For availability see N78-11083 02-07)
Avail NTIS HC A14/MF A01

Detailed measurements in the secondary flow regions in a transonic one-stage compressor have been transformed for different values of the inlet boundary layer and tip clearance The behavior of the secondary flows is examined in the light of these measurements. Author

N78-11087 Technische Hochschule, Aachen (West Germany)
SECONDARY FLOWS AND ANNULUS WALL BOUNDARY LAYERS IN AXIAL-FLOW COMPRESSOR AND TURBINE STAGES
H E Gallus and W Kuemmel *In* AGARD Secondary Flows in Turbomachines Sep 1977 15 p refs (For availability see N78-11083 02-07)
Avail NTIS HC A14/MF A01

The complex interdependencies of the various loss sources in axial turbomachines require very complicated correlations in the prediction of the total losses Thus, it is worth proving how the total losses can be predicted by more simplified and idealized loss models In this paper, an appropriate method is presented In a first attempt, this method is demonstrated by the calculation of only three essential loss components in an axial-flow compressor stage and their comparison with the measured total losses The loss components taken into account are profile losses, losses by the collateral wall boundary layer, and a certain part of losses caused by secondary flows In the stator of the axial compressor stage mentioned before systematical measurements in the casing wall boundary layer were performed Some results such as streamline patterns, pressure distributions and velocity profiles are presented At last, experimental investigations aiming at the reduction of secondary flow losses in an axial-flow turbine stage are dealt with A considerable reduction was achieved by boundary layer grooves or fences for the very small aspect ratio of 0 25 Author

N78-11088 Texas A&M Univ, College Station Gas Turbine Laboratories
SECONDARY FLOWS IN AXIAL FLOW COMPRESSORS WITH TREATED BLADES

Meherwan P Boyce *In* AGARD Secondary Flows in Turbomachines Sep 1977 14 p refs (For availability see N78-11083 02-07)
Avail NTIS HC A14/MF A01

As a means of increasing the performance and surge margin of axial flow compressors, boundary layer control in many forms have to be applied A technique is described which controls the flow in the separation region The technique deals with the treatment of the suction surface of the blade The overall goals of the program were to extend the surge-to-stall margin, and to accomplish this, an extensive test program of flow visualization was conducted, using a different cascade model These results were then compared with various theoretical models to understand the complex flow field in an axial compressor The results indicate that blade treatment is effective in controlling the onset of surge, and thus increases the surge-to-stall margin by creating a stable flow situation Author

N78-11089 Office National d'Etudes et de Recherches Aerospatiales, Paris (France)
INFLUENCE OF INITIAL DISTORTIONS ON SECONDARY FLOWS IN A FIXED ANNULAR CASCADE
Jacques Huard *In* AGARD Secondary Flows in Turbomachines Sep 1977 7 p refs In FRENCH, ENGLISH summary (For availability see N78-11083 02-07)
Avail NTIS HC A14/MF A01

A test rig comprising, in a cylindrical duct of constant height an accelerating cascade that provided a giating flow at high subsonic Mach number and a receiving cascade representing the downstream stator of an axial compressor deflecting the flow back to the axial direction was used for the experimental study In the reference configuration, the flow is uniform in azimuth at inlet By means of angular sectors of screens with different permeabilities, a pressure drop is created upstream of the first cascade The exploration of the flow between the two cascades reveals a strong perturbation near the hub, where the azimuthal variation of the tangential component induces the transformation of the flow, whose static pressure was initially variable in both radius and azimuth, into one with only radial pressure variation It is this flow that impinges the decelerating cascade, which amplifies the secondary affects near the hub, where intense flow separations take place A strong amplification of initial flow distortions has thus been brought to light, as regards secondary flows Author

N78-11090 Vrije Universiteit, Brussels (Belgium) Dept of Fluid Mechanics
HOT-WIRE MEASUREMENTS IN AN AXIAL COMPRESSOR AND CONFRONTATION WITH THEORETICAL PREDICTIONS OF SECONDARY FLOWS
J. De Ruyck, Ch Hirsch, and P Kool *In* AGARD Secondary Flows in Turbomachines Sep 1977 18 p refs (For availability see N78-11083 02-07)
Avail NTIS HC A14/MF A01

Measurements of the three-dimensional flow field behind a single stage compressor rotor are presented and a brief description of the measurement technique is given Components of vorticity are extracted from the experimental data and compared with secondary flow theory Author

N78-11091 Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Porz (West Germany)
DUAL BEAM LASER ANEMOMETRY STUDY OF THE FLOW FIELD IN A TRANSONIC COMPRESSOR
H B Weyer and R Dunker *In* AGARD Secondary Flows in Turbomachines Sep 1977 11 p refs (For availability see N78-11083 02-07)
Avail NTIS HC A14/MF A01

An advanced laser anemometer (L-2-F-technique) was used to study in detail the internal flow of a transonic axial flow compressor at tip Mach numbers of 0 9 and 1 4 (corresponding to 70 and 100% speed) This investigation having yielded quite complete data on the span- and gap-wise velocity profiles reveals a good survey on the real flow pattern even in the high-speed transonic rotor detailed informations are available on the flow deceleration at subsonic and supersonic inlet velocities on the 3-dimensional shock-waves, on transition phenomena from subsonic to supersonic flow along the blade height, on blade wakes, and flow unsteadiness Experimental results are applied to a discussion of primary characteristics of transonic rotor flow Author

N78-11092 Imperial Chemical Industries, Wilton (England)
SECONDARY FLOW AND LOSSES IN TURBINE CASCADES WITH INLET SKEW
H B Carrick *In* AGARD Secondary Flows in Turbomachines Sep 1977 21 p refs (For availability see N78-11083 02-07)
Avail NTIS HC A14/MF A01

A skewed boundary layer was produced upstream of an impulse turbine cascade, using a moving belt Measurements of the flow field upstream, downstream and within the cascade passage were made with pressure probes Typical results for total pressure, velocity and static pressure are presented, and the effect of the skewed inlet boundary layer on the secondary losses and flow pattern within the cascade is discussed Three numerical methods were used to calculate the endwall flow field, a passage averaged boundary layer method, a three-dimensional boundary layer method for a cascade passage and a three-dimensional inviscid method Typical results of these methods are displayed and their advantages and disadvantages discussed Author

N78-11093 Office National d'Etudes et de Recherches Aerospatiales, Paris (France)
EFFECTS OF SECONDARY FLOWS IN STRAIGHT CASCADES
Georges Meauze *In* AGARD Secondary Flows in Turbomachines Sep 1977 6 p refs In FRENCH, ENGLISH summary (For availability see N78-11083 02-07)
Avail NTIS HC A14/MF A01

Secondary flows in straight cascades play a considerable role, and jeopardize the validity of the tests performed on this experimental set-up, especially at high compression rates, when the secondary flow may fill a relatively important part of the interblade channels In order to palliate this difficulty, a system of lateral boundary layer suction has been developed It permits the elimination of the secondary flow and the definition of a primary flow practically uniform over the whole cascade width The results obtained are satisfactory in subsonic, transonic and supersonic flow, with or without simulation of section convergence Author

N78-11094 Von Karman Inst for Fluid Dynamics, Rhode-Saint-Genese (Belgium)
SECONDARY FLOWS WITHIN TURBOMACHINERY BLADINGS
Ph Marchal and C H Sieverding *In* AGARD Secondary Flows in Turbomachines Sep 1977 20 p refs (For availability see N78-11083 02-07)
Avail NTIS HC A14/MF A01

Detailed experimental investigations of boundary layer development within blade passages were made Research was done because of the complexity of secondary flows in turbomachinery bladings and the difficulty to describe these in a theoretical sound formulation Contributions in the field of secondary flows in compressor cascades were recalled and results of the experiments carried out presently on turbine cascades were presented Secondary flow developments under the influence of a variation of inlet boundary layer thickness and blade loading were described Attention was devoted to the role of the leading edge vortex Experimental techniques used included three-directional pressure probes, oil flow visualizations and smoke visualizations combined with the light sheet technique using illumination by laser Author

N78-11095 Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Goettingen (West Germany)
INFLUENCE OF SECONDARY FLOW EFFECTS ON BLADE SURFACE PRESSURE MEASUREMENTS IN 2-D TRANSONIC TURBINE CASCADES
Hans-J Heinemann *In* AGARD Secondary Flows in Turbomachines Sep 1977 14 p refs (For availability see N78-11083 02-07)
Avail NTIS HC A14/MF A01

A turbine cascade with high deflection was considered Surface pressure measurements were carried out in different planes of the blade height, which was twice as great as usual The blade was moveable through the end-walls Measurements in different planes were possible with the same tappings and the ratio of blade height to blade length was slightly larger than two Tests were performed in a plane cascade tunnel for subsonic transonic and supersonic Mach number The inlet angle and the pitch/chord ratio was varied and flow was visualized by oil flow pictures of the blade surface taken during wind tunnel runs This method was also used for motion pictures in which

flow behavior on the blade surface was observed for a high-turning rotor cascade and a stator cascade Author

N78-11096 Durham Univ (England) Dept of Engineering Science
SECONDARY FLOW IN CASCADES
D Glynn, A Spurr, and H Marsh *In* AGARD Secondary Flows in Turbomachines Sep 1977 12 p refs (For availability see N78-11083 02-07)
Avail NTIS HC A14/MF A01

Recent work on secondary flow in linear cascades is described The use of a power law profile for the end wall boundary layer was shown to lead to a discontinuity in the slope of the variation of exit angle across the span of the blades The change in the shape of the wall boundary layer across a cascade was estimated and the corresponding change in axial velocity was included in the secondary flow theory An iterative scheme was proposed where the distributed secondary vorticity is based on the predicted outlet angle rather than the mainstream flow angle The pitch averaged streamwise vorticity was calculated at exit from the cascade and was shown to be in close agreement with experimental results Author

N78-11097 Air Force Aero Propulsion Lab, Wright-Patterson AFB, Ohio
UNDERSTANDING TURBINE SECONDARY FLOW
Wayne A Tall *In* AGARD Secondary Flows in Turbomachines Sep 1977 12 p refs (For availability see N78-11083 02-07)
Avail NTIS HC A14/MF A01

Careful control of flow in three dimensions, particularly in low aspect ratio, axial turbines, was considered in practical utilization of high temperature technology A review of the literature of radial fluid motion and three-dimensional viscous flow in such cascades was done and many contradictory interpretations were disclosed which did not lead to improved understanding of low aspect ratio cascade flow More recent experiments demonstrated that earlier experiments were guided by a false understanding of such flows, especially near the cascade endwalls A recent effort using annular cascades and a three-dimensional, viscous flow analysis to improve stage performance rather than merely to correlate cascade results, demonstrated the tremendous potential of three-dimensional viscous flow analysis techniques to help in the understanding of this flow problem Author

N78-11098* National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
EFFECT OF ENDWALL COOLING ON SECONDARY FLOWS IN TURBINE STATOR VANES
Louis J Goldman and Kerry L McLallin *In* AGARD Secondary Flows in Turbomachines Sep 1977 29 p refs (For availability see N78-11083 02-07)
Avail NTIS HC A14/MF A01 CSCL 21E

An experimental investigation was performed to determine the effect of endwall cooling on the secondary flow behavior and the aerodynamic performance of a coreturbine stator vane The investigation was conducted in a cold-air, full-annular cascade, where three-dimensional effects could be obtained Two endwall cooling configurations were tested In the first configuration, the cooling holes were oriented so that the coolant was injected in line with the inviscid streamline direction In the second configuration, the coolant was injected at an angle of 15 deg to the inviscid streamline direction and oriented toward the vane pressure surface In both cases the stator vanes were solid and uncooled so that the effect of endwall cooling could be obtained directly Total-pressure surveys were taken downstream of the stator vanes over a range of cooling flows at the design, mean-radius critical velocity ratio of 0 778 Changes in the total-pressure contours downstream of the vanes were used to obtain the effect of endwall cooling on the secondary flows in the stator Comparisons were made between the two cooled-endwall configurations and with the results obtained previously for solid endwalls Author

N78-11099 Politecnico di Torino (Italy) Istituto di Macchine e Motori per Aeromobili
A NUMERICAL TIME-DEPENDENT APPROACH FOR DESCRIBING COMPRESSIBLE INVISCID NON-ISENTROPIC ROTATIONAL FLOWS IN CURVED DUCTS
G Bussi and M Pandolfi *In* AGARD Secondary Flows in Turbomachines Sep 1977 4 p refs (For availability see N78-11083 02-07)
Avail NTIS HC A14/MF A01

A time-dependent technique of numerical analysis was used to describe transient and steady flow patterns Complete Euler equations for 3D unsteady flow were integrated in time according to a two level scheme of integration A crucial point in this problem was represented by the computation at the boundaries The philosophy consisted of matching local quasi-steady conditions representing the boundary and compatibility equations along characteristic lines Details on the algorithms at solid walls, and at the inlet and the outlet of the duct are given Author

N78-11100 Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Porz (West Germany) Inst fuer Luftstrahlantriebe
SECONDARY FLOW STUDIES IN HIGH-SPEED CENTRIFUGAL COMPRESSOR IMPELLERS
D Eckardt and H Krain *In* AGARD Secondary Flows in Turbomachines Sep 1977 13 p refs (For availability see N78-11083 02-07)
Avail NTIS HC A14/MF A01

The flow fields within radial discharge and backward leaning impellers, running at tip speeds up to 400 m/s, were investigated by means of new laser techniques Results, concerning the through-flow pattern of a radial bladed impeller, are presented Detailed information about the superimposed secondary flow pattern was derived from flow angle measurements On the basis of these studies an impression of the complex secondary vortex distribution in radial compressor impellers was gained Finally, a comparison between measured and calculated streamwise vorticity near the exit of a radial discharge impeller is presented Author

N78-11101 Chalmers Univ of Technology, Goteborg (Sweden) Dept of Turbomachinery
SOME OBSERVATIONS FROM LOW-SPEED CASCADE TESTS CONCERNING SIDE WALL BOUNDARY LAYER SUCTION
B A Gustafson *In* AGARD Secondary Flows in Turbomachines Sep 1977 10 p ref (For availability see N78-11083 02-07)
Avail NTIS HC A14/MF A01

The influence of distributed porosity on cascade test results was investigated Various side wall configurations were used Flow pattern on the blade surfaces was visualized using ink traces on paper which covered the blades Strong deviation from parallel flow was observed on the suction surface at high axial-velocity-density values At lower values the streamlines straightened out It was found that the flow velocity has a component towards the wall partly as an effect of the side wall through-flow and partly as an effect of secondary flow due to boundary layer cross flow B L P

N78-11102 Stuttgart Univ (West Germany) Inst fuer Raumfahrtantriebe
THREE-DIMENSIONAL FLOW IN HIGHLY LOADED ANNULAR CASCADES WITH ZERO SECONDARY VORTICITY
Hans-Heiner Fruehauf *In* AGARD Secondary Flows in Turbomachines Sep 1977 6 p refs (For availability see N78-11083 02-07)
Avail NTIS HC A14/MF A01

Significant three-dimensional effects occurring in inviscid high Mach number irrotational stator flows and absolute rotor flows were considered The magnitude of these effects was determined quantitatively Limitations of simplified flow models in predicting these flows were discussed Author

N78-11103 Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Porz (West Germany) Inst fuer Luftstrahlantriebe
CORNER BOUNDARY LAYER AND SECONDARY FLOW WITHIN A STRAIGHT COMPRESSOR CASCADE
Juergen H Renken *In* AGARD Secondary Flows in Turbomachines Sep 1977 16 p refs (For availability see N78-11083 02-07)
Avail NTIS HC A14/MF A01

Measurements at Mach number M | 0 3 and Reynolds numbers Re | 300 000 in a straight compressor cascade with 48 deg cambered double circular arc profiles and contractable sidewalls are presented and compared with two and three-dimensional calculations From the differences between measurement and calculation and from the evaluation of numerous corner layer publications conclusions were drawn towards secondary flow effects Author

N78-11104 Birmingham Univ (England) Dept of Mechanical Engineering
NOTE ON RELATIVE VORTICITY
J W Railly *In* AGARD Secondary Flows in Turbomachines Sep 1977 2 p refs (For availability see N78-11083 02-07) Avail NTIS HC A14/MF A01

The presence of secondary flows in rotor passages was examined in flow relative to a rotor which has zero absolute vorticity at entry Axial flow machines were considered for simplicity and the blades were regarded as being replaced by *filaments of bound vorticity which lie along surfaces having the shape of the blade camber surfaces* An analysis was made to determine the mean angular momentum distribution throughout a rotor by using the sectorial angle rotor angular velocity, as well as hub and tip radii Author

N78-12086*# National Aeronautics and Space Administration, Washington, D C
PROTECTION OF COOLED BLADES OF COMPLEX INTERNAL STRUCTURE
P Glamiche Oct 1977 22 p refs Transl into ENGLISH from AGARD Conf Preprint No 229 Presented at Conf on High Temp Probl in Gas Turbine Engines, Ankara, 19-23 Sep 1977, sponsored by AGARD Transl by Kanner (Leo) Associates Redwood City, Calif Original doc prep by Natl Inst of Aerospace Studies and Res
(Contract NASw-2790)
(NASA-TM-75217 AGARD-CP-229) Avail NTIS HC A02/MF A01 CSCL 21E

The problem of general protection of cooled blades of complex internal structure was solved by a method called SF technique which makes possible the protection of both external and internal surfaces, as well as those of the orifices of cooling air, whatever their diameter The SF method is most often applied in the case of pack process, at controlled or high activity, it can be of *use on previously uncoated parts*, but also on pieces already coated by a thermochemical, chemical or PVD method The respective thickness of external and internal coatings may be precisely predetermined no parasitic particle being liable to remain inside the parts after application of the protecting treatment Results obtained to date by application of this method are illustrated by the presentation and examination of a various selection of advanced turbo engines Author

N78-14048# Advisory Group for Aerospace Research and Development, Paris (France)
TECHNICAL EVALUATION REPORT ON THE 49TH(B) PROPULSION AND ENERGETICS SPECIALISTS MEETING ON POWER PLANT RELIABILITY
G P Sallee (Pratt and Whitney Aircraft Group, East Hartford, Conn) Nov 1977 11 p refs Meeting held at The Hague, 31 Mar - 1 Apr 1977
(AGARD-AR-110, ISBN-92-835-0207-8) Avail NTIS HC A02/MF A01

The following observations reflect the tone of the meeting and the major results (1) *Engine reliability is not satisfactory in* either commercial or military services In particular the newer commercial engines are not living up to operators expectations (2) It seems that civil and military authorities are considering the promulgation of more stringent requirements and standards concerning the development, certification/qualification and acquisition of future engines with respect to the reliability requirements that must be met (3) Manufacturers are designing for improved maintainability and employing improved testing techniques to expose problems early Further progress is contingent on the availability of engineering data on actual engine usage in military service Detailed part failure data is needed to determine the causes for part failure with respect to usage and the relationships that exist between the various modes of failure (4) The economic impact of military engine unreliability has not been discussed The cost consequences of premature engine removals, aborts, part failures, etc , are needed to establish *the role* of engine reliability in engine life cycle cost (5) The growth of engine health monitoring in the commercial airlines and the increased experimentation of such approaches in the military are indicative of the serious consequences of poor engine *reliability The future growth/potential for such techniques* is impressive Author

N78-14052# Advisory Group for Aerospace Research and Development Paris (France)
TECHNICAL EVALUATION REPORT ON THE 49TH(A) PROPULSION AND ENERGETICS PANEL SPECIALISTS' MEETING ON SECONDARY FLOWS IN TURBOMACHINES
K Papailiou (Ecole Centrale de Lyon) Nov 1977 11 p refs Meeting held at The Hague, 28-30 Mar 1977
(AGARD-AR-109, ISBN-92-835-1263-4) Avail NTIS HC A02/MF A01

Problems dealing with secondary flows *in turbomachinery* were investigated in a total of fifteen invited papers and seven short presentations, followed by a round table discussion Theoretical works covered earlier research on secondary flow effects in compressors and turbines Most of the presentations described experimental results Techniques used include probe surveys, laser velocimetry, and several forms of flow visualization Author

N78-15054# Advisory Group for Aerospace Research and Development, Paris (France)
ENGINES FOR SMALL PROPELLER-DRIVEN RPVs, REPORT OF SUB-GROUP A OF AGARD WORKING GROUP ON PROPULSION AND POWER SUPPLIES FOR UNMANNED VEHICLES, VOLUME 1
Nov 1977 102 p
(AGARD-AR-101-Vol-1, ISBN-92-835-1259-6) Avail NTIS HC A06/MF A01

The propulsion technology applicable to small propeller-driven RPV's used for military missions was surveyed An inventory of *existing engines* applicable to small RPV's, the power requirements of small RPV's and parametric calculations used to study the relationship between the RPV and the engine are presented.
J M S

N78-21118# Advisory Group for Aerospace Research and Development, Paris (France)
HIGH TEMPERATURE PROBLEMS IN GAS TURBINE ENGINES
Feb 1978 585 p refs Presented at the 50th Meeting of the AGARD Propulsion and Energetics Panel, Ankara, 19-23 Sep 1977
(AGARD-CP-229 ISBN-92-835-0209-4) Avail NTIS HC A25/MF A01

The design and operation of gas turbines at high turbine inlet temperatures are considered Emphasis is placed on turbine cooling techniques, high temperature materials and coatings, *combustors, afterburners*, and nozzles, the effect of cooling on aerodynamic performance, and prediction methods For individual titles, see N78-21119 through N78-21158

N78-21119# Motoren- und Turbinen-Union Muenchen G m b H (West Germany)
TECHNICAL EVALUATION REPORT ON 50TH PROPULSION AND ENERGETICS PANEL MEETING ON HIGH TEMPERATURE PROBLEMS IN GAS TURBINE ENGINES
R Eggebrecht and S Lombardo (Curtiss-Wright Corp , Wood-Ridge, N J) *In* AGARD High Temp Probl in Gas Turbine Eng Feb 1978 16 p refs (For availability see N78-21118 12-07)
Avail NTIS HC A25/MF A01

A review is given of the technology *associated with the* design and operation of gas turbines at high turbine inlet temperatures Test results from different cascade rigs, the effect of coolant injection on turbine aerodynamics, and external turbine blade heat transfer in the absence of boundary layer coolant injection are considered along with film cooling, influence of transpiration cooling on turbine blade boundary layers, and prediction methods for steady state and transient temperature distributions Other topics discussed include the effect of turbine cooling on aerodynamic performance, combustors and afterburners, high temperature materials and coatings, and overall engine design and performance J M S

N78-21120# Rolls-Royce Ltd , Bristol (England) Aero Div
PROJECT OPTIMISATION OF MILITARY GAS TURBINES WITH RESPECT TO TURBINE LIFE
E A White and M J Holland *In* AGARD High Temp Probl in Gas Turbine Eng Feb 1978 17 p (For availability see N78-21118 12-07)
Avail NTIS HC A25/MF A01

Computerized analytical techniques developed for examining the characteristics of high pressure turbine blades under the various stresses of operation are considered Emphasis is placed on turbine service life and cooling requirements for military aircraft in terms of and developing a cost effective weapon system
J M S

N78-21121# Turbomeca S A Brevets Szydlowski, Bizanos (France)

PROBLEMS CONCERNING HIGH TEMPERATURES IN SMALL TURBOMACHINES [PROBLEMES DES HAUTES TEMPERATURES DANS LES PETITES TURBOMACHINES]

P Belaygue *In* AGARD High Temp Probl in Gas Turbine Eng Feb 1978 12 p In FRENCH (For availability see N78-21118 12-07)

Avail NTIS HC A25/MF A01

The power of small aeronautical turbomachinery is discussed in detail Problems arising from elevating temperature and pressure at the turbine entrance which affect components such as the compressor, as well as the combustion chamber, and the turbine were examined The aerodynamic and thermodynamic limitations that occur due to this rise in temperature and pressure are also summarized in relation to the small dimensions of the components Transl by B B

N78-21122*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

PROGRESS IN ADVANCED HIGH TEMPERATURE TURBINE MATERIALS, COATINGS, AND TECHNOLOGY

John C Freche and G Marvin Ault *In* AGARD High Temp Probl in Gas Turbine Eng Feb 1978 31 p refs (For availability see N78-21118 12-07)

Avail NTIS HC A25/MF A01 CSCL 21E

Advanced materials, coatings, and cooling technology is assessed in terms of improved aircraft turbine engine performance High cycle operating temperatures, lighter structural components, and adequate resistance to the various environmental factors associated with aircraft gas turbine engines are among the factors considered Emphasis is placed on progress in development of high temperature materials for coating protection against oxidation, hot corrosion and erosion, and in turbine cooling technology Specific topics discussed include metal matrix composites, superalloys, directionally solidified eutectics, and ceramics J M S

N78-21123# Teledyne CAE, Toledo, Ohio

THE STATUS OF SMALL, COOLED, AXIAL-FLOW TURBINES

H F Due, A E Easterling (Army AMRDL, Fort Eustis, Va), and J E Haas (Army AMRDL, Cleveland) *In* AGARD High Temp Probl in Gas Turbine Eng Feb 1978 15 p refs (For availability see N78-21118 12-07)

Avail NTIS A25/MF A01

The design of a high performance small, cooled, axial flow turbine is considered in terms of aerodynamic performance, structural life, flow conditions, and cycle variations Analytical techniques which predict losses, flow conditions, operating velocity triangles, and stage matching are reviewed It is concluded that the design techniques are not adequate for meeting the requirements of high performance gas turbine engines without relying on semi-empirical relationships J M S

N78-21124# Societe Nationale d'Etude et de Construction de Moteurs d'Aviation, Villaroche (France)

ADAPTING A TURBINE ENGINE TEST STAND FOR HIGH TEMPERATURE RESEARCH [ADAPTATION D'UN BANC DE TURBINE AUX RECHERCHES POUR LES HAUTES TEMPERATURES]

J Francois, Y Le Bot (ONERA, Paris), J Michard (ONERA, Paris), and P Deguest (CEP, Saclay, France) *In* AGARD High Temp Probl in Gas Turbine Eng Feb 1978 10 p refs In FRENCH (For availability see N78-21118 12-07)

Avail NTIS HC A25/MF A01

A description of an apparatus for high temperature research is presented, and the influence of the turbine environment on the effectiveness of film thermal protection was studied Detailed measurements were carried out on the assemblage provided the validation of the aerodynamic and thermal performance prediction of gas turbines Transl by B B

N78-21125# Motoren- und Turbinen-Union Muenchen G.m.b.H. (West Germany).

HOT CASCADE TEST RESULTS OF COOLED TURBINE BLADES AND THEIR APPLICATION TO ACTUAL ENGINE CONDITIONS

H Koehler, D K Hennecke, K Pfaff, and R Eggebrecht *In* AGARD High Temp Probl in Gas Turbine Eng Feb 1978 12 p refs (For availability see N78-21118 12-07)

Avail NTIS HC A25/MF A01

Experimental results of the cooling performance of various convection and film cooled turbine blade models in a two dimensional stationary cascade are presented The Reynolds number and the cooling air/main stream mass flow ratio were varied within a range which is typical for turbine rotor blades in jet engines From the analysis of the test results basic understanding about the characteristics of cooling effectiveness and about the distribution of the hot gas side heat transfer coefficient was obtained In applying model test results to a real engine, the differences between cascade and engine conditions, for example the rotation and the changed radiation environment, are taken into account Some engine phenomena, such as free stream turbulence, which still have a largely unknown influence on heat transfer processes, are discussed Blade temperature *from engine tests are compared with cascade test results and* theoretical temperature distributions For a simulated engine acceleration process the temperature and the stress distributions in the mid-section of a turbine blade was computed using a time dependent finite element program The results which serve as a basis for a comparative blade live assessment show that, during the transient phase, the mechanical loading of the blade by far exceeds the steady state valves Author

N78-21126# Technische Hochschule, Aachen (West Germany) Inst fuer Strahlantriebe und Turboarbeitsmaschinen

INVESTIGATIONS OF THE LOCAL HEAT TRANSFER COEFFICIENT OF A CONVECTION COOLED ROTOR BLADE

W Kuehl *In* AGARD High Temp Probl in Gas Turbine Eng Feb 1978 11 p refs (For availability see N78-21118 12-07)

Avail NTIS HC A25/MF A01

Temperature measurements made within the convection air cooled rotor blade of a gas turbine during operation are used to determine the local heat transfer coefficients of turbine blades The analytical method is described along with results which include the local gas side heat transfer and the complete temperature field within the blade Unsteady flow effects are discussed J M S

N78-21127# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Cologne (West Germany) Inst. fuer Antriebstechnik.

INVESTIGATION ON TEMPERATURE DISTRIBUTION NEAR FILM COOLED AIRFOILS

H Kruse *In* AGARD High Temp Probl in Gas Turbine Eng Feb 1978 13 p (For availability see N78-21118 12-07)

Avail NTIS HC A25/MF A01

Using a practically adiabatic airfoil as a simple model of a turbine blade, some typical film cooling configurations were investigated The dimensions and operating conditions were chosen so that both the Reynolds numbers and the ratio of hole diameter to boundary layer thickness would correspond to realistic values in the turbine The temperature ratio between the mainstream and the coolant was in the range of 1.25 in order to get reasonable temperature differences The temperature distributions within the gas and on the adiabatic wall were measured by means of miniaturized thermocouples Information is given on the distribution of film cooling effectiveness and on the distribution of temperature in the near region downstream of the blowing point To point out the influence of curvature near the nose of the airfoil some typical results were compared with those from flat plate measurements Author

N78-21128# Middle East Technical Univ , Ankara (Turkey). Dept of Mechanical Engineering

EROSION PREVENTION AND FILM COOLING ON VANES

M. Saryal, I. M Chantous, and A Citici *In* AGARD High Temp Probl. in Gas Turbine Eng. Feb 1978 8 p refs (For availability see N78-21118 12-07)

Avail NTIS HC A25/MF A01

A preliminary research on the behavior of solid particles *approaching a cascade of leaf nozzles having air injected through* a slit at the leading edge, was carried out The results showed a definite prevention of erosion of solid particles at the leading edge region and the blade shoulder The only vulnerable region was the pressure side trailing edge region. The ability of this method to provide means for effective cooling of gas turbine blades and possibilities of pulverized coal direct firming were studied Results are summarized Author

N78-21129# Sussex Univ , Brighton (England) Dept of Mechanical Engineering

PERFORMANCE AND DESIGN OF TRANSPIRATION-COOLED TURBINE BLADING

F J Bayley *In* AGARD High Temp Probl in Gas Turbine Eng Feb. 1978 15 p refs (For availability see N78-21118 12-07)
Avail NTIS HC A25/MF A01

Experimental and theoretical studies of transpiration cooled turbine blades are reviewed and a design method for such cooling system is proposed An integral boundary layer method of analysis is shown to produce good agreement between observed and predicted heat transfer coefficients over most of the blade section where the effect of the coolant flow is significant, while a simple momentum mixing theory appears adequate for assessing the effect of the coolant on the blade profile loss Author

N78-21130# Ohio State Univ., Columbus
THE INFLUENCE OF TRANSPIRATION COOLING ON TURBINE BLADE BOUNDARY LAYER
Lit S Han and Leon Winget *In* AGARD High Temp Probl in Gas Turbine Eng Feb 1978 14 p refs Sponsored in part by AF (For availability see N78-21118 12-07)
Avail NTIS HC A25/MF A01

The external boundary layer and the heat transfer distribution of a film cooled turbine blade are calculated Results are used to determine the necessary film injection rate when the airfoil shape, the external gas, and the desired blade temperature are specified J M S

N78-21131# National Gas Turbine Establishment, Pyestock (England)
EXPERIMENTAL EVALUATION OF A TRANSPIRATION COOLED NOZZLE GUIDE VANE
W. H. Morris, J. B Bullard, and L. D Wigg *In* AGARD High Temp Probl in Gas Turbine Eng Feb 1978 15 p refs (For availability see N78-21118 12-07)
Avail NTIS HC A25/MF A01

The design and experimental evaluation of a transpiration cooled nozzle guide vane is described The thermal evaluation of the coolant system design at gas temperature up to 1615 K indicated achievment of design effectiveness levels and good uniformity of temperature distribution. However, the effect of transpiring flow on turbine stage efficiency was to bring about a significant loss in performance, relative to an uncooled nozzle a loss of about 5 per cent in efficiency at a coolant mass flow ratio of 3 per cent was observed. Application of the experimental data to transpiration cooling of nozzle guide vanes is discussed Author

N78-21132# Technische Hogeschool Delft (Netherlands) Lab voor Verbrandingsmotoren en Gas-turbines
HEAT TRANSFER CHARACTERISTICS OF THE CLOSED THERMOSYPHON SYSTEM
R W Stuart-Mitchell and J Andries *In* AGARD High Temp Probl in Gas Turbine Eng Feb 1978 13 p refs (For availability see N78-21118 12-07)
Avail: NTIS HC A25/MF A01

A closed thermosyphon system of gas turbine blade cooling, using liquid metals and a secondary cooling circuit in a blade root, was studied Experimentally determined heat transfer characteristics were determined for a 10.6 mm diameter cylindrical closed thermosyphon with a length diameter ratio 11.6:1 and a heated-to cooled-length ratio of 1:1 using water and mercury under a uniform heat flux, hot wall boundary condition. Results were obtained with the thermosyphon stationary and variously angled to the vertical between 0 deg and 45 deg and mounted in a rotating arm apparatus at rotational speeds between 500 r.p.m and 1000 r.p.m The results from the rotating experiments were correlated using a Grashof Number based on the gravitational acceleration, while the centrifugal acceleration was included in a third dimensionless parameter Comparison of the results from the stationary and rotating experiments shows that angling the stationary thermosyphon to the vertical does not simulate the heat transfer in the rotating thermosyphon Author

N78-21133# Sussex Univ., Brighton (England) School of Engineering and Applied Sciences.
HEAT TRANSFER FROM TURBINE AND COMPRESSOR DISCS
J. M Owen *In* AGARD High Temp. Probl in Gas Turbine Eng Feb 1978 12 p refs (For availability see N78-21118 12-07)
Avail NTIS HC A25/MF A01

Mean and local Nusselt numbers were determined for three different rotating disc configurations Heat transfer measurements are presented for (1) a single disc rotating close to a stator with a radial outflow of coolant, representing the flow between an air cooled turbine disc and a casing (2) a rotating cavity with a central axial throughflow of coolant, representing the flow between corotating compressor discs and (3) a rotating cavity with a radial outflow of coolant representing the flow between corotating air cooled turbine discs Results are presented for a range of axial gaps coolant flow rates and rotational speeds, and the similarities and differences between the three cases are discussed In particular it is shown that vortex breakdown dramatically alters the flow and heat transfer Author

N78-21134# Centre de Villaroche, Moissy (France) Dept Combustion-Pollution-Rechauffe
A REVIEW OF TECHNIQUES FOR THE THERMAL PROTECTION OF THE WALLS OF THE COMBUSTION CHAMBER AND REHEATING DUCTS OF TURBOREACTORS [REVUE DES TECHNIQUES DE PROTECTION THERMIQUE DES PAROIS DES FOYER PRINCIPAUX ET DE RECHAUFFE DES TURBOREACTEURS]
M Buisson, J P Gaillac, and B Deroide *In* AGARD High Temp Probl in Gas Turbine Eng Feb 1978 15 p refs In FRENCH (For availability see N78-21118 12-07)
Avail NTIS HC A25/MF A01

Techniques and limitations involved in the recooling of the combustion chamber in turboreactors were reviewed A critical analysis of classical solutions such as forced convection, and film recooling showed the necessity for the utilization for more elaborate procedures, which include more simplified calculations Transl by B B

N78-21135# Lucas Aerospace Ltd., Burnley (England) Fabrications Div
PRACTICAL SOLUTIONS TO THE COOLING OF COMBUSTORS OPERATING AT HIGH TEMPERATURES
J Winter and H Todd *In* AGARD High Temp Probl in Gas Turbine Eng Feb 1978 14 p (For availability see N78-21118 12-07)
Avail NTIS HC A25/MF A01

Flame tube life potential for small gas turbine engine applications where high temperature operating conditions occur was studied A small annular reverse flow combustion chamber was developed which utilizes a high proportion of the incoming air for wall film cooling purposes, prior to the redirection of the cooling air for combustion and mixing The concept is shown to minimize the cooling difficulties encountered on conventional small annular chambers particularly when operating at elevated turbine entry temperatures A combustor developed for a regenerative gas turbine engine where impingement cooling liners are employed to overcome problems of high metal temperatures on a low cost unit is described Author

N78-21136# Technische Hochschule, Darmstadt (West Germany) Inst fuer Technische Thermodynamik
THE INFLUENCE OF COOLANT TURBULENCE INTENSITY ON FILM COOLING EFFECTIVENESS
R Best *In* AGARD High Temp Probl in Gas Turbine Eng Feb 1978 14 p refs (For availability see N78-21118 12-07)
Avail NTIS HC A25/MF A01

In pipe flow experiments cold air was injected tangentially to the tube wall of the test section through an annular slot into a hot fully developed turbulent pipe flow The adiabatic wall temperature was measured along the pipe length for different velocity ratios, injection slot heights, and degrees of turbulence of coolant and main streams Simultaneously the velocity and the temperature profiles as well as the distribution of the turbulent fluctuation velocities were measured The measurements indicate that an increasing turbulence intensity of the coolant can significantly reduce film cooling effectiveness By means of turbulent fluctuation velocity measurements and a physical model the film cooling effectiveness can be calculated The derived correlations reveal cooling effectiveness with increasing turbulence There is good agreement between experiments and theoretical predictions. Author

N78-21137# Centro per l'Automatica E. Piaggio, Pisa (Italy)
HIGH TEMPERATURE H2-AIR VARIABLE GEOMETRY COMBUSTOR AND TURBINE: TEST FACILITY AND MEASUREMENTS
L Martorano and D Dini *In* AGARD High Temp Probl in Gas Turbine Eng Feb 1978 10 p refs (For availability see N78-21118 12-07)
Avail NTIS HC A25/MF A01

A design concept for gas turbine H2 air combustor is presented and its potential verified by experimental data The combustor performance with a view to the use of H2-air in conventional variable geometry gas turbines was emphasized Proposals and development for varying and controlling the air flow distribution characteristics appear feasible Results are given of the first high temperature tests carried out on variable geometry combustor and turbine blading Author

N78-21138# Air Force Aero Propulsion Lab., Wright-Patterson AFB, Ohio.

LOW FREQUENCY COMBUSTION INSTABILITY IN AUGMENTORS

F N. Underwood, J P Rusnak (Pratt and Whitney Aircraft, West Palm Beach, Fla.), R C Ernst (Pratt and Whitney Aircraft, West Palm Beach, Fla.), E A Petrino (Pratt and Whitney Aircraft, West Palm Beach, Fla.), P L Russell (Pratt and Whitney Aircraft, West Palm Beach, Fla.), and R Murphy, Jr. *In* AGARD High Temp Probl in Gas Turbine Eng Feb 1978 19 p ref (For *availability see* N78-21118 12-07)

Avail NTIS HC A25/MF A01

An analytical model was developed to aid in designing afterburners that are free from low frequency instability Rumble mechanisms investigated include the system airflow dynamics, combustion efficiency oscillations, fuel vaporization, recirculation wake energy, and turbulence upstream of the flameholders Comparisons of the model predictions with experimental data are good Author

N78-21139# Office National d'Etudes et de Recherches Aerospatiales, Paris (France)

NEW MATERIALS FOR HIGH TEMPERATURE TURBINES: ONERA'S DS COMPOSITES CONFRONTED WITH THE BLADE PROBLEMS

Herve Bibring *In* AGARD High Temp. Probl in Gas Turbine Eng. Feb. 1978 12 p refs In FRENCH, ENGLISH summary (For availability see N78-21118 12-07)

Avail NTIS HC A25/MF A01

The needs required for a blade material in aircraft turbines operating at higher temperatures are compared with the actual performance as found on Cotac DS composites testing The structure and the properties of the more fully developed 74 and 741 types are discussed In particular, the high temperature structural stability, the impact of thermal and mechanical fatigue, the oxidation resistance, and the coating capability are thoroughly evaluated. The great benefit in operational temperature of these materials can be immediately exploited in the field of uncooled solid blades The problem of cooling passages in DS eutectic blades is also outlined Author

N78-21140# Politecnico di Milano (Italy) Istituto di Chimica Fisica

HIGH TEMPERATURE CORROSION OF Ni-BASE FOR TURBINE BLADES ALLOYS IN SULPHATE-CHLORIDE CONTAINING ENVIRONMENTS

U Ducati, G LecisCoccia, D Cavallotti, and F Borile (Cinisello Balsamo, Milan) *In* AGARD High Temp Probl in Gas Turbine Eng Feb 1978 17 p refs (For availability see N78-21118 12-07)

Avail NTIS HC A25/MF A01

The effect of sulfates, chlorides and their mixtures on the corrosion behavior of some commercial Ni base superalloys was studied For comparison some experimental alloys and a Co base superalloy were considered The tests were performed on untreated samples and on samples submitted to various treatments specified to various solubilization aging, and grain growth After an inspection of the thermogravimetric results, it was shown that the differences in behavior exhibited by the same base material submitted to various heat treatments are greater than those among different materials submitted to equal heat treatments Author

N78-21141# Office National d'Etudes et de Recherches Aerospatiales, Paris (France)

PROTECTION OF COOLED BLADES OF COMPLEX INTERNAL STRUCTURE

Philippe Galmiche *In* AGARD High Temp Probl in Gas Turbine Eng Feb 1978 9 p refs In FRENCH, ENGLISH summary (For availability see N78-21118 12-07)

Avail NTIS HC A25/MF A01

The problem of the general protection of cooled blades of complex internal structure was studied A corresponding method called the SF technique permits the realization in a single operation of the protection of both external and internal surfaces, as well as those of the orifices of cooling air, whatever their diameter In a general way, the respective thickness of external and internal coatings may be precisely predetermined, with no parasitic particle being able to remain inside the parts after application of the protecting treatment Results obtained by application of the SF method are illustrated by the presentation and examination of various parts of advanced turbomachines, which were handed over for treatment followed by tests or operational use by engine manufacturers or airlines Author

N78-21142# Advisory Group for Aerospace Research and Development, Paris (France)

COBALT-BASE ALLOYS FOR HOT CORROSION PROTECTIVE COATINGS

A Davin (CRM, Liege, Belgium), J M Drapier (CRM, Liege, Belgium), D Coutsouradis (CRM, Liege, Belgium), and L Habraken *In its* High Temp Probl in Gas Turbine Eng Feb 1978 12 p refs (For availability see N78-21118 12-07)

Avail NTIS HC A25/MF A01

In the field of gas turbine applications, the severe requirements of extended operation in marine environments or an increase in the inlet temperature, limit the life of the diffusion aluminide base coatings for nickel and cobalt superalloys Protective overlay coatings such as Co/Ni-Cr-Al-Y-Ta were developed in order to satisfy the requirements of the gas turbine designers and showed an exceptional hot corrosion resistance They were optimized to obtain an acceptable compromise between hot corrosion and thermal shock resistance Experience gained with the development of such cobalt base and particularly Co-Al-Cr-Ta-Ni-Y alloys and corresponding coatings were evaluated by various techniques Author

N78-21143# Pratt and Whitney Aircraft Group, West Palm Beach, Fla. Government Products Div

TRENDS OF FUTURE TURBINE LIFE PREDICTION: TIME PHASE AUTOMATED ANALYSIS AND TEST VERIFICATION

J L Price and I J Gershon (AFAPL) *In* AGARD High Temp Probl in Gas Turbine Eng. Feb. 1978 11 p refs (For availability see N78-21118 12-07)

Avail NTIS HC A02/MF A01

A review of the most significant design parameters affecting turbine durability and the structural analysis and verification techniques which are being developed for identification of structural inadequacies early in th propulsion system development cycle are reviewed Author

N78-21144# Liege Univ (Belgium). Institut de Mecanique

FINITE ELEMENT ANALYSIS OF SOME PROBLEMS ARISING IN COOLED TURBINE BLADES

P Beckers, G Sander, and M Hogge *In* AGARD High Temp Probl in Gas Turbine Eng Feb 1978 16 p refs (For availability see N78-21118 12-07)

Avail NTIS HC A25/MF A01

The finite element method was applied successfully to a large number of engineering problems The main approaches to some problems of heat transfer and stress computation that arise in the analysis of turbine blades were summarized The introduction of nonlinear boundary conditions and temperature dependent material properties was considered in the heat transfer analysis Various nonlinear effects were also taken into account in the static and dynamic stress analysis It includes centrifugal forces, initial stresses, temperature dependent properties and elastoplastic behavior Author

N78-21145# Lucas Aerospace Ltd., Burnley (England) Fabrications Div

EVALUATION OF A CERAMIC COMBUSTION CHAMBER FOR A SMALL GAS TURBINE ENGINE

G Sedgwick *In* AGARD High Temp Probl in Gas Turbine Eng Feb 1978 10 p refs (For availability see N78 21118 12-07)

Avail NTIS HC A25/MF A01

A description is presented of the design, component evaluation and combustion testing of a reverse flow annular combustion chamber in silicon nitride Heat transfer assessments were made of the temperature levels which components would reach during combustion testing A thermal test program was formulated which enables thermal loadings well in excess of those estimated for the actual flame tube environment to be imposed upon specimen components Thermal stress and probability of survival

values were obtained using the method based on a Weibull statistical analysis using the weakest link volume critical flaw assumption Finite element and brittle failure analyses were carried out on both thermal stress test specimens and the components making up the flame tube Author

N78-21146# Massachusetts Inst of Tech , Cambridge
SYSTEMATIC STUDIES OF HEAT TRANSFER AND FILM COOLING EFFECTIVENESS
J F Louis *In* AGARD High Temp Probl in Gas Turbine Eng Feb 1978 36 p refs (For availability see N78 21118 12-07)
(Contracts F33625 76 C-2018, N00014 76 C 0253)
Avail NTIS HC A25/MF A01

A review of studies in heat transfer and film cooling effectiveness was given to develop an in depth understanding of heat transfer and film cooling in gas turbines A common experimental procedure is described for heat transfer measurements under isothermal wall conditions using fast response heat transfer gauges in tests conducted in a shock tunnel and a blowdown facility The tests were conducted at flow and thermodynamic conditions modeling the operating conditions of advanced gas turbines The configurations under study were single slot, single line of holes, double line of holes on a flat plate, and double line of holes on an airfoil Author

N78-21147*# General Electric Co , Evendale, Ohio Aircraft Engine Group
EFFECTS OF FILM INJECTION ON PERFORMANCE OF A COOLED TURBINE
James D McDonel and James E Eiswerth *In* AGARD High Temp Probl in Gas Turbine Eng Feb 1978 11 p refs (For availability see N78-21118 12-07)
(Contract NAS3-16732)
Avail NTIS HC A25/MF A01

Tests were conducted in a 20 inch diameter single stage air cooled turbine designed to evaluate the effects of film cooling air on turbine aerodynamic performance A comparison was made of the experimental results and an analytical method of evaluating film injection effects on turbine performance The results are used to determine the effects of film cooling on overall engine performance for selected cycle conditions The engine performance studies are used to show the cycle benefits of increased gas temperature at various coolant flow rates Author

N78-21148# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Goettingen (West Germany)
THE INFLUENCE OF JETS OF COOLING AIR EXHAUSTED FROM THE TRAILING EDGES OF A SUPERCRITICAL TURBINE CASCADE ON THE AERODYNAMIC DATA
Ortwin Lawnczeck *In* AGARD High Temp Probl in Gas Turbine Eng Feb 1978 13 p refs (For availability see N78-21118 12-07)
Avail NTIS HC A25/MF A01

In a case of a stator cascade the influence of jets of coolant air on the aerodynamic behavior was tested The jets exhaust from the trailing edges of four blades By the evaluation of wake flow measurements over two pitches the losses and the downstream flow angle were determined In addition schlieren pictures were taken The downstream velocity was varied from a subsonic over a transonic up to a supersonic flow The rate of the coolant air with respect to the primary air running through two adjacent blades was changed from zero to four percent The measurements were carried out in the wind tunnel for two dimensional cascades Author

N78-21149# Oxford Univ (England). Dept of Engineering Science.
A NEW TRANSIENT CASCADE FACILITY FOR THE MEASUREMENT OF HEAT TRANSFER RATES
D L Schultz, T V Jones, M L G Oldfield, and L C Daniels *In* AGARD High Temp Probl in Gas Turbine Eng Feb 1978 27 p refs (For availability see N78-21118 12-07)
Avail NTIS HC A25/MF A01

A type of transient cascade was developed for testing turbine blades and nozzle guide vanes at full scale engine Reynolds number and Mach number It was based on a free piston compressor capable of producing uniform flow conditions for periods between 0 3 and 1 0 secs Heat transfer rate measurements were made using thin film surface resistance thermometers deposited onto insulating substrated such as quartz or machinable glass ceramic Flow visualization using schlieren and holographic techniques were also employed and typical results from rotor blades were presented The principle of operation of the cascade is described together with the basis of its mechanical design and the predicted performance compared with experimental observations The technique was shown to have advantages both in cost and effectiveness over continuous running cascades Author

N78-21150# Wales Univ Inst of Science and Technology, Cardiff Dept of Mechanical Engineering and Engineering Production
HEAT TRANSFER TO A PVD ROTOR BLADE AT HIGH SUBSONIC PASSAGE THROAT MACH NUMBERS
B W Martin, A Brown, and S E Garrett *In* AGARD High Temp Probl in Gas Turbine Eng Feb 1978 12 p refs (For availability see N78-21118 12-07)
Avail NTIS HC A25/MF A01

Heat transfer measurements round a PVD rotor blade using a transient method were reported Instrumented syndanio-asbestos blades forming part of a cascade were suddenly introduced into a heated air stream The temperature time response of surface thermocouples attached to copper inserts in the blades then were used to determine local heat transfer coefficients for (1) passage throat Mach numbers between 0 79 and 0 94, (2) turbulence intensities from 4 15 to 9 05 percent, and (3) blade chord Reynolds numbers from 7 8 x 10.000 to 8 9 x 100.000 Measured transition lengths or the suction surface, over which the heat transfer nearly trebles, are somewhat short in relation to other measurements The onset of transition, which is downstream of predictions for the higher Reynolds numbers but accords with the trends of existing correlations, is little influenced by turbulent intensity variators in the above range Over the pressure surface the heat transfer is less than for a fully turbulent boundary layer Author

N78-21151# Office National d'Etudes et de Recherches Aerospatiales, Paris (France).
MEASURING TECHNIQUES IN HIGH TEMPERATURE TURBINES
Yves LeBot, Marc Charpenel, and Pierre-Jacques Michard *In* AGARD High Temp Probl. in Gas Turbine Eng Feb 1978 12 p refs In FRENCH, ENGLISH summary (For availability see N78-21118 12-07)
Avail. NTIS HC A25/MF A01

An instrument for performing on industrial machines measurements usually limited to laboratory studies was developed Qualifications of the flow turbulence is described and an analysis of mobile blade wakes by short response time pressure probes was included Flow temperature fluctuations by thermocouple or resistor probes associated to signal processing electronics and by optical pyrometry were studied Mobile blade surface temperatures were read by short response time optical pyrometry The local thermal transfer coefficient on stator blades was measured by an analysis of evolution in time of the wall temperature after sudden cutting off of cooling air The effectiveness of the wall thermal protection from results of a chromatographic analysis of gaseous samples was also calculated The main characteristics of the instrumentation are presented and illustrated by examples of application on various test facilities Author

N78-21152# Von Karman Inst for Fluid Dynamics, Rhode-Saint-Genese (Belgium)
THE MEASUREMENT OF FILM COOLING EFFECTIVENESS ON TURBINE COMPONENTS IN SHORT DURATION WIND TUNNELS
J P Ville and B E Richards *In* AGARD High Temp Probl in Gas Turbine Eng Feb 1978 13 p refs In ENGLISH, FRENCH summary (For availability see N78-21118 12-07)
(Grant DA-ERO-75-G-074)
Avail NTIS HC A25/MF A01

A method to measure an adiabatic wall effectiveness, n and its associated heat transfer coefficient, h of a film cooling system for turbine components in a short duration facility is described Such a facility was used to provide flow conditions selected to simulate those of advanced aircraft turbines The measurement of heat transfer rates under different coolant temperature conditions and the definition of a linear relationship between a heat transfer coefficient, h, based on mainstream recovery temperature and a nondimensional coolant temperature, leads to the evaluation of n, and h sub f The measurements on a flat plate, cooled by air ejected through inclined holes at a Mach number of 0 6, unit Reynolds number of 2 4 x 10 to the 7th power per meter, wall to mainstream temperature ratio of 0 76 coolant to mainstream temperature of 0 70 to 0 95 and

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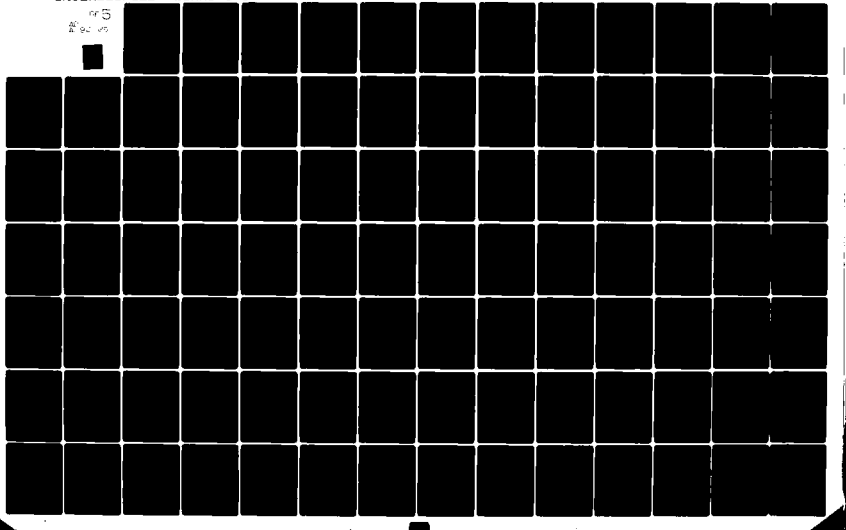

mass velocity ratio from 0.5 to 1.5 confirm the linearity of the h, theta relation and prove the ability of a short duration facility to provide useful film cooling data for blade cooling system development. Author

N78-21153# Politecnico di Milano (Italy).
LOCAL FLAME TEMPERATURE MEASUREMENTS BY RADIATIVE METHODS
U. Ghezzi, G. Zizsk (CNPM Politecnico, Milan), A. Coghe (CNPM Politecnico, Milan), F. Cignoli (CNPM Politecnico, Milan), and S. Benecchi (CNPM Politecnico, Milan) *In* AGARD High Temp. Probl. in Gas Turbine Eng. Feb. 1978 8 p refs (For availability see N78-21118 12-07)
Avail: NTIS HC A25/MF A01

The reliability of local flame temperature measurements by means of atomic fluorescence spectrometry was analyzed. Conventional radiative methods give a measure averaged over the optical path through the gas. Whenever the probe volume is not homogeneous, different layers, each having an individual temperature and thickness, contribute to the measure. Results obtained using an electronic signal processing system based on photo counting were reported and indicate that it is possible to obtain satisfactory space resolution and good reliability. Author

N78-21154# Office National d'Etudes et de Recherches Aerospatiales, Paris (France).
NEW COMPUTATION METHOD OF TURBINE BLADES FILM COOLING EFFICIENCY
Emile LeGrives and Jacques Jules Nicolas *In* AGARD High Temp. Probl. in Gas Turbine Eng. Feb. 1978 12 p refs In FRENCH; ENGLISH summary (For availability see N78-21118 12-07)
Avail: NTIS HC A25/MF A01

An analytical technique is presented for the computation of film cooling effectiveness of gas turbine blades. It is based on a mathematical description of the counter rotating vortex structure associated with the injection of coolant through discrete holes. The transport of mass induced by these vortices plays the major part in the mixing process of hot gas with the individual jets, which defines the adiabatic effectiveness of the resulting film. When merging of the jets and entrainment by turbulent diffusion effects were also taken into account, data from various experiments performed on flat plate were found to be in good agreement with predictions following this approach. Simple rules for computing film effectiveness with injection through several rows of holes allow an extension of the analysis to a large variety of injection patterns. Author

N78-21155# Sussex Univ., Brighton (England). Dept. of Mechanical Engineering.
THE EFFECT OF FREE-STREAM TURBULENCE UPON HEAT TRANSFER TO TURBINE BLADING
F. J. Bayley and R. W. Milligan *In* AGARD High Temp. Probl. in Gas Turbine Eng. Feb. 1978 13 p ref (For availability see N78-21118 12-07)
Avail: NTIS HC A25/MF A01

An initial investigation of the separate effects of free stream turbulence intensity and frequency upon the local heat transfer to a heavily loaded gas turbine blade section is described. It was shown that over the whole blade the rate of heat transfer is significantly increased by both those parameters, with the pressure surface showing the greatest response and the downstream half of the suction surface the least. Author

N78-21156# Sussex Univ., Brighton (England). Dept. of Mechanical Engineering.
FLOW AND HEAT TRANSFER IN ROTATING COOLANT CHANNELS
W. D. Morris *In* AGARD High Temp. Probl. in Gas Turbine Eng. Feb. 1978 14 p refs (For availability see N78-21118 12-07)
Avail: NTIS HC A25/MF A01

A selection of experimental results is presented which illustrates the influence of rotation on heat transfer in tubes that rotate about at axis either parallel to or perpendicular to the central tube axis. It was demonstrated that Coriolis and centripetal inertial effects can significantly alter the heat transfer characteristics in relation to the nonrotating case.Author

N78-21157# Pisa Univ. (Italy). Dept. of Engineering.
CALCULATION OF TEMPERATURE DISTRIBUTION IN DISKS AND COOLING FLOW IN A TRANSIENT STATE
M. Caprili and R. Lazzeretti *In* AGARD High Temp. Probl. in Gas Turbine Eng. Feb. 1978 23 p refs (For availability see N78-21118 12-07)
Avail: NTIS HC A25/MF A01

The temperature distribution in irregularly shaped disks and that of the cooling fluid was determined for a transient stator. The method of calculation used is described, and the stability of the numerical solution is discussed. The calculation program makes it possible to evaluate the influence of the functional parameters on temperature distribution. Author

N78-21158# Imperial Coll. of Science and Technology, London (England). Dept. of Chemical Engineering.
A COMPARISON BETWEEN PREDICTED AND MEASURED SPECIES CONCENTRATIONS AND VELOCITIES IN A RESEARCH COMBUSTOR
W. P. Jones (Natl. Gas Turbine Estab., Pyestock, Engl.), W. C. Clifford, C. H. Priddin (Rolls Royce Ltd., Derby, Engl.), and R. deChair (Rolls Royce Ltd., Briston, Engl.) *In* AGARD High Temp. Probl. in Gas Turbine Eng. Feb. 1978 16 p refs (For availability see N78-21118 12-07)
Avail: NTIS HC A25/MF A01

A comparison is presented between the predictions of a mathematical model of chemically reacting flow and measurements of species concentrations and velocities in a small scale research combustor burning propane and air. The mathematical model is a three dimensional finite difference method for solving the time-averaged conservation equations in turbulent flow. The Reynolds stress terms are modelled with a two-equation model of turbulence and account is taken of the effect of turbulent fluctuations on the combustion reactions. Generally good agreement is obtained between predictions and measurements which include local gas velocities and the important chemical species (H2O, O2, N2, CO2, CO, and UHC). The tests were performed with an air inlet temperature of 570 K, a chamber pressure of 2.1 bar and an equivalence ratio of 0.69 in the primary zone (0.34 overall). Author

N78-22111# Advisory Group for Aerospace Research and Development, Paris (France).
AERODYNAMICS OF CASCADES
Norbert Scholz Jan. 1978 604 p refs Transl. into ENGLISH from Aerodynamik der Schaufelgitter, West Germany, 1965 (AGARD-AG-220) Avail: NTIS HC A99/MF A01

Physical-phenomenological and the theoretical aspects of two dimensional cascade flows were examined, as well as various experimental techniques and three dimensional flow problems. Author

N78-27135# Advisory Group for Aerospace Research and Development, Paris (France).
TECHNICAL EVALUATION REPORT ON THE 50TH MEETING OF THE PROPULSION AND ENERGETICS PANEL: A SYMPOSIUM ON HIGH TEMPERATURE PROBLEMS IN GAS TURBINE ENGINES
R. Eggebrecht (MTU GmbH, Munich) and S. Lombardo (Curtiss-Wright Corp., Wood-Ridge, N. J.) Mar. 1978 19 p ref Symp held at Ankara, 19-23 Sep. 1977
(AGARD-AR-116) Avail NTIS HC A02/MF A01

A symposium was held to review the main problems associated with the attainment of high temperatures in aircraft gas turbine engines. Specific topics examined were the following: (1) turbine cooling techniques; (2) combustors, afterburners and nozzles; (3) materials and coatings; (4) effect of cooling on aerodynamic performances; and (5) prediction methods. B.B.

N78-32104# Advisory Group for Aerospace Research and Development, Paris (France).
TECHNICAL EVALUATION REPORT ON THE 51ST(B) PEP SPECIALISTS' MEETING OF THE PROPULSION AND ENERGETICS PANEL ON SEAL TECHNOLOGY IN GAS TURBINE ENGINES
B. Wrigley (Rolls-Royce Ltd., Derby, England) Jul. 1978 10 p refs Meeting held at London, 6-7 Apr. 1978
(AGARD-AR-123; ISBN-92-835-1289-8) Avail: NTIS HC A02/MF A01

The following topics are discussed in relation to aircraft and industrial gas turbines: (1) material technology, particularly as applied to main flow path blade tip seals; (2) user's view of seal technology; (3) measurements of seal behavior; (4) laboratory experiments; and (5) design aids. B.B.

N78-32106# Advisory Group for Aerospace Research and Development, Paris (France).
TECHNICAL EVALUATION REPORT ON THE 51ST (A) SPECIALISTS' MEETING OF THE PROPULSION AND ENERGETICS PANEL ON ICING TESTING FOR AIRCRAFT ENGINES
D Tedstone Aug 1978 8 p Meeting held at London, 3-4 Apr. 1978
(AGARD-AR-124; ISBN-92-835-1295-2) Avail: NTIS HC A02/MF A01

The Propulsion and Energetics 51st (A) Specialists' Meeting on Icing Testing for aircraft engines contains a survey of the thirteen papers presented. The discussions which followed each paper, as well as of the concluding Round Table Session, are included. Conclusions are drawn and recommendations made regarding future work. Author

N79-11056# Advisory Group for Aerospace Research and Development, Paris (France)
SEAL TECHNOLOGY IN GAS TURBINE ENGINES
Aug 1978 277 p refs Presented at the Propulsion and Energetics Panel's 51st (B) Specialists' Meeting, London, 6-7 April 1978
(AGARD-CP-237 ISBN-92-835-0218-3) Avail NTIS HC A13/MF A01

Both gas and oil path seals are discussed as well as developments in material technology that influences seal design and operation. The impact of turbine engine operation on seal performance is examined as well as the effect of seal performance on engine maintenance. Laboratory measurements and test facilities for investigating seal behavior are described as well as design methods. For individual titles, see N79-11057 through N79-11073

N79-11057*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
GAS PATH SEALING IN TURBINE ENGINES
Lawrence P Ludwig *In* AGARD Seal Technol in Gas Turbine Eng Aug 1978 41 p refs (For primary document see N79-11056 02-07)
Avail NTIS HC A13/MF A01 CSCL 21E

Gas path seals are discussed with emphasis on sealing clearance effects on engine component efficiency, compressor pressure ratio, and stall margin. Various case-rotor relative displacements, which affect gas path seal clearances, are identified. Forces produced by nonuniform sealing clearances and their effect on rotor stability are examined qualitatively, and recent work on turbine-blade-tip sealing for high temperatures is described. The need for active clearance control and for engine structural analysis is discussed. The functions of the internal-flow system and its seals are reviewed. A.R.H

N79-11058# Rolls-Royce Ltd., Bristol (England). Mechanical Research Dept.
USE OF COATINGS IN TURBOMACHINERY GAS PATH SEALS
J G Ferguson *In* AGARD Seal Technol in Gas Turbine Eng Aug 1978 15 p (For primary document see N79-11056 02-07)
Avail NTIS HC A13/MF A01

Abradable coatings, found in many seals throughout a gas turbine engine from the fan to the turbine, have to cope with a temperature range from a little above ambient to 1 250 K. Test methods exist for laboratory and rig evaluation of coatings, and these are discussed, but improved methods for evaluation of erosion and abradability are required. To overcome shortcomings in current abradable coating materials, many are at present being tailored specially to meet the conditions in particular seals within an engine. This means that there are several different coatings, within any given engine, each having a limited range of use. New coatings are still required which can be used in a wide range of applications throughout an engine. There is, in particular, an urgent need for abradable materials which can be used in turbine seals covering a temperature range from 870 K to 1 250 K. A.R.H

N79-11059# Solar Turbines International, San Diego, Calif. Materials Engineering Dept.
ABRASIVE COATINGS AS SELF CLEANING GAS TURBINE COMPRESSOR VANE TIP SEALS
A R Stetson, J W Vogan, and W A Compton *In* AGARD Seal Technol in Gas Turbine Eng Aug 1978 16 p (For primary document see N79-11056 02-07)
Avail NTIS HC A13/MF A01

Efficiency of a gas turbine is reduced by vane tip losses in the compressor section. Vane tip/rotor rubs can result in catastrophic failure of a gas turbine engine. A test rig is described as well as experimental data obtained evaluating abrasive coatings for clearance control between the vanes and the rotor in a gas turbine compressor. Plasma/flame sprayed oxides, carbides and chemically bonded abrasives were tested under conditions duplicating those encountered in the compressor section. The effectiveness of the coatings in grinding away the vane tips to provide minimum clearance without damage to the vane or rotor was determined. Coatings with rough, sharp abrasive grains were most effective. The laboratory tests were confirmed by engine development tests with a full-scale rotor. A.R.H

N79-11060# Office National d'Etudes et de Recherches Aerospatiales, Paris (France)
APPLICATION OF THE OHP METALLIC FELTS TO TURBOMACHINE SEALS
Emile Genieys (Societe Heurchrome, France) and Andre Hivert *In* AGARD Seal Technol in Gas Turbine Eng Aug 1978 7 p refs In FRENCH (For primary document see N79-11056 02-07)
Avail NTIS HC A13/MF A01

Metallic felts characterized by a very high porosity (up to 95%) and a fine structure (10 to 30 micron dia tubular fibers) were fabricated by the electrodeposition of a metal, such as nickel, on carbon fibers made by pyrolysis of cellulose. Loose fibers were transformed into felts by means of paper works techniques of sedimentation by gravity or centrifugation. A sintering operation consolidates the material and eliminates the carbon. The extreme plasticity of these felts and their aptitude to receive by gaseous diffusion chromium or aluminum make them particularly suitable for turbomachine seals. Metallo ceramic sealing techniques for the low and medium temperatures (up to 500 C) and brazing processes for higher temperatures were developed. The seals are operational up to 800 C; they are at the bench testing stage for higher temperatures up to 1050 C. A.R.H

N79-11061# American Airlines, Inc., Tulsa, Okla.
AMERICAN AIRLINES' OPERATIONAL AND MAINTENANCE EXPERIENCE WITH AERODYNAMIC SEALS AND OIL SEALS IN TURBOFAN ENGINES
C R Smith *In* AGARD Seal Technol in Gas Turbine Eng Aug 1978 11 p (For primary document see N79-11056 02-07)
Avail NTIS HC A13/MF A01

User experience with aerodynamic and oil system seal designs currently used in commercial turbofan engines is reported with emphasis on operational performance, seal reliability, seal repair techniques, and seal maintainability costs. Gas path deterioration resulting from sealing problems and the effects of associated hardware problems on seal performance are examined. The impact of this deterioration on fuel consumption, maintenance requirements (engine management), and airline operations and operating costs is discussed. A.R.H

N79-11062# Rolls Royce Ltd., Derby (England). Technical Design Group
OIL SEALING OF AERO ENGINE BEARING COMPARTMENTS
D C Whitlock *In* AGARD Seal Technol in Gas Turbine Eng Aug 1978 11 p (For primary document see N79-11056 02-07)
Avail NTIS HC A13/MF A01

The basic problem of oil sealing of aero engine bearing compartments is to provide a seal between rotating and static components or between rotating components, accommodating axial movements and possible radial excursions (such a shaft whirling). The sealing arrangements must also conform to modular concepts of engine construction. Such seals incur penalties on the oil system such as heat generation, air leakage and debris generation. Means of reducing these penalties and improving sealing integrity by developments of existing techniques are considered. A.R.H

N79-11063# Ecole Polytechnique Federale de Lausanne (Switzerland). Institut de Thermique Appliquee
TRANSPORT PHENOMENA IN LABYRINTH SEALS OF TURBOMACHINES
Tahsin Boyman and Peter Suter *In* AGARD Seal Technol in Gas Turbine Eng Aug 1978 10 p refs (For primary document see N79-11056 02-07)
Avail NTIS HC A13/MF A01

The oil fog and the oil vapor produced in the region of bearings may be transported through the labyrinth glands in the direction

opposite to the buffering fluid flow This undesired transport results from the diffusion of the oil-vapor due to the concentration gradient, and the transport of small oil droplets due to the complex flow created in the labyrinth seals The intensity and limits of these two phenomena are studied theoretically as well as experimentally, using a real size model and in a second large scale model, both of the straight through type with moving fins and a stationary outer cylinder A R H

N79-11064# Stuttgart Univ (West Germany) Institut fuer Thermische Stromungsmaschinen

STUDIES ON VIBRATIONS STIMULATED BY LATERAL FORCES IN SEALING GAPS

H Benckert and J Wachter *In* AGARD Seal Technol in Gas Turbine Eng Aug 1978 11 p refs (For primary document see N79-11056 02-07)

Avail NTIS HC A13/MF A01

Vibrational problems in high power density turbomachines arise from exciting forces in sealing gaps which result in unsymmetrical pressure distribution within the sealing A test facility is described for studying the flow in sealing gaps in a variety of labyrinth configurations The following parameters can be varied the shaft rotation, the pressure difference on the seal, the entry-swirl, the eccentricity of the rotor and the geometry of the labyrinth Test results indicate systematic dependence of the excited lateral forces on these parameters For a given labyrinth the corresponding force coefficient is resulted to the energy conditions of the flow and the pressure difference on the seal Two examples of calculation demonstrate the application of the test results A R H

N79-11065# Rolls-Royce Ltd Bristol (England) Advanced Projects Dept

THE CONTRIBUTION OF DYNAMIC X-RAY TO GAS TURBINE AIR SEALED TECHNOLOGY

P A E Stewart and K A Brasnett *In* AGARD Seal Technol in Gas Turbine Eng Aug 1978 13 p refs (For primary document see N79-11056 02-07)

Avail NTIS HC A13/MF A01

A radiographic technique is described for studying the behavior of components (particularly seals) during the full range of gas turbine operation Its application to a wide range of engines, particularly during transient conditions is discussed A R H

N79-11066# Politecnico di Milano (Italy) Instituto di Macchine

EXPERIMENTAL RESULTS ON HIGH SPEED DOUBLE MECHANICAL SEALS

Enrico Bollina, Corrado Casci, and Ennio Macchi *In* AGARD Seal Technol in Gas Turbine Eng Aug 1978 10 p refs (For primary document see N79-11056 02-07)

Avail NTIS HC A13/MF A01

A facility for testing high speed mechanical seals is described Its main features are (1) the possibility of continuously varying the rotating speed up to 60 000 rpm (2) the possibility of independently selecting the flow rate the pressure and the nature of the sealing and cooling fluid, (3) the seal power consumption is accurately measured by means of a force transducer The performance of a number of double face mechanical seals having different geometries was investigated Results concerning the mechanical losses and the leakage flow rates of these seals under various operating conditions are presented and discussed Author

N79-11067# Rolls-Royce Ltd Derby (England) Electronics and Instrumentation Research Dept

SYSTEMS FOR THE MEASUREMENT OF ROTOR TIP CLEARANCE AND DISPLACEMENT IN A GAS TURBINE

C R Amsbury and J W H Chivers *In* AGARD Seal Technol in Gas Turbine Eng Aug 1978 11 p refs (For primary document see N79-11056 02-07)

Avail NTIS HC A13/MF A01

The rotor tip clearance system was developed which consists basically of a stepper motor driven insulated wire which is polarized at a high voltage and which sparks to the rotor blade tips when within a certain distance The incidence of sparking is detected and the radial immersion of the wire is determined by electronically counting the motor drive pulses The displacement system is based upon a capacitance transducer specifically designed for operation within a gas turbine at temperatures of up to 600 C and pressures of 300 psi The transducer capacitance which is a function of probe/rotating seal clearance is connected into the feedback loop of an amplifier the output of which is proportional to the clearance A R H

N79-11068*# Detroit Diesel Allison, Indianapolis Ind Flow Systems Group

DETERMINING AND IMPROVING LABYRINTH SEAL PERFORMANCE IN CURRENT AND ADVANCED HIGH PERFORMANCE GAS TURBINES

Harold L Stocker *In* AGARD Seal Technol in Gas Turbine Eng Aug 1978 22 p refs (For primary document see N79-11056 02-07)

(Contracts NAS3-20056, N00140-73-C-005, N00140-74-C-0759)

Avail NTIS HC A13/MF A01 CSCL 21E

Abradable and honeycomb lands were evaluated with a conventional straight-through seal using a static two dimensional (rectangular flowpath) seal rig and a rotating three dimensional seal rig Test results show that some abradable lands leak significantly more than a solid-smooth land However, honeycomb lands were found to reduce leakage up to 24 percent Through aerodynamic testing, an advanced design labyrinth seal was developed which reduced leakage 54 2 percent compared to a conventional straight through seal and 26 3 percent compared to a conventional stepped seal A R H

N79-11069# Air Force Aero Propulsion Lab, Wright-Patterson AFB, Ohio Components Branch

FACTORS ASSOCIATED WITH RUB TOLERANCE OF COMPRESSOR TIP SEALS

Charles W Elrod In AGARD Seal Technol in Gas Turbine Eng Aug 1978 12 p refs (For primary document see N79-11056 02-07)

Avail NTIS HC A13/MF A01

Air Force facilities for investigating different facets of the problem of ineffective tolerance of compressor blade tip seals to high speed rubs are described and the integration of the test data in the overall rub tolerance program is delineated A compressor rub test facility (CRTF) including a single compressor stage driven by an electric motor drive is used to study rub interaction in a realistic compressor environment The apparatus is unique in its capability to provide a full range of compressor operating conditions and rub interaction rates for a full scale tip seal configuration A laser test facility is used to examine the phenomena of self sustained combustion of titanium in a simulated compressor environment, especially the environment involved in the CRTF The burn rate and damage criteria is used to develop proper procedures for safe test operation The pressure temperature and velocity relationships on self sustained combustion of titanium are noted to have significant relevance to many situations outside the CRTF environment A R H

N79-11070*# National Aeronautics and Space Administration Lewis Research Center Cleveland Ohio

SELF ACTING SHAFT SEALS

Lawrence P Ludwig *In* AGARD Seal Technol in Gas Turbine Eng Aug 1978 29 p refs (For primary document see N79-11056 02-07)

Avail NTIS HC A13/MF A01 CSCL 13I

The operating principle and design of the self acting seal is reviewed Mathematical models for obtaining a seal force balance and the equilibrium operating film thickness are outlined Particular attention is given to primary ring response (seal vibration) to rotating seat face runout This response analysis reveals three different vibration modes with secondary seal friction being an important parameter Leakage flow inlet pressure drop and affects of axisymmetric and nonaxisymmetric sealing face deformations are discussed Experimental data on self acting face seals operating under simulated gas turbine conditions are given, these data show the feasibility of operating the seal at conditions of 345 N sq cm (500 psi) and 152 m/sec (500 ft sec) sliding speed Also a spiral groove seal design operated to 244 m/sec (800 ft/sec) is described A R H

N79-11071# Pisa Univ (Italy) Istituto di Macchine

SELF ACTIVE PAD SEAL APPLICATION FOR HIGH PRESSURE ENGINES

Dino Dini *In* AGARD Seal Technol in Gas Turbine Eng Aug 1978 10 p refs (For primary document see N79-11056 02-07)

Avail NTIS HC A13/MF A01

A more effective and improved engine sealing system is analyzed and discussed for application to an advanced high pressure engine Very high leakage in labyrinth seal applied at high pressure and temperature locations of high performance engines is overcome by a self acting lift pad seal added to the primary sealing surface enabling a very thin gas film separation

of the surfaces during shaft rotation Details of construction and design to operate at a clearance less than 1/10th that associated with labyrinth seals are given Operation was obtained at a rotating speed of 600 ft/sec and a sealed air temperature of 600 F The maximum speed and pressure capability is at present tested for use in high-pressure engine applications A R H

N79-11072# Rolls-Royce Ltd., Derby (England) Technical Design Group

GAS TURBINE DISC SEALING SYSTEM DESIGN

D A Campbell *In* AGARD Seal Technol in Gas Turbine Eng Aug 1978 16 p refs (For primary document see N79-11056 02-07)

Avail NTIS HC A13/MF A01

The turbine sealing system must seal the disc space against ingress of hot turbine gases, and absorb windage and conducted heat with limited air temperature rises Air leakage in the system must be controlled to minimize engine performance losses, to avoid loss of blade cooling effectiveness and to maintain the integrity of associated shaft and bearing cooling systems The effect of the required bleed flow on engine performance is considered and found to be fairly small provided that an accurate assessment of this offtake is made at the beginning of the design process Subsequent increases of the air bleed during the development phase can bring substantial penalties in turbine entry temperature The various factors to be considered when determining the sealing and cooling flows are reviewed and the areas where further research would be useful are indicated Author

N79-11073# British Hydromechanics Research Association, Cranfield (England)

A COMPUTATIONAL TOOL FOR MECHANICAL SEAL DESIGN

B S Nau and R T Rowles *In* AGARD Seal Technol in Gas Turbine Eng Aug 1978 10 p refs (For primary document see N79-11056 02-07)

Avail NTIS HC A13/MF A01

The significance and treatment of various factors affecting the performance of rotary mechanical seals are discussed as well as their incorporation into a computer program developed for design purposes Topics covered include surface topography, interfacial film dynamics, with caviation allowed for, self-generated heat, thermal distortion, and distortion from sealed pressure The program structure is outlined A R H

N79-16848# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).

THE AGARD PROPULSION AND ENERGETICS PANEL, 1952-1977

S. S. Penner (California Univ. at San Diego, La Jolla) Jan. 1978 34 p refs

(AGARD-AR-111; ISBN-92-835-1258-8) Avail: NTIS HC A03/MF A01

Work done during the past 25 years by the AGARD Propulsion and Energetics Panel formerly named Combustion and Propulsion Panel, and initially, Combustion Panel is summarized. The adaptation of the Panel to challenging demands of propulsion technology and the impact of Panel activities on research and development within NATO countries are analyzed. A move in future Panel activities, particularly long term emphasis of energy related topics is suggested. Proposals on publication and publicity policies are included A.R.H.

N79-20127# Advisory Group for Aerospace Research and Development, Paris (France).

GUIDE TO IN-FLIGHT THRUST MEASUREMENT OF TURBOJETS AND FAN ENGINES

Jan. 1979 202 p refs

(AGARD-AG-237; ISBN-92-835-1304-5) Copyright. Avail: NTIS HC A10/MF A01

Topics include: fundamentals of thrust measurement in flight, propulsion system thrust and drag book-keeping; thrust expressions, methodology, and options; error assessment and control, and instrumentation. For individual titles, see N79-20128 through N79-20132

N79-20128# Advisory Group for Aerospace Research and Development, Paris (France).

FUNDAMENTALS OF THRUST MEASUREMENT IN FLIGHT

In its Guide to In-Flight Thrust Measurement of Turbojets and Fan Engines Jan. 1979 p 19-25 (For primary document see N79-20127 11-07)

Avail NTIS HC A10/MF A01

The basic requirement for separating the airframe from the engine in aircraft propulsion performance assessment is presented. The planning and management of the overall test program is discussed, and the required procedure is summarized. S.E.S

N79-20129# Advisory Group for Aerospace Research and Development, Paris (France).

PROPULSION SYSTEM THRUST AND DRAG BOOK-KEEPING

In its Guide to In-Flight Thrust Measurement of Turbojets and Fan Engines Jan. 1979 p 27-61 (For primary document see N79-20127 11-07)

Avail: NTIS HC A10/MF A01

A consistent and standardized structure of definitions for the various components of thrust and drag is presented. The power plant and the division of technical responsibilities for the parts of the power plant are discussed. Definition of terms used in a book-keeping system is recommended. The items which should appear in the book-keeping system were examined. Wind tunnel tests needed to define the thrust/drag components and mutual interference effects are described. The prediction of performance and flight test analysis were studied. S.E.S.

N79-20130# Advisory Group for Aerospace Research and Development, Paris (France).

THRUST EXPRESSIONS, METHODOLOGY, AND OPTIONS

In its Guide to In-flight Thrust Measurement of Turbojets and Fan Engines Jan. 1979 p 63-118 (For primary document see N79-20127 11-07)

Avail: NTIS HC A10/MF A01

Methods for determining engine standard gross and net thrust which, directly or indirectly, form the basis of virtually all procedures for evaluating thrust in flight are presented. The methods include: brochure, gas generators, swinging probe, trunnion thrust, and engine calibration conditions. S.E.S.

N79-20131# Advisory Group for Aerospace Research and Development, Paris (France).

ERROR ASSESSMENT AND CONTROL

In its Guide to In-Flight Thrust Measurement of Turbojets and Fan Engines Jan. 1979 p 119-173 (For primary document see N79-20127 11-07)

Avail: NTIS HC A10/MF A01

Mathematical models are used to describe the properties of error distributions to enable the uncertainty of various results to be calculated. Thrust in-flight experiment to identify methods of high validity, to eliminate mistakes, and to assess and control errors is presented. S.E.S

N79-20132# Advisory Group for Aerospace Research and Development, Paris (France).

INSTRUMENTATION

In its Guide to In-Flight Thrust Measurement of Turbojets and Fan Engines Jan. 1979 p 175-198 refs (For primary document see N79-20127 11-07)

Avail: NTIS HC A10/MF A01

Systems design, design methods for reducing error, methods for reducing error in specific measurements, cost effectiveness in instrumentation, and properties of an accurate system of instrumentation are presented. S.E.S.

N79-27148# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).

STRESSES, VIBRATIONS, STRUCTURAL INTEGRATION AND ENGINE INTEGRITY (INCLUDING AEROELASTICITY AND FLUTTER)

Apr. 1979 494 p refs In ENGLISH and FRENCH Presented at the Propulsion and Energetics Panel's 52d Meeting, Cleveland, Ohio, 23-28 Oct. 1978

(AGARD-CP-248; ISBN-92-835-0235-3) Avail NTIS HC A21/MF A01

Experimental stress analysis, stress analysis techniques-life prediction, and engine structural integrity-vibration, containment are covered. Also, engine-airframe integration/compatibility and aeroelasticity and flutter are included For individual titles, see N79-27149 through N79-27181

N79-27149# Avco Lycoming Div., Stratford, Conn

STRUCTURAL ANALYSIS OF A GAS TURBINE IMPELLER USING FINITE-ELEMENT AND HOLOGRAPHIC TECHNIQUES

Peter S. Kuo and Kenneth S. Collinge *In* AGARD Stresses, Vibrations, Struct. Integration and Eng. Integrity (Including Aeroelasticity and Flutter) Apr. 1979 15 p refs (For primary document see N79-27148 18-07)
Avail. NTIS HC A21/MF A01

A rigorous finite element structural analysis method is presented which, combined with the holographic technique, deals with the highly stressed, curved vanes and the vibration of the flexible circular backplate so that the magnitude and the pattern of static, dynamic, and thermal loadings can be improved. The method demonstrates a computerized procedure for the design of a modern centrifugal impeller. Holography used as a means for determining the dynamic behavior of the engine component offers an accurate experimental measurement of natural frequencies and modes. The interference fringe pattern representing the contours of equal surface displacement provides a permanent record for vibration amplitude evaluation. Comparison between the theoretical and the experimental results is made. J.M.S

N79-27150# Institut National des Sciences Appliquees de Lyon, Villeurbanne (France). Lab. de Mechanique des Structures.
THE ANALYSIS OF ENGINE VIBRATIONS [ANALYSE DES VIBRATIONS DE MOTEUR]
Michel Lalanne, Philippe Trompette, Remy Henry, and Guy Ferraris *In* AGARD Stresses, Vibrations, Struct. Integration and Eng. Integrity (Including Aeroelasticity and Flutter) Apr. 1979 13 p refs In FRENCH (For primary document see N79-27148 18-07)
Avail: NTIS HC A21/MF A01

The control of the vibrations of a structure is generally achieved at some stage of the project by the theoretical determination of frequencies and modes. The principal elements of an aircraft engine, for practical purposes, can be classed in three categories compressor, combustion chamber, and turbine. These elements are fixed, or in rotation and are then under the Coriolis effect, and at a supplementary stiffening introduced by centrifugal force The calculation of thick and thin blades, of axisymmetric systems in rotation, and of disk-blade assemblies is reviewed. Once the prototype of the engine is constructed, it can withstand troubling frequencies, and instead of making structural modifications designed to displace these frequencies, damping materials can be selected to provide sufficient reduction in the amplitude of the resonance. The calculation of these types of damped structures is outlined; the finite element method is used. The diverse types of calculations performed in the study of frequencies and modes, and in predicting the damping introduced by the addition of materials, are illustrated by applications to the motor elements. Transl. by A.R.H

N79-27151# General Electric Co., Cincinnati, Ohio. Aircraft Engine Group.
AIRCRAFT ENGINE DESIGN USING EXPERIMENTAL STRESS ANALYSIS TECHNIQUES
Bernard L. Koff *In* AGARD Stresses, Vibrations, Struct. Integration and Eng. Integrity (Including Aeroelasticity and Flutter) Apr. 1979 12 p (For primary document see N79-27148 18-07)
Avail: NTIS HC A21/MF A01

A perspective of prominent experimental techniques used in current aircraft engine stress analyses is given. The verification of temperature, stress, steady state and dynamic deformation pressure, and fatigue strength is addressed. Advancements in instrumentation are described, including, high-energy X-rays and high durability strain gages; computers and software to reduce vast amounts of data; increased photoelastic capabilities, and advancements for reproducing loading and environmental conditions in laboratory component tests. J.M.S

N79-27152# Societe Nationale d'Etude et de Construction de Moteurs d'Aviation, Evry Cedex (France). Div. Metallurgie-Resistance
THE CONTRIBUTION OF PHOTOELASTICITY MEASUREMENT TO THE STUDY OF TURBINE PARTS [CONTRIBUTION DE LA PHOTOELASTICIMETRIE A L'ETUDE DES PIECES DE TURBOMACHINES]
J. L. Guillo *In* AGARD Stresses, Vibrations, Struct. Integration and Eng. Integrity (Including Aeroelasticity and Flutter) Apr. 1979 19 p In FRENCH (For primary document see N79-27148 18-07)
Avail NTIS HC A21/MF A01

In the study of machine parts, the principal domain of photoelastic analysis is the investigation and measurement of local stress concentrations For industrial applications, the frozen stress method is used exclusively for analyzing three dimensional stress states. Methods used in preparing for and conducting frozen stress operations are described and the equipment use is illustrated. The method is applied to the study of the vital elements of a gas turbine, at the design and development stage The diversity of the parts analyzed and the modes of influences applied are accounted for. Besides determining the maximum local stress in the parts, two avenues of research are given particular attention the study of residual stress gradients which can account for the influence of scaling factor in the transposition to engine parts (some results from fatigue tests on small test pieces are included), and the determination of the stress intensity factor which governs crack propagation under cyclic influences. Transl. by A.R.H

N79-27153# Motoren- und Turbinen-Union Muenchen G.m.b.H. (West Germany).
A CONTRIBUTION ON THERMAL FATIGUE IN COOLED TURBINE BLADING
W. Peschel and R. Schreieck *In* AGARD Stresses, Vibrations, Struct. Integration and Eng. Integrity (Including Aeroelasticity and Flutter) Apr. 1979 10 p refs (For primary document see N79-27148 18-07)
Avail: NTIS HC A21/MF A01

Thermal fatigue, an important criterion for predicting the life of cooled turbine blading, is caused by thermal stresses which arise from local inhibition of thermal expansion and which are not amenable to direct measurement In the case of turbine blading, temperature distribution in the mean section of the blade can readily be dealt with as a problem of heat conduction in a plane. For stress calculation, it is assumed that the cross section remains plane. Stresses in the sectional plane and normal stresses in the direction of blade span result, the latter being the dominant ones. For thermal fatigue test conditions, stress and strain profiles in the blade are calculated using measured and calculated temperature distributions. Non-elastic material behavior (creep) is taken into account. In the thermal fatigue tests, the pattern of damage vary with superimposed external stresses; this behavior is explained in the light of the calculated stress-strain cycles. J.M.S.

N79-27154# Societe Nationale d'Etude et de Construction de Moteurs d'Aviation, Villaroche (France).
FORECASTING ENGINE LIFE [PREVISION DE LA DUREE DE VIE DES MOTEURS]
D. Grandoulier *In* AGARD Stresses, Vibrations, Struct. Integration and Eng. Integrity (Including Aeroelasticity and Flutter) Apr. 1979 10 p In FRENCH (For primary document see N79-27148 18-07)
Avail NTIS HC A21/MF A01

The compromise between light weight and endurance for aircraft gas turbine engines requires the precise prediction of the durability of the engine parts Those parts whose rupture threatens the integrity of the engine must be rated to meet two criteria: the initiation of a crack must be avoided during the predicted life of the part, and a flaw not detected during a general inspection must not develop to a critical point before the next inspection A turbine disk is used to present a method for predicting low cycle fatigue life and for showing the importance of knowing the behavior laws of materials. Transl. by A.R.H

N79-27155# Liege Univ. (Belgium). Lab. d'Aeronautique
STRESS INTERPRETATION IN THE FINITE ELEMENT METHOD
P. Beckers *In* AGARD Stresses, Vibrations, Struct. Integration and Eng. Integrity (Including Aeroelasticity and Flutter) Apr. 1979 10 p refs (For primary document see N79-27148 18-07)
Avail NTIS HC A21/MF A01

The classical methods are compared based on the computation of local stresses at various points like the vertices of the elements or the Gaussian points. An alternative interpretation of the stresses can be based on the definition of energy conjugate stresses that have the nature of weighted average of the stresses. A third possibility is offered which is rather new It is based on the definition of connecting forces that have a direct and simple interpretation in terms of surface tractions. The corresponding finite elements are named delinquent elements as they are, in fact, displacement elements which used some of the connection modes of stress equilibrium elements It is shown that none of the three interpretation techniques is in itself completely satisfactory in every situation, but that the combined use of them allows a much better caption of the state of stress. J.M.S.

N79-27156# AiResearch Mfg. Co., Phoenix, Ariz
THREE-DIMENSIONAL FINITE-ELEMENT TECHNIQUES FOR GAS TURBINE BLADE LIFE PREDICTION
M. R. Peterson, R. G. Alderson, R. J. Stockton, and D. J. Tree *In* AGARD Stresses, Vibrations, Struct Integration and Eng. Integrity (Including Aeroelasticity and Flutter) Apr. 1979 14 p refs (For primary document see N79-27148 18-07)
(Contract F33615-74-C-2012)
Avail: NTIS HC A21/MF A01

The use of three dimensional finite element analyses in conjunction with test derived data to predict the vibratory fatigue life of turbine blades is described. Vibratory strain measurements are interpreted and extended using predicted strain distributions from the finite element analysis. The statistical nature of test data is considered. Also, some techniques employed in three dimensional finite element analyses to enhance their use for stress and vibration analysis are described. These techniques include a method for reduction of the size of the eigenvalue problem for vibration analysis by a transformation to generalized coordinates derived from static solutions. An example of the application of these methods to a turbine blade analysis is presented Author

N79-27157# Office National d'Etudes et de Recherches Aerospatiales, Paris (France).
CALCULATION OF STRESS CONCENTRATIONS IN DISC ALVEOLES
Madeleine Chaudonneret *In* AGARD Stresses, Vibrations, Struct Integration and Eng. Integrity (Including Aeroelasticity and Flutter) Apr. 1979 13 p refs In FRENCH, ENGLISH summary (For primary document see N79-27148 18-07)
Avail: NTIS HC A21/MF A01

The presence of notches in a loaded structure, such as alveoles in a turbine disc, is the cause of stress concentrations leading to important elastic and plastic deformations; moreover, the turbine operating conditions involve temperatures high enough to provoke viscoplastic deformations. Such stress concentrations, and their evolution in time, are accounted for by the integral equation method. In elasticity, a comparision in proposed with the finite element method concerning a section of the turbine disc. An extension is undertaken of this method to solve viscoplasticity problems by a process of time-step linearization, the behavior of the material being represented by viscoplastic constitutive laws. This method is used in particular to study the viscoplastic behavior of a notched plate subjected to te' sile tests, and the results obtained this way are compared with those provided by the tests, a comparison that shows a very good agreement.
Author

N79-27158# Fiat Aviazione S.p.A., Turin (Italy).
SOME THEORETICAL AND EXPERIMENTAL INVESTIGATIONS OF STRESSES AND VIBRATIONS IN A RADIAL FLOW ROTOR
A. Grasso, J. J. Blech, and G. Martinelli *In* AGARD Stresses, Vibrations, Struct Integration and Eng Integrity (Including Aeroelasticity and Flutter) Apr 1979 refs (For primary document see N79-27148 18-07)
Avail: NTIS HC A21/MF A01

The problem of an integrally bladed radial compressor under the influence of a centrifugal force is considered. Two calculation methods based also on finite element method are proposed. The first adopts a mixed three dimensional and two dimensional analysis, using plate elements for blades and axisymmetrical ring for the disk coupled by substructuring technique. The second implements axisymmetric anisotropic ring elements for the blades and the isotropic ring elements for the disk. A dynamic analysis of the blade with the finite element method is also presented. As an example the various methods are applied to the centrifugal compressor design of the FIAT 6803 engine and compared with results of experimental investigation J.M.S.

N79-27159# Pisa Univ. (Italy). Inst. di Macchine
PREDICTION OF AEROELASTIC INSTABILITIES IN ROTORCRAFT
Dino Dini *In* AGARD Stresses, Vibrations, Struct Integration and Eng Integrity (Including Aeroelasticity and Flutter) Apr. 1979 29 p refs (For primary document see N79-27148 18-07)
Avail: NTIS HC A21/MF A01

Design of modern rotorcraft engines requires that aeroelastic considerations be included for prediction of instabilities due to engines-rotors-airframe interference. Computational approaches are presented which have generality in the selection of stress analysis methods and are applicable to rotorcrafts involving a large number of operation variables. An instability criterion for the prediction of fatigue effects of alternating stresses on engine structural integrity is identified and applied to the corresponding airframe behavior during high speed forward flight and severe rotorcraft maneuvers. J.M.S.

N79-27160# National Gas Turbine Establishment, Pyestock (England).
APPLICATION OF ENGINE USAGE ANALYSIS TO COMPONENT LIFE UTILIZATION
M. Holmes *In* AGARD Stresses, Vibrations, Struct Integration and Eng. Integrity (Including Aeroelasticity and Flutter) Apr. 1979 15 p refs (For primary document see N79-27148 18-07)
Avail: NTIS HC A21/MF A01

Engine parameters were monitored during operation in service aircraft to investigate the maximum life potential of aero engine components. Analytical methods were used for determining low cycle fatigue. The influence of data availability and computing capability on the procedures were investigated by comparing the software appropriate to an airborne unit monitoring engine revolutions per minute with that for a ground based computing facility analyzing recorded flight data. R.E.S.

N79-27161# Pratt and Whitney Aircraft Group, East Hartford, Conn. Commercial Products Div.
BOUNDARY-INTEGRAL EQUATION ANALYSIS OF AN ADVANCED TURBINE DISK RIM SLOT
R. B. Wilson, R. G. Potter, and J. K. Wong *In* AGARD Stresses, Vibrations, Struct. Integration and Eng. Integrity (Including Aeroelasticity and Flutter) Apr. 1979 9 p refs (For primary document see N79-27148 18-07)
Avail: NTIS HC A21/MF A01

The mathematical basis and numerical implementation of the boundary-integral equation method are presented. The method was shown to be capable of predicting rapidly varying stress and strain fields in complex geometries, using either plane triangular or higher order elements. Ease of geometrical modeling and higher order boundary data variation combined to make shape function based codes most efficient for design analysis use. R.E.S.

N79-27162*# Massachusetts Inst. of Tech., Cambridge. Dept of Aeronautics and Astronautics
ENGINE ROTOR BURST CONTAINMENT/CONTROL STUDIES
Emmett A. Witmer, Thomas R. Stagliano, and Jose J. A. Rodal *In* AGARD Stresses, Vibrations, Struct. Integration and Eng. Integrity (Including Aeroelasticity and Flutter) Apr. 1979 30 p refs (For primary document see N79-27148 18-07)
(Grant NGR-22-009-339)
Avail: NTIS HC A21/MF A01

Investigations on the impact-interaction of both complex engine rotor fragments and simple fragments with various types of single-layer and multilayer containment structures were reviewed. The resulting data were used (1) to develop empirical design rules and (2) to evaluate proposed theoretical methods for predicting the impact induced responses of containment structures. Examples of typical numerical methods for predicting the large deflection, elastic-plastic transient structural responses of simple two dimensional and three dimensional containment shields were illustrated R.E.S.

N79-27163# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France)
SMALL TURBINES: EXPERIENCES WITH DISK RUPTURES [PETITES TURBOMACHINES: EXPERIENCES SUR LA RUPTURE DES DISQUES]
J. M. Foueillassar and A. R. VonDerMuhll *In its* Stresses, Vibrations, Struct Integration and Eng Integrity (Including Aeroelasticity and Flutter) Apr 1979 16 p In FRENCH (For primary document see N79-27148 18-07)
Avail: NTIS HC A21/MF A01

On turbines with small dimensions, the construction of casings capable of integrally retaining all the debris in the case of disk rupture can be realized with a very acceptable mass penalty. Practical experience and systematic tests of disk rupture under real operating conditions provide useful data concerning the shape and size of the most penetrating elements; the shape and most efficacious arrangement of elements serving as casings; and the most adaptable materials to be used for casings. For rotors whose security relies on the fact that the blades tear away without disk rupture, or for the cylinder, properly so-called, in case of failure from excess speed, the tests equally confirm the confidence

that can be put in casing elements constructed according to the same principles of evaluation. Transl. by A.R.H.

N79-27164# Sussex Univ., Brighton (England).
AN INVESTIGATION OF VIBRATION DAMPERS IN GAS-TURBINE ENGINES
R. Holmes and B. Humes (Roy. Armament Res. and Develop. Estab., Sevenoaks, Engl.) *In* AGARD Stresses, Vibrations, Struct. Integration and Eng. Integrity (Including Aeroelasticity and Flutter) Apr. 1979 10 p refs Sponsored in cooperation with the Natl. Gas Turbine Estab. (For primary document see N79-27148 18-07)
Avail: NTIS HC A21/MF A01

The feasibility of using the squeeze-film both as a damper and a load bearing member was investigated. It was found that when the squeeze-film provided a load carrying capability as well as damping, cavitation, which has a deleterious effect, is generated in the film. Equations are presented for predicting the vibration amplitude and the force transmitted to the engine frame when the squeeze-film is used for damping. F.O.S.

N79-27165# Sulzer Bros. Ltd., Winterthur (Switzerland).
MODAL ANALYSIS OF COMPRESSOR BLADES BY MEANS OF IMPULSE EXCITATION
U. Bolleter, J. Eberl, and E. Buehlmann *In* AGARD Stresses, Vibrations, Struct. Integration and Eng. Integrity (Including Aeroelasticity and Flutter) Apr. 1979 11 p refs (For primary document see N79-27148 18-07)
Avail: NTIS HC A21/MF A01

An experimental method of modal analysis is described which is based on impulse excitation. Due to low damping the application to free-standing turbomachinery blading requires special care in the digital processing of the data. The modal behavior, particularly with respect to bending and torsional coupling, is demonstrated using a subsonic compressor blade as an example. Measured damping coefficients and inter-modal phase differences are discussed. Applications of the quantitative results of stress responses to point excitation are illustrated. Thus stresses due to various assumed loads allow one to judge the importance of higher modes, stress ratios for various modes can be an aid to failure analysis, and multiple strain measurements can yield an estimate of aerodynamic loads. F.O.S.

N79-27166# Naval Air Propulsion Test Center, Trenton, N.J. Research and Technology Div.
ROTOR BUST PROTECTION: DESIGN GUIDELINES FOR CONTAINMENT
James T. Salvino, Gaetan J. Mangano, and Robert A. DeLucia *In* AGARD Stresses, Vibrations, Struct. Integration and Eng. Integrity (Including Aeroelasticity and Flutter) Apr. 1979 16 p refs (For primary document see N79-27148 18-07)
Avail: NTIS HC A21/MF A01

The results are presented of tests that were conducted to develop guidelines for the weight optimum design of turbine rotor burst fragment containment rings. The ring materials used for each of the several ring configurations were Kevlar 29 cloth, centrifugally cast 4130 steel and coiled 304 stainless steel. A comparative assessment of the containment capability for each material is provided in terms of a specific energy variable that was developed for this purpose. Also included in this assessment is the effect of the number of equal pie sector shaped fragments on the ring containment capability. *Author*

N79-27167# Boeing Co., Seattle, Wash.
ENGINE/AIRCRAFT STRUCTURAL INTEGRATION: AN OVERVIEW
T. E. Dunning, M. N. Aarnes, and G. L. Bailey *In* AGARD Stresses Vibrations, Struct. Integration and Eng. Integrity (Including Aeroelasticity and Flutter) Apr. 1979 35 p refs (For primary document see N79-27148 18-07)
Avail: NTIS HC A21/MF A01

The structural installation of engines in aircraft is discussed in terms of modeling techniques, development of a computerized data base, and planning the propulsion system tests. Problems encountered in engine installation are described. F.O.S.

N79-27168# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (West Germany). Military Airplane Div.
DYNAMIC PRESSURE LOADS IN THE AIR INDUCTION SYSTEM OF THE TORNADO FIGHTER AIRCRAFT
K. W. Lotter and N. C. Bissinger *In* AGARD Stresses, Vibrations, Struct. Integration and Eng. Integrity (Including Aeroelasticity and Flutter) Apr. 1979 20 p refs
Avail: NTIS HC A21/MF A01

The engine fact, duct and forward intake peak pressures applied for structural design of the European fighter airplane, Tornado, and the experimental data obtained during the development phase from full scale intake/engine compatibility test are described. S.E.S.

N79-27169# National Aerospace Lab., Amsterdam (Netherlands). Performance and Evaluation Dept.
HANDLING PROBLEMS THROUGH COMPRESSOR DETERIORATION
J. P. K. Vleghert *In* AGARD Stresses, Vibrations, Struct. Integration and Eng. Integrity (Including Aeroelasticity and Flutter) Apr. 1979 7 p (For primary document see N79-27148 18-07)
Avail: NTIS HC A21/MF A01

RNLAF has experienced performance loss and an increased rate of in flight compressor stalls due to compressor deterioration of some of their 15 year old engines. The Maintenance Depot test bed showed that significant loss of air mass flow occurred near the surge line under conditions which were not covered by the normal post overhall acceptance tests. Impending stall was always preceded by increasing fluctuations, although the level of these pressure fluctuations varied with different engines. A method was developed to routine check for this phenomenon. *The surge margin of the affected engines was recovered by* replacing the rear compressor casing. S.E.S.

N79-27170# Pratt and Whitney Aircraft of Canada Ltd., Longueuil (Quebec).
SMALL TURBINE ENGINE INTEGRATION IN AIRCRAFT INSTALLATIONS
M. Botman and R. K. Blinco *In* AGARD Stresses, Vibrations, Struct. Integration and Eng. Integrity (Including Aeroelasticity and Flutter) Apr. 1979 12 p (For primary document see N79-27148 18-07)
Avail: NTIS HC A21/MF A01

Various design and development problems related to the integration of small turbine engines in aircraft installations are reviewed. Important considerations in turbo-prop installations are vibration transmissibility, propeller-whirl flutter, engine structure strength and stiffness, mount failure modes, and nacelle clearances. Requirements are adequate compartment ventilation and engine oil cooling with minimum aerodynamic loss. The installations of the PT6 series of turbo-prop engines are discussed. S.E.S.

N79-27171# Avions Marcel Dassault-Breguet Aviation, Saint-Cloud (France).
DETERMINING THE DYNAMIC RESPONSE DUE TO AN IMBALANCE AT THE ATTACHMENTS OF A MOTOR ON A POD [DETERMINATION DES EFFORTS DYNAMIQUES DUS A UN BALOURD AUX ATTACHES D'UN MOTEUR MONTE EN PODE]
B. Schneider *In* AGARD Stresses, Vibrations, Struct. Integration and Eng. Integrity (Including Aeroelasticity and Flutter) Apr. 1979 16 p refs In FRENCH (For primary document see N79-27148 18-07)
Avail: NTIS HC A21/MF A01

The loss of a rotor blade produces an imbalance which is transmitted to the attachments of an engine on a pod. The reactions of these attachments are calculated as a function of *the angular velocity of the rotor by means of the matrix of* flexibility of the pod, of inertial characteristics of the rigid engine and of the generalized mass, as well as of the frequency of the damping of the distortions of the flexible modes of the motor. A problem is seen regarding the complexity of the vibration tests of an engine, the flexible modes of the engine, whose frequency remains too low for intervening in the coupling, cannot be used because they have not been completely measured. Furthermore, it seems that the damping mode is a fundamental parameter, as in all phenomena of excitation; therefore, particular care must be taken to its determination outside of the test itself. At the same time, the calculation of generalized forces requires knowledge of the deformation of the rotor for each flexible mode used, which imposes the use of specialized lock-ons outside of vibration tests. Transl. by A.R.H.

N79-27172# British Aerospace Aircraft Group, Preston (England). Advanced Projects Dept.
INTEGRATION OF AN AIRFRAME WITH A TURBOFAN AND AFTERBURNER SYSTEM
Michael S. Wooding and Harry Hurdis (Rolls-Royce Ltd., Derby, Engl.) *In* AGARD Stresses, Vibrations, Struct. Integration and

Eng. Integrity (Including Aeroelasticity and Flutter) Apr. 1979 10 p (For primary document see N79-27148 18-07)
Avail. NTIS HC A21/MF A01

Alternative ways for improving the performance of installed military engines are described. The weight, performance, and cost tradeoffs that might result for a single engined fixed wing combat aircraft are discussed. S.E.S.

N79-27173# Arnold Engineering Development Center, Arnold Air Force Station, Tenn.
A NEW FACILITY FOR STRUCTURAL ENGINE TESTING
Robert L. B. Swain and James G. Mitchell *In* AGARD Stresses, Vibrations, Struct. Integration and Eng. Integrity (Including Aeroelasticity and Flutter) Apr. 1979 6 p (For primary document see N79-27148 18-07)
Avail: NTIS HC A21/MF A01

A test facility to simulate the maneuver environment an engine actually experiences in flight is presented. The facility and its potential benefits to the engine development process are described. S.E.S.

N79-27174# *Centre d'Essais des Propulseurs, Orsay (France).*
THE INTEGRITY OF AIRCRAFT JET ENGINES UNDER THE IMPACT OF FOREIGN BODIES [INTEGRITE DES REACTEURS D'AVIONS SOUS IMPACTS DE CORPS ETRANGERS]
Dominique Hedon and Jean Barrere *In* AGARD Stresses, Vibrations, Struct. Integration and Eng. Integrity (Including Aeroelasticity and Flutter) Apr. 1979 13 p In FRENCH (For primary document see N79-27148 18-07)
Avail: NTIS HC A21/MF A01

The ingestion of foreign bodies, especially of birds, remains a major hazard to aircraft. The improvement of the resistance of engines to impacts has, for several years, been the object of important efforts on the part of aircraft manufacturers working with official services. The Centre D'Essais des Propulseurs furnished a special installation for this type of research. The experience acquired from tests made show that consideration of impact resistance must be made part of engine design and can influence the general architecture of the project as well as the definition of internal details or of preparations. Transl. by A.R.H.

N79-27175# Rolls-Royce Ltd., Derby (England). Aero Div.
THE EFFECT OF INTAKE CONDITIONS ON SUPERSONIC FLUTTER IN TURBOFAN ENGINES
D. G. Halliwell *In* AGARD Stresses, Vibrations, Struct. Integration and Eng. Integrity (Including Aeroelasticity and Flutter) Apr. 1979 8 p refs (For primary document see N79-27148 18-07)
Avail: NTIS HC A21/MF A01

The nature of supersonic flutter, to which high tip speed, front stage fans of modern aircraft turbofan engines are susceptible, is introduced. The effect of varying engine intake conditions of altitude, flight speed and ambient temperature were examined, and test data was compared with theory. Some important flight conditions for minimum flutter margins in typical civil and military applications are outlined. The effect of engine intake type is then covered with respect to the degree of pressure distortion presented to the fan. A tentative relationship is derived between this distortion and flutter onset speed. Author

N79-27176# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Cologne (West Germany). Inst. fuer Antriebstechnik.
UNSTEADY ROTOR BLADE LOADING IN AN AXIAL COMPRESSOR WITH STEADY-STATE INLET DISTORTIONS
M. Lecht and H. B. Weyer *In* AGARD Stress, Vibrations, Struct. Integration and Eng. Integrity (Including Aeroelasticity and Flutter) Apr. 1979 13 p refs (For primary document see N79-27148 18-07)
Avail: NTIS HC A21/MF A01

A steady state measuring technique with conventional probes and pressure tapes combined with an adequate data analysis was used to investigate the unsteady rotor flow with particular respect to the variation of the blade loading during rotor revolution. Some relevant results of this investigation are submitted and discussed. M.M.M.

N79-27177# *Liege Univ. (Belgium).* Inst. de Mecanique.
DISTORTIONS, ROTATING STALL AND MECHANICAL SOLICITATIONS
J. Colpin *In* AGARD Stresses, Vibrations, Struct. Integration and Eng. Integrity (Including Aeroelasticity and Flutter) Apr. 1979 24 p refs (For primary document see N79-27148 18-07)
Avail: NTIS HC A21/MF A01

A one stage axial flow compressor is studied aerodynamically and mechanically when operating with moldistributed inlet flow, i.e. inlet flow total pressure distortions and rotating stall. A theoretical model is presented which calculates the distortion propagation through the compressor stage. That enables the computation of the unsteady aerodynamic loading of the rotor blades. The theoretical results are successful compared with the measured flow fields. An experimental study defines the rotating stall characteristics of the compressor stage and relates the blades vibrations and stresses with the existence of a distortion and/or rotating stall cell. Author

N79-27178# Office National d'Etudes et de Recherches Aeronautiques, Paris (France).
STUDY IN A STRAIGHT CASCADE WIND TUNNEL OF AEROELASTIC INSTABILITIES IN COMPRESSORS
Edmond Szechenyi, Henri Loiseau, and Brigitte Msquennenhan (SNECMA) *In* AGARD Stresses, Vibrations, Struct. Integration and Eng. Integrity (Including Aeroelasticity and Flutter) Apr. 1979 13 p refs In FRENCH, ENGLISH summary (For primary document see N79-27148 18-07)
Avail: NTIS HC A21/MF A01

Most of the aeroelastic instabilities encountered in turbomachines, in particular in compressor first stages, occur in flow conditions that can not be calculated on purely theoretical bases. The very nature of these instabilities is not always known, and tests in a straight cascade wind tunnel should make it possible, first to understand the physical mechanisms of phenomena observed in compressors. The experimental results would then be used to develop mathematical models to be used for prediction calculations. A straight cascade wind tunnel permits the simulation of subsonic and transonic flows up to very close to Mach 1 with angles of attack reaching 12 degrees, and of supersonic flows at fixed Mach numbers thanks to interchangeable nozzles. The first tests in this facility brought to light several kinds of flutter. The parametric study, of which the paper gives the first results, shows the influence of reduced frequency, incidence, pitch axis position and Mach number. A few results obtained in supersonic regime are also given. A.R.H.

N79-27179*# National Aeronautics and Space Administration. *Lewis Research Center, Cleveland, Ohio.*
REVIEW OF THE AGARD S AND M PANEL EVALUATION PROGRAM OF THE NASA-LEWIS SRP APPROACH TO HIGH-TEMPERATURE LCF LIFE PREDICTION
Marvin H. Hirschberg *In* AGARD Stresses, Vibrations, Struct. Integration and Eng. Integrity (Including Aeroelasticity and Flutter) Apr. 1979 9 p refs (For primary document see N79-27148 18-07)
Avail: NTIS HC A21/MF A01 CSCL 21E

The strain range partitioning SRP method method presented is a significant step forward in high temperature low cycle fatigue life prediction. Several concerns and recommendations regarding SRP were described. These dealt primarily with the problems associated with the application of SRP to cases involving small inelastic strains (and therefore long lives). The difficulties associated with partitioning these narrow hysteresis loops and the present inability of SRP to handle mean stress effects were also noted. M.M.M.

N79-27180# Detroit Diesel Allison, Indianapolis, Ind. Cascade and Flow Systems Research.
THE UNSTEADY AERODYNAMICS OF A CASCADE IN TRANSLATION
Sanford Fleeter, Ronald E. Riffel, Thomas H. Lindsey, and Mark D. Rothrock *In* AGARD Stresses, Vibrations, Struct. Integration and Eng. Integrity (Including Aeroelasticity and Flutter) Apr. 1979 13 p refs (For primary document see N79-27148 18-07) (Contract N00014-72-C-0351)
Avail: NTIS HC A21/MF A01

The fundamental time variant translation mode aerodynamics are determined for a classical airfoil cascade in a supersonic inlet flow field over a range of interblade phase angles at a realistic reduced frequency value. These experimental data are then correlated with predictions obtained from an appropriate state-of-the-art harmonically oscillating flat plate cascade aerodynamic analysis. M.M.M.

N79-27181*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
SUPERSONIC UNSTALLED FLUTTER

J. J. Adamczyk, M. E. Goldstein, and M. J. Hartmann *In* AGARD Stresses, Vibrations, Struct. Integration and Eng. Integrity (Including Aeroelasticity and Flutter) Apr. 1979 14 p refs (For primary document see N79-27148 18-07)
Avail: NTIS HC A21/MF A01 CSCL 21E

A parametric study to show the effects of cascade geometry, inlet Mach number, and backpressure on the onset of single and multi degree of freedom unstalled supersonic flutter is presented. Several of the results are correlated against experimental qualitative observation to validate the models. M.M.M

N79-28181# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France)
TECHNICAL EVALUATION REPORT ON THE 52ND SYMPOSIUM OF THE PROPULSION AND ENERGETICS ON STRESSES, VIBRATIONS, STRUCTURAL INTEGRATION AND ENGINE INTEGRITY (INCLUDING AEROELASTICITY AND FLUTTER)
L. Beitch (Gen. Elec. Co., Evandale, Ohio) Mar. 1979 12 p refs Symp. held in Cleveland, Ohio, 23-27 Oct. 1978
(AGARD-AR-133, ISBN-92-835-1314-2) Avail: NTIS HC A02/MF A01

A wide spectrum of topics associated with engine development, engine-aircraft integration, and engine operation were addressed. M.M.M

X80-72091# Advisory Group for Aerospace Research and Development, Paris (France).
AERO ENGINE DETERIORATION IN AIR FORCE SERVICE (U)
Sep. 1977 28 p This document is not available from the NASA STI Facility. All requests must be directed to AGARD Hq.
(AGARD-AR-104) NATO Restricted report

Results are presented of a study undertaken by a Working Group of the Propulsion and Energetics Panel of AGARD to determine the change in engine performance, maintenance cost and reliability of fighter aircraft with respect to time in service. M.M.M.

X80-72092# Advisory Group for Aerospace Research and Development, Paris (France).
AERO ENGINE DETERIORATION IN AIR FORCE SERVICE (U)
Nov. 1977 30 p In FRENCH This document is not available from the NASA STI Facility. All requests must be directed to AGARD Hq.
(AGARD-AR-104(FR)) NATO Restricted report

Results are presented of a study undertaken by a Working Group of the Propulsion Energetic Panel of AGARD to determine the change in engine performance, maintenance cost, and reliability of fighter aircraft with respect to time in service. M.M.M.

X80-72093# Advisory Group for Aerospace Research and Development, Paris (France).
PROPULSION AND POWER SUPPLIES FOR UNMANNED VEHICLES, SMALL RPV's POWERED BY TURBOJET OR TURBOFAN, VOLUME 2 (U)
May 1978 140 p
This document is not available from the NASA STI Facility. All requests must be directed to AGARD Hq.
(AGARD-AR-101-Vol-2) NATO Confidential report

Small, remotely piloted vehicles using either turbojet engines or turbofan engines are discussed in relation to various missions. Four types of missions were considered based on propulsion requirements: reconnaissance, attack, target drone, and target designation/electromagnetic countermeasures. Existing turbojets and turbofans with thrusts lower than 2500 daN are reviewed. The catalog includes 124 engines (either in the production, or development, or project stage) and presents statistically processed data. Recommendations for research on, or development of turbojets or turbofans, either to fill existing gaps, or to improve both performance and chances of carrying out the various missions considered are discussed. A.W.H

X80-72094# Advisory Group for Aerospace Research and Development, Paris (France).
PROPULSION AND POWER SUPPLIES FOR UNMANNED VEHICLES, SMALL RPV's POWERED BY TURBOJET OR TURBOFAN, VOLUME 2 (U) [PROPULSION ET FOURNITURE DE PUISSANCE POUR LES VEHICLES SANS PILOTE, PETITS VEHICULES TELEPILOTES PROPULSES PAR TURBOREACTEUR OU TURBOSOUFFLANTE (U)]
May 1978 142 p In FRENCH
This document is not available from the NASA STI Facility. All requests must be directed to AGARD Hq.
(AGARD-AR-101(FR)-Vol-2) NATO Confidential report

Different missions for which turbojets or turbofans seem appropriate for small remotely piloted vehicles are considered from the point of view of propulsive needs: reconnaissance, attack, target aircraft, and designation objective/electromagnetic countermeasures. For each of the missions, the availability and convenience of existing engines is examined for use on the vehicle suited to complete the mission as well as the eventual need to develop new types of engines. The effect of new technologies on performance and mission cost is also investigated. Existing turbojets and turbofans with power supplies less than 2500 daN are critically evaluated, including 125 engines with (in production, under development, or planned). Considerable statistical information is included, along with recommended research and development to make up for lacunae or to improve performance or chances of completing the different missions studied. Transl. by A.R.H

X80-72095# Advisory Group for Aerospace Research and Development, Paris (France).
PROPULSION SYSTEMS FOR FALSE TARGETS, VOLUME 3 (U)
Jun. 1978 82 p Also announced as N78-15054 and AD-A049375 This document is not available from the NASA STI Facility. All requests must be directed to AGARD Hq.
(AGARD-AR-101-Vol-3) NATO Confidential report

The current state-of-the-art in propulsion, suitable for false targets, is described. Recommendations are made regarding future activities for research and for further studies. Mission requirements for the false targets are analyzed. The feasiblity of the false target concept on an operationally cost effective basis is discussed. A.W.H

X80-72096# Advisory Group for Aerospace Research and Development, Paris (France).
REPORT OF WORKING GROUP 06 ON PROPULSION AND POWER SUPPLY OF UNMANNED VEHICLES, VOLUME 4 (U) Executive Summary Report
Feb. 1979 48 p
This document is not available from the NASA STI Facility. All requests must be directed to AGARD Hq.
(AGARD-AR-101-Vol-4) NATO Confidential report

The state-of-the-art of propulsion systems for remotely piloted vehicles (RPVs) was surveyed in order to (1) set up an inventory of existing engines; (2) identify areas for future research and development; and (3) recommendations for necessary actions. The study was performed in three subgroups: small propeller-driven RPVs, small RPVs powered by turbojet or turbofan, and false targets. In addition, a general parametric study on RPVs with turbine and ramjet engines is given covering all types and missions considered by the subgroups. R.E.S

08 AIRCRAFT STABILITY AND CONTROL

Includes aircraft handling qualities; piloting; flight controls; and autopilots.

N77-26161# Advisory Group for Aerospace Research and Development, Paris (France).
TASK-ORIENTED FLIGHT CONTROL SYSTEMS
May 1977 116 p refs Lecture ser. held at London, 9-10 Jun. 1977, and Wright-Patterson AFB, Ohio, 14-15 Jun. 1977
(AGARD-LS-89; ISBN-92-835-1242-1) Avail: NTIS HC A06/MF A01

Control law design techniques, the need for and implementation of task oriented control laws, and additional degrees of freedom and associated task oriented flight control system functions were discussed. A bibiography is presented. For individual titles, see N77-26162 through N77-26167.

N77-26162# Royal Aircraft Establishment, Farnborough (England).
TASK-ORIENTED FLIGHT CONTROL SYSTEMS: INTRODUCTION AND OVERVIEW
Geoffrey H. Hunt *In* AGARD Task-Oriented Flight Control Systems May 1977 3 p ref (For primary document see N77-26161 17-08)
Avail: NTIS HC A06/MF A01

The development of high-integrity programmable control systems is discussed. A range of possibilities for their introduction into future aircraft, including that of task-oriented controls, is presented. An overview of some of the implications and problems, as well as the advantages, of applying these control systems to piloted aircraft is given. Author

N77-26163# Royal Aircraft Establishment, Farnborough (England). Flight Systems Dept.
ENGINEERING OF CONTROL SYSTEMS AND IMPLICATIONS ON CONTROL LAW DESIGN
F. R. Gill *In* AGARD Task-Oriented Flight Control Systems May 1977 18 p refs (For primary document see N77-26161 17-08)
Avail: NTIS HC A06/MF A01

The state-of-the-art of multiplexed digital flight control systems (FCS) against a background of the integrity requirements and the means of achieving integrity was reviewed. As an introduction, the need for variable and changeable control is discussed, and the potential of pilot selectable task oriented control is examined. Limitations to the performance of aircraft plus its FCS result from limitations in FCS components and subsystems, and the control policies that can be applied with confidence. Author

N77-26164# General Electric Co., Fairfield, Conn.
THE NEED FOR TASK ORIENTED CONTROL LAWS
R. P. Quinlivan *In* AGARD Task-Oriented Flight Control Systems May 1977 9 p refs (For primary document see N77-26161 17-08)
Avail: NTIS HC A06/MF A01

Several example weapon delivery problems were examined and their requirements pointed out. The need for task oriented control laws was discussed as becoming important when aircraft controllability is important to mission completion. Task oriented control laws addressed the question of input-output relation which requires consideration of the location of the system zeros as well as the poles. The aircraft, the kinematics, weapon aiming dynamics, required guidance laws, and the pilot are all discussed as part of the task oriented control law. Author

N77-26165# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick (West Germany). Inst. fuer Flugfuehrung.
IMPLEMENTATION OF TASK-ORIENTED CONTROL LAWS
R. Onken *In* AGARD Task-Oriented Flight Control Systems May 1977 17 p refs (For primary document see N77-26161 17-08)
Avail: NTIS HC A06/MF A01

The implementation of control laws was considered as a certain phase of the control system development, where the system environment around the control law was taken into account with respect to the specific system mission. A number of implications on the control law are typical for this development phase. Those, caused by design aspects, choice of components and the external atmospheric environment, are discussed. Author

N77-26166# McDonnell Aircraft Co., St. Louis, Mo. Guidance and Control Mechanics.
ADDITIONAL DEGREES OF FREEDOM
M. J. Wendl *In* AGARD Task-Oriented Flight Control Systems May 1977 19 p refs (For primary document see N77-26161 17-08)
Avail: NTIS HC A06/MF A01

Additional degrees of freedom consisting of direct lift and direct side force are introduced, and associated task oriented flight control system functions are discussed. Direct lift systems which improve the capability of both commercial and conventional fighter aircraft are presented. The impact of a fly-by-wire implementation on the aerodynamic and structural design of a Vectored Lift Fighter concept is discussed. It is shown that these additional degrees of freedom lead to innovative modes of operation. Maneuver enhancement with direct lift and wings level turning with direct side force are presented. Technical considerations related to vertical and lateral translation and fuselage aiming mode implementations are reviewed. Pilot interface techniques and blended control are introduced. Guidelines for using the additional degrees of freedom are presented. Author

N77-26167# Defence Research Information Centre, Orpington (England).
BIBLIOGRAPHY ON TASK-ORIENTED FLIGHT CONTROL SYSTEMS
H. J. Birkby, comp. and G. H. Hunt, comp. (RAE, Farnborough, England) *In* AGARD Task-Oriented Flight Control Systems May 1977 39 p refs (For primary document see N77-26161 17-08)
Avail: NTIS HC A06/MF A01

This bibliography lists the benefits, problems, design and engineering aspects of recent developments in the flight control systems of manned aircraft. A broad review of the state-of-the-art in modern flight control theory and practice is given. The concepts of task-oriented control systems, and some recent relevant simulator and flight trials are also discussed. Author

N77-30136# Advisory Group for Aerospace Research and Development, Paris (France).
A STUDY OF STANDARDIZATION METHODS FOR DIGITAL GUIDANCE AND CONTROL SYSTEMS
May 1977 548 p refs
(AGARD-AR-90; ISBN-92-835-1244-8) Avail: NTIS HC A23/MF A01

Standardization methods for digital guidance and control systems are examined, particularly with regard to data transmission techniques and high level programming languages. Discussion of the general problems and techniques is included as well as reports on the particular experiences of the individual nations. Annexes contain full details of the techniques studied, and include comparisons of data transmission methods and high level languages. These comparisons are designed to outline the relevent features of the different techniques. Author

N77-33208# Advisory Group for Aeronautical Research and Development, Paris (France).
STRUCTURAL ASPECTS OF ACTIVE CONTROLS
Aug. 1977 102 p refs Partly in ENGLISH and FRENCH Proc. of 44th Meeting of AGARD Struct. and Mater. Panel, Lisbon, 21 Apr. 1977
(AGARD-CP-228; ISBN-92-835-0200-00) Avail: NTIS HC A06/MF A01

Design and implementation factors regarding flight control systems are reviewed. Flutter suppression system testing is discussed, including wind tunnel tests, as well as actual flight tests. Also considered is the impact flight command stability systems have on aircraft dynamic response. For individual titles, see N77-33209 through N77-33215.

N77-33209# British Aircraft Corp., Filton (England). Commercial Aircraft Div.
A PRACTICAL OPTIMUM SELECTION PROCEDURE FOR A MOTIVATOR IN ACTIVE FLUTTER SUPPRESSION SYSTEM DESIGN ON AN AIRCRAFT WITH UNDERWING STORES
M. R. Turner and C. G. Lodge *In* AGARD Structural Aspects of Active Controls Aug. 1977 19 p (For primary document see N77-33208 24-08)
Avail: NTIS HC A06/MF A01

Theoretical active flutter control of a variable sweep wing with external stores with four combinations of store configuration/wing sweep/Mach number was studied. Electrically modified outputs of a structure-mounted transducer were used to drive an auxiliary control surface on the wing or store. The best transducer/force positions on the wing and stores were found using Nyquist plots, representing the control surface loads by point forces. The object was to see if a common active flutter control system using a control surface on the wing could be found for a range of stores, Mach numbers and wing sweep angles. Difficulties were due to two instabilities with close frequencies in two of the configurations and very low dampings in some of the stable modes. Author

N77-33210# Vereinigte Flugtechnische Werke-Fokker G.m.b.H., Bremen (West Germany).

IMPACT OF A COMMAND AND STABILITY AUGMENTATION SYSTEM ON GUST RESPONSE OF A COMBAT AIRCRAFT

K. D. Colfmann and O. Sensburg (Messerschmitt-Boelkow-Blohm GmbH, Munich) *In* AGARD Structural Aspects of Active Controls Aug. 1977 17 p refs (For primary document see N77-33208 24-08)

Avail: NTIS HC A06/MF A01

To get reasonable results for just response calculations it is necessary to introduce the elastic aircraft behaviour as well as the Command and Stability Augmentation System (CSAS) into the mathematical model. It is demonstrated how calculation results are influenced by using aerodynamic interference air forces; the influence of the CSAS is then presented. It is shown that the influence of the CSAS on the dynamic response is of prime interest and often far exceeds the influence of the elastic structure. The unsteady aerodynamic forces should be determined with three-dimensional theories including interference, and corrections to match the steady derivatives measured in the wind tunnel should be included. The impedance function, control loop transfer functions are highly nonlinear due to the nonlinearities of the hydraulic actuators. All these functions must be determined experimentally and introduced into the elastic aircraft equation. Response plots of the total system should be calculated and compared with results of so-called 'structural mode coupling tests'. If correlation is good, a major part for the investigation of structural response of the aircraft due to various input functions is verified. Author

N77-33211# British Aircraft Corp., Filton (England). Unternehmensbereich Flugzeuge.

ACTIVE FLUTTER SUPPRESSION OF AN AIRPLANE WITH WING MOUNTED EXTERNAL STORES

H. Hoenlinger *In* AGARD Structural Aspects of Active Controls Aug. 1977 15 p refs (For primary document see N77-33208 24-08)

Avail: NTIS HC A06/MF A01

A wing store flutter suppression system with store mounted vanes was designed. The system was proved effective when implemented and flight-tested on a Fiat G 91/T3 aircraft. The relatively small vanes used were very effective in controlling flutter and their use did not alter aircraft flight mechanical characteristics. J.L.H.

N77-33212# Boeing Co., Wichita, Kans.

AIRPLANE MATH MODELING METHODS FOR ACTIVE CONTROL DESIGN

Kenneth L. Roger *In* AGARD Structural aspects of active controls Aug. 1977 11 p refs (For primary document see N77-33208 24-08)

Avail: NTIS HC A06/MF A01

Selected analytical methods are described which are useful and practical in math modeling for airplane active control system design. A technique for writing state equations is presented which is suitable for incorporating lifting surface aerodynamic solutions. An economical method of computing unsteady aerodynamic influence matrices is presented for line doublets and plate doublets, the latter usable at any Mach number. An economical way to analyze three-dimensional turbulence and a convenient way of using design criteria in n-dimensions are presented to aid in designing for statistical performance. Recommendations include the use of a single airplane math model for analysis of multiple performance parameters and the use of control hardware math modeling during preliminary design. Author

N77-33213# Air Force Flight Dynamics Lab., Wright-Patterson AFB, Ohio. Flight Control Div.

CONSISTENCY IN AIRCRAFT STRUCTURAL AND FLIGHT CONTROL ANALYSIS

Robert C. Schwanz *In* AGARD Structural Aspects of Active Controls Aug. 1977 18 p refs (For primary document see N77-33208 24-08)

Avail: NTIS HC A06/MF A01

Military Specifications (MILSPECS) are often employed by the USAF procuring authority as guidelines for design, development, acceptance testing and mission application of military aircraft. The MILSPECS must usually be satisfied by formulations of the aerodynamic and dynamic analyses that are consistent or equivalent, if not identical. When control configured vehicle considerations are involved, however, inconsistencies resulting from analysis expediency or previous engineering convention may occur. In this paper YF-16, C-5A, B-52E and large transport aircraft design studies and flight tests provide data for a discussion and numerical illustration of these inconsistencies. It is concluded that they may be minimized or avoided altogether if flight control specialists become more familiar with restrictions of present-day unsteady aerodynamic theory, and structural specialists increase their knowledge of modern dynamics and control theory. Author

N77-33214# Boeing Aerospace Co., Seattle, Wash.

YC-14 CONTROL SYSTEM REDUNDANCY

William T. Hamilton *In* AGARD Structural Aspects of Active Controls Aug. 1977 7 p refs (For primary document see N77-33208 24-08)

Avail: NTIS HC A06/MF A01

The YC-14 is the Boeing entry in the USAF Advanced Medium STOL Transport program. The task of operating a large jet aircraft into and out of a semi-prepared, 2,000 feet long airstrip with a 27,000 pound payload presents an unusual flight control challenge. The YC-14 answers this challenge using an advanced flight control system that includes digital computers. Excellent STOL flying qualities have been achieved through control wheel steering and speed hold modes. Fail operational-fail safe performance is provided by a triplex flight control system. Aircraft dynamics following an engine failure are docile and do not require immediate pilot attention or unusual skill. The superior capability of digital computers to perform logic functions enables a comprehensive, semi-automated, preflight test. Failures are detected and identified to the Line Replaceable Unit. The YC-14's use of redundant digital computers in the flight control role is a first for an aircraft designed to demonstrate operational use Author

N77-33215# Office National d'Etudes et de Recherches Aerospatiales, Paris (France). Div. de Recherche.

WIND TUNNEL STUDY OF AN ACTIVE FLUTTER SUPPRESSION SYSTEM

Roger Destuynder *In* AGARD Structural Aspects of Active Controls Aug. 1977 9 p refs In FRENCH; ENGLISH summary (For primary document see N77-33208 24-08)

Avail: NTIS HC A06/MF A01

Active flutter control was tested in a wind tunnel on a model of wing carrying an external tank. The aerodynamic forces of the control system were generated by a classical aileron, piloted by a miniaturized servo-control from a signal issued by an accelerometer detecting the wing movement. A single control law was used in the whole velocity range. A gain of more than 15% was obtained on the flutter critical velocity. Author

N78-17074# Advisory Group for Aerospace Research and Development, Paris (France).

AN INTRODUCTION TO THE PROBLEM OF DYNAMIC STRUCTURAL DAMPING

Paolo Santini (Rome Univ.), Antonio Castellani (Rome Univ.), and Alfonso Nappi (Rome Univ.) Jan. 1978 24 p refs Presented at the 45th Struct. and Mater. Panel Meeting, Voss, Norway, Sep. 1977

(AGARD-R-663; ISBN-92-835-1268-5) Avail: NTIS HC A02/MF A01

Major topics in the area of dynamic damping are described. A list of typical problems where damping is of primary importance is provided. Typical structural components are considered and a brief account on the effect of materials is given. Mathematical models and intermodal coupling are also examined, and the extreme difficulty of obtaining reasonably accurate information from them is emphasized. Possible philosophies of ground tests and flight tests are discussed. Author

N78-17075# Advisory Group for Aerospace Research and Development, Paris (France).

TECHNICAL EVALUATION REPORT ON THE AVIONICS PANEL/GUIDANCE AND CONTROL PANEL JOINT SYMPOSIUM ON AVIONICS/GUIDANCE AND CONTROL FOR REMOTELY PILOTED VEHICLES (RPVs)

Morris A. Ostgaard Dec 1977 14 p Symp. held at Florence, 3-6 Oct 1976

(AGARD-AR-113, ISBN-92-835-1264-2) Avail: NTIS HC A02/MF A01

A symposium was held to examine the state-of-the-art in the field of avionics and guidance control related to the problems of remotely piloted vehicles. Some of the following topics were discussed: (1) Electro-optical sensors and their adverse weather capability limitations, (2) Experimental testing of various types of sensors, (3) Sensor requirements for medium range surveillance and target acquisition systems and (4) Data processing data display systems. B.B.

N78-17076# Advisory Group for Aerospace Research and Development, Paris (France)

EFFECTS OF STRUCTURAL NON-LINEARITIES ON AIRCRAFT VIBRATION AND FLUTTER

E. Breitbach (Aerodynamische Versuchsanstalt, Goettingen, West Ger.) Jan. 1978 17 p refs Presented at the 45th Struct. and Mater. Panel Meeting, Voss, Norway, Sep. 1977

(AGARD-R-665, ISBN-92-835-1270-7) Avail: NTIS HC A02/MF A01

The physical sources of various types of nonlinearities were examined and their influence on the different parts of the flutter clearance process was investigated. Methods which permit quantitative solutions of nonlinear aeroelastic problems were also surveyed. Author

N78-31126# Advisory Group for Aerospace Research and Development, Paris (France).

CONSIDERATIONS ON WING STORES FLUTTER: ASYMMETRY, FLUTTER SUPPRESSION

Jul. 1978 42 p Presented at the 46th Struct. and Mater. Panel Meeting, Aalborg, Denmark, 10-14 Apr. 1978

(AGARD-R-668, ISBN-92-835-1290-1) Avail: NTIS HC A03/MF A01

The problems pertaining to aeroelasticity and flutter of aircraft wing stores are explained and solutions are suggested. For individual titles, see N78-31127 through N78-31128.

N78-31127# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (West Germany).

ASYMMETRIC STORE FLUTTER

A. Lotze *In* AGARD Considerations on Wing Stores Flutter Jul. 1978 p 1-19 refs (For primary document see N78-31126 22-08)

Avail: NTIS HC A03/MF A01

A large number of asymmetrical store configurations were investigated by analysis and wind tunnel testing, to establish the physical background for the flutter mechanism of asymmetrical stores and to find out whether unfavorable effects of asymmetries exist only for mild flutter or could also occur for flutter cases exhibiting large gradients of aerodynamic damping with airspeed. Based on the results it is recommended to establish flutter trends by variation of important parameters before actual store configurations are calculated. Once the regions with possible lower flutter speeds of asymmetrical stores are defined, those configurations can be selected which have to be investigated. L.S.

N78-31128*# National Aeronautics and Space Administration, Langley Research Center, Hampton, Va.

DEMONSTRATION OF AIRCRAFT WING/STORE FLUTTER SUPPRESSION SYSTEMS

Chintsun Hwang (Northrop Corp., Hawthorne, Calif.), Bertil A. Winther (Northrop Corp., Hawthorne, Calif.), Thomas E. Noll (AFFDL, Wright-Patterson AFB, Ohio), and Moses G. Farmer In AGARD Considerations on Wing Stores Flutter Jul. 1978 p 21-37 refs (For primary document see N78-31126 22-08)

Avail: NTIS HC A03/MF A01

Preliminary results are presented of the design analysis and the test progress of active wing/store flutter suppression systems on a lightweight fighter aircraft. Three configurations were selected for final testing. Two of these configurations were deliberately designed to exhibit low flutter speeds with rapid reduction in damping at the incipient flutter condition. After initial tunnel entries, which showed the need for certain improvements in the model and the control system design, substantial increases in the flutter speeds were achieved using both leading and trailing edge control surfaces separately. For the most critical configuration, a demonstrated improvement of 18% and a projected improvement of 29% in the dynamic pressure were accomplished. L.S.

N79-15061# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France)

DYNAMIC STABILITY PARAMETERS

Nov. 1978 623 p refs In ENGLISH and FRENCH Symp. held in Athens, 22-24 May 1978

(AGARD-CP-235, ISBN-92-835-0223-X) Avail: NTIS HC A99/MF A01

The mission of AGARD is to bring together the leading personalities of the NATO nations in the fields of science and technology relating to aerospace. This symposium was organized in recognition of the strong present-day interest in dynamic stability of aerospace vehicles. The purpose of the symposium was to discuss the specific needs for dynamic stability information, the form in which it should be presented and the various means of obtaining it. The symposium was divided into the following sessions: (1) wind tunnel techniques 1, (2) wind tunnel techniques 2, (3) flight testing techniques, (4) analytical techniques, (5) motion analysis and nonlinear formulations, (6) sensitivity and simulator studies, and (7) workshop session. For individual titles, see N79-15062 through N79-15097.

N79-15062# National Aeronautical Establishment, Ottawa (Ontario). Unsteady Aerodynamics Lab.

TECHNIQUES FOR DYNAMIC STABILITY TESTING IN WIND TUNNELS

K. J. Orlik-Rueckemann *In* AGARD Dyn. Stability Parameters Nov. 1978 24 p refs (For primary document see N79-15061 06-08)

Avail: NTIS HC A99/MF A01

A systematic review is presented of the methods and techniques that are used for wind tunnel measurements of the dynamic stability parameters (derivatives) of an aircraft. The review is illustrated by numerous examples of experimental equipment available in various aerospace laboratories in Canada, France, the United Kingdom, the United States and West Germany. G.Y.

N79-15063# Institut de Mecanique des Fluides de Lille (France).

A NEW METHOD FOR TESTING FREE MODELS IN THE LABORATORY TO DETERMINE AERODYNAMIC CHARACTERISTICS [NOUVELLE TECHNIQUE D'ESSAIS SUR MAQUETTES LIBRES EN LABORATOIRE POUR LA DETERMINATION DE CARACTERISTIQUES AERODYNAMIQUES]

W. Charon and R. Verbrugge *In* AGARD Dyn. Stability Parameters Nov. 1978 26 p In FRENCH (For primary document see N79-15061 06-08)

Avail: NTIS HC A99/MF A01

A methodology relating to the study on free flight models under laboratory conditions linked with flight control was outlined. Experimental technique was put into operation in the area of work concerning the regulation of lift by rapid moving flaps on transport aircraft. Unstable aerodynamic coefficients were identified, and some of the following aspects of the testing technique were developed: (1) theory and experimental method, (2) structural analysis of test models, and (3) measure and treatment of unstable data. Transl. by B.B.

N79-15064*# National Aeronautics and Space Administration, Ames Research Center, Moffett Field, Calif.

NEW NASA-AMES WIND-TUNNEL TECHNIQUES FOR STUDYING AIRPLANE SPIN AND TWO-DIMENSIONAL UNSTEADY AERODYNAMICS

Gerald N. Malcolm and Sanford S. Davis *In* AGARD Dyn. Stability Parameters Nov. 1978 12 p refs (For primary document see N79-15061 06-08)

Avail: NTIS HC A99/MF A01 CSCL 01C

Two new wind tunnel test apparatuses were developed at NASA-Ames Research Center. The first is a rotary-balance apparatus to be used in the Ames 12-Foot Pressure Tunnel for investigating the effects of Reynolds number, spin rate, and angle of attack on the aerodynamics of fighter and general aviation aircraft in a steady spin motion. The second apparatus provides capability for oscillating a large two dimensional wing (0.5 m chord, 1.35 m span) instrumented with steady and unsteady pressure transducers in the Ames 11 x 11 ft Transonic Wind Tunnel. A complete description of both apparatuses, their capabilities, and some typical wind tunnel results are presented. G.Y.

N79-15065# British Aerospace Aircraft Group, Warton (England) Warton Div

EXPERIMENTAL DETERMINATION OF DYNAMIC DERIVATIVES DUE TO ROLL AT BRITISH AEROSPACE, WARTON DIVISION

A. W Matthews *In* AGARD Dyn. Stability Parameters Nov 1978 16 p (For primary document see N79-15061 06-08)
Avail NTIS HC A99/MF A01

Two rigs for the determination of dynamic derivatives due to roll are under development. Using the principle of continuously *rolling a model in a wind tunnel about an axis parallel to the* wind, they are intended to cover a test envelope up to M 0.95, R sub e = 46,100,000/m, alpha 90 degrees, pb/2V 0.25. The general features of the rigs themselves, together with the instrumentation and control systems are described. The problems met during design, manufacture, calibration, commissioning and testing are also described, together with their solutions. Data from complete models is presented and compared with that compiled for similar configurations from flight testing and other wind tunnel sources. G.Y.

N79-15066# Technische Universitaet, Darmstadt (West Germany).

WIND TUNNEL TESTING OF DYNAMIC DERIVATIVES IN WEST GERMANY

X. Hafer *In* AGARD Dyn. Stability Parameters Nov. 1978 12 p refs (For primary document see N79-15061 06-08)
Avail. NTIS HC A99/MF A01

A survey of the activities of the German national working group engaged in the development of dynamic wind tunnel test installations is given. The development of four different test rigs was planned. So far, the development of three test rigs is complete. Each rig was designed to meet very specific test requirements which are discussed in detail. Test results are presented giving a comparison of systematic tests with the same model mounted on different test rigs in different wind tunnels. Some flight test results of the corresponding original plane are compared. In addition, some results of linearized flight dynamic investigations are presented to demonstrate the influence of the several dynamic derivatives on the longitudinal and lateral aircraft dynamics. G.Y.

N79-15067# *Dornier-System G.m.b.H., Friedrichshafen (West Germany).*

ON THE TEST PROCEDURES OF THE DERIVATIVE BALANCES USED IN WEST GERMANY

Jan VonderDecken, Eberhard Schmidt (DFVLR, Braunschweig, West Germany), and Bernd Schulze (Messerschmitt-Boelkow-Blohm G.m.b.H., Munich, West Germany) *In* AGARD Dyn. Stability Parameters Nov. 1978 17 p refs (For primary document see N79-15061 06-08)
Avail: NTIS HC A99/MF A01

The low-speed wind tunnels in West-Germany are equipped with three different test installations to measure dynamic stability derivatives on rigid models of aeroplanes and missiles: (1) a mobile oscillatory apparatus with inexorable mechanical drive; (2) a multi-degree-of-freedom forced-oscillation apparatus with electrodynamic excitation; (3) a steady-state forced-roll apparatus with hydraulic motor drive. A short description of the measuring technique and the appropriate derivative evaluation method used with each installation is given. G.Y.

N79-15068# National Aeronautical Establishment, Ottawa (Ontario). Unsteady Aerodynamics Lab.

EXPERIMENTS ON CROSS-COUPLING AND TRANSLATIONAL ACCELERATION DERIVATIVES

K. J. Orlik-Rueckemann and E. S. Hanff *In* AGARD Dyn. Stability Parameters Nov. 1978 8 p refs (For primary document see N79-15061 06-08)
Avail: NTIS HC A99/MF A01

Categories of dynamic stability problems are discussed that are of particular importance for aircraft flying at high angles of attack or at non-zero sideslip angles. These encompass the static and dynamic cross-coupling effects between the lateral and the longitudinal degrees of freedom, the strong nonlinear effects at high angles of attack, and the effects of translational acceleration. Experimental techniques developed to determine these effects are briefly described and some illustrative examples of the measured cross-coupling and acceleration derivatives are presented. G.Y.

N79-15069# National Aeronautical Establishment, Ottawa (Ontario) Unsteady Aerodynamics Lab.

A GENERALIZED TECHNIQUE FOR MEASURING CROSS-COUPLING DERIVATIVES IN WIND TUNNELS

E. S. Hanff and K. J. Orlik-Rueckemann *In* AGARD Dyn. Stability Parameters Nov 1978 10 p refs (For primary document see N79-15061 06-08)
Avail NTIS HC A99/MF A01

A novel generalized oscillatory wind tunnel technique for the determination of dynamic cross and cross-coupling derivatives is described. The technique was successfully used, by means of specially developed apparatuses, to obtain all moment derivatives *due to pitching, yawing and rolling* using the full model approach, as well as to determine C sub m alpha using a half model plunging approach. A separate three-degrees-of-freedom dynamic calibrator, also described herein, was developed to independently verify the validity of the experimental and analytical procedures used for the determination of the derivatives. G.Y.

N79-15070# Office National d'Etudes et de Recherches Aerospatiales, Paris (France).

DETERMINING THE NONLINEARITIES OF DYNAMIC STABILITY [DETERMINATION DE NON-LINEARITES DE STABILITE DYNAMIQUE]

Xavier Vaucheret *In* AGARD Dyn. Stability Parameters Nov. 1978 14 p refs In FRENCH (For primary document see N79-15061 06-08)
Avail: NTIS HC A99/MF A01

Aside from classical theories of nonlinear mechanics, a classification of nonlinearity, based on their effects was proposed. Two concrete cases of strong nonlinear oscillations, one which contains a limited cycle, illustrate the methods developed.
Transl. by B.B.

N79-15071# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (West Germany).

SOME FACTORS AFFECTING THE DYNAMIC STABILITY DERIVATIVES OF A FIGHTER-TYPE MODEL

W. Staudacher, B. Laschka, B. Schulze, P. Poisson-Quinton (ONERA, Modane, France), and M. Canu (ONERA, Modane, France) *In* AGARD Dyn. Stability Parameters Nov. 1978 13 p refs (For primary document see N79-15061 06-08)
Avail: NTIS HC A99/MF A01

In the course of a Franco-German cooperation dynamic stability coefficients of a fighter-type pilot model were derived experimentally. In a first step, forced oscillation tests were carried out. The angle of attack regime investigated was alpha = 0 + 25 degrees. This first test phase concentrated on the investigation of the effects of a strakes, on the total derivatives of the configuration. Emphasis of a further second test period are put on configurational items as strakes, flap systems, tails, etc and experimental characteristics as Reynolds number, frequency and amplitudes. G.Y.

N79-15072# Southampton Univ. (England). Dept of Aeronautics and Astronautics.

AN EXPERIMENTAL STUDY OF THE HYPERSONIC DYNAMIC STABILITY OF PITCHING BLUNT CONICAL AND HYPERBALLISTIC SHAPES IN A SHORT RUNNING TIME FACILITY

R. A. East, A. M. S. Qasrawi, and M. Khalid *In* AGARD Dyn. Stability Parameters Nov. 1978 20 p refs (For primary document see N79-15061 06-08)
Avail: NTIS HC A99/MF A01

Experimental data are presented for the shapes in question at a Mach number of 6.85. The data was obtained using a free decaying oscillation technique using a light free piston compression facility having particularly steady flow characteristics during a running time up to 0.5 second. Details of the mode of operation of the facility and the dynamic stability apparatus are described. The effects of variations of Reynolds numbers and angles of attack up to 7.5 degree on the stability derivatives -Cm sub alpha and -(Cm sub q + Cm sub alpha) are presented. Comparison of the blunt cone data with previous experimental work and existing theoretical methods are given. Comparison is also made with the predictions of a new theoretical method. The reported experimental values of -Cm sub alpha and -(Cm sub q + Cm sub alpha) for the hyperballistic shapes highlight the gross errors which can be obtained from Newtonian based prediction methods. G.Y.

N79-15073# Bristol Univ. (England). Dept. of Aeronautical Engineering.

UNSTEADY AERODYNAMICS OF OSCILLATING CONTAINERS AND APPLICATION TO THE PROBLEM OF DYNAMIC

STABILITY OF HELICOPTER UNDERSLUNG LOADS
A. Simpson and J. W. Flower *In* AGARD Dyn. Stability Parameters Nov. 1978 33 p refs (For primary document see N79-15061 06-08)
Avail: NTIS HC A99/MF A01

Loads slung beneath helicopters can develop alarming oscillations at quite low airspeeds due to aerodynamic forces, and hence severely curtail the performance of the helicopter. The investigation highlights the (sometimes overriding) importance of load movement on the aerodynamic forces for the particular case of the standard 20 x 8 x 8 foot container. Forces and moments were derived from pressure measurements on two models, inexorably oscillated in a variety of modes and at various amplitudes, with some comparison with other results from decaying oscillation investigations. Extreme nonlinearities are evident. Flow visualization techniques show complex flow situations and extreme phase lags in the separated flow patterns. A mathematical model based on the observed patterns compares well with the force and moment results. G.Y.

N79-15074# Air Force Flight Test Center, Edwards AFB, Calif.
AIR FORCE FLIGHT TEST CENTER EXPERIENCE IN THE IDENTIFICATION OF STABILITY AND CONTROL PARAMETERS FROM DYNAMIC FLIGHT TEST MANEUVERS
Paul M. Jeglum *In* AGARD Dyn. Stability Parameters Nov. 1978 5 p refs (For primary document see N79-15061 06-08)
Avail: NTIS HC A99/MF A01

Air Force Flight Test Center experience in the flight test determination of stability derivatives is generalized in terms of the attainment of known benefits, and the practical and philosophical necessity for the use of the technique are discussed. Data from recent flight test programs is used to illustrate that Stability Derivative Extraction (STABDEX) techniques result in savings of flight time, a significantly better and safer flight test program and high quality data which would otherwise be unobtainable. Concluding remarks discuss the importance of the technique for the flight testing of advanced designs. G.Y.

N79-15075*# National Aeronautics and Space Administration, Hugh L. Dryden Flight Research Center, Edwards, Calif.
ESTIMATION OF AERODYNAMIC CHARACTERISTICS FROM DYNAMIC FLIGHT TEST DATA
Kenneth W. Iliff *In* AGARD Dyn. Stability Parameters Nov. 1978 26 p refs (For primary document see N79-15061 06-08)
Avail: NTIS HC A99/MF A01

Significant effort was spent in estimating unknown aircraft coefficients, such as stability and control derivatives from dynamic flight maneuvers. The techniques used to estimate these coefficients are becoming increasingly complex; however, these techniques make it possible to obtain estimates of coefficients that in the past were nearly impossible to obtain. A survey of the investigations that were undertaken to obtain estimates of coefficients from dynamic flight maneuvers is presented. One method, the maximum likelihood estimation technique, is described briefly and some of the successful applications of the technique are presented. Possible techniques for analyzing responses obtained in the stall/spin regime are discussed. Recent data obtained in the stall/spin flight regime are presented along with a discussion of how some basic results can be obtained with simple analysis techniques. G.Y.

N79-15076# Air Force Flight Dynamics Lab., Wright-Patterson AFB, Ohio.
AERODYNAMIC INTERACTIONS ON THE FIGHTER CCV TEST AIRCRAFT
Robert A. Whitmoyer *In* AGARD Dyn. Stability Parameters Nov. 1978 13 p refs (For primary document see N79-15061 06-08)
Avail: NTIS HC A99/MF A01

The Fighter CCV YF-16 testbed aircraft completed an 87 flight 125 hour test program in June 1977. The aircraft achieved higher levels of direct force control that had previously been flight tested. The direct force capabilities were used to implement six unconventional control modes on the aircraft, consisting of flat-turns, decoupled normal acceleration control, independent longitudinal and lateral translations, and uncoupled elevation and azimuth aiming. The flight test program and supporting wind tunnel testing, produced a wealth of data concerning the complex aerodynamic interactions between the force and moment producers on a Control Configured Vehicle design. The interactions were prime factors in determining the viability of the unconventional control concepts investigated. G.Y.

N79-15077*# Calspan Corp., Buffalo, N. Y. Flight Sciences Dept.
IDENTIFICATION OF THE STABILITY PARAMETERS OF AN AEROELASTIC AIRPLANE
Edmund G. Rynaski, Dominick Andrisani, II, and Norman Weingarten *In* AGARD Dyn. Stability Parameters Nov. 1978 9 p refs Sponsored in part by NASA Langley Res. Center (For primary document see N79-15061 06-08)
(Contract F33615-73-C-3051)
Avail: NTIS HC A99/MF A01 CSCL 01C

The problem of the parameter identification of large scale dynamic systems involving a system matrix characterized by approximately 200 elements is addressed. By using phase variable transformations, a mathematical model of an aeroelastic airplane is described in a form that is amenable to partial or piecemeal acceptance of parameters estimated from flight data. A mathematical model of the U.S. Air Force Total In-Flight Simulator was computed using the FLEXSTAB digital computer program. As data became available during the progress of the flight test program, this data was processed and substituted in the mathematical model for parameters analytically obtained from the FLEXSTAB program. The results tend to show a progressive and orderly transition from an analytically defined mathematical model to one obtained from the flight tests of the actual aircraft. G.Y.

N79-15078# Boeing Commercial Airplane Co., Renton, Wash.
NONLINEAR PARAMETER IDENTIFICATION AND ITS APPLICATION TO TRANSPORT AIRCRAFT
T. J. Galbraith and T. J. Petersen *In* AGARD Dyn. Stability Parameters Nov. 1978 20 p refs (For primary document see N79-15061 06-08)
Avail: NTIS HC A99/MF A01

A nonlinear parameter identification computer program and results obtained from analyzing jet transport flight data characterized by nonlinear motion and parameters is described. The program is called NLAK for nonlinear aerodynamics and kinematics and is part of a system of computer programs for analyzing airplane dynamic response data. NLAK's formulation is based on the full six degrees-of-freedom equations of motion and up to third order polynomials for aerodynamic coefficients and thrust parameters. NLAK employs a maximum likelihood estimation algorithm which is capable of both recursive and batch processing. The flight data analyzed was low speed, below 150 knots. The analysis system is outlined and all interfaces with the NLAK program are described. The basic concepts and some of NLAK's formulation details are also described in relation to obtaining consistent estimation results, especially for the nonlinear problem. G.Y.

N79-15079# Northrop Corp., Hawthorne, Calif. Aerosciences Research Dept.
A SURVEY OF ANALYTICAL AND EXPERIMENTAL TECHNIQUES TO PREDICT AIRCRAFT DYNAMIC CHARACTERISTICS AT HIGH ANGLES OF ATTACK
A. M. Skow and A. Titiriga, Jr. *In* AGARD Dyn. Stability Parameters Nov. 1978 37 p refs (For primary document see N79-15061 06-08)
Avail: NTIS HC A99/MF A01

A survey of some of the techniques that will aid the fighter aircraft designer in building good high angle-of-attack aerodynamic characteristics into the airframe is presented. Some of the more well known analytical and experimental methods and endeavors to highlight the contributions each method provides are summarized. G.Y.

N79-15080# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (West Germany).
PRESENTATION OF STABILITY DERIVATIVES IN MISSILE AERODYNAMICS AND THEORETICAL METHODS FOR THEIR PREDICTION
C. P. Schneider *In* AGARD Dyn. Stability Parameters Nov. 1978 31 p refs (For primary document see N79-15061 06-08)
Avail: NTIS HC A99/MF A01

Analytical procedures are indicated for the determination of pitching derivatives and coefficients essentially of arbitrary planform wings, of bodies of revolution, and of combinations in the linear and nonlinear angle-of-attack range in subsonic and supersonic flow. A frame of classification of theory for missile design in particular is prepared due to the abundance of unsteady flow problems. The methods for the prediction of pitching derivatives and for solving stability problems arising with longitudinal acceleration of missile are described. Results indicate the importance of derivatives with respect to missile stability. S.E.S.

N79-15081# National Aerospace Lab., Amsterdam (Netherlands).
THE USE OF PANEL METHODS FOR STABILITY DERIVATIVES
R. Roos *In* AGARD Dyn. Stability Parameters Nov. 1978 11 p refs (For primary document see N79-15061 06-08)
Avail: NTIS HC A99/MF A01

The possibilities of panel methods for computing aerodynamic stability derivatives are reviewed. Reasons were given why not all derivatives, especially those which are dominated by viscous drag, can be computed with the same level of accuracy. The unsteady panel methods, developed for aeroelastic applications, were shown to be very useful for computing dynamic stability derivatives. The value of such methods was demonstrated with the aid of some computed examples compared with experimental data. S.E.S.

N79-15082# *Waterloo Univ. (Ontario). Dept. of Applied* Mathematics.
AN ANALYTIC THEORY OF SUPERSONIC/HYPERSONIC STABILITY AT HIGH ANGLES OF ATTACK
W. H. Hui *In* AGARD Dyn. Stability Parameters Nov. 1978 9 p refs (For primary document see N79-15061 06-08)
Avail: NTIS HC A99/MF A01

The problem of dynamic stability is studied based on inviscid flow theory. The amplitude and frequency of the pitching oscillation are assumed small and a perturbation method employed. Systematic investigations of the closed form analytic formulae for the stability derivatives of oscillating wedges, flat plates, delta wings (with attached shock waves or detached shock waves) lead to the following general conclusions: (1) increasing flight Mach number M sub infinity tends to increase the dynamic stability and the stability derivatives tend to constant for large M sub infinity; (2) the sweep-back angle of a delta wing has only small effects on its dynamic stability; (3) for small angles of attack alpha the damping-in-pitch derivative increases with alpha but after alpha reaches certain critical angle the trend is reversed and further increase in alpha may rapidly cause dynamical instability; and (4) the effects of the specific heat ratio gamma of the gas on dynamical stability are small for small angles of attack alpha, but are large for large alpha, and in the latter case increasing gamma can also cause dynamic instability.S.E.S.

N79-15083# Adjutant General Center, Washington, D. C.
IDENTIFICATION OF UNSTEADY EFFECTS IN LIFT BUILDUP
P. Mereau, R. Hirsch, G. Coulon, and A. Rault *In* AGARD Dyn. Stability Parameters Nov. 1978 14 p refs (For primary document see N79-15061 06-08)
Avail: NTIS HC A99/MF A01

A methodology to identify unsteady aerodynamic forces from flight test data is proposed and developed in the case of uncoupled *longitudinal motion. This method includes several steps* based upon linearity and frequency separation: data filtering, classical stability and control parameters identification, transient forces estimation, unsteady terms identification. The mathematical model includes state equations and convolution integrals, thus requiring particular identification algorithms, well adapted to each form of representation. The results obtained in the case of non-powered flights of a reduced scale plane are very satisfactory in the sense that their comparison with existing theoretical developments are very close and thus validate the theoretical characterizations. S.E.S.

N79-15084*# *Lockheed Missiles and Space Co., Sunnyvale,* Calif.
EFFECT OF FLOW SEPARATION VORTICES ON AIRCRAFT UNSTEADY AERODYNAMICS
L. E. Ericsson and J. P. Reding *In* AGARD Dyn. Stability Parameters Nov. 1978 12 p refs (For primary document see N79-15061 06-08)
(Contracts NAS8-28130; NAS8-30652; NAS9-11445)
Avail: NTIS HC A99/MF A01 CSCL 01C

The unsteady aerodynamic flow field over the space shuttle orbiter was studied. The results indicate at moderate to high angles of attack separation-induced vortices exact a dominating influence on the unsteady aerodynamics of the space shuttle orbiter and of high performance aircraft. The main characteristics are as follows: (1) The vortex-induced aerodynamic loads are large and highly nonlinear, sometimes discontinuous in character; and (2) the vortex-induced loads have opposite effects on static and dynamic stability characteristics. Analytic approximations are presented which can predict these vortex-induced aerodynamic effects with the accuracy needed for most engineering design. S.E.S.

N79-15085# California Inst. of Tech., Pasadena.
OSCILLATORY AERODYNAMICS AND STABILITY DERIVATIVES FOR AIRFOIL SPOILER MOTIONS
R. Bernier and G. V. Parkinson *In* AGARD Dyn. Stability Parameters Nov. 1978 7 p refs Prepared in cooperation with British Columbia Univ., Vancouver (For primary document see N79-15061 06-08)
Avail: NTIS HC A99/MF A01

An extension of a previously developed linearized incompressible potential flow theory is used in the lift, pitching moment, and spoiler hinge moment for a thin airfoil section with an upper-surface spoiler oscillating about a mean erection angle. Integral transforms, the transient lift and moment following spoiler erection are calculated. Results indicate that either the oscillatory or the transient loadings can be related to the conventional stability derivatives for spoiler displacement and rate. The oscillatory loadings produce frequency-dependent functions for the stability derivatives, while the transient loadings lead to a conventional constant displacement derivatives, but a time-dependent function for the rate derivative. S.E.S.

N79-15086*# National Aeronautics and Space Administration Ames Research Center, Moffett Field, Calif.
THE ROLE OF TIME-HISTORY EFFECTS IN THE FORMULATION OF THE AERODYNAMICS OF AIRCRAFT DYNAMICS
Murray Tobak and Lewis B. Schiff *In* AGARD Dyn. Stability Parameters Nov. 1978 10 p refs (For primary document see N79-15061 06-08)
Avail: NTIS HC A99/MF A01

The scope of any aerodynamic formulation proposing to embrace a range of possible maneuvers is shown to be determined principally by the extent to which the aerodynamic indicial response is allowed to depend on the past motion. Starting from the linearized formulation, in which the indicial response is independent of the past motion, two successively more comprehensive statements about the dependence on the past motion are assigned to the indicial response (1) dependence only on the recent past and (2) dependence additionally on a characteristic feature of the distant past. The first enables the rational introduction of nonlinear effects and accommodates a description of the rate-dependent aerodynamic phenomena characteristic of airfoils in low-speed dynamic stall; the second permits a description of the double-valued aerodynamic behavior characteristic of certain kinds of aircraft stall. An aerodynamic formulation based on the second statement, automatically embracing the first, may be sufficiently comprehensive to include a large part of the aircraft's possible maneuvers. The results suggest a favorable conclusion regarding the role of dynamic stability experiments in flight dynamics studies. Author

N79-15087# *Royal Aircraft Establishment, Farnborough* (England). Aerodynamics Dept.
MATHEMATICAL MODELS OF AIRCRAFT DYNAMICS FOR EXTREME FLIGHT CONDITIONS (THEORY AND EXPERIMENT)
H. H. B. M. Thomas and Geraldine Edwards *In* AGARD Dyn. Stability Parameters Nov. 1978 52 p refs (For primary document see N79-15061 06-08)
Avail: NTIS HC A99/MF A01

The basic features of various formulations of the aerodynamic forces and moments acting on an aircraft are examined. Results from mathematical models of an aircraft indicates that motions, such as spin entry, pose new problems. These relate to the question of which contributions to the aerodynamic forces and moments may be linearized and which have to be included within a term, which is a function of some of the state variables. The essential overall validation that tests using free-flight models can provide is discussed. A related wind tunnel test program, which can provide validation, is outlined. The sensitivity of the motion to changes is examined. S.E.S.

N79-15088# Kansas Univ., Lawrence Dept. of Aerospace Engineering.
LINEAR OR NON-LINEAR ANALYSIS METHODS: WHEN AND HOW
Jan Roskam *In* AGARD Dyn. Stability Parameters Nov. 1978 17 p refs (For primary document see N79-15061 06-08)
Avail: NTIS HC A99/MF A01

The direct method of Lyapunov is used to predict under motion disturbances. Examples that large differences can exist between roll and heading responses predicted from conventional linear methods and from 'complete' non-linear methods are

presented. The causes of this nonlinear behavior are identified and a simple three-step criterion for its early detection is suggested. An energy based criterion for determining the stability behavior is suggested. Examples of energy-time histories that identify specific stability derivatives which can be major causes of non-linear behavior are shown. The relative importance of the conventional stability derivatives and of specific non-linear dynamic terms in the equations of motion in inducing non-linear behavior is discussed. S.E.S.

N79-15089# Northrop Corp., Hawthorne, Calif. Aircraft Group.

AIRCRAFT STABILITY CHARACTERISTICS AT HIGH ANGLES OF ATTACK

Juri Kalviste *In* AGARD Dyn. Stability Parameters Nov. 1978 18 p refs (For primary document see N79-15061 06-08)

Avail: NTIS HC A99/MF A01

An analysis technique where six-degree-of-freedom equations are partitioned into rotational and translational equations of motion retaining all the cross coupling between the longitudinal and lateral directional modes of motion is reported. The aircraft stability is characterized in terms of aircraft rotational motion due to static aerodynamic coefficients. A new dynamic stability axes system is defined. Stability parameters are defined about the dynamic stability axes system. A new set of stability criteria is defined in terms of the new dynamic stability derivatives. The analysis takes into account nonlinear aerodynamics and nonzero moments at zero sideslip condition. The definition of the Lateral Control Departure Parameter (LCDP) is extended for nonlinear aerodynamics and defined in terms of angle of attack and sideslip. The new criteria was validated with complete six-degree-of-freedom perturbation equation stability analysis, nonlinear time history simulation, and flight test results. S.E.S.

N79-15090# *Office National d'Etudes et de Recherches* Aerospatiales, Paris (France).

NON-LINEAR FORMULATION OF THE AERODYNAMIC FORCES FOR FLIGHT DYNAMIC STUDIES

Michel Scherer *In* AGARD Dyn. Stability Parameters Nov. 1978 24 p refs In FRENCH; ENGLISH summary (For primary document see N79-15061 06-08)

Avail: NTIS HC A99/MF A01

The information on the nonlinear domain involved in flight at high angle of attack is studied. Adequate aerodynamic data for the application of nonlinear analysis methods are discussed. Examples of formulation proposed by various authors in flight dynamics studies are presented. S.E.S.

N79-15091# Royal Aircraft Establishment, Bedford (England). Structures Dept.

NONLINEAR OSCILLATIONS AT HIGH INCIDENCE

G. D. Padfield *In* AGARD Dyn. Stability Parameters Nov. 1978 16 p refs (For primary document see N79-15061 06-08)

Avail: NTIS HC A99/MF A01

Approximations were developed for free aircraft motion when nonlinear effects are present and when the aircraft is flying close to a stability boundary. The analysis is based on the behavior of the isolated critical mode. The method of multiple scales is used to predict the transient oscillatory growth to a limit cycle condition. Results for the lateral motion of slender aircraft with nonlinear aerodynamic moments have revealed that limit cycles are possible above and below the critical incidence. Aircraft motions can be stable when the linear theory predicts instability and unstable when stability is predicted. Within the framework of the perturbation analysis it is shown how damping moments may be synthesized from response measurements. S.E.S.

N79-15092# Royal Military Coll. of Science, Shrivenham (England). Dept. of Mathematics and Ballistics.

THE DYNAMIC STABILITY IN FLIGHT OF SPINNING BLUNT BODY PROJECTILES

P. C. Parks *In* AGARD Dyn. Stability Parameters Nov. 1978 8 p ref (For primary document see N79-15061 06-08)

Avail: NTIS HC A99/MF A01

Precessional motions of spinning blunt projectiles with highly non-linear pitching moment characteristics were analyzed. The precessional motion for a particular cylindrical projectile was investigated. A solution is proposed involving an optimum rounding of the leading edge of the projectile: this alters the pitching moment characteristics and also reduces drag. The precessional motion in pitch and yaw about the flight path of the projectile was examined. Proposals for improving their performance in flight by rounding the leading edge were made. S.E.S.

N79-15093*# National Aeronautics and Space Administration Langley Research Center, Hampton, Va.

RESULTS OF PILOTED SIMULATOR STUDIES OF FIGHTER AIRCRAFT AT HIGH ANGLES OF ATTACK

Joseph R. Chambers, William R. Gilbert, and Luat T. Nguyen *In* AGARD Dyn. Stability Parameters Nov. 1978 13 p refs (For primary document see N79-15061 06-08)

Avail: NTIS HC A99/MF A01

The experience gained at the NASA Langley Research Center during the application of simulator techniques to high angle of attack flight conditions for several current fighters is discussed. The discussion includes (1) the simulator hardware, (2) requirements for static and dynamic aerodynamic data inputs, (3) evaluation procedures, (4) correlation with flight, and (5) the effects of dynamic stability parameters. Results obtained with the simulator technique have correlated well with flight test experience, resulting in early identification of potential problems, identification of critical flight conditions, and solutions to various deficiencies in stability and control characteristics. Dynamic stability parameters, results indicate that certain parameters can have a large influence on the flying qualities and tactical effectiveness of fighters at high angles of attack. S.E.S.

N79-15094# Sandia Labs., Albuquerque, N. Mex.

SENSITIVITY OF AIRCRAFT MOTION TO AERODYNAMIC CROSS-COUPLING AT HIGH ANGLES OF ATTACK

W. H. Curry and K. J. Orlik-Rueckemann *In* AGARD Dyn. Stability Parameters Nov. 1978 18 p refs Prepared in cooperation with National Aeronautical Establishment, Ottawa Sponsored in part by DOE (For primary document see N79-15061 06-08)

Avail: NTIS HC A99/MF A01

The equation of motion was examined using a six-degree-of-freedom simulation on a hybrid computer. Both straight and turning flight conditions were included, and to simplify the problem, the equations were formulated for the constant-thrust, stick-fixed condition. The aerodynamic cross-coupling derivatives were considered both as constants and as locally linearized functions of angle of attack. The effects of varying certain derivatives from an assumed nominal set on the response of the aircraft to an initial perturbance are presented graphically. Results indicate that the dynamic cross-coupling moment derivatives due to pitching have a marked effect, while those due to yawing are relatively unimportant. S.E.S.

N79-15095# ARO, Inc., Arnold Air Force Station, Tenn.

AIRCRAFT MOTION SENSITIVITY TO VARIATIONS IN DYNAMIC STABILITY PARAMETERS

R. W. Butler and T. F. Langham *In* AGARD Dyn. Stability Parameters Nov. 1978 11 p refs Sponsored by the Air Force (For primary document see N79-15061 06-08)

Avail: NTIS HC A99/MF A01

A 6-DOF nonlinear and 5-DOF linearized dynamic sensitivity study was conducted on a fighter/bomber and attack type aircraft. The dynamic derivatives investigated in the study were C sub l sub q, C sub n sub q, C sub m sub r, C sub l sub Beta, and C sub n sub Beta. The cross-coupling derivatives C sub l sub q and C sub n sub q are shown to have significant effects on the aircraft motion in 1 g flight and 2 g turning flight while the derivatives C sub m sub r show little effect in the same regime. The acceleration derivatives C sub n sub Beta each have a significant influence on the aircraft motion in 1 g flight. The interactive nature of the dynamic derivatives in the aircraft equations of motion is documented. G.Y.

N79-15096# Systems Technology, Inc., Hawthorne, Calif.

IDENTIFICATION OF KEY MANEUVER-LIMITING FACTORS IN HIGH-ANGLE-OF-ATTACK FLIGHT

Donald E. Johnston *In* AGARD Dyn. Stability Parameters Nov. 1978 12 p refs (For primary document see N79-15061 06-08) (Contracts F33615-73-C-3101; F33615-76-C-3072)

Avail: NTIS HC A99/MF A01

Results of a current analytic and simulation investigation of maneuver-limiting (e.g., loss of control) factors in fighter aircraft at high angle-of-attack are reported. Two goals of the program are to identify the key parameters which result in high-angle-of-attack maneuver-limiting phenomena such as wing rock, nose slice, and rolling divergence and to demonstrate the influence of these key parameters in controlling the nature of the maneuver-limiting phenomena. This analysis and simulation have centered on unsymmetric flight. Author

N79-16861# Institut fuer Flugmechanik, Brunswick (West Germany)
GUST-VEHICLE PARAMETER IDENTIFICATION BY DYNAMIC SIMULATION IN WIND-TUNNELS
B Krag *In* AGARD Dyn Stability Parameters Nov 1978 6 p (For primary document see N79-15061 06-08)
Avail NTIS HC A99/MF A01

A description of the DFVLR (Deutsche Forschungs und Versuchsanstalt fuer LUFT und Raumfahrt) installation for dynamic simulation in wind tunnels is given The application of the research installation in a research program and its capability and limitation are described G Y

N79-16864# Advisory Group for Aerospace Research and Development, Neuilly-Sur Seine (France)
ACTIVE CONTROLS IN AIRCRAFT DESIGN
Peter R Kurzhals ed Nov 1978 176 p refs Prepared in cooperation with NASA Washington D C
(AGARD-AG-234 ISBN 92-835-0225-6) Avail NTIS HC A08/MF A01

Related control configured vehicle design and system considerations are considered Representative applications of active control for fighter and transport aircraft are included For individual titles see N79-16865 through N79-16876

N79-16865*# National Aeronautics and Space Administration Ames Research Center, Moffett Field, Calif
ACTIVE CONTROLS IN AIRCRAFT DESIGN. EXECUTIVE SUMMARY
Peter R Kurzhals *In* AGARD Active Controls in Aircraft Design Nov 1978 4 p Presented at the FMP Symp on Stability and Control, Ottawa Oct 1978 (For primary document see N79-16864 08-08)
Avail NTIS HC A09/MF A01

Control-configured vehicle design and system considerations are discussed Representative applications of active control for fighter and transport aircraft are summarized J M S

N79-16866# Service Technique de l'Aeronautique, Paris (France)
CONTROL CONFIGURED VEHICLE DESIGN PHILOSOPHY
Jean-Michel Duc *In* AGARD Active Controls in Aircraft Design Nov 1978 6 p (For primary document see N79-16864 08-08)
Avail NTIS HC A09/MF A01

Evolution of the control configured vehicle (CCV) is reviewed Functions of the CCV discussed include augmented stability, increased maneuverability, turbulence alleviation, reduction of static loads, and flutter suppression J M S

N79-16867# Douglas Aircraft Co., Inc., Long Beach, Calif
ACTIVE CONTROL DESIGN CRITERIA
Robert S Harris and William W Rickard *In* AGARD Active Controls in Aircraft Design Nov 1978 13 p refs (For primary document see N79-16864 08-08)
Avail NTIS HC A09/MF A01

The definition and background of active control technology are discussed along with the functions contemplated to be performed by active control systems The various design criteria for each are included and the subject of government regulations affecting aircraft design is covered J M S

N79-16868# British Aircraft Corp, Preston (England) Military Aircraft Div
CONTROL-CONFIGURED COMBAT AIRCRAFT
B R A Burns *In* AGARD Active Control in Aircraft Design Nov 1978 17 p refs (For primary document see N79-16864 08-08)
Avail NTIS HC A09/MF A01

The effects of Active Controls Technology on combat aircraft, in terms of weight reduction achieved, performance and handling improvements are reviewed It is shown that very significant improvements in performance can be achieved with artificial longitudinal stability coupled with automatic operation of combat flaps The adoption of spin prevention and automatic maneuver limitation will give carefree maneuvering The combination of the performance and handling improvements will lead to greatly increased operational capability The engineering features of a full-time fly by wire system to achieve these ends are discussed briefly J M S

N79-16869# General Dynamics/Fort Worth, Tex Aerospace Technology Div
F-16 MULTI-NATIONAL FIGHTER
Charles A Anderson *In* AGARD Active Controls in Aircraft Design Nov 1978 15 p refs (For primary document see N79-16864 08-08)
Avail NTIS HC A09/MF A01

The F-16 multinational fighter flight control system is described The basic functions of the flight control system are discussed as well as the unique features such as relaxed static longitudinal stability fly-by-wire, and side-stick pilot's controller In addition, the basic philosophy behind the selection of the flight control system functions and unique features, as well as, flight test results and future applications are discussed J M S

N79-16870*# National Aeronautics and Space Administration Hugh L Dryden Flight Research Center, Edwards, Calif
F-8 ACTIVE CONTROL
Gary L Hartmann, Gunter Stein, Kenneth J Szalai, Samuel R Brown, and Kevin L Petersen *In* AGARD Active Controls in Aircraft Design Nov 1978 28 p refs Prepared in cooperation with Honeywell Systems and Res Center, Minneapolis, Minn (For primary document see N79-16864 08-08)
Avail NTIS HC A09/MF A01

An advanced flight control research program conducted with a modified F-8C aircraft is described Key technologies investigated include system redundancy management and active control laws Two control law packages proposed for flight test are discussed The first is the control configured vehicle package which incorporates command augmentation, boundary control, ride smoothing, and maneuver flap functions The second package is an adaptive control law based on a parallel channel maximum likelihood estimation algorithm The design implementation, and flight test experience with both sets of control laws are described J M S

N79-16871*# National Aeronautics and Space Administration Hugh L Dryden Flight Research Center, Edwards, Calif
HIGHLY MANEUVERABLE AIRCRAFT TECHNOLOGY
Dwain A Deets and Carl A Grother (Rockwell Intern Corp Los Angeles) *In* AGARD Active Controls in Aircraft Design Nov 1978 14 p refs (For primary document see N79-16864 08-08)
Avail NTIS HC A09/MF A01

A remotely piloted research vehicle (RPRV) with active controls designed to develop high maneuverable aircraft technologies (HiMAT) is described The HiMAT RPRV is the central element in a new method to bring advanced aircraft technologies to a state of readiness The RPRV is well into the construction phase, with flight test evaluations planned The closely coupled canard-wing vehicle includes relaxed static stability direct force control, and a digital active control system Nonlinearities in the aerodynamics led to unusual demands on the active control systems For example, the longitudinal static margin is 10-percent negative at low angles of attack, but increases to 30-percent negative at high angles of attack and low Mach numbers The design procedure followed and experiences encountered as they relate to the active control features are discussed Emphasis is placed on the aspects most likely to be encountered in the design of a full-scale operational vehicle In addition a brief overview of the flight control system features unique to the RPRV operation is presented J M S

N79-16872*# National Aeronautics and Space Administration Hugh L Dryden Flight Research Center, Edwards, Calif
PROPULSION-FLIGHT CONTROL INTEGRATION TECHNOLOGY
Frank W Burcham Jr *In* AGARD Active Controls in Aircraft Design Nov 1978 9 p refs (For primary document see N79-16864 08-08)
Avail NTIS HC A09/MF A01

The propulsion-flight control integration technology (PROFIT) concept to be implemented on a high performance supersonic twin-engine aircraft which will make possible the evaluation of a wide variety of integrated control concepts is discussed The aircraft's inlet, engine, and flight control systems are to be integrated with a digital computer The airplane control hardware is to be modified to provide the necessary capability for control research software will be used to provide flexibility in the control integration capability The background for flight and propulsion control system development and probable future trends are described Examples of integrated control research that have application to future aircraft designs are also presented J M S

N79-16873# British Aircraft Corp., Weybridge (England) Commercial Aircraft Div

ACTIVE CONTROLS FOR CIVIL TRANSPORTS
H Hitch *In* AGARD Active Controls in Aircraft Design Nov 1978 12 p (For primary document see N79-16864 08-08)
Avail NTIS HC A09/MF A01

The principles involved in Active Control Technology (ACT) for civil transports are described and estimates are made of the probable benefits. The ACT functions, maneuver load alleviation, gust load alleviation, relaxed stability, flutter suppression, ride quality improvement, and fatigue improvement are discussed in turn and the problems and benefits outlined. It is concluded that load alleviation approaching 50% may be accepted as a target and that direct operating cost of about 7% is possible and worthwhile. Author

N79-16874# Lockheed-California Co., Burbank. Structural and Material Div
FUEL CONSERVATIVE SUBSONIC TRANSPORT
W A Stauffer, R L Foss, and J G Lewolt *In* AGARD Active Controls in Aircraft Design Nov 1978 13 p refs (For primary document see N79-16864 08-08)
Avail NTIS HC A09/MF A01

A fuel saving active control system being developed for commercial application of the L-1011 airplane in the early 1980s is described. Highlighted are features of the TriStar that permit an effective yet simple load relieving system to be adopted. A description of the active control system, which involves integrated movement of both the aileron and horizontal tail, is given. The load relieving benefits obtained and the ability to increase wing span without major structural change are discussed. The potential fuel savings offered by this system is indicated. Comments on the structural design criteria established for the system, the analytic models employed in the active controls analysis, and the initial breadboard control system hardware defined for ground and flight test purposes are included. Also described are ground simulation and flight test plans and results and thoughts on further application of active controls for future consideration. J M S

N79-16875# Lockheed-Georgia Co., Marietta. C-5 Structural Requirements Dept
C-5A LOAD ALLEVIATION
T E Disney *In* AGARD Active Controls in Aircraft Design *Nov 1978 16 p refs (For primary document see N79-16864 08-08)*
Avail NTIS HC A09/MF A01

The load alleviation systems for the C-5A are considered. The evolution of the present load alleviation system is described including the system mechanization and a simplified functional block diagram. *Comparisons of analytical and flight test measured maneuvers and continuous turbulence loads are shown.* Comparisons are also shown for Active Lift Distribution Control System ON and OFF airplane response and wing stress measurements obtained during the C-5A Service Loads Recording Program. The effects of loads changes on fatigue damage rate predictions *are discussed, with particular emphasis on the implications of multiple component load changes*, i.e., reduced bending moments and increased torsional moments. J M S

N79-16876# Rockwell International Corp., Los Angeles, Calif. Dynamics Technology Div
B-1 RIDE CONTROL
John H Wykes and Christopher J Borland *In* AGARD Active Controls in Aircraft Design Nov 1978 15 p refs (For primary document see N79-16864 08-08)
Avail: NTIS HC A09/MF A01

The B-1 aircraft is one of the first aircraft to include a control-configured vehicle (CCV) concept ride control in the early design phases. A substantial savings in weight was achieved with this approach as compared to direct material stiffening. The design development, including system requirements and mechanization details is discussed. The design implementation is also discussed, including hardware and installation details. Finally, flight test performance evaluations, comparisons of analytical and test data, system improvements, and flight crew evaluations are presented. While the detailed information is provided for a system designed to improve ride quality through control of structural motion, it is concluded that the technology discussed is applicable to load relief and even flutter suppression of flexible vehicles, military or commercial. J M S

N79-20137# Advisory Group for Aerospace Research and Development, Paris (France)
EXCITATION AND ANALYSIS TECHNIQUE FOR FLUTTER TESTS
G Haidl (Messerschmitt-Boelkow-Blohm GmbH, Munich) and M Steininger (Messerschmitt Boelkow-Blohm GmbH., Munich) Jan 1979 31 p refs Presented at 47th Structures and Mater Panel Meeting, Florence, Sep 1978
(AGARD-R-672, ISBN-92-835-1309-6) Avail NTIS HC A03/MF A01

Excitation methods applied recently for flight flutter testing were surveyed. Examples of excitation by frequency sweep, pseudo-random, harmonic oscillation and control feedback technique are given and their effectiveness and adaption to digital processing is discussed. Experience with generating aerodynamic forces by control surfaces or additional vanes is presented. The digital analysis of flight flutter test data is described. Recommendations for selection of analysis parameters and how to avoid errors due to digital processing are given. For data evaluation in flight flutter tests the autopower spectrum and transfer and coherence function are used. Errors and effects of digital blockwise computation and analysis procedures like block overlapping, windowing, averaging or curve fitting are demonstrated. The filter correlation and the modal analysis technique are applied for mode separation and damping evaluation based on the above mentioned functions. Practical experiences and examples from wind tunnel, flight and laboratory tests are discussed. An on-line computer program for realtime calculation of resonance frequencies and damping factors is presented. S E S

N79-20138# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France)
AGARD FLIGHT TEST INSTRUMENTATION SERIES. VOLUME 9: AEROELASTIC FLIGHT TEST TECHNIQUES AND INSTRUMENTATION
J W G vanNunen, ed and G Piazzoli, ed Feb 1979 50 p (AGARD-AG-160-Vol 9, ISBN-92-835-1311-8) Avail NTIS HC A03/MF A01

The flight test instrumentation for determining the flutter behavior of an aircraft is presented. The mechanism of flutter is reviewed and the following items are discussed: (1) requirements which the type of excitation should obey in order to enable the determination of the flutter characteristics, (2) possible means of excitation, (3) appropriate instrumentation, and (4) data analysis procedures. S E S

N79-20139# Advisory Group for Aerospace Research and Development, Paris (France)
TECHNICAL EVALUATION REPORT ON THE FLIGHT MECHANICS PANEL SYMPOSIUM ON STABILITY AND CONTROL
Charles H Chalk (Calspan Corp., Buffalo, N Y.) Jan 1979 18 p ref Symp held at Ottawa, 25-28 Sep 1978
(AGARD-AR-134 ISBN-92-835-1308-8) Avail NTIS HC A02/MF A01

Some of the possibilities for matching control systems and characteristics to aircraft mission requirements were examined. *The technology of active control concepts and CCV to operational* aircraft is reported. Questions concerning the operational needs, cost effectiveness, reliability, and maintenance of the active control concepts and CCV are discussed. S E S

N79-23981# Advisory Group for Aerospace Research and Development, Paris (France)
TECHNICAL EVALUATION REPORT ON THE FLUID DYNAMICS PANEL SYMPOSIUM ON DYNAMIC STABILITY PARAMETERS
Lars E Ericsson (LMSC, Sunnyvale, Calif.) Apr 1979 16 p Symp held at Athens, 22-24 May 1963
(AGARD-AR-137, ISBN-92-835-1320-7) Avail NTIS HC A02/MF A01

An evaluation of the symposium is given along with the presentations made in the areas of wind tunnel techniques, flight testing techniques, analytical techniques, motion analyses and nonlinear formulations, and sensitivity and simulator studies. In addition, a workshop session and roundtable discussion on the presentations are discussed. Conclusions on the state of the art and recommendations for future activity complete the evaluation. J M S

N79-25037# Advisory Group for Aerospace Research and Development, Paris (France)
TECHNICAL EVALUATION REPORT ON THE 25TH GUIDANCE AND CONTROL PANEL SYMPOSIUM ON GUIDANCE AND CONTROL DESIGN CONSIDERATIONS FOR LOW ALTITUDE AND TERMINAL AREA FLIGHT

M A Ostgaard (AFFDL, Wright-Patterson AFB, Ohio) Mar 1979 13 p Symp held at Dayton, Ohio, 17-20 Oct 1977
(AGARD-AR-129, ISBN 92-835-1316-9) Avail NTIS

Lack of well defined operational concepts and requirements are outlined for the development efforts to fulfill low altitude operational needs and stimulate concepts that are cost effective Crew workload which is the predominant factor in low altitude operation is discussed The application of control technology to provide gust alleviation is presented SES

N79-30198# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France)
THE GUIDANCE AND CONTROL OF HELICOPTERS AND V/STOL AIRCRAFT AT NIGHT AND IN POOR VISIBILITY
May 1979 237 p refs Partly in ENGLISH and FRENCH Papers presented at the Guidance and Control Panel Symp, The Hague, 9-12 Oct 1978
(AGARD-CP-258, ISBN-92-835-0238-8) Avail NTIS HC A11/MF A01

The following topics are discussed (1) operational requirements, (2) controls and displays, (3) forward looking sensors, (4) man/machine aspects, (5) landing operations and systems, and (6) system implementation For individual titles, see N79-30199 through N79-30217

N79-30199# Army Training and Doctrine Command, Fort Monroe, Va
ADDING THE CHALLENGE OF NAP-OF-THE-EARTH
Joseph C Tirre *In* AGARD The Guidance and Control of Helicopters and V/STOL Aircraft at Night and in Poor Visibility May 1979 5 p (For primary document see N79-30198 21-08)
Avail NTIS HC A11/MF A01

In an attempt to defy the law of physics as it pertains to having two or more bodies occupy the same space at the same time, NAP-of-the Earth (NOE) was developed The problems of night, weather, and NOE flying discussed include (1) navigation, (2) communication, (3) aircraft control, (4) wire detection, and (5) target acquisition/engagement SES

N79-30200# Smiths Industries Ltd, Cheltenham (England)
THE DEVELOPMENT AND IN-FLIGHT EVALUATION OF A TRIPLEX DIGITAL AUTOSTABILIZATION SYSTEM FOR A HELICOPTER
J Meadows and P Robinson (RAE, Farnborough, Engl) *In* AGARD The Guidance and Control of Helicopters and V/STOL Aircraft at Night and in Poor Visibility May 1979 22 p refs (For primary document see N79-30198 21-08)
Avail NTIS HC A11/MF A01

The program and the triplex autostabilization system and its installation in the aircraft were reviewed The final stages of development, with particular emphasis on the major contribution afforded by a comprehensive systems rig, both to the hardware and software development program are discussed The results of in-flight evaluation program including performance under fault-free and simulated runaway conditions A number of problem areas encountered during the initial phases of the flight trials and means to overcome these are presented SES

N79-30201# Marconi-Elliott Avionic Systems Ltd, Rochester (England)
SOME ASPECTS OF THE DESIGN AND DEVELOPMENT OF THE MARITIME AUTOPILOT MODES FOR THE WESTLAND LYNX HELICOPTER
K S Snelling and M V Cook (Cranfield Inst of Technol) *In* AGARD The Guidance and Control of Helicopters and V/STOL Aircraft at Night and in Poor Visibility May 1979 18 p refs (For primary document see N79-30198 21-08)
Avail NTIS HC A11/MF A01

The stability augmentation system and the transistion autopilot mode were reviewed The requirement for Sea State filtering of the height control signal is discussed The design and development of the Cable Angle and Cable Height hold autopilot modes that together provide sonar modes for stabilizing the position of a dunking sonar SES

N79-30202*# National Aeronautics and Space Administration Langley Research Center, Hampton, Va
DESIGN AND TESTING OF A REDUNDANT SKEWED INERTIAL SENSOR COMPLEX FOR INTEGRATED NAVIGATION AND FLIGHT CONTROL
R E Ebner (Litton Systems, Inc, Woodland Hills, Calif) and W E Howell *In* AGARD The Guidance and Control of Helicopters and V/STOL Aircraft at Night and in Poor Visibility May 1979 13 p refs (For primary document see N79-30198 21-08)
Avail NTIS HC A11/MF A01 CSCL 01C

Requirements for a redundant strapdown inertial sensor complex applied to V/STOL aircraft as developed by NASA are presented Flight test data of a redundant skewed axis strapdown inertial system are given, demonstrating the feasibility of the primary design aspects This data consisted of parity equation responses through various flight conditions, showing residual noise levels on redundant gyro and accelerometer comparisons as a measure of minimum failure-level detectability, plus failure isolation and navigation performance through several simulated instrument failures SES

N79-30203# Dornier Werke G m b H Friedrichshafen (West Germany)
SCAN CONVERTER AND RASTER DISPLAY CONTROLLER FOR NIGHT VISION DISPLAY SYSTEMS
H W Killian and W Voswinckel *In* AGARD The Guidance and Control of Helicopters and V/STOL Aircraft at Night and in Poor Visibility May 1979 10 p (For primary document see N79-30198 21-08)
Avail NTIS HC A11/MF A01

A modular Raster Display System and its functional modules are described Digital scan conversion of images of electro optical sensors and digital storage of images with several gray tones are allowed With the help of the digital symbol generator digital information is converted into adequate symbology which again can be superimposed on the sensor image Superposition of two sensor images is performed with the same equipment Some technical features are discussed which exceed the common modes of current display systems and may help to support missions of military helicopters flying low level at poor visibility conditions SES

N79-30204# Army Avionics Research and Development Activity, Fort Monmouth, N J
APPLICATIONS OF PATTERN RECOGNITION SYSTEMS FOR DAY/NIGHT PRECISION AIRCRAFT CONTROL
Alfred Kleider *In* AGARD The Guidance and Control of Helicopters and V/STOL Aircraft at Night and in Poor Visibility May 1979 7 p refs (For primary document see N79-30198 21-08)
Avail NTIS HC A11/MF A01

The philosophical and practical foundations for the utilization of advanced technological developments in lasers and Charge Coupled Devices (CCD) to provide light weight, low cost solutions to these problems in day/night operations are explored The special case of weather limited visibility is presented and projected operational parameters are discussed relative to near term availability of infrared devices (IRCCD) The concept of feature extraction is explored using the complimentary one dimensional characteristics of wire/wire-like obstacles and a 1728 linear CCD Array as the foundation of the Wire Obstacle Warning System (WOWS) presently in development In this instance the appropriate geometrical, optical, and electronic capabilities were combined to provide a real time automatic pattern recognition system for Nap-of-the-Earth (NOE) helicopter operations SES

N79-30205# Army Avionics Research and Development Activity, Fort Monmouth, N J
HETERODYNING CO2 LASER RADAR FOR AIRBORNE APPLICATIONS
R L DelBoca and R J Mongeon (United Technol Res Center) *In* AGARD The Guidance and Control of Helicopters and V/STOL Aircraft at Night and in Poor Visibility May 1979 17 p refs (For primary document see N79-30198 21-08)
Avail NTIS HC A11/MF A01

The design considerations, hardware configuration, and test results of flyable breadboard models are discussed which have demonstrated the feasibility of employing CO2 scanning laser systems for wire detection, precision hover, Doppler navigation, and terrain following SES

N79-30206# Standard Elektrik Lorenz A G, Stuttgart (West Germany)
A SELF CONTAINED COLLISION AVOIDANCE SYSTEM FOR HELICOPTERS
S Bloch, G Hoefgen, and D zurHeiden *In* AGARD The Guidance and Control of Helicopters and V/STOL Aircraft at Night and in Poor Visibility May 1979 6 p refs (For primary document see N79-30198 21-08)
Avail NTIS HC A11/MF A01

A proposed solution to the problem of obstacle detection and collision warning pertaining to the operation of helicopters

at low altitude and within a formation is described A simple yet effective algorithm is used in order to assess the collision hazard posed by stationary obstacles as well as other helicopters in the proximity of the protected aircraft The raw data needed (range and closing speed) is provided by a 35 GHz versatile low cost FM/CW radar that was originally developed for the protection of road vehicles With the exception of the antenna assembly only minor modifications are needed in order to make this radar fit the requirements of an airborne anti collision system Author

N79-30207# Ferranti Ltd. Edinburgh (Scotland) Radar Group

A HELICOPTER HIGH DEFINITION ROTOR BLADE RADAR

C M Steward *In* AGARD The Guidance and Control of Helicopters and V/STOL Aircraft at Night and in Poor Visibility May 1979 10 p ref (For primary document see N79-30198 21-08)

Avail NTIS HC A11/MF A01

By installing a radar aerial within the rotor blade, a sensor having unique capabilities for the operation of helicopters in darkness or bad weather can be provided A description of such a system is given outlining the factors affecting the choice of the principal radar parameters and their interaction with the helicopter rotor design Examples of the high definition pictures from the display are shown with the appropriate section of map for comparison and some suggestions are made on operational roles where such a radar system would have particular advantages Author

N79-30208# Naval Air Development Center, Warminster, Pa

DESIGN PROCEDURE FOR AIRCREW STATION LABELING SELECTION AND ABBREVIATION

Patrick M Curran and Norman E Lane *In* AGARD The Guidance and Control of Helicopters and V/STOL Aircraft at Night and in Poor Visibility May 1979 16 p refs (For primary document see N79-30198 21-08)

Avail NTIS HC A11/MF A01

Methods are described of preparing the functional statements of what, where, when, and how the operator should act upon gathering information on a characteristic of a system/subsystem or component The usage of common labeling of associated controls and displays is presented as well as specific procedures for abbreviating display/control labels M M M

N79-30209# Royal Aircraft Establishment, Farnborough (England) Flight Systems Dept

SUBJECTIVE ASSESSMENT OF A HELICOPTER APPROACH SYSTEM FOR IFR CONDITIONS

H Howells *In* AGARD The Guidance and Control of Helicopters and V/STOL Aircraft at Night and in Poor Visibility May 1979 7 p refs (For primary document see N79-30198 21-08)

Avail NTIS HC A11/MF A01

The contribution of subjective assessment techniques used in the flight evaluation of 3 azimuth approach guidance laws presented on crosspointers of electromechanical instruments in a fully stabilized helicopter is outlined The pilots were instructed to confine their attention to monitoring the instruments within the cockpit as a safety pilot was carried The use of subjective assessment techniques, in conjunction with the interpretation of radar plots and comments of an airborne trials observer, provide a type of information not obtainable from other sources The technique, although used here on electromechanical instruments, would be equally applicable to an assessment of electro-optical displays M M M

N79-30210# Army Avionics Research and Development Activity, Fort Monmouth, N J

THE IMPACT OF A MULTI-FUNCTION PROGRAMMABLE CONTROL DISPLAY UNIT IN AFFECTING A REDUCTION OF PILOT WORKLOAD

Bernard S Gurman *In* AGARD The Guidance and Control of Helicopters and V/STOL Aircraft at Night and in Poor Visibility May 1979 8 p refs (For primary document see N79-30198 21-08)

Avail NTIS HC A11/MF A01

Three digitally addressed Multi-Legend Display Switches (MLD/S) which employ different mechanizations, and the incorporating of these MLD/S's in a multi-purpose programmable Control Display Unit (CDU) are described Several programs are cited which logically led to the development of the Multi-Legend Display Switches and the CDU These programs and that possible applications are presented Developments that lead to the reduction of pilot workload and improve overall pilot/vehicle performance are pointed out M M M

N79-30211# GIE ISPENA, Paris (France)

THE EQUIPMENT-SYSTEM INTERFACE IN AN ANTITANK HELICOPTER AT NIGHT [ETUDE D'INTERFACE EQUIPAGE SYSTEME DANS UN HELICOPTERE ANTI-CHAR DE NUIT]

G Ferlet and J L Mascle *In* AGARD The Guidance and Control of Helicopters and V/STOL Aircraft at Night and in Poor Visibility May 1979 10 p In FRENCH (For primary document see N79-30198 21-08)

Avail NTIS HC A11/MF A01

A direct consequence of the growing complexity of modern aircraft missions is the increase of equipment workloads, which can reach a critical level in many cases It is important to consider this problem from the beginning of the aircraft definition stage so that some really integrated solutions which guarantee maximum operational efficiency can be proposed for the equipment-system interface Such a step requires the adoption of a rigorous, systematic work method that is capable of accounting for diverse data such as technological constraints or operational requirements, in order to obtain optimal solutions A methodology used in the study of the equipment-system interface for an antitank helicopter capable of performing its mission by day as well as by night is presented The technique distinguishes five stages in the iterative process, thus permitting progressive improvement in the definition of the interface, as a function of the difficulties considered at different stages Transl by A R H

N79-30212# Naval Air Systems Command Washington, D C Advanced Aircraft Development and Systems Objectives Office

PROJECT NAVTOLAND (NAVY VERTICAL TAKEOFF AND LANDING CAPABILITY DEVELOPMENT)

Thomas S Momiyama *In* AGARD The Guidance and Control of Helicopters and V/STOL Aircraft at Night and in Poor Visibility May 1979 20 p refs (For primary document see N79-30198 21-08)

Avail NTIS HC A11/MF A01

The U S Navy's integrated systems approach to improve the helicopter and fixed-wing VSTOL aircraft operational capabilities at sea and in tactical sites is described The current capability is limited to generally 400 foot ceiling and one mile visibility to 200 foot and 1/2 mile weather minima due to elementary flight control systems or lack of precision approach and landing guidance Inability to cope with ship motions limits the small air capable ship operations generally to Sea State 3 The NAVTOLAND project goals are zero ceiling and 1/8 mile visibility weather minima and Sea State 5 operation An integrated development of the aircraft flight control and display systems to provide flying qualities with satisfactory level of pilot workload and the shipboard and tactical site installed guidance systems and visual landing aids to effect precision in touchdown is applied toward improvement of the helicopter and AV-8 HARRIER operations and toward development of all-weather and rough sea operations of all future Navy and Marine Corps VSTOL aircraft M M M

N79-30213# Bodenseewerk Geraetetechnik G m b H, Ueberlingen (West Germany)

GCU, THE GUIDANCE AND CONTROL UNIT FOR ALL WEATHER APPROACH

Hartmut Boehret *In* AGARD The Guidance and Control of Helicopters and V/STOL Aircraft at Night and in Poor Visibility May 1979 11 p refs (For primary document see N79-30198 21-08)

Avail NTIS HC A11/MF A01

The guidance and control unit GCU development by Bodenseewerk and sponsored by the German Ministry of Defense demonstrated in flight test the improvements of future landing procedures The short-captured steep approach paths generated by the GCU can be flown manually with the flight director instrument due to the high accuracy of signal processing by means of Kalman filter techniques The technical equipment is presented and the flight test results are discussed M M M

N79-30214# McDonnell-Douglas Corp St Louis, Mo Electronics Branch

SIMULATION AND STUDY OF V/STOL LANDING AIDS FOR USMC AV-8 AIRCRAFT

W E Bode, R A Kendrick and E J Kane *In* AGARD The Guidance and Control of Helicopters and V/STOL Aircraft at Night and in Poor Visibility May 1979 16 p (For primary document see N79-30198 21-08)

Avail NTIS HC A11/MF A01

Motion base simulations, flown by USMC Harrier pilots, in which 600 low speed IFR approaches to a forward site and ship were made. Glideslope angles from 3 degrees to 9 degrees were simulated and flown both head up and head down. An attitude hold autopilot was evaluated and flight director steering was studied. The effects of crosswind, turbulence, sea state and system errors were included in the simulation. Visual landing aids for ships and forward sites were devised and aircraft and ground/ship based equipment selected. At the heart of the study was the evaluation by the pilots of the degree of improvement offered by the simulated landing aids. M.M.M.

N79-30215# Dornier Werke G.m.b.H., Friedrichshafen (West Germany)
IMPLEMENTATION OF FLIGHT CONTROL IN AN INTEGRATED GUIDANCE AND CONTROL SYSTEM
H. J. Bangen, W. Hoffmann, and W. Metzdorff. *In* AGARD The Guidance and Control of Helicopters and V/STOL Aircraft at Night and in Poor Visibility. May 1979. 11 p. refs (For primary document see N79-30198 21-08)
Avail: NTIS HC A11/MF A01

The hardware and software technology is presented as it is required to solve the control problem in the integrated helicopter guidance and control system. M.M.M.

N79-30216# Societe de Fabrication d'Instruments de Mesure SFIM, Massy (France)
STABILIZING ELECTRO-OPTICAL SYSTEMS ON HELICOPTERS [STABILISATION DES SYSTEMES ELECTRO-OPTIQUES SUR HELICOPTERES]
Dominique dePonteves. *In* AGARD The Guidance and Control of Helicopters and V/STOL Aircraft at Night and in Poor Visibility. May 1979. 5 p. In FRENCH; ENGLISH summary (For primary document see N79-30198 21-08)
Avail: NTIS HC A11/MF A01

The stabilization of both the APX-BEZU M260 gyrostabilized sights used for surveillance and the aiming of antitank missiles, and the APX M397 sight, used with an IR goniometer to aim the HOT missile, is implemented by a mechanical relation between a mirror and a conventional gyro. The development of infrared sensors needing large optical aperture led to the design and implementation of a two-axis, tuned gyro which can be used either as a free gyro or as a rate gyro. Its performance allows the stabilization of the most performing optical sensors with a MTF degradation of not more than 15 percent. Preliminary flight tests were performed on an electro-optical system which combines a TV camera with a very high focal length, a laser range finder, and a twin-focal FLIR in order to determine its feasibility for aiming a weapon aiming system using 8 to 13 microns band. Transfer functions are discussed. A.R.H.

N79-30217# Rockwell International Corp., Cedar Rapids, Iowa. Collins Government Avionics Div.
AN ADVANCED GUIDANCE AND CONTROL SYSTEM FOR RESCUE HELICOPTERS
Kenneth W. McElreath. *In* AGARD The Guidance and Control of Helicopters and V/STOL Aircraft at Night and in Poor Visibility. May 1979. 17 p. (For primary document see N79-30198 21-08)
Avail: NTIS HC A11/MF A01

After identifying the tasks in accomplishing a search and rescue mission, Rockwell-Collins established guidelines and priorities for designing and integrating the system elements. The development of the avionics system architecture is reported and the features of each element which contribute to the adverse weather capability of the integrated system are described. M.M.M.

N79-30218# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France)
STABILITY AND CONTROL
May 1979. 359 p. refs. In ENGLISH and FRENCH. Presented at the Flight Mech. Panel Symp. on Stability and Control, Ottawa, 25-28 Sep. 1978
(AGARD-CP-260. ISBN-92-835-0239-6) Avail: NTIS HC A16/MF A01

The fundamental relationship between the use of advanced control concepts and appropriate aircraft design is considered. Experiences in stability and control, the application of active control and the general problems concerning its use, including those of mathematical models, and results obtained with control configured vehicles are discussed. Criteria for satisfactory behavior of aircraft with advanced stability and control systems and the participation of the pilot are included. For individual titles, see N79-30219 through N79-30243.

N79-30219*# National Aeronautics and Space Administration, Washington, D. C.
SYSTEMS IMPLICATIONS OF ACTIVE CONTROLS
Peter R. Kurzhals. *In* AGARD Stability and Control. May 1979. 16 p. refs (For primary document see N79-30218 21-08)
Avail: NTIS HC A16/MF A01

Control configured vehicle design and system considerations are outlined and representative applications of active control for fighter and transport aircraft are summarized. Specific examples include relaxed static stability and angle of attack limiting on the F-16, envelope limiting and ride smoothing on the F-8, maneuver load and control and relaxed static stability on the L-1011, load alleviation for the C-5, and B-1 ride control. Principal features, problem areas, and mechanization trends for these and projected future active control applications are outlined. J.M.S.

N79-30220# Lockheed Missiles and Space Co., Sunnyvale, Calif.
A SUMMARY OF AGARD FDP MEETING ON DYNAMIC STABILITY PARAMETERS
L. E. Ericsson. *In* AGARD Stability and Control. May 1979. 23 p. refs (For primary document see N79-30218 21-08)
Avail: NTIS HC A16/MF A01

Wind tunnel and flight testing techniques, analytical techniques, including motion analysis and nonlinear formulations were covered along with sensitivity and simulator studies to assess the importance of the various dynamic stability parameters, including cross coupling effects between lateral and longitudinal degrees of freedom. The extent to which the practice of decoupling lateral and longitudinal degrees of freedom must be abandoned was addressed. It was decided that when describing the vehicle dynamics of advanced aircraft and aerospace vehicles, which perform sustained operations at high angles of attack, the cross coupling effects are usually significant, and lateral and longitudinal degrees of freedom must be considered together. J.M.S.

N79-30221# Office National d'Etudes et de Recherches Aerospatiales, Paris (France).
STRUCTURAL ASPECTS OF ACTIVE CONTROLS
Roger Destuynder. *In* AGARD Stability and Control. May 1979. 12 p. refs. In FRENCH; ENGLISH summary (For primary document see N79-30218 21-08)
Avail: NTIS HC A16/MF A01

Various papers presented at the specialists meeting sponsored by the Structures and Materials Panel in Lisbon (1977) are summarized. Emphasis is placed on the following main points: (1) the use of preliminary simple calculations to cover the different configurations and the possible control laws; (2) improvement with the help of corrections obtained by wind tunnel tests, and (3) proof, through flight test or wind tunnel test, of the validity of the solution. Progress in flutter suppression obtained at ONERA is also reported. A.R.H.

N79-30222# British Aerospace Dynamics Group, Bristol (England). Theoretical Studies Dept.
CONTROL OF MISSILE AIRFRAMES
Derek J. Frary. *In* AGARD Stability and Control. May 1979. 16 p. refs (For primary document see N79-30218 21-08)
Avail: NTIS HC A16/MF A01

The main differences between manned aircraft and missiles and the approach to the design of missile airframe control systems is presented. The requirements placed on airframe control loops by guidance systems are described to illustrate the advantages of using a neutrally stable airframe. Various airframe control systems in current use are reviewed, showing how active control technology is applied to missile systems. Design factors such as body flexure and nonlinearities are discussed. Also included is a brief description of some typical airframe control systems and avionics loops which are used for unmanned aircraft. J.M.S.

N79-30223# General Dynamics/Fort Worth, Tex.
ENHANCED FIGHTER MISSION EFFECTIVENESS BY USE OF INTEGRATED FLIGHT SYSTEMS
John H. Watson and Willie S. Bennett. *In* AGARD Stability and Control. May 1979. 13 p. refs (For primary document see N79-30218 21-08)
Avail: NTIS HC A16/MF A01

The performance of the modern fighter aircraft and its flight systems is discussed. Improvement in effectiveness through proper

functional integration of the pilot, his crew station, and the flight systems is emphasized. The incorporation of advanced control modes, the integration of avionic systems and the flight control systems, and the unification of all aircraft functions under the control of a flight management system are among the factors considered. J.M.S.

N79-30224# Societe Nationale Industrielle Aerospatiale, Toulouse (France)

RESULTS RELATED TO SIMULATED AND IN-FLIGHT EXPERIMENTATION WITH AN ELECTRIC FLIGHT CONTROL SYSTEM THAT CAN BE GENERALIZED [RESULTATS RELATIFS A L'EXPERIMENTATION SUR SIMULATEUR ET EN VOL D'UN SYSTEME DE COMMANDES DE VOL ELECTRIQUES GENERALISABLES]

A. Cazenave and J. Irvoas. *In* AGARD Stability and Control May 1979 21 p. In FRENCH (For primary document see N79-30218 21-08)

Avail: NTIS HC A16/MF A01

Studies of the performance of a transport aircraft with slender airfoils whose longitudinal stability is assured by the use of elevators show the advantage of moving back the center of gravity in order to improve finesse at low speeds; the optimal centering is located beyond the operationally acceptable rear limit for handling with classical flight controls. An electric flight control system which permits control under conditions of pronounced instability across the control stick was designed, used in a simulator, and then flight tested on the T.S.S. Concorde. The form of the control laws considered is described as well as the improvements made after the simulation. Characteristics and the results obtained in flight are presented and compared to predictions. Transl. by A.R.H.

N79-30225# Northrop Corp., Hawthorne, Calif. Aircraft Corp.

IMPROVEMENT OF FIGHTER AIRCRAFT MANEUVERABILITY THROUGH EMPLOYMENT OF CONTROL CONFIGURED VEHICLE TECHNOLOGY

Janusz Stalony-Dobrzanski and Naren Shah. *In* AGARD Stability and Control May 1979 22 p. refs (For primary document see N79-30218 21-08)

Avail: NTIS HC A16/MF A01

The control configured vehicle (CCV) design concept employing concurrently the traditional disciplines as well as full authority automatic control system design, is shown to offer a very large combat performance improvement over conventional design approach. This improvement is due primarily to the freedom, under CCV concept, of designing statistically longitudinally unstable configurations. The configuration selected for the evaluation is a tailless clipped delta employing advanced structure and engine technologies. The performance gains are achieved simultaneously with decreased aircraft and fuel weight for the same mission. The feasibility of designing a stability and command augmentation (SCAS) for the statically unstable configurations is demonstrated. The full authority SCAS provides excellent flying qualities in general flying and target tracking modes. The departure prevention feature permits true 'head-out-of-cockpit' flying without the pilot having ever to consult flight instruments for safety. The system was evaluated extensively on a moving base simulator. The practical limitations to the degree of static instability are discussed. J.M.S.

N79-30226# Royal Aircraft Establishment, Farnborough (England). Flight Systems Dept.

LATERAL STABILITY AT HIGH ANGLES OF ATTACK, PARTICULARLY WING ROCK

A. Jean Ross. *In* AGARD Stability and Control May 1979 19 p. refs (For primary document see N79-30218 21-08)

Avail: NTIS HC A16/MF A01

The Gnat aircraft exhibits wing rock at high subsonic Mach numbers, but the onset of wing rock is delayed to higher angles of attack if fuel tanks are carried on the wings. Flight responses of Dutch roll and wing rock oscillations in steady turns were analyzed to give the variation of the stability derivatives with angles of attack at various Mach numbers for both aircraft configurations. The results show that the onset of wing rock occurs when the damping of the Dutch roll mode is zero, due mainly to loss in damping-in-roll derivative at high angle of attack. The stability derivatives from flight tests were compared with wind tunnel results, and show the same trends with angle of attack. The values of the linear derivatives were used as a basis for evaluating the effects of various added aerodynamic nonlinearities, both to explore the possible mechanisms for the limit cycle type of wing rock responses, and to calculate the changes in response due to an idealized stability augmentation system. Author

N79-30227# Hochschule der Bundeswehr, Munich (West Germany).

STALL BEHAVIOUR EVALUATION FROM FLIGHT TEST RESULTS

G. Sachs and H. Wuennenberg (Dornier-Werke G.m.b.H., Friedrichshafen). *In* AGARD Stability and Control May 1979 9 p. refs (For primary document see N79-30218 21-08)

Avail: NTIS HC A16/MF A01

By comparing the dynamic stall behavior of a combat aircraft with a simulation, a special type of discrepancy in roll was found. The simulation was based on the best wind tunnel data available. The examination leads to the conclusion, that the aircraft is disturbed by random-type 'fluctuation' forces and moments. The order of magnitude was estimated from the scattering region of the wind tunnel data beyond C sub L max. By introducing these effects into the mathematical model it was possible to simulate the pilot in the loop dynamic stall behavior with the aid of a simple mathematical pilot model. For a general application in the design stage of a new project, new wind tunnel test techniques including the measurement of the time dependent parameters will be necessary. Author

N79-30228# Marconi-Elliott Avionic Systems Ltd., Rochester (England). Flight Controls Div.

HYBRID COMPUTER INVESTIGATION OF DISCRETE GUST AND WINDSHEAR EFFECTS ON AUTOMATIC LANDING SYSTEM PERFORMANCE

K. W. Rosenberg. *In* AGARD Stability and Control May 1979 14 p. refs (For primary document see N79-30218 21-08)

Avail: NTIS HC A16/MF A01

A hybrid computer investigation is described which includes a search routine which allows the gust parameters and point of application of the gust to be varied so that the limiting touchdown range and vertical velocity for a given gust intensity can be determined. The results are discussed and compared with the performance assessment using conventional certification criteria. The feasibility of this method as a general design tool for flight control systems is also discussed. Author

N79-30229# Technische Hogeschool, Delft (Netherlands). Dept. of Aerospace Engineering.

AIRCRAFT RESPONSE TO WINDSHEARS AND DOWNDRAUGHTS

J. C. vanderVaart. *In* AGARD Stability and Control May 1979 16 p. refs (For primary document see N79-30218 21-08)

Avail: NTIS HC A16/MF A01

After a short review of current methods of modelling low altitude random atmospheric turbulence and variations of mean wind with altitude (windshears), a description is given of an analytical method to find deterministic wind or turbulence time histories that cause largest deviations of aircraft motion variables. Some numerical examples illustrate that small variations of wind, in particular of horizontal wind, may cause relatively large deviations relative to a desired aircraft trajectory. Finally, it is shown that the problem of finding 'worst case' response to deterministic changes in wind can be reduced to that of the statistics of a random white noise driven linear system. Author

N79-30230# Aeritalia S.p.A., Torino (Italy). Combat Aircraft Group.

GUST ALLEVIATOR FEASIBILITY STUDY FOR G91Y

R. Carabelli. *In* AGARD Stability and Control May 1979 12 p. ref (For primary document see N79-30218 21-08)

Avail: NTIS HC A16/MF A01

A feasibility study was carried out of an active system to alleviate the turbulence effects on a light attack aircraft during the penetration phase of a ground attack mission. The study was tailored to the G91Y and the conclusions were that proceeding through an experimental research by developing a flying prototype would be preferable. The risks implicit in the achievement of the required accuracy in measuring the gust velocity were very high. The proposed system works on two axes. An open loop subsystem driven by the normal component of the gust velocity on the pitch axis and a roll damper on the lateral is indicated as an adequate solution to meet profitable cockpit 'g' reductions and weapon delivery accuracy improvement as well. R.E.S.

N79-30231# Air Force Flight Dynamics Lab., Wright-Patterson AFB, Ohio.

DESIGN CONSIDERATIONS FOR RELIABLE FBW FLIGHT CONTROL

James K Ramage and James W Morris *In* AGARD Stability and Control May 1979 15 p refs (For primary document see N79-30218 21-08)

Avail NTIS HC A16/MF A01

Critical design considerations which both aircraft designers and flight control systems engineers must bear in mind in the design and implementation of fly by wire flight control systems are presented R.E.S.

N79-30232# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick (West Germany). Inst. fuer Flugmechanik.

OPEN/CLOSED LOOP IDENTIFICATION OF STABILITY AND CONTROL CHARACTERISTICS OF COMBAT AIRCRAFT

R Koehler and M Marchand *In* AGARD Stability and Control May 1979 11 p (For primary document see N79-30218 21-08)

Avail NTIS HC A16/MF A01

General aspects of assessing flying qualities of augmented aircraft using system identification methods are discussed. The aircraft under test was equipped with a stability augmentation system which had a complex dynamic behavior. The dynamics influenced the flying qualities as well as the applicability of investigation methods. Therefore, the influence and recognizability of the stability augmentation system dynamics on handling quality evaluations and system identifications were inquired and pilot-in-the-loop investigations were made using the system identification results R.E.S.

N79-30233# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick (West Germany). Inst. fuer Flugmechanik.

DYNAMIC WINDTUNNEL SIMULATION OF ACTIVE CONTROL SYSTEMS

P G Hamel and B. Krag *In* AGARD Stability and Control May 1979 10 p refs (For primary document see N79-30218 21-08)

Avail NTIS HC A16/MF A01

Research studies were conducted to demonstrate the application potential of dynamic simulation in a wind tunnels test facility. Elastic mode control and ride smoothing systems were scaled to model frequency and tested in a 3 m subsonic gust windtunnel. An open loop active control ride smoothing system was optimized for the Dornier-TNT light transport aircraft experimental program. Dynamic wind tunnel flight tests of this program were successfully completed. R.E.S.

N79-30234# *Messerschmitt-Boelkow-Blohm* G.m.b.H., Ottobrunn (West Germany). Military Aircraft Div

STABILITY AND CONTROL ASPECTS OF THE CCV-F104C

H Beh, U Korte, and G Loebert *In* AGARD Stability and Control May 1979 18 p refs (For primary document see N79-30218 21-08)

Avail NTIS HC A16/MF A01

The control configured vehicle and its implementation, and the design of the control laws are described. The superior flight performance of the control configured vehicle-flight control system is compared with that of the basic F 104G on the basis of simulator results. The validity of these results was demonstrated by comparison of the principal characteristics of longitudinal and lateral motion measured in flight with the corresponding predicted values. R.E.S.

N79-30235# Air Force Flight Dynamics Lab., Wright-Patterson AFB, Ohio

DESIGN GUIDANCE FROM FIGHTER CCV FLIGHT EVALUATIONS

Frank R Swortzel and Jack D McAllister (Gen. Dyn./Ft. Worth, Tex.) *In* AGARD Stability and Control May 1979 21 p refs (For primary document see N79-30218 21-08)

Avail NTIS HC A16/MF A01

Flight control of the Fighter Control Configuration Vehicle (CCV) marked the first exploitation of six degree-of-freedom flight control concepts for a new way to fly. An 87 flight, 125 flight hour test was conducted on a modified YF-16. Validation of the new control concepts was accomplished and significant capabilities to improve overall mission effectiveness of fighter aircraft were demonstrated. The program also included pilot evaluation of the CCV control modes applied to air-to-air and air-to-ground mission oriented tasks. Resulting control features included direct force control, independent fuselage aiming and translation, maneuver enhancement and gust alleviation. Performance benefits of relaxed static stability were also evaluated. G.Y.

N79-30236# Lockheed-California Co., Burbank

L-1011 ACTIVE CONTROLS, DESIGN PHILOSOPHY AND EXPERIENCE

David M. Urie *In* AGARD Stability and Control May 1979 9 p refs (For primary document see N79-30218 21-08)

Avail NTIS HC A16/MF A01

Aircraft active control can be defined as control effectors activated by sensors through computers without pilot commands. A certificated commercial transport airplane, the Lockheed L-1011, currently employs several highly sophisticated systems satisfying this definition. The experience gained through development flight testing, commercial flight operation, and flight simulation research on active control applications is presented with the intent of relating design philosophy and results. G.Y.

N79-30237# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick (West Germany). Inst. fuer Flugmechanik.

IN-FLIGHT HANDLING QUALITIES INVESTIGATION OF VARIOUS LONGITUDINAL SHORT TERM DYNAMICS AND DIRECT LIFT CONTROL COMBINATIONS FOR FLIGHT PATH TRACKING USING DFVLR HFB 320 VARIABLE STABILITY AIRCRAFT

D. Hanke and H.-H. Lange *In* AGARD Stability and Control May 1979 10 p refs (For primary document see N79-30218 21-08)

Avail NTIS HC A16/MF A01

An in-flight investigation of DLC for wide body transport aircraft was carried out using DFVLR 320 variable stability aircraft which incorporates an advanced all digital model following system. The aircraft/DLC configuration parameters was investigated in an altitude compensatory tracking task in which the pilot has to minimize the error between commanded and actual altitude. To determine the influence of motion cues, the tracking task is carried out both on the ground and in-flight. Using the HFB 320 as a fixed base and an in-flight simulator, an ideal situation for comparing the fixed base and in-flight simulation results exists. In addition pilot-in-the-loop analysis for flight path tracking with DLC is performed. The results are given in the form of subjective pilot effort ratings and pilot-aircraft performance measures. The results are further compared with a flight path tracking criterion. G.Y.

N79-30238# British Aerospace Aircraft Group, Warton (England)

FLYING QUALITIES AND THE FLY-BY-WIRE AEROPLANE

J C Gibson *In* AGARD Stability and Control May 1979 8 p refs (For primary document see N79-30218 21-08)

Avail NTIS HC A16/MF A01

The tornado flight control system was designed to give good stability, damping, and resistance to external disturbances. This was achieved by optimization of feedback gains and filters. Response to pilot inputs was then shaped by stick commands gains and filters. This process resulted in generally excellent flying qualities. Pilots reported a high level of confidence inspired by the easy and precise control with extremely good circuit handling and instrument flight characteristics. However, some deficiencies were noted associated in some cases with nonaircraft-like responses and these were eliminated by modifications to the command shaping. This experience emphasized that a specification which ensures entirely satisfactory flying qualities does not exist. Several areas where requirements are deficient or absent are illustrated. G.Y.

N79-30239# Naval Air Systems Command, Washington, D.C.

ARE TODAY'S SPECIFICATIONS APPROPRIATE FOR TOMORROW'S AIRPLANES?

R C. AHarrah, W. J. Lamanna (McDonnell Aircraft Co., St. Louis, Mo.), and J. Hodgkinson *In* AGARD Stability and Control May 1979 12 p refs (For primary document see N79-30218 21-08)

Avail NTIS HC A16/MF A01

An approach for taking any system of a higher order that is addressed in the current specifications, and producing an equivalent system of an appropriate order, which is directly relatable to the specification parameters is presented. Example applications of the equivalent systems approach to various higher order systems are presented, the insights of this approach to the newest fighter aircraft design are discussed, and very preliminary results are presented on a flight program which investigates equivalent systems. G.Y.

N79-30240# National Aerospace Lab., Amsterdam (Netherlands)
A SIMULATOR INVESTIGATION OF HANDLING QUALITY CRITERIA FOR CCV TRANSPORT AIRCRAFT
H A Mooij, W P deBoer, and M F C vanGool *In* AGARD Stability and Control May 1979 14 p refs Sponsored in cooperation with Netherlands Agency for Aerospace Programs and Dept. of Civil Aviation of the Netherlands (For primary document see N79-30218 21-08)
Avail NTIS HC A16/MF A01

The introduction of CCV (Control Configured Vehicle) concepts in the design of certain categories of future transport aircraft requires definition of handling quality criteria for such aircraft. These criteria should be applicable to guidance in flight control system design as well as in airworthiness certification. In an attempt to contribute new insight in this matter, approach and landing flight simulation investigations were performed using a moving base flight simulator. The conceptual aircraft was a jet transport aircraft developed around the relaxed static stability concept and equipped with a primary flight control system of the rate-command/attitude-hold type for pitch and roll control. Based on measured pilot/aircraft performance, pilot ratings and pilot commentary, boundary values for satisfactory handling qualities for the parameters investigated were established. G.Y.

N79-30241# National Aerospace Lab., Amsterdam (Netherlands)
MATHEMATICAL MODELS OF MANNED AEROSPACE SYSTEMS
P H Wewerinke *In* AGARD Stability and Control May 1979 8 p refs (For primary document see N79-30218 21-08)
Avail NTIS HC A16/MF A01

Mathematical models of human operator's participation in manned aerospace systems are reviewed. Pilot's functioning is described in terms commensurate with those used for other system elements. This is desirable in order to deal with the complex interaction between pilot-related and task-related characteristics. The result is an integrated model of the man-machine system serving as a diagnostic tool (for existing systems) and allowing the extrapolation to new situations. G.Y.

N79-30242# Office National d'Etudes et de Recherches Aerospatiales, Paris (France).
ONERA'S MODEL OF THE PILOT IN DISCRETE TIME [LE MODELE DE PILOTE EN TEMPS DISCRET DE L'ONERA]
Daniel Cavalli *In* AGARD Stability and Control May 1979 11 p refs In FRENCH (For primary document see N79-30218 21-08)
Avail NTIS HC A16/MF A01

Numerical simulation of pilot performance provides a tool for evaluating the efficiency of pilot-aircraft systems and permits the study of the handling quality of new aircraft from the concept stage. Pilot performance is considered as a discreet time process in which decision making has a sequential character. The development of the ONERA model is described and its originality demonstrated by comparison with already existing models. Results obtained during application of the model in a study of performance degradation when the static margins of the simulated aircraft were decreased are presented. Transl. by A.R.H.

N79-30243*# National Aeronautics and Space Administration Ames Research Center, Moffett Field, Calif.
FLIGHT EXPERIENCE WITH ADVANCED CONTROLS AND DISPLAYS DURING PILOTED CURVED DECELERATING APPROACHES IN A POWERED-LIFT STOL AIRCRAFT
W. S. Hindson (Natl. Res. Council of Can., Ottawa) and G. H. Hardy *In* AGARD Stability and Control May 1979 12 p refs (For primary document see N79-30218 21-08)
Avail: NTIS HC A16/MF A01

A program to assess the feasibility of piloted STOL approaches along predefined, steep, curved, and decelerating approach profiles was carried out with a powered-lift STOL aircraft. To reduce the pilot workload associated with the basic control requirements of a powered-lift aircraft equipped with redundant controls and operating on the backside of the power curve, separate stability augmentation systems for attitude and speed were provided, as well as a supporting flight director and special electronic cockpit displays. The control, display, and procedural features are described for the flight experiment that led to the conclusion that, given an adequate navigation environment, such constrained approaches may be feasible from a pilot acceptance point of view. G.Y.

N79-33219# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France)
INTEGRITY IN ELECTRONIC FLIGHT CONTROL SYSTEMS
Peter R. Kurzhals and R. Onken (DFVLR Brunswick, West Germany) Jul 1979 20 p refs Prepared in cooperation with NASA, Washington, D. C.
(AGARD-AR-136; ISBN 92-835-1329-0) Avail NTIS HC A02/MF A01

The evolution of the requirements of improved flight control systems, the status of flight control reliability, and highlights of the methods promising integrity of those systems are outlined. M.M.M.

N80-15140# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France)
TECHNICAL EVALUATION REPORT ON THE 28TH GUIDANCE AND CONTROL PANEL SYMPOSIUM ON ADVANCES IN GUIDANCE AND CONTROL SYSTEMS USING DIGITAL TECHNIQUES
Morris A. Ostgaard (AFFDL, Wright-Patterson AFB, Ohio) Nov 1979 14 p Symp. held at Ottawa 8-11 May 1979
(AGARD-AR-148; ISBN-92-835-1314-X) Avail NTIS HC A02/MF A01

A summary of the conclusions and recommendations resulting from audience comments and participation and technical assessment of the papers and the meeting is presented. Some of the conclusions are as follows: (1) there is a rapid emergence of digital processor application to guidance and control that represent integration opportunities heretofore unavailable in analog systems; (2) there appears to be a proliferation of microprocessor device application and architectures that, by themselves, limit potential for generalized application; (3) with the availability of more information from the data buss and the power of the computational capability, the multi-variable design techniques are offering significant potential for improving system performance and reducing equipment complexity; and (4) there is a strong need for fundamental studies in functional architecture that can employ microprocessors and still retain standards that permit the application of emerging electronic technology without restructuring the total system. R.E.S.

N80-15141# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France)
LOW COST AIRCRAFT FLUTTER CLEARANCE
Sep. 1979 110 p Papers presented at the 48th Meeting of the Structures and Mater. Panel, Williamsburg, Va., 4 Apr. 1979
(AGARD-CP-278; ISBN-92-835-0245-0) Avail NTIS HC A06/MF A01

An evaluation of the usage of low cost aircraft flutter clearance procedures is presented. Some results occurring from such procedures (weight efficiency, safety, flight incidents, and overall costs) were discussed relative to those from methods using advanced state of the art. The relative technological-financial position of the small light weight aircraft manufacturer was also discussed. For individual titles, see N80-15142 through N80-15148.

N80-15142# Lockheed-Georgia Co., Marietta
COMPARISON OF INTERNATIONAL FLUTTER REQUIREMENTS AND FLUTTER FREEDOM SUBSTANTIATION OF LIGHT AIRCRAFT IN THE USA
H. F. Hunter and G. E. Goodblood (FAA) *In* AGARD Low Cost Aircraft Flutter Clearance Sep. 1979 10 p refs (For primary document see N80-15141 06-08)
Avail NTIS HC A06/MF A01

A comparison of current flutter specification requirements for light aircraft produced by NATO and other free-world countries is presented as well as an overview of flutter substantiation procedures presently used in the USA by the Federal Aviation Administration. Current flutter assessment procedures for light aircraft parallel very nearly those for transport-type aircraft. Significant deviations could occur because specific requirements for follow-on flight verification are lacking. The lack of such requirements has not created a great problem, since certain elements of the flight structure call for flight demonstration, in most cases. The body of data acquired may be something less than that derived for a transport program. The attempt is made, however, to acquire sufficient data to validate the analysis from a safety standpoint. M.M.M.

N80-15143# Beech Aircraft Corp., Wichita, Kans. Structural Dynamics Dept.
THE STATE-OF-THE-ART OF FLUTTER SUBSTANTIATION PROCEDURES AMONG US GENERAL AVIATION MANUFACTURERS

E H Hooper *In* AGARD Low Cost Aircraft Flutter Clearance Sep 1979 19 p ref (For primary document see N80 15141 06-08)
Avail NTIS HC A06/MF A01

An overview is presented of the state of the art of flutter substantiation procedures among U S general aviation manufacturers to serve as a guide to the small plane designer in the prevention of flutter aileron reversal and wing divergence The material presented relies upon (1) a statistical study of the geometric, inertia, and elastic properties of those airplanes which had experienced flutter in flight and the methods used to eliminate the flutter (2) limited wind tunnel tests conducted with semi-rigid models These were solid models of high rigidity with motion controlled at the root by springs to simulate wing bending and torsion Springs at the control surface were used to simulate rotation, and (3) analytic studies based on the two dimensional study of a representative section of an airfoil M M M

N80-15144# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Goettingen *(West Germany)*
AN EMPIRICAL APPROACH FOR CHECKING FLUTTER STABILITY OF GLIDERS AND LIGHT AIRCRAFT
F Kiessling *In* AGARD Low Cost Aircraft Flutter Clearance Sep 1979 17 p refs (For primary document see N80-15141 06-08)
Avail NTIS HC A06/MF A01

Data of flutter accidents and computations of gliders and light aircraft are presented, and the empirical rules of a simplified flutter investigation are applied A procedure for checking the flutter stability of small airplanes is proposed, which takes into account the varying levels of knowledge with conventional and unconventional designs M M M

N80-15145# Office National d'Etudes et de Recherches Aerospatiales, Paris (France)
DYNAMIC IDENTIFICATION OF LIGHT AIRCRAFT STRUCTURES AND THEIR FLUTTER CERTIFICATION
Gerard Piazzoli and Jean-Louis Meurzec *In* AGARD Low Cost Aircraft Flutter Clearance Sep 1979 19 p refs In FRENCH, ENGLISH summary (For primary document see N80-15141 06-08)
Avail NTIS HC A06/MF A01

Within the framework of the general orientation of the treatment of the light aircraft structures, and with a view to determining specifications for their aeroelastic certification, the following points are discussed (1) application of fast identification methods and of technological means to be implemented during the tests, (2) exploitation of flutter onset calculations, coupled on the computer with the experimental data, making it possible, in most cases, to define in situ a remedy (such as a new mass balance of the control surface) and to check its efficiency, (3) development of mixed methods, based on the theoretical definition of the participation of the control surfaces in the structural modes revealed by the test, with a view to palliating the possible orthogonally defects of the experimental modal basis on which the definitive flutter prediction calculations are established, and (4) methods and techniques used during the aeroelastic flight test, carried out in the particular cases where flutter certification cannot be based only on the calculation file because of insufficient safety margins M M M

N80-15146# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Goettingen (West Germany)
A SIMPLIFIED GROUND VIBRATION TEST PROCEDURE FOR SAILPLANES AND LIGHT AIRCRAFT
N Niedbal *In* AGARD Low Cost Aircraft Flutter Clearance Sep 1979 11 p refs (For primary document see N80-15141 06-08)
Avail NTIS HC A06/MF A01

A test procedure to obtain all characteristic modal data for an aeroelastic analysis is presented It is shown that by taking into consideration the beam-like structural behaviour of such aircraft, and the comparatively small bandwidth of the design variables, substantial simplifications are possible when the dynamic behavior of similar aircraft structures is known The mechanical steering mechanism of the control surfaces causes high damping and nonlinear effects, which require a separate examination and analysis of the control surfaces M M M

N80-15147# Royal Aircraft Establishment, Farnborough (England) Structures Dept
A FLUTTER SPEED FORMULA FOR WINGS OF HIGH ASPECT RATIO
Ll T Niblett *In* AGARD Low Cost Aircraft Flutter Clearance Sep 1979 14 p refs (For primary document see N80-15141 06-08)
Avail NTIS HC A06/MF A01

Flutter speed formulae for unswept wings of high aspect ratio and not carrying concentrated masses are derived A high aspect ratio wing was defined as one whose fundamental torsional frequency is well above its first overtone flexural frequency Because of the comparative fewness of the factors governing the flutter of such wings, flutter-speed formulae aimed at giving a lower bound for the flutter speed is of simple form M M M

N80-15148# British Aerospace Aircraft Group, Weybridge (England) Weybridge-Bristol Div
THE MINIMUM COST APPROACH TO FLUTTER CLEARANCE
B W Payne and R E J Brazier *In* AGARD Low Cost Aircraft Flutter Clearance Sep 1979 11 p (For primary document see N80-15141 06-08)
Avail NTIS HC A06/MF A01

Flutter prediction methods are assessed using criteria and simple flutter analyses The difference in cost of these alternative approaches is no longer great, and the better data, available from the flutter analysis, answer far more of the questions which arise when obtaining a flutter clearance Current regulations, although not making flutter calculations mandatory, do insist on ground and flight resonance testing Data from a flutter analysis can allow a substantial saving in flight test time It is concluded that flutter calculations provide the swiftest, surest and safest route to flutter clearance of the orthodox design and the only route for the unorthodox Author

N80-15149# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France)
AERODYNAMIC CHARACTERISTICS OF CONTROLS
Sep 1979 510 p Presented at the Fluid Dyn Panel Symp, Pozzuoli, Italy, 14-17 May 1979
(AGARD-CP-262, ISBN-92-835-0252-3) Avail NTIS HC A22/MF A01

The rapidly expanding flight envelopes of aircraft, the growing applications of active control technology (ACT) and the associated development of control configured vehicles (CCV) are considered Conventional and novel methods of control, prediction methods, experimental data derived from wind tunnel and flight measurements, and flight experience of ACT and CCV are included For individual titles, see N80-15150 through N80-15178

N80-15150# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick (West Ger.) Inst for Design Aerodynamics
THEORETICAL AERODYNAMIC METHODS FOR ACTIVE CONTROL DEVICES
Horst Koerner *In* AGARD Aerodyn Characteristics of Controls Sep 1979 28 p refs (For primary document see N80-15149 06-08)
Avail NTIS HC A22/MF A01

The theoretical aerodynamic aspects of active control devices are surveyed Various calculation methods for subsonic, transonic, and supersonic attached flow are reviewed followed by comments on separated flow Typical correlations between theoretical and experimental results for steady and unsteady characteristics of control are presented along with the shortcomings of the theoretical approaches and some recommendations for future efforts. J M S

N80-15151# Royal Aircraft Establishment, Farnborough (England)
A SURVEY OF EXPERIMENTAL DATA ON THE AERODYNAMICS OF CONTROLS, IN THE LIGHT OF FUTURE NEEDS
A Jean Ross and H H B M Thomas *In* AGARD Aerodyn Characteristics of Controls Sep 1979 48 p refs (For primary document see N80-15149 06-08)
Avail NTIS HC A22/MF A01

Control data for current aircraft are used to provide material for discussion, principally to describe trends and to highlight gaps in knowledge Both direct and indirect effects for a range of conventional and unconventional motivators are included Maximum control power at the extremes of the flight envelope is particularly emphasized, since that available at high angle of attack and high subsonic speed is likely to be the critical design case The indirect and coupling effects are also more marked at high angle of attack and/or high control deflection, and are of importance in the control system design Hinge moment

characteristics are described, although experimental data published recently are sparse. Some thought is given to the means of generating required control powers for aircraft configurations made possible by Active Control Technology, and to the integration of the motivators in the control system. J M S

N80-15152# McDonnell Aircraft Co., St. Louis, Mo.
CORRELATION OF F-15 FLIGHT AND WIND TUNNEL TEST CONTROL EFFECTIVENESS
J. W. Agnew and J. F. Mello. *In* AGARD Aerodyn. Characteristics of Controls, Sep. 1979, 11 p, refs (For primary document see N80-15149 06-08)
Avail: NTIS HC A22/MF A01

The F-15 aerodynamic configuration and control system development relied on data obtained in an extensive wind tunnel test program. Subsequently, a large body of flight test data was obtained. Control surface effectiveness characteristics were derived from flight test data and were compared with the data obtained in the wind tunnel test program. Data correlations are available for the ailerons, rudders, and stabilators. The latter surfaces are deflected symmetrically for longitudinal control and are deflected differentially for roll control. Primary axis effectiveness is addressed for each of these control surfaces. Significant secondary axis contributions (e.g., yawing moments due to aileron deflection) are also addressed. In addition to the conventional control surfaces, the longitudinal control effectiveness of the F-15 movable inlet ramp is discussed. As a result of the excellent resistance to departure from controlled flight, the spin resistance and spin recovery characteristics of the F-15, it was possible to flight test and to obtain control effectiveness data to 90 deg angle of attack at low speeds and to approximately 40 deg at transonic speeds. Thus, the correlation of control effectiveness is addressed for a large range of conditions. J M S

N80-15153# Royal Aircraft Establishment, Farnborough (England)
SOME WIND TUNNEL MEASUREMENTS OF THE EFFECTIVENESS AT LOW SPEEDS OF COMBINED LIFT AND ROLL CONTROLS
D. S. Woodward, R. F. A. Keating, and C. S. Barnes. *In* AGARD Aerodyn. Characteristics of Controls, Sep. 1979, 36 p, refs (For primary document see N80-15149 06-08)
Avail: NTIS HC A22/MF A01

Using a half-model technique, measurements were made, at low speeds, of the effectiveness of spoilers for direct lift or roll control, with high lift devices deployed. The wing planform was representative of that of a transport aircraft outboard of the trailing edge crank. Results are presented which show that appropriate venting beneath the leading edge of hinged plate spoilers, together with venting through the flap shroud, achieved acceptably linear spoiler characteristics. Similarly, linear characteristics were obtained for a vented spoiler formed by moving the rear of the flap shroud. No reversal of spoiler effectiveness was found at any test condition within the normal operating range of incidence. In the same way, measurements were made of the maximum lift and roll performance of a typical swing wing fighter aircraft, for which the design of the leading and trailing edge controls was totally determined by the need to maximize the maneuverability at high speed. The maximum lift performance is compared with that obtainable from conventional slate and slotted flaps. Somewhat surprisingly, it is found that adequate rolling moments can be obtained by using full-span plain flaps differentially about a basic drooped position of 30 deg. J M S

N80-15154# Boeing Military Airplane Development, Seattle, Wash. Flight Control Technology
FLIGHT CONTROL AND CONFIGURATION DESIGN CONSIDERATIONS FOR HIGHLY MANEUVERABLE AIRCRAFT
William T. Kehret. *In* AGARD Aerodyn. Characteristics of Controls, Sep. 1979, 11 p (For primary document see N80-15149 06-08)
Avail: NTIS HC A22/MF A01

Working within wing geometry and other design constraints, the controllable limits of instability and the maneuver capabilities of various design approaches were investigated. Preliminary studies conducted to evaluate competitive configuration arrangements indicate that an aft tail controller concept will be superior to canard and tailless delta configurations. The latter configurations suffer controllability limitations that compromise the ability to achieve design goals for maneuverability and efficient supersonic cruise. Thrust vectoring was explored as a means of improving maneuver load factor capability. R E S

N80-15155# Dornier Werke G.m.b.H., Friedrichshafen (West Germany)
WIND TUNNEL MEASUREMENTS AND ANALYSIS OF SOME UNUSUAL CONTROL SURFACES ON TWO SWEPT WING FIGHTER CONFIGURATIONS
D. Welte and S. Ehekircher. *In* AGARD Aerodyn. Characteristics of Controls, Sep. 1979, 10 p (For primary document see N80-15149 06-08)
Avail: NTIS HC A22/MF A01

Force measurements were made in a low speed and in a high speed wind tunnel with a 1:20 scale 35 deg swept wing fighter configuration model. Surfaces which are deflected for longitudinal trim are horizontal tail leading- and trailing-edge flaps, a strake and a strake leading-edge flap. For lateral control the following surfaces are deflected: ailerons, tiperons, flaperons and a strake leading-edge flap. The main conclusions are: (1) trailing edge flaps are very useful to trim an unstable configuration and have minimum drag; (2) tiperons are very effective means for roll-yaw control up to very high angles of attack; and (3) differentially deflected leading edge flaps and a vortex fin, positioned on the wing upper surface, decrease the directional instability at high angles of attack. In addition, low speed tests were made with a new wing concept for a future fighter configuration, so called supersonic biplane, to investigate the effectiveness of the upper- and lower-wing trailing edge flaps. As supplement to the wind tunnel measurements some flight mechanical maneuver calculations were made to check the suitability and to compare the effectiveness of the different controls. R E S

N80-15156# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick (West Germany)
ROLL CONTROL BY DIGITALLY CONTROLLED SEGMENT SPOILERS
Klaus Jonas (Dornier-Werke G.m.b.H.), Horst Wuennenberg (Dornier-Werke G.m.b.H.), and Karl-Heinz Horstmann. *In* AGARD Aerodyn. Characteristics of Controls, Sep. 1979, 8 p, refs (For primary document see N80-15149 06-08)
Avail: NTIS HC A22/MF A01

To realize total wing span flaps for improving the maneuvering and landing performances of a combat aircraft the roll control has to be realized by spoilers. To overcome the nonlinearity and control reversal problems at low deflections, the continuously deflected spoiler is replaced by a certain set of digitally controlled single spoilers, which provide only three discrete deflections. It was found by simulator tests that by a proper combination of these segment spoilers it is possible to provide a roll control which is judged as continuous by the pilot, with a relatively low number of single spoilers. Wind tunnel programs were performed to investigate system efficiency and aerodynamic effectiveness. Several roll spoiler configurations were tested in two and three dimensional configurations with and without landing flaps at different spanwise positions, spoiler deflections and -spans. It is shown that the effectiveness related to the deflection is linear for flaps-up and highly nonlinear for flaps-down configurations. The spoiler span is of no more influence at a certain value and the optimum spanwise location is about 0.8 of the semispan. Furthermore the effectiveness and the influence on lift and pitching moment for a possible test aircraft are shown. The practical application within an intended flight test program is discussed. R E S

N80-15157# Boeing Aerospace Co., Seattle, Wash.
THE YC-14 UPPER SURFACE BLOWN FLAP: A UNIQUE CONTROL SURFACE
Alan H. Lee. *In* AGARD Aerodyn. Characteristics of Controls, Sep. 1979, 8 p, refs (For primary document see N80-15149 06-08)
Avail: NTIS HC A22/MF A01

The application of powered-lift technology applied to the Boeing YC-14 is assessed. The YC-14 can be controlled during short takeoff landings using conventional pilot techniques. That capability stems from the use of its upper surface blown (USB) flaps as control surfaces. The USB flaps are used to help control aircraft lift and airspeed. They are positioned automatically by the flight control system to eliminate undesired lift changes caused by thrust changes or external disturbances and to work with the autothrottle to attain and hold a selected airspeed. The aerodynamic and physical characteristics of USB flaps are described. R E S

N80-15158# Northrop Corp., Los Angeles, Calif.
FLAPERON CONTROL: THE VERSATILE SURFACE FOR FIGHTER AIRCRAFT

John F. Moynes and Wallace E. Nelson, Jr. *In* AGARD Aerodyn. Characteristics of Controls Sep. 1979 18 p refs (For primary document see N80-15149 06-08)
Avail: NTIS HC A22/MF A01

The versatility of a flaperon is presented for roll performance and for several longitudinal active control modes. Particular emphasis is given to the advantages of a segmented flaperon over a full span for a YF-17 type aircraft. The areas of ride smoothing, direct lift, pitch pointing, vertical flight path control and flight control system reconfiguration are addressed for the active longitudinal control modes. The effect of flaperon pitching moment on the implementation of these modes is discussed. Author

N80-15159# Air Force Flight Dynamics Lab., Wright-Patterson AFB, Ohio.
AFFDL EXPERIENCE IN ACTIVE CONTROL TECHNOLOGY
Robert P. Johannes and Robert A. Whitmoyer *In* AGARD Aerodyn. Characteristics of Controls Sep. 1979 20 p refs (For primary document see N80-15149 06-08)
Avail: NTIS HC A22/MF A01

The evolution of active control technology (ACT) from the viewpoint of the Air Force Flight Dynamics Laboratory (AFFDL) is presented. Emphasis is placed on the aerodynamic control forces necessary to exploit ACT and in describing AFFDL development programs which merge these two disciplines and transition technology into operational flight equipment. Specific ACT programs described are: (1) the LAMS program; (2) the CCV B-52 program; (3) the SFCS F-4 program, (4) the CCV/PACT F-4 programs; (5) the Variable Stability NT-33 program; (6) the CCV YF-16 program; (7) the A-7D Digital Multimode program; (8) the IFFC I/FIREFLY III program; and (9) the AFTI-16 program. Experiences indicating areas of need for extension of fluid dynamics technology are also discussed. M.M.M.

N80-15160*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
CONTROL CONSIDERATIONS FOR CCV FIGHTERS AT HIGH ANGLES OF ATTACK
Luat T. Nguyen, William P. Gilbert, and Sue B. Grafton *In* AGARD Aerodyn. Characteristics of Controls Sep. 1979 10 p ref (For primary document see N80-15149 06-08)
Avail: NTIS HC A22/MF A01 CSCL 01C

Wind tunnel and piloted simulation studies were conducted to investigate the potential high angle of attack control problems that are introduced by the use of the CCV concept of relaxed static pitch stability (RSS) on fighter aircraft. A conventional wing/aft tail design incorporating modest levels of static instability and a close-coupled canard/wing design exhibiting very high levels of instability was investigated. Two types of high angle of attack control problems can result from the use of RSS: pitch departures caused by coupling and deep stall trim. Avoidance of these problems requires that the airplane have sufficient nose-down pitch control at high angles of attack. The effectiveness of several pitch control configurations were investigated including conventional aft-mounted stabilators, wing-mounted elevators, canard-mounted flaps, and all-moveable canards. Varying the incidence of the canards was the most effective scheme, however, very large deflections may be required on highly unstable configurations to prevent pitch departure without sacrificing roll performance and to avoid deep stall trim. For situations where the high angle of attack pitch control requirement is not met, control laws were developed to inhibit the departure and to allow deep stall recovery. However, these schemes involve limiting airplane roll capability and therefore can potentially compromise maneuverability. M.M.M.

N80-15161# British Aerospace Aircraft Group, Brough (England).
FIN DESIGN WITH ACT IN THE PRESENCE OF STRAKES
D. J. Walker *In* AGARD Aerodyn. Characteristics of Controls Sep. 1979 6 p (For primary document see N80-15149 06-08)
Avail: NTIS HC A22/MF A01

Wind tunnel tests on a combat aircraft model are reported in which the effect of fin size and various types of fin controls were investigated. It was shown that a rudder (rather than an all moving fin) using active control technology is probably the best solution for incidences of up to about 50 deg. Also the use of such a system would allow a 20% reduction in the size of the basic fin. M.M.M.

N80-15162# McDonnell Aircraft Co., St. Louis, Mo.
CONTROL INTEGRATION TECHNOLOGY IMPACT
Charles A. Scolatti *In* AGARD Aerodyn. Characteristics of Controls Sep. 1979 6 p refs (For primary document see N80-15149 06-08)
Avail: NTIS HC A22/MF A01

Some of the essential elements of an integrated technology development program are presented. The integrated flight and fire control system programs, called IFFC I/FIREFLY III, is used as an example. The operational relevance of the example is discussed. The major problems in air-to-ground attack, and the introduction of maneuvering weapon delivery (with IFFC mechanization required to achieve bombing solutions), are covered. The impact of this IFFC technology, and its extension on other areas of technology, such as aerodynamics, is indicated. M.M.M.

N80-15163# Dornier-Werke G.m.b.H., Friedrichshafen (West Germany).
DIRECT SIDE FORCE AND DRAG CONTROL WITH THE AID OF PYLON SPLIT FLAPS
Peter Esch and Horst Wuennenberg *In* AGARD Aerodyn. Characteristics of Controls Sep. 1979 9 p refs (For primary document see N80-15149 06-08)
Avail: NTIS HC A22/MF A01

Two configurations of split flaps are examined, a long one with small deflections and a short one with large deflections. The short one led to the same effectiveness at reduced values of hinge moments and cross coupling effects. Due to high interference effects it was not possible to get the effects of all flaps by superposition of the single flap results. The angle of attack, the landing flap setting and the lateral projection area of the external stores have a significant influence on the effectiveness whereas the Mach number is less important. The examination of the wind tunnel results led to the necessary control laws for the operation of the flaps and the compensation equipment. The flight test program with an Alpha Jet preproduction aircraft is expected to start in 1980. M.M.M.

N80-15164*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
CONTROL OF FOREBODY THREE-DIMENSIONAL FLOW SEPARATIONS
David J. Peake and F. Kevin Owen (Owen Intern., Inc., Palo Alto, Calif.) *In* AGARD Aerodyn. Characteristics of Controls Sep. 1979 49 p refs (For primary document see N80-15149 06-08)
Avail: NTIS HC A22/MF A01 CSCL 01C

The development of the turbulent symmetric and asymmetric vortex flow about the lee side of a 5 deg semiangle conical forebody at high relative incidence was investigated. The cone was immersed in a Mach 0.6 airstream at a Reynolds number of 13.5 x 10 to the 6th power based on the 1.4 m axial length of the cone. Small amounts of air injected normally or tangentially to the cone surface, but on one side of the leeward meridian and beneath the vortex farthest from the wall, were effective in biasing the asymmetry. With this reorientation of the forebody vortices, the amplitude of the side force could be reduced to the point where its direction was reversed. This phenomenon was obtained either by changing the blowing rate at constant incidence or by changing incidence at constant blowing rate. Normal injection appeared more effective than tangential injection. The contrarotating vortices in the penetrating jet flow were of opposite hand to the rotational directions of the forebody vortices. A distinctively organized and stable flow structure emerged with the jet vortices positioned above the forebody vortices. K.L.

N80-15165# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick (West Germany).
IN-FLIGHT MEASURED CHARACTERISTICS OF COMBINED FLAP-SPOILER DIRECT LIFT CONTROLS
O. Rix and D. Hanke *In* AGARD Aerodyn. characteristics of Controls Sep. 1979 22 p refs (For primary document see N80-15149 06-08)
Avail: NTIS HC A22/MF A01

The influence of direct lift control on longitudinal aircraft dynamics and the requirements for the characteristics of direct lift controls for large transport aircraft in the landing approach phase are discussed. The characteristics of flaps, spoilers, and the influence of surface rate on aircraft behavior are also described. Flight tests were carried out with the DFVLR HFB 320 In-Flight Simulator to determine in-flight flap and spoiler characteristics and the characteristics of simultaneously deflected flaps and spoilers as a DLC device. The results show that flap and spoiler characteristics can be described by linear models for flap and spoiler inputs up to + or - 10 deg and + or - 30 deg, respectively, and relatively high surface rates of 10 deg/sec and

62 deg/sec. In addition, combined flap-spoiler deflections show no nonlinear or unsteady effects and the aircraft response is described by simple linear modelling. The spoiler derivatives valid for combined flap-spoiler deflections are identified. K.L.

N80-15166# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (West Germany)

WIND TUNNEL INVESTIGATION OF CONTROLS FOR DF ON A FIGHTER-TYPE CONFIGURATION OF HIGHER ANGLES OF ATTACK

Wolfgang Sonnleitner *In* AGARD Aerodyn. Characteristics of Controls Sep. 1979 11 p refs (For primary document see N80-15149 06-08)

Avail: NTIS HC A22/MF A01

Stability and control characteristics of a fighter-type model were investigated at incidences up to 40 deg. Isolated and combined effects of different control shapes and control in different positions were demonstrated. K.L.

N80-15167# Office National d'Etudes et de Recherches Aerospatiales, Paris (France)

PROBLEMS OF UNSTEADY AERODYNAMICS RAISED BY THE USE OF CONTROL SURFACES AS ACTIVE CONTROLS [PROBLEMES D'AERODYNAMIQUE INSTATIONNAIRE POSES PAR L'UTILISATION DES GOUVERNES DANS LE CONTROLE ACTIF]

Roger Destuynder *In* AGARD Aerodyn. Characteristics of Controls Sep. 1979 17 p refs In FRENCH; ENGLISH summary (For primary document see N80-15149 06-08)

Avail: NTIS HC A22/MF A01

The unsteady aerodynamic forces created by spoilers or auxiliary surfaces are investigated. Control problems concerning turbulence, gust control, and flutter phenomena are studied considering both subcritical and supercritical flows. Theoretical and mixed methods based on corrections defined after wind tunnel tests are applied. K.L.

N80-15168# Office National d'Etudes et de Recherches Aerospatiales, Paris (France)

UNSTEADY EFFECTS OF A CONTROL SURFACE IN TWO DIMENSIONAL, SUBSONIC AND TRANSONIC FLOW [EFFETS INSTATIONNAIRES D'UNE GOUVERNE EN ECOULEMENT BIDIMENSIONNEL SUBSONIQUE ET TRANSSONIQUE]

Richard Grenon, Andre Desopper, and Jacques Sides *In* AGARD Aerodyn. Characteristics of Controls Sep. 1979 14 p refs In FRENCH; ENGLISH summary (For primary document see N80-15149 06-08)

Avail: NTIS HC A22/MF A01

The unsteady effects of an oscillating surface are studied. The experimental results of steady and unsteady pressure measurements carried out in subsonic and transonic flow on a 16% relative thickness supercritical airfoil, equipped with a trailing edge flap, are compared with those obtained by various methods of steady and unsteady inviscid flow calculations. Calculation results are presented in which viscous effects have been taken into account, for both steady and unsteady flows. K.L.

N80-15169# Royal Aircraft Establishment, Bedford (England) Structures Dept.

AERODYNAMIC CHARACTERISTICS OF MOVING TRAILING-EDGE CONTROLS AT SUBSONIC AND TRANSONIC SPEEDS

D. G. Mabey, D. M. McOwat, and B. L. Welsh *In* AGARD Aerodyn. Characteristics of Controls Sep. 1979 26 p refs (For primary document see N80-15149 06-08)

Avail: NTIS HC A22/MF A01

Oscillatory pressures calculated and measured at high subsonic speeds for a swept back wing of aspect ratio 6 with a part span trailing edge flap were compared. The flap was driven at frequencies of 1 Hz (quasi-steady) and 90 Hz at Mach numbers from 0.40 to 0.95 with both fixed and free transition over a range of Reynolds numbers from 1 million to 4 million. The measured oscillatory pressures depended strongly on the boundary layer displacement thickness at the hinge line. Extrapolation from model to full scale required great care. In subsonic flow, tests with free transition gave the thinnest turbulent boundary layer at the hinge line and come nearest to full scale. At transonic speeds, transition was fixed at a safe distance upstream of the most forward excursion of the shock wave to obtain results appropriate to higher Reynolds number. Tests with flap driven simultaneously at two frequencies (90 Hz and 131 Hz) at subsonic and transonic speeds produced the same oscillatory pressures at 131 Hz as when driven independently. The principle of superposition applies, at least for small amplitude motions with attached flows. R.C.T.

N80-15170# Queen Mary Coll., London (England) Dept. of Aeronautical Engineering

UNSTEADY AERODYNAMICS OF TWO-DIMENSIONAL SPOILERS AT LOW SPEEDS

S. R. Siddalingappa and G. J. Hancock *In* AGARD Aerodynam. Characteristics of Controls Sep. 1979 13 p refs (For primary document see N80-15149 06-08)

Avail: NTIS HC A22/MF A01

Complementary aspects of spoiler behavior are reviewed. The emphasis is on the understanding of the local flow about a spoiler. A two dimensional spoiler on the floor of a small blower tunnel (solid floor, and side walls but open at the top) was investigated. Steady pressures were measured along the tunnel floor for various steady spoiler angles and gap sizes between the bottom of the spoiler and the tunnel floor. Transient pressures were recorded following sudden changes in spoiler angle and for oscillating spoilers. A two dimensional spoiler attached to a two dimensional airfoil was investigated. The manner in which the spoiler affects the overall pressure distribution on the airfoil plus spoiler combination was emphasized. Both the airfoil and the spoiler were pressure plotted. The results of steady pressures, transient pressures following rapid and slower ramp changes in spoiler angle, and transient pressures when the spoiler is moving in simple harmonic motion are included. R.C.T.

N80-15171# Rome Univ. (Italy) School of Aerospace Engineering

TRAJECTORY BEHAVIOUR OF A CONTROL CONFIGURATED AIRCRAFT SUBJECTED TO RANDOM DISTURBANCES

Achille Danesi, Scott Smolka (Boston Univ.), and Francesco Borrini *In* AGARD Aerodyn. Characteristics of Controls Sep. 1979 17 p refs (For primary document see N80-15149 06-08)

Avail: NTIS HC A22/MF A01

The longitudinal behavior of a Boeing V-747 aircraft with some of its original aerodynamic effectors operating as active controllers in addition to the conventional elevators were studied. The ailerons were collectively used as outboard active flaps and the inboard section of the high lift triple slotted flaps was employed as inboard active flaps. The flight control system structure was implemented as an optimal model following system in which the optimal feedback gains were computed to minimize the integral performance index. Errors in dynamical response in wing root bending moment, and in aerodynamic drag computed as deviations from the same quantities related to a specified model responding satisfactorily to disturbances with zero increments in wing root bending moment and aerodynamic drag in flight maneuver at given load factor, were considered. At the same time the minimum effectors activity was included as a design objective. A lighter wing structure was realized as the result of wing loads reduction and further weight saving (reduced tail size) was obtained by taking advantage of the beneficial effect of the active controller activity in reducing the elevator deflections required in the pull up maneuver. R.C.T.

N80-15172# Northrop Corp., Hawthorne, Calif. Aircraft Group

FOREBODY VORTEX BLOWING: A NOVEL CONTROL CONCEPT TO ENHANCE DEPARTURE/SPIN RECOVERY CHARACTERISTICS OF FIGHTER AND TRAINER AIRCRAFT

Andrew M. Skow, William A. Moore, and Dale J. Lorincz *In* AGARD Aerodyn. Characteristics of Controls Sep. 1979 17 p refs (For primary document see N80-15149 06-08)

Avail: NTIS HC A22/MF A01

Active blowing concepts which control the asymmetric orientation of the vortex system emanating from an aircraft forebody at high angles of attack are described. The side force generated by the asymmetric nature of the vortices was utilized. The choice between these two preferred positions was influenced strongly by very small geometric imperfections in an otherwise symmetric model and by small asymmetries in the upstream flow such as are caused by flow angularity or turbulent eddies in the free stream. The magnitude of the side force was very large due to the fluid amplification afforded by the vortex growth. The results of water tunnel flow visualization studies and a wind tunnel test program are presented which bear out this assumption and show that tangential blowing can effectively alter the forebody vortex system at angles of attack between 25 and 55 deg and can generate yawing moments comparable to those produced by a conventional rudder at low angles of

attack. The results of a six deg of freedom digital simulation are presented which show that this concept can substantially enhance departure recovery characteristics and could have potential as a departure inhibitor for some aircraft. The results of a preliminary system design indicate that such a system could be applied to aircraft R.C.T.

N80-15173# Neilsen Engineering and Research, Inc., Mountain View, Calif.
NONLINEAR AERODYNAMICS OF ALL-MOVABLE CONTROLS
Charles A. Smith and Jack N. Nielsen *In* AGARD Aerodyn. Characteristics of Controls Sep. 1979 20 p refs (For primary document see N80-15149 06-08)
(Contract N00014-74-C-0050)
Avail: NTIS HC A22/MF A01

The nonlinear effects and their consequences on control effectiveness are described. Both independent control effectiveness (e.g., pitch control) as well as control cross coupling (e.g., pitch control in the presence of yaw control) are discussed. It is shown that, at sufficiently high angles of attack, the presence of these nonlinearities can completely dominate control effectiveness. The current status of techniques to predict control effects using both analytical and data correlation techniques are reviewed. R.C.T.

N80-15174# Ruhr Univ., Bochum (West Germany).
ON THE EFFECT OF WING WAKE ON TAIL CHARACTERISTICS
K. Gersten and D. Glueck *In* AGARD Aerodyn. Characteristics of Controls Sep. 1979 8 p refs (For primary document see N80-15149 06-08)
Avail: NTIS HC A22/MF A01

A nonlinear theory was developed to calculate lift and moment forces for airfoils in a two dimensional flow field. The oncoming velocity distribution is approximated by a series of step functions which results in a flow field composed of a number of potential flow fields. The potential flow fields are matched properly at several dividing streamlines where the total pressure changes discontinuously. The solution of the problem is determined by using vortex distributions on both the contour of the airfoil and the dividing streamlines. A special approach makes it possible to calculate the flow field when one of the dividing streamlines merges with the profile. A comparison between theoretical and experimental results for the aerodynamic characteristics of a tail unit placed in the wake of a wing is presented. A prediction method for the tail characteristics at high angles of attack (super stall) is discussed. A.W.H.

N80-15175# Office National d'Etudes et de Recherches Aerospatiales, Paris (France).
AERODYNAMIC INTERACTION ON A CLOSE-COUPLED CANARD WING CONFIGURATION [INTERACTION AERODYNAMIQUE ENTRE UN CANARD PROCHE ET UNE VOILURE]
Yves Brocard and Volker Schmitt *In* AGARD Aerodyn. Characteristics of Controls Sep. 1979 11 p refs In FRENCH; ENGLISH summary (For primary document see N80-15149 06-08)
Avail: NTIS HC A22/MF A01

Half model tests performed on a close coupled canard wing configuration in a low speed, pressurized wind tunnel are discussed. Results are presented in terms of longitudinal aerodynamic characteristics and pressure distribution on the main wing. The effects of canard deflection and of Reynolds number variation are investigated. Surface oil flow pattern on the wind tunnel model and water tunnel visualization on a smaller model are examined. Comparisons between the experimental results and theoretical predictions are presented. A.W.H.

N80-15176# Queen Mary Coll., London (England). Dept. of Aeronautical Engineering
ON THE EFFECTS OF GAPS ON CONTROL SURFACE CHARACTERISTICS
C. Michael and G. J. Hancock *In* AGARD Aerodyn. Characteristics of Controls Sep. 1979 13 p ref (For primary document see N80-15149 06-08)
Avail: NTIS HC A22/MF A01

A two dimensional airfoil comprising an elliptic nose, parallel section of 5% t/c ratio, and a 20% trailing edge control surface was investigated at low speeds. Three different geometries of the rear of the main airfoil were investigated. Gaps were created by moving the control surface aft of the main airfoil. Extensive pressure plotting is presented for the above range of gaps and control surface angular deflections up to 8 degrees and a range of measurements of mean boundary layer profiles in the neighborhood of the gap are discussed. The variations of the overall lift coefficient with control angle and gap size for the three geometries are reported. A.W.H.

N80-15177# MATRA Service Aerodynamique, Velizy-Villacoublay (France)
AERODYNAMIC STUDY OF MISSILE CONTROL SURFACES [ETUDE AERODYNAMIQUE DES GOUVERNES DE MISSILE]
J. Perinelle and L. Mifsud *In* AGARD Aerodyn. Characteristics of Controls Sep. 1979 19 p In FRENCH; ENGLISH summary (For primary document see N80-15149 06-08)
Avail: NTIS HC A22/MF A01

The basic characteristics of low aspect ratio surfaces for missile control surfaces are reviewed. After a review of the different aerodynamic configurations and their implications on performances, the aerodynamic of canard missiles control surfaces are discussed in relation to the maximum lift at high angles of attack and the hinge moment. A.W.H.

N80-15178# Messerschmitt-Boelkow-Blohm G.m.b.H., Hamburg (West Germany). Commercial Aircraft Div.
SOME INVESTIGATIONS CONCERNING THE EFFECTS OF GAPS AND VORTEX GENERATORS ON ELEVATOR EFFICIENCY AND OF LANDING FLAP SWEEP ON AERODYNAMIC CHARACTERISTICS
Herbert Neppert and Richard Sanderson *In* AGARD Aerodyn. Characteristics of Controls Sep. 1979 12 p refs (For primary document see N80-15149 06-08)
Avail: NTIS HC A22/MF A01

The effect of gaps and vortex generators on elevator effectiveness and drag is examined. The effect of single rudder deflection on the effectiveness of a split rudder is discussed. Wind tunnel results and proposals for improving the aerodynamic characteristics of a tailplane by means of a reduction in the sweep on the landing flap hinge line are described. A.W.H.

X80-72103# Advisory Group for Aerospace Research and Development, Paris (France).
THE GUIDANCE AND CONTROL OF HELICOPTERS AND V/STOL AIRCRAFT AT NIGHT AND IN POOR VISIBILITY (U)
May 1979 56 p Presented at the Guidance and Control Panel Symp., The Hague, 9-12 Oct. 1978
This document is not available from the NASA STI Facility. All requests must be directed to AGARD Hq.
(AGARD-CP-258-Suppl) NATO Confidential report

Nineteen papers covering operational requirements, controls and displays, forward looking sensors, man/machine aspects, landing operations and systems, and system implementation are presented. Author

X80-72104# Advisory Group for Aerospace Research and Development, Paris (France).
ADVANCES IN GUIDANCE AND CONTROL SYSTEMS USING DIGITAL TECHNIQUES (U)
Oct. 1979 42 p This document is not available from the NASA STI Facility. All requests must be directed to AGARD Hq.
(AGARD-CP-272-Suppl) NATO Confidential report

Guidance and control systems are discussed. The topics covered were: functional design concepts, trends, and requirements; advances in analytical and design techniques, advances in digital system design and architecture to assure high integrity; data processing and computation techniques, software design validation techniques including simulation; and operational and system development experience. R.C.T.

09 RESEARCH AND SUPPORT FACILITIES (AIR)

Includes airports, hangars and runways; aircraft repair and overhaul facilities; wind tunnels; shock tube facilities and engine test blocks.

For related information see also *14 Ground Support Systems and Facilities (Space)*.

N77-32177# Advisory Group for Aerospace Research and Development, Paris (France)

A FURTHER REVIEW OF CURRENT RESEARCH RELATED TO THE DESIGN AND OPERATION OF LARGE WIND TUNNELS

Aug. 1977 130 p refs

(AGARD-AR-105) Avail: NTIS HC A07/MF A01

Research related to windtunnel design and operation is presented. Current results and planned effort for 346 studies and research investigations underway in nine countries are reviewed and commented upon. The work of the Wind Tunnel Test Techniques (TES) Subcommittee is described and the rationale for the effort is given. Main conclusions and recommendations are summarized, and lists of titles, investigators' names and locations for the research and studies reviewed are included.

Author

N77-33220# Advisory Group for Aerospace Research and Development, Paris (France).

A CRITICAL COMPILATION OF COMPRESSIBLE TURBULENT BOUNDARY LAYER DATA

H. H. Fernholz (Tech. Univ., Berlin) and P. J. Finley (Imp. Coll. of Sci. and Technol., London) Jun. 1977 455 p refs Document includes a non-standard size microfiche supplement of profile data. This supplement is available in microfiche on request from Computer Software Management and Information Center, Barrow Hall, Univ. of Georgia, Athens, Ga. 30601

(AGARD-AG-223; AGARDOGRAPH-223;

ISBN-92-835-1245-6) Avail: NTIS HC A20/MF A01

Data obtained in 59 experimental studies of compressible, two dimensional, turbulent boundardy layers are provided. The data are presented in standardized form as tables and microfiche, and are available on magnetic tape. The entries which describe the experiments are preceded by a general introduction describing the principles and methods applied in the compilation of the data catalogue. An initial discussion of some of the problems of interpretation encountered in this field is also provided.

Author

N79-15973# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).

PILOTED AIRCRAFT ENVIRONMENT SIMULATION TECHNIQUES

Oct. 1978 306 p refs In ENGLISH and FRENCH Presented at the Flight Mech. Specialists' Meeting, Brussels, 24-27 Apr. 1978

(AGARD-CP-249; ISBN-92-835-0222-1) Avail: NTIS HC A14/MF A01

Papers presented at the Flight Mechanics Panel Specialists' Meeting on Piloted Aircraft Environment Simulation Techniques held in Brussels, Belgium, 24-27 April 1978 are reported. The conference was divided into the following sessions: (1) requirements on simulation of the environment; (2) simulation of the atmospheric environment; (3) atmospheric models for simulation; (4) out of the cockpit visual scenes; (5) visual versus nonvisual motion cues; (6) motion simulation; and (7) up and away mission phases. For individual titles, see N79-15974 through N79-15999.

N79-15974# Tactical Air Warfare Center, Eglin AFB, Fla.

CURRENT DEFICIENCIES IN SIMULATION FOR TRAINING

Charles D. Brown *In* AGARD Piloted Aircraft Environ. Simulation Tech. Oct. 1978 7 p (For primary document see N79-15973 07-09)

Avail: NTIS HC A14/MF A01

A representative of the Tactical Air Warfare Center (USAF TAWC) is given the opportunity to air some of his views on the subject of aircrew training devices and their utilization. Some of the major simulator modifications of some combat aircraft are discussed.

G.Y.

N79-15975# British Aerospace Aircraft Group, Warton (England).

SIMULATING THE VISUAL APPROACH AND LANDING

A. G. Barnes *In* AGARD Piloted Aircraft Environ. Simulation Tech. Oct. 1978 13 p refs (For primary document see N79-15973 07-09)

Avail: NTIS HC A14/MF A01

A general view is taken of the standards of simulation which are currently achieved in training and research simulators. The approach and landing is subdivided into separate phases, straight-in approach, curved approach, flare and ground roll. The piloting task is critically examined in each case with particular reference to the use of outside world visual cues. The merits and deficiences of existing simulators, as a means of providing the equivalent information, are then discussed. Improvements to the overall simulation of the landing approach are more likely to emerge if a better understanding of the information which the pilot uses in each phase is available. This paper is an attempt to assemble some of the information pieces, and to relate them to the technology of simulation.

G.Y.

N79-15976# Boeing Aerospace Co., Seattle, Wash. Crew Systems

VISUAL CRITERIA FOR OUT OF THE COCKPIT VISUAL SCENES

Conrad L. Kraft and Larry W. Shaffer *In* AGARD Piloted Aircraft Environ. Simulation Tech. Oct. 1978 18 p refs Prepared in cooperation with Gen. Elec. Co., Daytona Beach, Fla. (For primary document see N79-15973 07-09)

Avail: NTIS HC A14/MF A01

In 1973 a small committee of four men, representative of the disciplines of electronics, flight and vision, were asked to develop the criteria for a visual system for flight crew training in air transportation. This is a review of the visual system criteria developed for this out of the cockpit visual scene generation. The available classes of visual systems in 1973 were three: film and anamorphic projection, closed circuit television and fixed terrain model, and computer generated image system. The last had the highest risk, but promised much greater flexibility, higher quality images and a day/night scene.

G.Y.

N79-15977*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

MISSION ENVIRONMENT SIMULATION FOR ARMY ROTORCRAFT DEVELOPMENT: REQUIREMENTS AND CAPABILITIES

David L. Key, Billy L. Odneal, and John B. Sinacori *In* AGARD Piloted Aircraft Environ. Simulation Tech. Oct. 1978 17 p refs Prepared in cooperation with Army Aviation Res. and Develop. Command, Moffett Field, Calif. (For primary document see N79-15973 07-09)

Avail: NTIS HC A14/MF A01 CSCL 01E

The rich and varied detail visible in terrain flight must be presented by a wide field-of-view system with much detail and high resolution. The rotary-wing R&D simulator must have great versatility for easy change of cab configurations and the capability to accommodate a two or three man crew. Basic specifications for an adequate visual display were developed and are compared with current and forecasted techniques for image generation and presentation. Results of a study performed to determine the feasibility of meeting these requirements using the current technology of TV camera-model image generation and projected display are discussed and an assessment of the possibility that computer generated imagery can achieve the desired level of detail is presented.

G.Y.

N79-15978# Naval Air Test Center, Patuxent River, Md. Rotary Wing Aircraft Test Directorate.

ENVIRONMENTAL REQUIREMENTS FOR SIMULATED HELICOPTER/VTOL OPERATIONS FROM SMALL SHIPS AND CARRIERS

C. W. Woomer and R. L. Williams *In* AGARD Piloted Aircraft Environ. Simulation Tech. Oct. 1978 13 p refs Prepared in cooperation with McDonnell-Douglas Electron. Co., St. Charles, Mo. (For primary document see N79-15973 07-09)

Avail: NTIS HC A14/MF A01

The specific requirements for the simulated environment to satisfactorily provide training for shipboard takeoff and landing are discussed. Test techniques to validate trainer fidelity in flying qualities, performance, and environmental simulation are discussed. The specific subject of calligraphic visual systems is extensively covered, including a report on the current state-of-the-art as related to the at-sea environment. The utilization of a high-fidelity trainer is explored for research as well as for expanded fleet training.

G.Y.

N79-15979# Boeing Co., Seattle, Wash
PROPOSED ADVANCEMENTS IN SIMULATION OF ATMOSPHERIC PHENOMENA FOR IMPROVED TRAINING
William J. Allsopp *In* AGARD Piloted Aircraft Environ. Simulation Tech. Oct. 1978 11 p refs (For primary document see N79-15973 07-09)
Avail: NTIS HC A14/MF A01

Obviously, flight simulators are a major training vehicle and the desire to reduce in-airplane training is the driving force to obtain better flight simulator visual systems. As the result of both commercial and military applications, major advancements were made in simulator visual systems, resulting in commercial use of the various electronically generated visual systems. Improvements appear to be required in many areas, such as field of view, resolution, brightness, scene content, lights, visual/motion integration, simulated airplane short-period response, and atmospheric environment. The latter is the subject of this paper G.Y.

N79-15980# Technische Hogeschool, Delft (Netherlands). Dept. of Aerospace Engineering.
NON-GAUSSIAN STRUCTURE OF THE SIMULATED TURBULENT ENVIRONMENT IN PILOTED FLIGHT SIMULATION
G. A. J. vandeMoesdijk *In* AGARD Piloted Aircraft Environ. Simulation Tech. Oct. 1978 27 p refs (For primary document see N79-15973 07-09)
Avail: NTIS HC A14/MF A01

A description of the general nongaussian characteristics of actual atmospheric turbulence as observed in the atmosphere is presented. A nongaussian turbulence simulation model is described. The nongaussian characteristics are classified as patchiness and intermittency, both dependent on higher order statistics. These nongaussian characteristics are mathematically elaborated and described. The effects of patchiness on pilot's behavior, using physiological parameters are evaluated in a small simulator experiment. G.Y.

N79-15981# Federal Aviation Administration, Washington, D. C. Systems Research and Development Service.
HANDLING QUALITIES OF A SIMULATED STOL AIRCRAFT IN NATURAL AND COMPUTER-GENERATED TURBULENCE AND SHEAR
S. R. M. Sinclair and T. C. West *In* AGARD Piloted Aircraft Environ. Simulation Tech. Oct. 1978 16 p refs Prepared in cooperation with Natl. Aeron. Estab., Ottawa (For primary document see N79-15973 07-09)
Avail: NTIS HC A14/MF A01

A program was undertaken to measure naturally-occurring wind shear and turbulence along the approach to an urban STOL-port and to investigate the effects of these atmospheric disturbances on the flying qualities of a powered-lift STOL aircraft. The experiment entailed both an in-flight phase using the NAE (National Aeronautical Establishment of Canada) Airborne V/STOL Simulator and a ground-based simulation phase G.Y.

N79-15982# Royal Aircraft Establishment, Farnborough (England).
VISIBILITY MODELLING FOR A LANDING SIMULATOR WITH SPECIAL REFERENCE TO LOW VISIBILITY
D. Johnson *In* AGARD Piloted Aircraft Environ. Simulation Tech. Oct. 1978 10 p refs (For primary document see N79-15973 07-09)
Avail: NTIS HC A14/MF A01

When a simulator is used to demonstrate or investigate the effects of restricted visibility on a pilot's ability to land an aircraft it is important that the visual sequence displayed is as realistic as possible. The characteristics of the visual world by day and by night are described. In particular the topics of contrast, the apparent horizon and the perception of the lights are considered. A brief account is also given of the characteristics of some of the more commonly encountered fogs whose effects could usefully be represented in simulating low visibility conditions. These include shallow fogs and those with marked vertical density gradients. Various ways of simulating the outside world in general are briefly described and discussed in relation to fog and vision. G.Y.

N79-15983*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
VISUAL SIMULATION REQUIREMENTS AND HARDWARE
John C. Dusterberry *In* AGARD Piloted Aircraft Environ. Simulation Tech. Oct. 1978 7 p refs (For primary document see N79-15973 07-09)
Avail: NTIS HC A14/MF A01 CSCL 01E

Requirements for any out-of-the-cockpit visual simulation system can easily lead to a set of system specifications which are clearly beyond the visual scene that can be produced by current technology. Therefore, the requirements of any proposed system must be assessed in light of the expected simulated aircraft and missions, experiments on pilot response, and available image generation and display hardware. A review is made of some of the recent experiments, and the results are related to aircraft and missions with particular emphasis on research and development simulators. Recent visual simulation hardware is considered in light of extending the range of applications of piloted aircraft simulators, and a method of design approach is proposed. G.Y.

N79-15984# Royal Aircraft Establishment, Farnborough (England)
LOW BUDGET SIMULATION IN WEAPON AIMING
P. Manville and E. D. Whybray *In* AGARD Piloted Aircraft Environ. Simulation Tech. Oct. 1978 8 p (For primary document see N79-15973 07-09)
Avail: NTIS HC A14/MF A01

The Flight Systems Department at RAE (Royal Aircraft Establishment) has developed and operated a low budget research simulator, designed to explore aiming sequences, accuracies and real time usage in air-to-ground weapon delivery from low altitude. The simulator was expanded to permit the aiming sequences of air-to-air combat and air-to-ground designators to be evaluated. This paper describes a special purpose research simulator that was developed to study the close interaction of the crew and system during the vital moments prior to weapon delivery. The description of the techniques and equipment employed illustrates how accuracy and fidelity can be achieved within modest resources. G.Y.

N79-15985# Deutsche Lufthansa Aktiengesellschaft, Frankfurt am Main (West Germany)
THE LUFTHANSA DAY/NIGHT COMPUTER GENERATED VISUAL SYSTEM
M. Wekwerth *In* AGARD Piloted Aircraft Environ. Simulation Tech. Oct. 1978 6 p (For primary document see N79-15973 07-09)
Avail: NTIS HC A14/MF A01

After defining some Computer Generated Image Visual System (CGI) terminology, the paper outlines the functioning of the system in a block diagram manner. The capabilities of the system with respect to display and computational capacity are discussed. The layout of the computer landscape model, the training aspects that influence the positioning of objects, the coloring and the color saturation are covered. A comparison between a conventional rigid model closed circuit television system and the CGI reveals the high flexibility of the CGI and its adaptability to varying training concepts. The shortcomings of CGI with respect to realism and picture detail are also shown. Remarks on future system requirements and improvements with respect to higher content (texture) and larger fields of view are presented. G.Y.

N79-15986# CAE Electronics Ltd., Montreal (Quebec)
RECENT ADVANCES IN TELEVISION VISUAL SYSTEMS
Brian L. Welch *In* AGARD Piloted Aircraft Environ. Simulation Tech. Oct. 1978 12 p refs (For primary document see N79-15973 07-09)
Avail: NTIS HC A14/MF A01

A closed circuit television model board visual system, which was designed for a CH-47 helicopter, is described. The attributes and deficiencies of the system are discussed in an attempt to show how a model board based visual system suitable for full mission simulation in Nap of the earth environments could be designed. A new computer generated image visual system which makes extensive use of texture is presented as an alternative to the model board approach. The importance of realism in full mission simulators as distinct from flight and weapons trainers is also discussed. G.Y.

N79-15987# Redifon Simulation Ltd., Crawley (England)
A HIGH RESOLUTION VISUAL SYSTEM FOR THE SIMULATION OF IN-FLIGHT REFUELLING
Martin J. P. Bolton *In* AGARD Piloted Aircraft Environ. Simulation Tech. Oct. 1978 14 p refs (For primary document see N79-15973 07-09)
Avail: NTIS HC A14/MF A01

A unique visual system, developed for the simulation of the in-flight refuelling task is described. It incorporates both wide bandwidth and computer generated image (CGI) techniques. The

in-flight refuelling task and the simulation requirements are reviewed. Redifon's previous experience in this field is outlined and the overall design of the latest visual system is described. The problem of providing the essential visual information within the constraints of cost and available technology is presented. The special effects unit, which provides all video processing and image generation functions under the control of an autonomous computer, is examined. S.E.S.

N79-15988# Naval Training Equipment Center, Orlando, Fla. Army Office of Project Manager for Training Devices.
WIDE ANGLE VISUAL SYSTEM DEVELOPMENTS
Carl R. Driskell. *In* AGARD Piloted Aircraft Environ. Simulation Tech. Oct. 1978 12 p (For primary document see N79-15973 07-09)
Avail: NTIS HC A14/MF A01

Two alternative approaches to a high resolution, wide angle visual system for military flight simulation were described. The basic feasibility of each system was established through studies and subsystem demonstrations but the practical realization of each total system design remains to be proven. Breadboard models of each visual system are developed. S.E.S.

N79-15989*# Massachusetts Inst. of Tech., Cambridge. Dept. of Aeronautics and Astronautics.
VISUALLY INDUCED MOTION IN FLIGHT SIMULATION
Lawrence R. Young. *In* AGARD Piloted Aircraft Environ. Simulation Tech. Oct. 1978 8 p refs (For primary document see N79-15973 07-09)
(Grant NsG-2236; Contract F33615-76-C-0039)
Avail: NTIS HC A14/MF A01 CSCL 01E

Visually induced yaw (circularvection) resulting from a moving wide field presentation, and its interaction with vestibular yaw cues generated by base motion is discussed. A model is presented for the interaction between visual and motion cues in yaw which rationalizes the high frequency utilization of vestibular cues and the low frequency use of visual cues to support sustained angular velocity. The implications for fixed and moving base flight simulator design are discussed. Similar considerations apply to visually induced linear velocity (linearvection) and interesting asymmetries in the fore-aft direction are noted. Visually induced pitch and roll are discussed and modelled in terms of conflict between the visually induced motion and the information regarding attitude based upon graviceptor signals. S.E.S.

N79-15990# Royal Aircraft Establishment, Bedford (England). Flight Systems Dept.
MOTION VERSUS VISUAL CUES IN PILOTED FLIGHT SIMULATION
J. R. Hall. *In* AGARD Piloted Aircraft Environ. Simulation Tech. Oct. 1978 13 p refs (For primary document see N79-15973 07-09)
Avail: NTIS HC A14/MF A01

In the ground based simulation of piloted flight the provision *of adequate cues to the pilot is essential for both training and* the successful evaluation of handling and ride qualities. Two examples are presented to show that motion cues can be vital even when adequate alternative visual cues are available. The first shows that practical, low gain, roll motion cues are better than nominally perfect peripheral vision cues for controlling a vehicle with an unstable dutch roll mode and the second that motion can be vital even for developing items such as head-up displays for which it might not at first sight seem necessary. Results indicate that for the prediction and evaluation of handling qualities using a piloted flight simulator it is not always sufficient for the pilot to achieve a similar performance in the simulator as in flight, it is also necessary that he should adopt the same control strategy. To achieve this it is often essential to provide the pilot with motion cues as no substitute in these circumstances has yet been found. S.E.S.

N79-15991# Air Force Human Resources Lab., Wright-Patterson AFB, Ohio. Advanced Systems Div.
MOTION AND FORCE CUING REQUIREMENTS AND TECHNIQUES FOR ADVANCED TACTICAL AIRCRAFT SIMULATION
William B. Albery, Don R. Gum, and Gerald J. Kron (Singer Co., Binghamton, N.Y.) *In* AGARD Piloted Aircraft Environ. Simulation Tech. Oct. 1978 10 p refs (For primary document see N79-15973 07-09)
Avail: NTIS HC A14/MF A01

Data base development efforts which are in process have provided a better understanding of the type of motion and force cuing required for U.S. Air Force tactical aircraft simulators and the type of devices necessary to effectively and efficiently provide this cuing. An advanced g-cuing system was developed which provides both rapid onset and sustained cuing. It is capable of stimulating the important tactile and pressure, as well as nonvestibular proprioceptive, human sensory modalities throughout the frequency spectrum and for the duration of motion and force cuing presented during most tactical flight maneuvers. High-g augmentation devices are investigated and designed which should efficiently provide some of the additional cuing present during extremely high-g flight environments. S.E.S.

N79-15992# National Aerospace Lab., Amsterdam (Netherlands).
INFLUENCE OF MOTION WASH-OUT FILTERS ON PILOT TRACKING PERFORMANCE
M. F. C. vanGool. *In* AGARD Piloted Aircraft Environ. Simulation Tech. Oct. 1978 5 p refs (For primary document see N79-15973 07-09)
Avail: NTIS HC A14/MF A01

The NLR moving base flight simulator was investigated to establish the influence of the simulator motion wash-out filters in the pitch and roll axis on the performance of four pilots when stabilizing an aircraft disturbed by turbulence in either of these axes. For this compensatory tracking task, pilot describing functions, remnant spectra and other performance measures *were determined. The results lead to the conclusion that,* for the task under consideration, no significant differences can be observed when the break frequency of the (linear second-order) wash-out filter is varied from 0.1 rad/sec to 0.5 rad/sec. Then performance in either condition is considerably better when compared to fixed-base results. This is also reflected in the pilot comments and effort ratings, stating that the task is easier with motion. S.E.S.

N79-15993# Aeronautical Systems Div., Wright-Patterson AFB, Ohio.
DYNAMIC CHARACTERISTICS OF FLIGHT SIMULATOR MOTION SYSTEMS
Paul T. Kemmerling, Jr. *In* AGARD Piloted Aircraft Environ. Simulation Tech. Oct. 1978 20 p refs (For primary document see N79-15973 07-09)
Avail: NTIS HC A14/MF A01

Recognition is made of the complete lack of substantive data on the quality of motion produced by multiple degree of freedom aircraft simulator motion systems, and efforts made to produce this data are discussed. Working Group #07 of the Flight Mechanics Panel of AGARD was given the charter to identify and define the pertinent physical characteristics of flight simulator motion systems, establish procedures for their measurement and prepare a report on their findings. The seven main characteristics identified by the Group are outlined, and efforts by several of the members to apply the characteristic techniques in laboratory measurements are discussed. Acknowledgement is made of the difficulties in establishing universally *workable definitions and techniques for cataloguing* motion characteristics, and alternatives are suggested. The conclusion is reached that a taxonomy of motion characteristics is a valuable asset in determining the optional use of currently available motion systems. Author

N79-15994# Cranfield Inst. of Technology Bedfordshire (England).
THE DEVELOPMENT AND EVALUATION OF A g SEAT FOR A HIGH PERFORMANCE MILITARY AIRCRAFT TRAINING SIMULATOR
N. O. Matthews and C. A. Martin. *In* AGARD Piloted Aircraft Environ. Simulation Tech. Oct. 1978 8 p (For primary document see N79-15973 07-09)
Avail: NTIS HC A14/MF A01

The original type of seat and attempts to improve its performance, leading to the design of a completely new concept in simulator g seats are tested. Philosophy behind the changes in design are considered and the implementation of these in terms of hardware are described. The proto-type model of the new seat were tested in conjunction with a 3 axis motion system of improved performance characteristics at Cranfield Institute of Technology, and the results of evaluations by a number of service test pilots and pilots are described. S.E.S.

N79-15995# Le Materiel Telephonique, Trappes (France). Div. Simulateurs et Systemes Electroniques.
SIX DEGREES OF FREEDOM LARGE MOTION SYSTEM FOR FLIGHT SIMULATORS

Michel Baret *In* AGARD Piloted Aircraft Environ. Simulation Tech. Oct 1978 8 p (For primary document see N79-15973 07-09)
Avail: NTIS HC A14/MF A01

The long-stroke, hollow-rod jack with hydrostatic bearings of the six degrees of freedom, large motion system is described. Techniques are provided that improve and reduce the level of unwanted accelerations normally generated by motion systems, while offering new possibilities in the study of control laws S.E.S

N79-15996# Centre d'Electronique de l'Armement, Bruz (France). Dept. Evaluation de Systeme et Simulation.
SIMULATION OF AERIAL COMBAT AT CELAR [SIMULATION DE COMBAT AERIEN DU CELAR]
Y. Hignard *In* AGARD Piloted Aircraft Environ. Simulation Tech. Oct. 1978 6 p *In* FRENCH (For primary document see N79-15973 07-09)
Avail: NTIS HC A14/MF A01

A simulator developed for the French Air Force in 1971 facilitates technical and tactical research associated with the use of missiles in near aerial combat. The simulator comprises a number of originally designed components and was built at moderate cost. Modifications for improving the pilot environment include conforming the cabin to the Mirage FI, miniaturizing the horizon lantern, and introducing zoom optics in the device for target projection. The new installation is expected to be operational at the end of 1978. Trans. by A.R.H.

N79-15997# Industrieanlagen-Betriebsgesellschaft m.b.H., Ottobrunn (West Germany).
DIFFERENCES BETWEEN SIMULATION AND REAL WORLD AT THE IABG AIR TO AIR COMBAT SIMULATOR WITH A WIDE ANGLE VISUAL SYSTEM
E. Vogl *In* AGARD Piloted Aircraft Environ. Simulation Tech. Oct. 1978 11 p refs (For primary document see N79-15973 07-09)
Avail: NTIS HC A14/MF A01

The experiences of IABG with its Dual Flight Simulator (DFS) for air-to-air combat are presented. First of all IABG has discovered that air-to-air combat simulation without a motion system is no problem to the pilots. During the verification phase it was found that the results of simulations at DFS were very good. All simulator effects in respect to human factors were researched. Results indicated that these effects are unimportant to air-to-air combat simulators. S.E.S.

N79-15998# McDonnell Aircraft Co., St. Louis, Mo. Flight Simulation Dept
MANNED AIR COMBAT SIMULATION: A TOOL FOR DESIGN DEVELOPMENT AND EVALUATION FOR MODERN FIGHTER WEAPON SYSTEMS AND TRAINING OF AIRCREWS
R. H. Mathews *In* AGARD Piloted Aircraft Environ. Simulation Tech. Oct. 1978 6 p (For primary document see N79-15973 07-09)
Avail: NTIS HC A14/MF A01

Manned air combat simulation has matured into a major element in modern fighter aircraft design and development. The simulation fidelity now available allows meaningful training to be accomplished such that the U.S. Government is now procuring an Air Combat Maneuvering Simulator (ACMS) for fighter tactics training. The contributions of manned air combat simulation to the F-15 fighter weapon systems from design concept through successful introduction to squadron service are presented. Specific examples are given of airframe, avionics, and integrated systems simulation support in the design and development process. Flight and simulation results in several test programs including air combat maneuvering are compared. The Air Combat Maneuvering Simulator provided to the U.S. Navy for air combat training is described. S.E.S.

N79-15999*# National Aeronautics and Space Administration, Langley Research Center, Hampton, Va.
USE OF PILOTED SIMULATION FOR STUDIES OF FIGHTER DEPARTURE/SPIN SUSCEPTIBILITY
William P. Gilbert and Luat T. Nguyen *In* AGARD Piloted Aircraft Environ. Simulation Tech. Oct. 1978 13 p refs (For primary document see N79-15973 07-09)
Avail: NTIS HC A14/MF A01 CSCL 01E

The NASA-Langley Research Center has incorporated into its stall/spin research program on military airplanes the use of piloted, fixed-base simulation to complement the existing matrix of unique research testing techniques. The piloted simulations of fighter stall/departure flight dynamics are conducted on the Langley Differential Maneuvering Simulator (DMS). The objectives of the simulation research are reviewed. The rationale underlying the simulation methods and procedures used in the evaluation of airplane characteristics is presented. The evaluation steps used to assess fighter stall/departure characteristics are discussed. Simulation results are presented to illustrate the flight dynamics phenomena dealt with. The considerable experience accumulated in the conduct of piloted stall/departure simulation indicates that simulation provides a realistic evaluation of an airplane's maneuverability at high angles of attack and an assessment of the departure and spin susceptibility of the airplane. This realism is obtained by providing the pilot a complete simulation of the airplane and control system which can be flown using a realistic cockpit and visual display in simulations of demanding air combat maneuvering tasks. The use of the piloted simulation methods and procedures described were found very effective in identifying stability and control problem areas and in developing automatic control concepts to alleviate many of these problems. A good level of correlation between simulated flight dynamics and flight test results were obtained over the many fighter configurations studied in the simulator. S.E.S.

N80-10238# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France)
DYNAMIC CHARACTERISTICS OF FLIGHT SIMULATOR MOTION SYSTEMS
Sep 1979 40 p refs
(AGARD-AR-144; ISBN-92-835-1338-X) Avail: NTIS HC A03/MF A01

A uniform method of measuring and reporting motion performance characteristics is presented. Such a uniform method, in addition to aiding system comparison, can assist in system diagnosis and might be used in writing performance specifications. The definitive characteristics selected for system description are excursion limits, describing function, linearity and acceleration noise, hysteresis, and dynamic threshold; definitions and methods of measurement and display are given, illustrated by measurements on particular motion systems. R.E.S.

N80-12102# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
DETERMINATION IN GROUND FACILITIES OF AERODYNAMIC STABILITY PARAMETERS OF AIRCRAFT
M. Scherer Sep. 1979 69 p refs In FRENCH; ENGLISH summary
(AGARD-AG-242; ISBN-92-835-2106-4) Avail: NTIS HC A04/MF A01

The present state of experimental ground facilities for determining the aerodynamic stability parameters of aircraft was deduced from the proceedings of the AGARD/FDP and FMP meetings of the last four years. A critical study of the experimental methods for analyzing unsteady aerodynamic phenomena brings to light the insufficiencies of present-day methods and means, especially as regards information necessary for the correct implementation of flight simulators in case of non-linear behavior (separation, shock wave). Suggestions are presented on the possible orientations of research for filling these gaps. Author

N80-19137# Advisory Group for Aerospace Research and Development, Paris (France).
TOWARD NEW TRANSONIC WINDTUNNELS
J. P. Hartzuiker, ed. (National Aerospace Lab., Amsterdam) Nov 1979 78 p refs
(AGARD-AG-240; ISBN-92-835-1343-6) Avail: NTIS HC A05/MF A01

Cryogenic concepts for transonic wind tunnels are examined including discussions of tunnel drive and support systems, tunnel performance, and cryogenic aerodynamics. Also presented is an investigation of the flow quality of three transonic tunnels with differing drive mechanisms. Factors effecting a more complete determination of tunnel flow quality are discussed. For individual titles, see N80-19138 through N80-19140

N80-19138# Royal Aircraft Establishment, Bedford (England)
AN INVESTIGATION OF THE QUALITY OF THE FLOW GENERATED BY THREE TYPES OF WIND TUNNEL (LUDWIEG TUBE, EVANS CLEAN TUNNEL AND INJECTOR DRIVEN TUNNEL)

P. G. Pugh, H. Grauer-Carstensen (DFVLR, Goettingen, West Germany), and C. Quemard (CERT, Toulouse) *In* AGARD Towards New Transonic Windtunnels Nov. 1979 23 p refs (For primary document see N80-19137 10-09)
Avail: NTIS HC A05/MF A01

Flow quality in three wind tunnels with differing drive systems is examined. The investigation included measurements of (1) fluctuating static pressure on the sidewall of the test section; (2) turbulence immediately upstream of the contraction and in the test section; (3) fluctuations of flow angle (both pitch and yaw) in the test section; and (4) fluctuations of both pitot and static pressures in the test section flow. Factors important to the description of wind tunnel flow quality are also discussed. It is shown that the use of fluctuating static pressure as in index of flow quality in invalid when comparing wind tunnels having different forms of drive system or, possibly, even widely different types of test section. Fluctuations in flow angle are of much more direct consequence to the gathering of the usual types of data and can be measured using either appropriately designed yawmeters or with hot-film probes. M.H.

N80-19139*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.
DEVELOPMENT OF THE CRYOGENIC TUNNEL CONCEPT AND APPLICATION TO THE US NATIONAL TRANSONIC FACILITY
Robert A. Kilgore *In* AGARD Towards New Transonic Windtunnels Nov. 1979 27 p refs (For primary document see N80-19137 10-09)
Avail: NTIS HC A05/MF A01 CSCL 14B

A fan-driven, high Reynolds number, transonic cryogenic wind tunnel is described. The tunnel has a 2.5- by 2.5 m test section and is capable of operating from ambient to cryogenic temperatures at stagnation pressures up to 8.8 atm. An overview of the cryogenic concept and discussions of drive power requirements, support systems, and operating characteristics and performance of the wind tunnel are included. M.G.

N80-19140# National Aerospace Lab., Amsterdam (Netherlands).
THE CRYOGENIC WIND TUNNEL: ANOTHER OPTION FOR THE EUROPEAN TRANSONIC FACILITY
J. P. Hartzuiker, J. Christophe (ONERA, Paris), W. Lorenz-Meter (DFVLR, Goettingen, West Germany), and P. G. Pugh (RAE, Bedford, England) *In* AGARD Towards New Transonic Wintunnels Nov. 1979 15 p refs (For primary document see N80-19137 10-09)
Avail: NTIS HC A05/MF A01

A cryogenic wind tunnel concept is discussed. The tunnel should have a maximum stagnation pressure of 6 bars, 10 seconds running time, and the Reynolds number (based on mean aerodynamic chord) should be variable between 25 and 40 million, to enable extrapolation of test results to full scale conditions. The advantages and drawbacks of cryogenic testing as well as fundamental aspects of cryogenic aerodynamics are discussed. Comparative estimates for capital and operating costs are finally presented. M.G.

15 LAUNCH VEHICLES AND SPACE VEHICLES

Includes boosters, manned orbital laboratories, reusable vehicles, and space stations

N79-27225# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France)
GUIDANCE AND CONTROL FOR TACTICAL GUIDED WEAPONS WITH EMPHASIS ON SIMULATION AND TESTING
May 1979 144 p refs Lecture series presented at Rome, 4-5 Jun 1979, Ankara, 7-8 Jun 1979, Eglin, Fla 11-12 Jun 1979
(AGARD-LS-101, ISBN-92-835-1324-X) Avail: NTIS HC A07/MF A01

The areas reviewed include (1) weapon delivery including targeting and acquisition, (2) missile control techniques; and (3) current guidance techniques For individual titles, see N79-27226 through N79-27231

N79-27226# Air Force Avionics Lab., Wright-Patterson AFB, Ohio.
TACTICAL MISSILE PERFORMANCE REQUIREMENTS: A METHODOLOGY FOR DEVELOPMENT
C. T. Maney *In* AGARD Guidance and Control for Tactical Weapons with Emphasis on Simulation and Testing May 1979 6 p (For primary document see N79-27225 18-15)
Avail: NTIS HC A07/MF A01

The philosophy by which tactical air launched missile design requirements are developed using the development planning process used by the United States Air Force is addressed The mission to be accomplished including the countering influence of the threat was examined The alternative approaches to the solution are compared A tradeoff design analysis of subsystem and system performance, effectiveness and costs is presented Typical generic factors of speed, maneuverability, range, and payload are discussed S.E.S

N79-27227# Royal Aircraft Establishment, Farnborough (England). Flight Systems Dept.
WEAPON DELIVERY AND ITS EVALUATION
P. Manville *In* AGARD Guidance and Control for Tactical Weapons with Emphasis on Simulation and Testing May 1979 23 p refs (For primary document see N79-27225 18-15)
Avail: NTIS HC A07/MF A01

The influences and constraints that govern the delivery of tactical air to ground guided weapons are reviewed. The need to consider the total weapon system delivery performance in the context of the real scenario is reported. The distinct roles of modelling, main-in-the-loop simulation, and flight demonstration are discussed. A sound technical choice to be made between alternative options is achieved. S.E.S.

N79-27228# Air Force Avionics Lab., Wright-Patterson AFB, Ohio. Systems Analysis and Simulation Branch.
NEW METHODS IN THE TERMINAL GUIDANCE AND CONTROL OF TACTICAL MISSILES
J. Gonzalez *In* AGARD Guidance and Control for Tactical Weapons with Emphasis on Simulation and Testing May 1979 23 p refs (For primary document see N79-27225 18-15)
Avail: NTIS HC A07/MF A01

The functions of major tactical missile subsystems and classical guidance laws are described. Some of the features of modern control and estimation theory are summarized. The major advantages and disadvantages of each technique, both in general and in relationship to short range air-to-air missile applications are presented. S.E.S.

N79-27229# Martin Marietta Corp., Orlando, Fla. Aerospace Div.
GUIDANCE SIMULATION TECHNIQUES
Philip C. Gregory *In* AGARD Guidance and Control for Tactical Weapons with Emphasis on Simulation and Testing May 1979 13 p refs (For primary document see N79-27225 18-15)
Avail: NTIS HC A07/MF A01

The economic and political constraints which allow, justify, and require flight control simulations are examined. Factors such as range time availability and cost increases are shown to drive the designer toward providing 100 percent assurance of each test. A six degree of freedom hybrid simulation is described, and equipment plus operating costs are identified and contrasted with range costs. The simulation described is an accurate aerodynamic simulation model used in a six degree of freedom (6-DOF) simulation program for an air defense missile. The program provides a 6-DOF simulation of the missile system, including detailed nonlinear models of the airframe and associated aerodynamics, the autopilot, inertial reference unit, control actuation system, and gyro and accelerometer sensors. Implemented on both digital and hybrid simulations, the 6-DOF simulation program serves as the primary tool for flight test planning, postflight data analyses, and preflight predictions of missile performance characteristics. M.M.M.

N79-27230# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Wesseling (West Germany). Inst. fuer Dynamik der Flugsysteme.
MISSILE GUIDANCE TECHNIQUES
W. Hofmann and D. Joos *In* AGARD Guidance and Control for Tactical Weapons with Emphasis on Simulation and Testing May 1979 27 p refs (For primary document see N79-27225 18-15)
Avail: NTIS HC A07/MF A01

A unifying approach is proposed for the systematic investigation of missile guidance techniques in guidance law and information processing design. It is based on the consequent distinction between the well modelled kinematic world and the fuzzy real world together with the separation of the overall guidance problem in a steering problem and a feedback problem. The approach provides for insight in guidance law structures and information requirements as well as in the necessity and the potential benefit of applying modern control theory. Modern filtering and controller design techniques are reviewed for this purpose. The exemplified investigation of the two point and three point guidance principles shows the kinematic guidance law character of extended proportional navigation and of line-of-sight guidance and the possible improvement of system behavior by the application of modern control techniques. Author

N79-27231# Martin Marietta Corp., Orlando, Fla. Aerospace Div.
TESTING OF MISSILE GUIDANCE AND CONTROL SYSTEMS
Philip C. Gregory *In* AGARD Guidance and Control for Tactical Weapons with Emphasis on Simulation and Testing May 1979 15 p (For primary document see N79-27225 18-15)
Avail: NTIS HC A07/MF A01

A radar guidance laboratory which allows simultaneous infrared simulations for developing and testing point tracker radar and IR dual mode guidance systems is described. These guidance systems must be tested for target acquisition, discrimination, and tracking capabilities under precisely controlled conditions in a dynamic, real-time, simulated environment. The radar guidance types can be passive at 3 to 5 or 8 to 14 microns. A review of system requirements is furnished, and the major laboratory subsystems are described, with emphasis on the features of the rotational and translational motion systems, anechoic chamber, linear array target antenna system, radar generation system, IR target system, and computation. M.M.M.

X80-72116# Advisory Group for Aerospace Research and Development, Paris (France)
MISSILE SYSTEM FLIGHT MECHANICS (U)
Nov 1979 580 p Presented at the Flight Mech. Panel Symp. on Missile System Flight Mech., London, 21-24 May 1979 This doc. is not avail. from the NASA STI Facility. All requests must be directed to AGARD Hq.
(AGARD-CP-270) NATO Restricted report

The flight mechanics of short range tactical missiles and guidance weapons of the air to surface and air to air types are discussed. Specific emphasis is placed on missile design, development, and testing and assessment, as well as on flight control/maneuverability and simulation. R.C.T.

X80-72117# Advisory Group for Aerospace Research and Development, Paris (France)
MISSILE SYSTEM FLIGHT MECHANICS (U)

Dec. 1979 112 p Presented at the Flight Mech. Panel Symp. on Missile System Flight Mech., London, 21-24 May 1979 This document is not available from the NASA STIF Facility All requests must be directed to AGARD Hq.
(AGARD-CP-270-Suppl) NATO Secret report

The flight mechanics aspects of missiles relying on aerodynamic means of achieving the required control and performance capabilities were discussed. Emphasis was given to short range tactical missiles and guided weapons of the air to air and air to surface types. Missile design, development, testing, and assessment were included. Flight control/maneuverability and simulation were also covered. R.C.T.

20 SPACECRAFT PROPULSION AND POWER

Includes main propulsion systems and components e.g., rocket engines; and spacecraft auxiliary power sources

For related information see also 07 Aircraft Propulsion, 28 Propellants and Fuels, and 44 Energy Production and Conversion.

N80-10280# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France)

TECHNICAL EVALUATION REPORT ON THE PROPULSION AND ENERGETICS PANEL 53RD SYMPOSIUM ON SOLID ROCKET MOTOR TECHNOLOGY

M. Barrere (ONERA, Chatillon sous Bagneux, France), W. H. Desinger (Dynamit Nobel AG, Cologne), and A. Homburg (Dynamit Nobel AG, Cologne) Sep. 1979 14 p *refs*

(AGARD-AR-151) Avail: NTIS HC A02/MF A01

The present situation in the field of solid propellant rocketry is discussed with focus on propellant steady state burning, propellant unsteady burning, and rocket motor technology; topics covered include (1) ignition, extinction and internal ballistics; (2) burn rate modelling and combustion of metal; (3) New Propellants; (4) combustion instability; (5) heat transfer and materials; and (6)testing and instrumentation. A.R.H.

N80-10281# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France)

SOLID ROCKET MOTOR TECHNOLOGY

Jul. 1979 523 p refs In ENGLISH; partly in FRENCH Presented at the 53d Meeting of the AGARD Propulsion and Energetics Panel, Oslo, 2-5 Apr. 1979

(AGARD-CP-259; ISBN-92-835-0243-4) Avail: NTIS HC A22/MF A01

The reports presented at the conference are presented. Topics discussed include (1) ignition, extinction and internal ballistics; (2) burn rate modeling; (3) combustion instability; (4) heat transfer and materials; and (5) testing and instrumentation. For individual titles, see N80-10282 through N80-10316.

N80-10282# Office National d'Etudes et de Recherches Aerospatiales, Paris (France)

RESEARCH IN THE FIELD OF SOLID PROPELLANT ROCKETS: A SURVEY

Marcel Barrere *In* AGARD Solid Rocket Motor Technol. Jul. 1979 28 p refs In FRENCH; ENGLISH summary (For primary document see N80-10281 01-20)

Avail: NTIS HC A22/MF A01

Current research of interest to solid propellant rocket manufacturers for military applications are reviewed. The analysis deals mainly with the combustion of propellants and the nature of burned products, as well as their impact on performances and the behavior of nozzles and casings. The combustion research is divided into two parts: the steady and the unsteady regime of the combustion chamber. The burning rate is studied of the propellant which plays an important role in the optimization of the propulsion system, in particular its level, its evolution with the pressure and its sensivity to the grain temperature. The influence of the gas velocity along the surface and acceleration effects are also dealt. The flame propagation in cracks and their initiation are analyzed. In the unsteady regime of combustion, the response of the propellant to pressure and velocity fluctuations are studied. Experimental and theoretical works on the determination of the transfer function are dealt with. F.O.S.

N80-10283# Hercules, Inc., McGregor, Tex

SOLID ROCKET MOTOR DESIGN AUTOMATION TECHNOLOGY

W. G. Haymes, J. E. Williamson, S. E. McClendon, and W. T. Brooks *In* AGARD Solid Rocket Motor Technol. Jul. 1979 15 p refs (For primary document see N80-10281 01-20)

Avail: NTIS HC A22/MF A01

The status of Solid Rocket Motor Design Automation Technology is reported. The total scope is reviewed, from initial preliminary design techniques to optimize rocket motor performance, mass, and envelope characteristics to those procedures used in final design activity. The latter include internal ballistics and grain design, combustion stability prediction, structural, thermal, and mass property analyses, and the like. The direction of current work in the United States of America is outlined. F.O.S.

N80-10284# Office National d'Etudes et de Recherches Aerospatiales, Paris (France)

IGNITION AND EXTINCTION OF SOLID PROPELLANTS

Guy Lengelle, Pierre Mentre, Joel Guernigou, Alain Bizot, and Yves Maisonneuve *In* AGARD Solid Rocket Motor Technol. Jul. 1979 16 p refs In FRENCH; ENGLISH summary (For primary document see N80-10281 01-20)

Avail: NTIS HC A22/MF A01

Activities are reported which were carried out at ONERA on ignition and extinction relative both to the propellant per se and to the motor grain with a given type of igniter. The ignition characteristics of composite and double base propellants were investigated by exposing samples to arc generated neutral gas jet as well as to aluminized, propellant motor exhaust. The means used to detect ignition were visualization, I.R. pyrometer and ultrasonic transducers continuously monitoring the thickness of the sample. With the various types of heating (convection - conduction, particles impact) it was found that the ignition laws remain the same, controlled by the degradation characteristics of the propellant components. The various experimental techniques used in scaled motors for the investigation of propellant ignition and of flame spreading are described, particularly fluxmeters. Examples of applications of these techniques to the study of the ignition of motors with composite as well as double based propellant grains, are presented. The extinction characteristics, low pressure deflagration limit and extinction under depressurization, of various composite propellants were studied revealing the influence of the composition parameters: particles size, nature of the binder, presence of additives. F.O.S.

N80-10285# Politecnico di Milano (Italy)

IGNITION AND EXTINCTION OF SOLID ROCKET PROPELLANTS

L. DeLuca, L. Galfetti, and C. Zanotti *In* AGARD Solid Rocket Motor Technol. Jul. 1979 14 p *refs* (For primary document see N80-10281 01-20)

Avail: NTIS HC A22/MF A01

Dynamic burning effects associated with ignition and extinction of solid rocket propellants are examined within the framework of a thermal theory of heterogeneous combustion and for quasi-steady gas phase. A nonlinear burning stability analysis was carried out via an integral method. This predicts that, for a given set of operating conditions, a well defined critical surface temperature exists below which extinction of a burning propellant necessarily follows independently on its past history. These critical surface temperature values define a lower dynamic stability boundary strictly depending on the propellant nature, but affected by the operating conditions. The analysis is based on an asymptotic stability criterion always valid for static (random disturbances) stability problems, but restricted to forcing functions levelling off in time for dynamic (external disturbances) stability. Under these circumstances, the lower dynamic stability boundary is independent on the nature of the transient (pressure or radiation driven), the shape in time of the forcing function (linear, exponential, parabolic, etc.) and the rate of change of the forcing function (even variable). The relevance of the lower dynamic stability boundary to ignition transients is discussed. Computer simulated runs show a very good agreement with the analytical predictions. Author

N80-10286# Aerospace Corp., El Segundo, Calif.

SOLID PROPELLANT SPECIFIC IMPULSE PREDICTION

Ellis M. Landsbaum and Manuel P. Salinas *In* AGARD Solid Rocket Motor Technol. Jul. 1979 11 p refs (For primary document see N80-10281 01-20)

Avail: NTIS HC A22/MF A01

The methods for the theoretical prediction of delivered specific impulse are relatively well-known. They involve computing the losses due to two-phase flow, divergence, boundary layer kinetics, nozzle submergence and combustion efficiency. The largest computed loss in typical aluminized solid propellants is the two-phase flow loss; this computation also has the largest uncertainty because the particle size and distribution are not known precisely. A correlation of mean particle diameter versus throat diameter from experimental data was used with the solid rocket performance prediction program (SPP) to predict the

propellant specific impulse of a number of motors These predictions are compared to the experimental values. The results indicate that the specific impulse efficiency appears to be an inherent property of the propellant In addition, the experimental specific impulse and specific impulse efficiency were statistically correlated against throat diameter and expansion ratio for propellants of similar oxidizer and aluminum content These correlations are as accurate as the longer, more expensive theoretical analysis In addition to specific impulse prediction, the equations are useful in optimization of motor design Author

N80-10287# Technische Hogeschool, Delft (Netherlands) Dept of Aerospace Engineering
A SIMPLE METHOD TO ESTIMATE THE INFLUENCE OF A SMALL VARIATION IN THE THROAT AREA ON THE PERFORMANCE OF SOLID ROCKETS
H F R Schoyer *In* AGARD Solid Rocket Motor Technol Jul 1979 7 p refs (For primary document see N80-10281 01-20)
Avail NTIS HC A22/MF A01

A technique is presented for the rapid estimation of rocket performance for different nozzle throat areas and the mutual dependence of motor parameters The method is based on linearization of the mean ballistic variables with respect to the variation in throat area The variation of the thrust, specific impulse, burning time, mass flow, and total impulse are predicted These predictions are compared with predictions by a computer program for the internal ballistics of solid rocket motors and show good agreement J M S

N80-10288# Dynamit Nobel A.G., Cologne (West Germany)
INTERNAL BALLISTIC PROBLEMS OF HELMUT HIGHLY ACCELERATED SOLID PROPELLANT ROCKETS
Walter Diesinger *In* AGARD Solid Rocket Motor Technol Jul 1979 11 p refs (For primary document see N80-10281 01-20)
Avail NTIS HC A22/MF A01

The state of the art in the field of internal ballistics in an accelerated (1g) environment is given It is shown how problems arising with high acceleration may be solved J M S

N80-10289# Dynamit Nobel A G., Troisdorf (West Germany)
PROPELLANT IGNITER DEVELOPMENT PROBLEMS
Hans Florin *In* AGARD Solid Rocket Motor Technol Jul 1979 24 p (For primary document see N80-10281 01-20)
Avail NTIS HC A22/MF A01

Igniters for propelling charges are described The light artillery rocket and anti-submarine training rocket serve as examples of the electric and internal ballistics data of igniters Special attention is given to the corresponding safety requirements The mechanical and electrostatic safety is covered in connection with the general environmental compatibility Some EMC tests of igniters are included J M S

N80-10290# Propellants, Explosives and Rocket Motor Establishment, Westcott (England)
SOME MEASUREMENTS OF IGNITION DELAY AND HEAT TRANSFER WITH PYROGEN IGNITERS
A R Hall, G R Southern, and D Sutton *In* AGARD Solid Rocket Motor Technol Jul 1979 9 p refs (For primary document see N80-10281 01-20)
Avail NTIS HC A22/MF A01

Measurements were made of ignition delay and the corresponding heat flux with a range of single orifice pyrogens charge with propellant and fired axially in small motors in order to elucidate design priciples Ignitions were inferred from pressure-time records of both pyrogen and main motor and mean heat flux with a range of single orifice pyrogens charged with propellant and fired axially in small motors in order to elucidate design principles Ignitions were inferred from pressure time records of both pyrogen and main motor and mean heat fluxes were calculated from the total temperature rise of copper capsules set in dummy motor charges The motor ignition delay, the mass rate of pyrogen discharge, and the mean heat flux were correlated Comparison of igniters at the same values of the mass rate of pyrogen discharge revealed that ignition delays tended to be longer if igniter products contained condensed phase and pyrogens performed as well as pyrotechnics J M S

N80-10291# Propellants, Explosives and Rocket Motor Establishment, Westcott (England) Solid Propellant Motors Div
BOUNDARY LAYER MODELS OF EROSIVE BURNING
R C Parkinson and P D Penny *In* AGARD Solid Rocket Motor Technol Jul 1979 13 p refs (For primary document see N80-10281 01-20)
Avail NTIS HC A22/MF A01

It is shown that erosive burning can be correlated by a boundary layer 'blow off' criterion A momentum integral boundary layer theory is used to predict the boundary layer reattachment point in a rocket motor conduit, with acceleration of the combustion gases in the conduit as an important modifying force The energy balance in the boundary layer is considered providing a means of relating boundary layer thickness with burning rate Both normal and erosive burning effects are included J M S

N80-10292# Cohen (Norman) Professional Services, Redlands, Calif
COMPOSITE PROPELLANT BURN RATE MODELING
Norman S Cohen *In* AGARD Solid Rocket Motor Technol Jul 1979 21 p refs (For primary document see N80-10281 01-20)
Avail NTIS HC A22/MF A01

The current status of the steady-state combustion modeling of composite solid propellants is reviewed Emphasis is placed upon revisions of original Beckstead-Derr-Price (BDP) model premises as applicable to simple monomodal AP propellants Extensions to more complicated propellants (multimodal, etc.) are discussed Results are presented which show parametric trends and comparisons with data Areas of agreement and disagreement, deficiencies, and continuing developments are pointed out J M S

N80-10293# Bayern Chemie G m b H., Ottobrunn (West Germany)
EROSIVE AND TRANSIENT BURNING EFFECTS ON PERFORMANCE PREDICTION ACCURACY OF TACTICAL ROCKETS
H P Sauerwein, A Lampert and R H Schmucker *In* AGARD Solid Rocket Motor Technol Jul 1979 11 p refs (For primary document see N80-10281 01 20)
Avail NTIS HC A22/MF A01

An erosive burning model which allows performance prediction without additional empirical parameters is presented A sensitivity analysis which uses the data of small tactical rockets shows the effects of the various geometric and ballistic parameters and the variation of pressure and thrust history due to transient effects M M M

N80 10294# Princeton Univ., N J
ALUMINUM COMBUSTION UNDER ROCKET MOTOR CONDITIONS
Leonard H Caveny and Alon Gany *In* AGARD Solid Rocket Motor Technol Jul 1979 13 p refs (For primary document see N80-10281 01-20)
(Grant AF AFOSR-3104-76)
Avail NTIS HC A22/MF A01

Combustion processes of aluminum particles emitted from the surface of solid propellants were studied under rocket motor, cross-flow conditions as well as strand burning conditions High-speed, color photographs were taken of Al2O3 agglomerates forming on the surface, moving along the surface, entering the flow field, and breaking-up in nozzles Experiments were conducted for cross-flow velocities as high as 30 m/s and pressures between 2 and 10 MPa Agglomerate size distributions were obtained by direct measurements from the films. Analysis of size distributions of the agglomerates leaving the surface reveals that the following parameters decrease with increasing pressure collision frequency on the surface, the agglomerate stay time on the surface, and mean agglomerate size Increasing the cross-flow velocity decreases the mean agglomerate size. However, chamber pressure has the most pronounced effect on agglomerate size M M M

N80-10295# Georgia Inst of Tech., Atlanta School of Aerospace Engineering
COMBUSTION OF ALUMINUM IN SOLID PROPELLANT FLAMES

E W Price *In* AGARD Solid Rocket Motor Technol Jul 1979 15 p refs (For primary document see N80 10281 01 20)
Avail NTIS HC A22/MF A01

The behavior of aluminum in the combustion zone the mechanisms causing this behavior and the significance to motor performance, with particular emphasis on ammonium perchlorate hydrocarbon binder aluminum propellants are described The features of aluminum behavior involve retention, concentration, sintering and coalescence of most particles on the propellant burning surface This is followed by detachment and ignition of the agglomerate material, burning in the combustor cavity with formation of a characteristic population of oxide droplets in a diameter distribution with most droplets 0 1 D 50 micrometers M M M

N80-10296# Naval Weapons Center China Lake, Calif Aerothermochemistry Div
THE ROLE OF PARTICULATE DAMPING IN THE CONTROL OF COMBUSTION INSTABILITY BY ALUMINUM COMBUSTION
Karl J Kraeutle, H B Mathes, and Ronald L Derr *In* AGARD Solid Rocket Motor Technol Jul 1979 14 p refs (For primary document see N80-10281 01-20)
Avail NTIS HC A22/MF A01

Methods used to minimize the risk of combustion instability in rocket motors by tailoring the oxide particle production are summarized A brief discussion of particulate damping theory is given Damping measurement with the T-burner and the procedure of damping calculation presently in use at the Naval Weapons Center are presented The importance of particle size analysis for damping calculations is discussed Particle size analysis methods are described which consider the peculiarities of combustion residues Examples of size distributions and damping calculations are given The results show that the theory adequately describes damping by aluminum oxide particles and that damping calculations supply information necessary for tailoring of aluminum oxide particle sizes toward increased damping M M M

N80-10297# Bayern-Chemie G m b H , Aschau (West Germany)
GAS GENERATOR PROPELLANTS FOR AIR-TO-AIR MISSILES
R A H Strecker and D Linde *In* AGARD Solid Rocket Motor Technol Jul 1979 11 p ref (For primary document see N80-10281 01-20)
Avail NTIS HC A22/MF A01

NB 410-propellants, representative of gas generator propellants which are superior to propellants containing unstabilized ammonium nitrate are presented These NB 410-propellants are especially suited for applications where systems are exposed to a large temperature range and frequent temperature cycling such as air-to-air missiles M M M

N80-10298# Naval Surface Weapons Center, White Oak, Md
NEW BINDER SYSTEM FOR COMPOSITE SOLID PROPELLANTS
Carl Gotzmer and Nat Seidan (Naval Ordnance Station, Indian Head, Md) *In* AGARD Solid Rocket Motor Technol Jul 1979 12 p (For primary document see N80-10281 01-20) (SF131332307)
Avail NTIS HC A22/MF A01

A binder system for application to both castable and extrudable composite solid propellants as developed and tested for several motor sizes at typical service temperatures The binder system consists of a low acrylonitrile type carboxy terminated polybutadiene acrylonitrile liquid copolymer which is crosslinked with di- and tri-epoxides A dual epoxide crosslinking system is employed to permit broad adjustment of propellant modulus for various applications This binder system provides propellants with relative insensitivity to atmospheric moisture during processing and a generous pot life Propellant costs are fully competitive with those of carbox or hydroxy terminated polybutadiene binder propellants K L

N80-10299# Institut fuer Chemie der Treib- und Explosivstoffe, Pfinztal (West Germany)
THE AGEING BEHAVIOUR OF SOLID ROCKET PROPELLANTS REGARDING THEIR MECHANICAL PROPERTIES
D Schmitt *In* AGARD Solid Rocket Motor Technol Jul 1979 8 p (For primary document see N80 10281 01 20)
Avail NTIS HC A22/MF A01

Composite and double base rocket propellant samples were aged at elevated temperatures to determine the effects of aging on tensile strength and deformation properties Results were extrapolated to service temperatures for double base propellants In composite propellants aging resulted in a change of the viscoelastic properties which manifested itself like the embrittlement of a material strength increased as deformation properties decreased This change in mechanical properties decreased from the outside to the inside Hence, particular attention must be given to surface aging K L

N80-10300# Centre de Recherches du Bouchet, Vert de Petit (France)
IMPROVING THE ALL WEATHER BALLISTIC AND MECHANICAL PROPERTIES OF SMOKELESS PROPERGOLS [AMELIORATION DES PROPRIETES BALISTIQUES ET DES PROPRIETES MECANIQUES TOUS TEMPS DES PROPERGOLS SANS FUMEE]
A Davenas *In* AGARD Solid Rocket Motor Technol Jul 1979 14 p refs In FRENCH (For primary document see N80-10281 01-20)
Avail NTIS HC A22/MF A01

The effect of RDX and HMX as well as the effect of the ratio of energetic plasticizers and of reticulation on the thermodynamic, kinematic, and mechanical properties of cast double-base propellants was investigated Results are compared with the properties of composite propellants with hydrocarbon and HMX binders The present characteristics of the propellants and the desired improvements are described Transl by A R H

N80-10301*# California Inst of Tech , Pasadena
SOME PROBLEMS OF NONLINEAR WAVES IN SOLID PROPELLANT ROCKET MOTORS
F E C Culick *In* AGARD Solid Rocket Motor Technol Jul 1979 15 p refs (For primary document see N80-10281 01-20) (Contract NAS7-100)
Avail NTIS HC A22/MF A01

An approximate technique for analyzing nonlinear waves in solid propellant rocket motors is presented which inexpensively provides accurate results up to amplitudes of ten percent The connection with linear stability analysis is shown The method is extended to third order in the amplitude of wave motion in order to study nonlinear stability, or triggering Application of the approximate method to the behavior of pulses is described K L

N80-10302# Office National d'Etudes et de Recherches Aerospatiales, Paris (France)
RECENT ONERA STUDIES ON COMBUSTION INSTABILITIES IN SOLID PROPELLANT ROCKET MOTORS
Paul Kuentzman *In* AGARD Solid Rocket Motor Technol Jul 1979 24 p refs In FRENCH, ENGLISH summary (For primary document see N80-10281 01-20)
Avail NTIS HC A22/MF A01

Experimental and numerical techniques to solve the problem created by combustion instabilities in solid propellant motors are reviewed A study of the similarity of combustion instabilities carried out on large size engines with geometrically complex grain revealed some instabilities In view of the poor agreement between the observed and predicted phenomena characteristics, it was proposed to conduct tests on a reduced scale The main results obtained and the limitation of this method are presented K L

N80-10303# Naval Weapons Center, China Lake, Calif Aerothermochemistry Div
APPLICATION OF COMBUSTION INSTABILITY RESEARCH TO SOLID PROPELLANT ROCKET MOTOR PROBLEMS
Ronald L Derr, H B Mathes, and James E Crump *In* AGARD Solid Rocket Motor Technol Jul 1979 12 p refs (For primary document see N80-10281 01-20)
Avail NTIS HC A22/MF A01

Experimental and analytical tools for minimizing the risk of combustion instability in solid rocket motors are reviewed and examples of practical application to motors are discussed Both

successful and unsuccessful examples are described for large and small rocket motors. Laboratory characterization of practice damping associated with a metallized propellant and optimization of particle damping to eliminate pressure oscillations in a tactical solid rocket motor are discussed. In addition, prediction of motor behavior and comparison with motor firing results are presented for solid rocket motors used in the NASA Space Shuttle system. The practical state of the art of combustion instability technology is assessed. K L

N80-10304# Politecnico di Milano (Italy). Centro di Studio per Ricerche sulla Propulsione e sullaEnergetica
SELF-SUSTAINED OSCILLATORY COMBUSTION OF SOLID ROCKET PROPELLANTS
L. DeLuca. *In* AGARD Solid Rocket Motor Technol. Jul. 1979 14 p. refs (For primary document see N80-10281 01-20)
Avail: NTIS HC A22/MF A01

Self-sustained oscillatory burning of solid rocket propellants is considered, within the framework of a thermal theory of heterogeneous combustion and for quasi-steady gas phase. A nonlinear burning stability analysis, carried out via an integral method, predicts the existence of three well defined static regimes: stationary, self-sustained oscillatory, and extinguished. The self-sustained oscillatory solution is related to large values of surface heat release, these values increase with pressure. The burning rate oscillations are of thermokinetic nature and feature characteristic spikes. The existence and the properties of these oscillations can be analytically predicted; they strictly depend on the operating conditions. Computer simulated runs show a very good agreement with the analytical expectations. Identical self-sustained oscillations were observed following different transients to the same final set of operating conditions. Frequencies, increasing with pressure, of the order of 100 Hz were found at pressures of the order of 10 atm; amplitudes were found to decrease with pressure. The same basic features can be observed for different flame models. R E S

N80-10305# Technische Hogeschool, Delft (Netherlands). Dept. of Aerospace Engineering.
***LOW FREQUENCY OSCILLATORY COMBUSTION*: EXPERIMENTS AND RESULTS**
H. F. R. Schoeyer. *In* AGARD Solid Rocket Motor Technol. Jul. 1979 16 p. refs (For primary document see N80-10281 01-20)
Avail: NTIS HC A22/MF A01

Combustion experiments were carried out with double base and composite propellants. There were noticeable differences between the oscillatory combustion of the double base and the composite propellant. Chuffing was frequently observed with the double base propellants, while dp/dt extinguishment was observed in the majority of cases of oscillatory combustion of the composite propellant. Both propellants displayed a relation between the frequency of the oscillations and the mean pressure. From the experiments, stability boundaries were estimated for both types of propellants. In addition, the imaginary part of the response function was estimated for the composite propellant. A computer program was developed and applied successfully for digital data reduction of the experimental results. R E S

N80-10306# Defence Research Establishment Valcartier (Quebec). Centre de Recherches pour la Defense
NONLINEAR COMBUSTION INSTABILITY IN SOLID PROPELLANT ROCKET MOTORS: INFLUENCE OF GEOMETRY AND PROPELLANT FORMULATION
P. M. Hughes and D. L. Smith. *In* AGARD Solid Rocket Motor Technol. Jul. 1979 26 p. refs (For primary document see N80-10281 01-20)
Avail: NTIS HC A22/MF A01

The characteristics of the longitudinal nonlinear (or steep fronted shock) mode of instability were compared in a single size of motor for three different grain cross sections (cylindrical, star and slotted tubular) and three propellant formulations. The formulations were all based on a hydroxy terminated polybutadiene binder containing no aluminum and varying only in the level of burning rate catalyst and oxidizer distribution. It was found that the degree of instability decreased with increasing burning rate was affected by the number of waves propagating. No correlation could be established between the strength of the unstable wave and either the formulation or grain cross section. A low level acoustic wave form was observed to transition naturally into a steep fronted, shock type waveform. The growth of the shock waveform was studied from initiation to steady state and it was found that the growth rate generally increased with decreasing propellant burning rate. The growth mechanism tended to be a complicated one in the earlier stages of a particular firing (before expending 50% of its propellant mass); however, it can generally be stated that a pulse will grow at a faster rate in the later stages of a firing. R E S

N80-10307# Imperial Metal Industries Ltd., Kidderminster (England)
THE SUPPRESSION OF COMBUSTION INSTABILITY BY PARTICULATE DAMPING IN SMOKELESS SOLID PROPELLANT MOTORS
G. I. Evans and P. K. Smith. *In* AGARD Solid Rocket Motor Technol. Jul. 1979 11 p. refs (For primary document see N80-10281 01-20)
Avail: NTIS HC A22/MF A01

An approach to the practical resolution of the problem of acoustic combustion instability without sacrificing performance in smokeless rocket motors is described. Experimental work shows that small quantities of refractory powder are very successful in suppressing combustion instability but that a wider range of particle sizes than is theoretically predicted proves to be effective. Manipulation of the size density function was shown to be an effective means of achieving maximum combustion stability with minimum amounts of exhaust smoke. R E S

N80-10308# Bayern-Chemie G.m.b.H., Ottobrunn (West Germany)
MATERIAL PROBLEMS IN JET VANE THRUST VECTOR CONTROL SYSTEMS
D. Kampa, A. Weib, and R. H. Schmucker. *In* AGARD Solid Rocket Motor Technol. Jul. 1979 10 p. refs (For primary document see N80-10281 01-20)
Avail: NTIS HC A22/MF A01

Five different refractory material types were studied using a highly aluminized HTPB composite propellant. Of these, pure and composite ceramics exhibited insufficient thermal shock resistance; pure carbon showed extreme ablation and erosion. Specifically selected graphite, covered with a tungsten layer and reinforced by a tip of this material, performed well, but the data available were not adequate for systems' use. The best results were obtained with pure tungsten vanes, covered with a layer of low thermal conductivity to maintain structural rigidity. Tests with low aluminum loading propellants showed less severe problems so that molybdenum was sufficient. The results were applied to an experimental thrust vector control system with a low primary smoke HTPB composite propellant. By proper vane shaping, heat shielding and surface coating, a functional system was attained. R E S

N80-10309# Propellants, Explosives and Rocket Motor Establishment, Waltham Abbey (England)
COMPOSITES IN FUTURE MOTOR HARDWARE: A RESEARCH VIEW
N. J. Parratt. *In* AGARD Solid Rocket Motor Technol. Jul. 1979 10 p. refs (For primary document see N80-10281 01-20)
Avail: NTIS HC A22/MF A01

The move from traditional materials to more recent concepts such as dual function composites and integrated construction in tactical motor design is traced. The question is then reviewed as to whether in fact the best use is being made of available materials, particularly in reducing weight and cost together. Suggestions as to how this might be done are then presented. It is concluded that particularly in the construction of motor cases, significant improvements can be made immediately with only minor changes in design, if supported by adequate measurement and prediction of any deterioration. R E S

N80-10310# Societe Europeenne de Propulsion, Bordeaux (France)
PREDICTING THE BEHAVIOR OF PHENOLIC ABLATIVE MATERIALS [PREDICTION DU COMPORTEMENT DES MATERIAUX PHENOLIQUES ABLATIFS]
Claude Bonnet. *In* AGARD Solid Rocket Motor Technol. Jul. 1979 16 p. refs. In FRENCH (For primary document see N80-10281 01-20)

Avail: NTIS HC A22/MF A01

Requirements for predicting the behavior of parts of a blast pipe made of phenolic materials throughout burn, the methods of fabricating composite materials and structures must be improved so that better reproductibility may be achieved New analysis methods and computer programs must be used to reliably predict the mechanical and thermodynamic behavior of blast pipes under fire. The materials and temperatures under which they are used (ambient to 2500 C) must be characterized Transl by A R H

N80-10311# Politecnico di Milano (Italy)

GAS PHASE VELOCITY MEASUREMENTS IN SOLID ROCKET PROPELLANTS BY LASER DOPPLER ANEMOMETRY

A. Coghe, L. DeLuca, G L. Sensalari, and A. Volpi *In* AGARD Solid Rocket Motor Technol Jul 1979 14 p refs (For primary document see N80-10281 01-20)

Avail NTIS HC A22/MF A01

A laser Doppler velocimetry (LDV) technique is described which performs velocity measurements in the gaseous region near the combustion surface of a burning solid rocket propellant. Several laser based optical techniques are examined which measure the condensed phase burning rate and the size of the particles carried away by the gas in the plume of the burning solid propellant. A steady state strand burner, with two symmetrical and opposite optical windows, developed for the LDV experiments, is described. The apparatus was applied to steady burning solid propellant The application of the apparatus for unsteady situations is discussed A.W.H.

N80-10312# United Technologies Corp., Sunnyvale, Calif. Chemical Systems Div.

PRESSURE AND VELOCITY RESPONSE FUNCTION MEASUREMENTS BY THE ROTATING VALVE METHOD

R. S. Brown and R. C. Wawgh *In* AGARD Solid Rocket Motor Technol. Jul. 1979 17 p refs (For primary document see N80-10281 01-20)

(Contracts F04611-72-C-0007; F04611-74-74-C-0045; F49620-77-C-0048)

Avail: NTIS HC A22/MF A01

The rotating valve method which measures the pressure and velocity coupled response functions of solid propellants is discussed. The method which is based on producing pressure or velocity oscillations in a small combustion chamber by varying the area of one or two secondary exhaust nozzles in a periodic manner, is described. Analytical studies are described in which the relationship between the propellant combustion response characteristics and the dynamic chamber ballistics is developed. An experimental rotating valve apparatus was constructed and its performance compared with predictions under cold flow conditions. A.W.H.

N80-10313# Propellants, Explosives and Rocket Motor Establishment, Westcott (England).

ULTRASONIC IMAGING AS APPLIED TO NON-DESTRUCTIVE TESTING OF ROCKET PROPELLANTS

D. S. Dean and D. T. Green *In* AGARD Solid State Rocket Motor Technol. Jul. 1979 13 p (For primary document see N80-10281 01-20)

Avail. NTIS HC A22/MF A01

An ultrasonic imaging technique, which is interface sensitive rather than dependent upon the amount of material missing, for nondestructive testing of rocket propellants is examined A focused image obtained by holographic encoding or computational manipulation of the phase information of the ultrasonic field is used to determine defects in solid propellant charges. The holographic method, which uses parallel processing of information to produce a near real time image is described. The use of large scale integrated circuits and minicomputers in the imaging technique is evaluated A.W.H.

N80-10314# Aerospace Corp., Los Angeles Calif.

A GENERALIZED SOLID MOTOR DEVELOPMENT TEST APPROACH WITH APPLICATION TO IUS

Ernst Stampfl and D. H. May (Space and Missile Systems Organ., Los Angeles, Calif.) *In* AGARD Solid Rocket Motor Technol Jul. 1979 14 p refs (For primary document see N80-10281 01-20)

Avail. NTIS HC A22/MF A01

The aspects of the inertial upper stage (IUS) solid motor propulsion test program are described, including the background and rationale leading to the baseline test approach that relies on overtesting. The background for the test approach is presented and a general description of IUS and its solid motors is given along with a delineation of system, motor, component, and material requirements. An overall perspective of the various test phases and their integration with each other and with design requirements is given. Objectives, test approaches, and a summary of available results of the various test phases are discussed, including their correlation with requirements. Author

N80-10315# Air Force Rocket Propulsion Lab., Edwards AFB, Calif.

THE USE OF STANDARDIZED TEST MOTORS AND LABORATORY TOOLS IN THE DEVELOPMENT OF MISSILE PROPULSION TECHNOLOGY

Richard R. Weiss *In* AGARD Solid Rocket Motor Technol Jul. 1979 14 p (For primary document see N80-10281 01-20)

Avail. NTIS HC A22/MF A01

The development of standardized test motors and laboratory tools for the evaluation of solid rocket motor component capabilities and propellant behavior is discussed The advantages and disadvantages offered by the use of standardized motors and laboratory tools are examined The test motor families and combustion tools used at engine testing laboratories for missile propulsion technology development are reviewed The rationale for their selection, design and use is provided along with a description of the devices themselves. A.W.H.

N80-10316# Propellants, Explosives and Rocket Motor Establishment, Westcott (England).

MEASUREMENT OF THRUST TRANSIENTS IN ROCKET MOTORS

D. S. Dean *In* AGARD Solid Rocket Motor Technol Jul 1979 12 p (For primary document see N80-10281 01-20)

Avail: NTIS HC A22/MF A01

Two systems for measuring the thrust transients in rocket motors are examined Construction and calibration of the systems are described. The first system is designed to measure starting transients of large rocket motor if there is no significant change in the mass. The second system is designed for use with short burning time motors if the moving mass and its distance of free travel are kept within practical bounds A.W.H.

24 COMPOSITE MATERIALS

Includes laminates

N78-17163# Advisory Group for Aerospace Research and Development, Paris (France)

CERTIFICATION PROCEDURES FOR COMPOSITE STRUCTURES

Jan 1978 40 p refs Four papers presented at the 44th Meeting of the Struct and Mater Panel of AGARD, April 1977 (AGARD-R-660, ISBN-92-835-0208-6) Avail NTIS HC A03/MF A01

The criteria which presently determine the permissible use of composites in production aircraft and the adaptation of an existing framework of aircraft certification practices to the special characteristics of composites were described. Factors involving the scheduling of full-scale static and fatigue tests and their effect on the use of composites were discussed. Static and fatigue design and test loads were studied. Small and large scale element testing was covered. Some of the structural design problems and load/strain criteria were reviewed. Typical procedures governing the development and interpretation of design data, laboratory and flight tests were explained. Author

26 METALLIC MATERIALS

Includes physical, chemical, and mechanical properties of metals, e.g., corrosion; and metallurgy.

N78-15260# Advisory Group for Aerospace Research and Development, Paris (France).
CORROSION FATIGUE OF AIRCRAFT MATERIALS
Oct. 1977 93 p refs Four papers presented at the 44th Meeting of the Structures and Mater. Panel of AGARD, Apr. 1977
(AGARD-R-659, ISBN-92-835-1261-8) Avail: NTIS HC A05/MF A01

Environmental effects on the fatigue life and crack propagation behavior of aircraft structural materials are considered. Specifically the corrosion fatigue of high strength aluminum, titanium, and steel alloys is discussed. Experimental results are given along with recommendations for further research. J.M.S.

N79-33304# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
CORROSION INFORMATION IN NATO NATIONS
N. E. Promise Jul. 1979 36 p refs
(AGARD-AR-141, ISBN-92-835-1327-4) Avail: NTIS HC A03/MF A01

Research was performed to: (1) determine the needs of the NATO aerospace industry and related Government establishments for technical data relevant to corrosion principles, material behavior in hostile environments, corrosion prevention, etc.; (2) to determine what national and international resources exist that could be responsive to these needs and what were the facilities for collecting, analyzing, coding, storing and retrieving the desired information; and (3) to suggest approaches to filling identified gaps and unsatisfied needs. The study was limited to the generic types of information needed and the mechanics of transferring this information. M.M.M.

28 PROPELLANTS AND FUELS

Includes rocket propellants, igniters, and oxidizers; storage and handling; and aircraft fuels.

For related information see also *07 Aircraft Propulsion and Power*, *20 Spacecraft Propulsion and Power*, and *44 Energy Production and Conversion*.

N79-13192# Advisory Group for Aerospace Research and Development, Paris (France).
AIRCRAFT ENGINE FUTURE FUELS AND ENERGY CONSERVATION
Sep. 1978 188 p refs Lecture Series held at Munich, 16-17 Oct. 1978 and London, 19-20 Oct. 1978
(AGARD-LS-96; ISBN-92-835-1297-9) Avail: NTIS HC A09/MF A01

Current and forecasted world energy demands, growth, and supply are reviewed in perspective to the status and outlook for future aviation fuels to meet NATO needs. The special problems associated with the refining of aviation fuels from lower quality feedstocks (including fuel refined from coal, oil shale, and tar sands) and techniques for reducing energy consumption in refining processes are examined. Special attention is given to the chemistry and combustion characteristics of future hydrocarbon fuels and the impact of using these fuels in aircraft engines and fuel systems. An assessment is made as to what technology advancements are currently underway and what other advancements are needed with reference to engine components, engine systems, aircraft designs and operational procedures to help conserve fuel resources. For individual titles, see N79-13193 through N79-13200.

N79-13193# Imperial Coll. of Science and Technology, London (England). Dept. of Mechanical Engineering.
FUTURE FUELS FOR AVIATION
J. J. MacFarlane *In* AGARD Aircraft Eng. Future Fuels and Energy Conserv. Sep. 1978 12 p refs (For primary document see N79-13192 04-28)
Avail: NTIS HC A09/MF A01

The historical background of the current aviation gas turbine fuel specification is described. Current local supply difficulties are discussed in relation to crude oil availability and the pattern of regional demand for petroleum products. The consensus of expert opinion on the effects of predicted future petroleum resource availability and of various trade and economic factors on future rates of production are described. Recent data on the demand for petroleum products and the crucial importance of future demand control are discussed. The prospects for petroleum based aviation fuel are evaluated. The long term sources of aviation fuel are described and the problem areas enumerated. The need for a research program on alternative fuels is demonstrated. Previous work using model flames on the effects of fuel composition on rich flame chemistry is reviewed and the potential contribution of fundamental research in the alternative aviation fuels program is outlined. J.M.S.

N79-13194# Shell Research Ltd., Chester (England). Thornton Research Centre.
FUTURE AVIATION FUELS FUEL SUPPLIERS VIEWS
A. Lewis *In* AGARD Aircraft Eng. Future Fuels and Energy Conserv. Sep. 1978 22 p refs (For primary document see N79-13192 04-28)
Avail: NTIS HC A09/MF A01

Developments in the potential future availability of aviation fuels from petroleum crude oils, shale oils, and coal are reviewed on the basis of published data. Much of the data were derived from statistics of the Organization for Economic Cooperation and Development and the Workshop on Alternative Energy Strategies. J.M.S.

N79-13195# Imperial Coll. of Science and Technology, London (England). Dept. of Mechanical Engineering.
THE ROLE OF FUNDAMENTAL COMBUSTION IN THE FUTURE AVIATION FUELS PROGRAM
J. J. MacFarlane *In* AGARD Aircraft Eng. Future Fuels and Energy Conserv. Sep. 1978 6 p refs (For primary document see N79-13192 04-28)
Avail: NTIS HC A09/MF A01

Alternative fuels research using can type engine combustors is briefly summarized. This research stressed the overall response of the system to fairly arbitrary changes in fuel properties and fuel preparation, observing such quantities as carbon deposit formation, wall temperature, combustor outlet temperature distribution, and combustion efficiency. Flame research undertaken to study the way in which carbon is formed in gas turbine primary zones was described. This research utilized experimental model combustors, prevaporized and premixed C5 and C6 hydrocarbons and kerosene, and sprayed kerosene. Contour maps of soot formation as a function of pressure and equivalence ratios were presented. The mechanism of carbon formation in spray flames was discussed. J.M.S.

N79-13196*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.
CHARACTERISTICS AND COMBUSTION OF FUTURE HYDROCARBON FUELS
R. A. Rudey and J. S. Grobman *In* AGARD Aircraft Eng. Future Fuels and Energy Conserv. Sep. 1978 23 p refs (For primary document see N79-13192 04-28)
Avail: NTIS HC A09/MF A01 CSCL 21D

Changes in fuel properties that are expected in future hydrocarbon fuels for aircraft are discussed along with the principal properties of 'syncrudes' and the fuels that can be derived from them. The impact that the resultant potential changes in fuel properties may have on combustion and thermal stability characteristics is illustrated and discussed in terms of ignition, soot formation, carbon deposition, flame radiation, and emissions. J.M.S.

N79-13197*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.
IMPACT OF FUTURE FUEL PROPERTIES ON AIRCRAFT ENGINES AND FUEL SYSTEMS
R. A. Rudey and J. S. Grobman *In* AGARD Aircraft Eng. Future Fuels and Energy Conserv. Sep. 1978 29 p refs (For primary document see N79-13192 04-28)
Avail: NTIS HC A09/MF A01 CSCL 21D

The effect of modifications in hydrocarbon jet fuels specifications on engine performance, component durability and maintenance, and aircraft fuel system performance is discussed. Specific topics covered include: specific fuel consumption; ignition at relight limits; exhaust emissions; combustor liner temperatures; carbon deposition; gum formation in fuel nozzles; erosion and corrosion of turbine blades and vanes; deposits in fuel system heat exchangers; and pumpability and flowability of the fuel. Data that evaluate the ability of current technology aircraft to accept fuel specification changes are presented, and selected technological advances that can reduce the severity of the problems are described and discussed. J.M.S.

N79-13198# Pratt and Whitney Aircraft Group, East Hartford, Conn.
ENGINE COMPONENT IMPROVEMENT AND PERFORMANCE RETENTION
William H. Sens *In* AGARD Aircraft Eng. Future Fuels and Energy Conserv. Sep. 1978 12 p (For primary document see N79-13192 04-28)
Avail: NTIS HC A09/MF A01

The importance of improving the fuel consumption of current engines *and their derivatives* is addressed in terms of making significant savings in aircraft fuel consumption in this century. Methods of reducing fuel consumption of current engines considered include: (1) cycle improvement incorporated in growth and derivative engine models by changes in bypass ratio, overall pressure ratio, and turbine inlet temperature; (2) component performance improvements through design refinements incorporated into the existing engines during routine overhaul; and (3) improved engine performance retention through revised maintenance procedures and improved design. J.M.S.

N79-13199# Pratt and Whitney Aircraft Group, East Hartford, Conn.
LOW ENERGY CONSUMPTION ENGINES
William H. Sens *In* AGARD Aircraft Eng. Future Fuels and

Energy Conserv. Sep 1978 13 p refs (For primary document see N79-13192 04-28)
Avail: NTIS HC A09/MF A01

Improvements in aircraft gas turbine engine economy over four decades are briefly reviewed. Possibilities for the evolution of the turbofan cycle to give improved engine performance are discussed with emphasis on the Energy Efficient Engine Program. Alternative cycles are also considered. These include: Brayton cycle; regenerative cycle; compound; fan; shrouded propeller; and the prop-fan. The prop-fan is considered the most promising. J.M.S.

N79-13200# Office National d'Etudes et de Recherches Aerospatiales, Paris (France).
ENERGY CONSERVATION AIRCRAFT DESIGN AND OPERATIONAL PROCEDURES
Philippe Poisson-Quinton *In* AGARD Aircraft Eng. Future Fuels and Energy Conserv. Sep. 1978 47 p refs (For primary document see N79-13192 04-28)
Avail: NTIS HC A09/MF A01

A review is given of studies and applications leading to improved fuel efficiency in the air transportation system. Major technological progress in aerodynamics, structures/materials, propulsion integration, and avionics is quantified for the subsonic transport aircraft as well as future VTOL, STOL, and SST. It is shown that improvements on flight and ground operational procedures are in the developmental stage and that these improvements must strongly reduce the energy waste of the current civil and military air transportation system. J.M.S.

31 ENGINEERING (GENERAL)

Includes vacuum technology; control engineering, display engineering, and cryogenics

N78-15311# Advisory Group for Aerospace Research and Development, Paris (France)
FACTORS OF SAFETY: HISTORICAL DEVELOPMENT, STATE OF THE ART AND FUTURE OUTLOOK
Nov 1977 69 p refs Three papers presented at the 43d, 44th, and 45th Meetings and the Technical Address given at the 44th Meeting of the Structures and Mater Panel of AGARD
(AGARD-R-661; ISBN-92-835-1255-3) Avail: NTIS HC A04/MF A01

The factors of structural safety presently applied to the design of fixed-wing aircraft are considered in terms of progress in establishing aerodynamic derivatives, defining load conditions, and predicting structural loads as well as enabling detailed analyses for stress and deformation to be made. J.M.S.

N78-31279# Advisory Group for Aerospace Research and Development, Paris (France).
IMPACT OF CHARGE COUPLED DEVICES AND SURFACE ACOUSTIC WAVE DEVICES ON SIGNAL PROCESSING AND IMAGERY IN ADVANCED SYSTEMS
Y. Brault, ed. Jun 1978 479 p refs Partly in ENGLISH and FRENCH Presented at Avionic Panel Symp., Ottawa, 11-15 Oct 1977
(AGARD-CP-230; ISBN-92-835-0216-7) Avail: NTIS HC A21/MF A01

The mission of AGARD is to bring together the leading personalities of the NATO nations in the fields of science and technology relating to aerospace. The mission of AGARD is carried out through the Panels which are composed of experts appointed by the National Delegates, the Consultant and Exchange Program and the Aerospace Applications Studies Program. The results of AGARD work are reported to the member nations and the NATO Authorities through the AGARD series of publications of which this is one. The reported symposium was divided into five sessions: (1) fundamental technology and trends; (2) technology and devices; (3) fundamental modules/subsystems; (4) imagery; and (5) signal processing. For individual titles, see N78-31280 through N78-31319.

N78-31280# Texas Instruments, Inc., Dallas.
STATE-OF-THE-ART OF CCD AND SAW TECHNOLOGIES

Lewis T. Claiborne *In* AGARD Impact of Charge Coupled Devices and Surface Acoustic Wave Devices on Signal Process. and Imagery in Advanced Systems Jun. 1978 11 p refs (For primary document see N78-31279 22-31)
Avail: NTIS HC A21/MF A01

A survey of the status of component technologies for charged coupled devices (CCD) and surface acoustic wave devices (SAW) is presented in terms of device performance and application to subsystem signal processing functions. The performance is discussed for imaging and image processing as well as analog and digital signal processing. Recent developments are mentioned including resonator filters and transform processing. G.Y.

N78-31281# Royal Signals and Radar Establishment, Malvern (England).
THE ROLES FOR CCD AND SAW IN SIGNAL PROCESSING
J. B. G. Roberts *In* AGARD Impact of Charge Coupled Devices and Surface Acoustic Wave Devices on Signal Process. and Imagery in Advanced Systems Jun. 1978 16 p refs (For primary document see N78-31279 22-31)
Avail: NTIS HC A21/MF A01

The recent emergence of two radically new methods for the real time processing of signals raised the important question of how they best be used and how they relate to one another and to other techniques. The key factors determining the effectiveness of CCD and SAW in a range of application fields are discussed. The roles in which they are likely to be most appropriate and how they compare with the rapidly expanding range of digital devices are assessed. As well as contrasting the techniques in mutually exclusive situations, it is shown how it is often possible to complement one with another to good effect. G.Y.

N78-31282# Rome Air Development Center, Griffiss AFB, N.Y. Deputy for Electronic Technology
MATERIAL CHOICE FOR OPTIMUM SAW DEVICE PERFORMANCE
Robert M. OConnell, Andrew J. Slorodnik, Jr., and Paul H. Carr *In* AGARD Impact of Charge Coupled Devices and Surface Acoustic Wave Devices on Signal Process. and Imagery in Advanced Systems Jun. 1978 19 p refs (For primary document see N78-31279 22-31)
Avail: NTIS HC A21/MF A01

The theory of surface acoustic wave propagation is reviewed and some of the various material design parameters which follow from that theory must be considered in making the optimum SAW device substrate choice. The parameters covered include SAW velocity, piezoelectric coupling constant, electro-mechanical power flow angle, temperature sensitivity, propagation losses and beam steering and diffraction. Depending upon the device being designed and the application, some of those parameters are more important than others. In the design of temperature stable, broadband, low insertion loss devices, the important requirements are a zero temperature coefficient of time delay and a large piezoelectric coupling constant. Alternatively, the design of high frequency devices requires low loss substrate materials with large SAW velocities. The state of the art in the development of new materials for these two classes of devices is reviewed. Author

N78-31283# Laboratoire Central de Recherches Thomson-CSF, Orsay (France)
MICROWAVE SURFACE-ACOUSTIC-WAVE COMPONENTS

P. Hartemann *In* AGARD Impact of Charge Coupled Devices and Surface Acoustic Wave Devices on Signal Process. and Imagery in Advanced Systems Jun. 1978 9 p refs (For primary document see N78-31279 22-31)
Avail: NTIS HC A21/MF A01

Various surface acoustic wave components operating at frequencies greater than 1 GHz were realized using an electron beam pattern generator. Fabrication process is described and the main features of devices are reported. Simple and tapped delay lines operating at about 1.3 GHz with a 3 db bandwidth close to 500 MHz were performed with lithium niobate substrates. The maximum delay time is equal to 10 micro seconds. Large bandwidth coded lines and dispersive delay lines were also tested. Narrow bandwidth filters were realized using sampled inter digital transducers deposited on surfaces of lithium niobate and quartz substrates. A relative bandwidth of 0.0008 was obtained. Oscillators were implemented with such filters up to 2 GHz, the substrates being ST cut quartz plates. G.Y.

N78-31284# Microwave and Electronic Systems Ltd., Newbridge (Scotland).
DEVELOPMENT OF A 100MHz BANDWIDTH PULSE COMPRESSION SUBSYSTEM FOR AIRBORNE APPLICATION
M. B. N. Butler *In* AGARD Impact of Charge Coupled Devices and Surface Acoustic Wave Devices on Signal Process. and Imagery in Advanced Systems Jun. 1978 10 p refs (For primary document see N78-31279 22-31)
Avail: NTIS HC A21/MF A01

A substrate design incorporating SAW devices for passive signal encoding and pulse compression with 100 MHz bandwidth and 5 microsecond dispersion is described. The paper is divided into three parts covering SAW devices design, subsystem design and environmental testing. In order to minimize weight and power consumption the SAW devices were designed for implementation on ST-X quartz substrates. With this material and appropriate mechanical layout only minor changes in device performance are visible over an operating temperature range in excess of 100 C. In this development a new approach to the design of double dispersive, angle chirp filter is taken. The technique resulted in SAW devices with T.B. 500, insertion loss less than 45 db and matched to give a compressed pulse width of 15 nanoseconds with 34 db sidelobe suppression. Subsystem design, including high gain, broadband amplifiers shows the need for care in mechanical and electrical layout and screening. Attention is given to design for low R.F.I. and good pulse compression performance in a unit operating in an airborne environment. Author

N78-31285# Sperry Research Center, Sudbury, Mass
SIGNAL PROCESSING WITH A REFLECTIVE DOT ARRAY (RDA)
L. P. Solie and H. VanDeVaart *In* AGARD Impact of Charge Coupled Devices and Surface Acoustic Wave Devices on Signal Process. and Imagery in Advanced Systems Jun. 1978 4 p refs (For primary document see N78-31279 22-31)
Avail: NTIS HC A21/MF A01

A new type of pulse compression filter is described using the Reflective Dot Array (RDA). The RDA is similar to the Reflective Array Compressor (RAC), except that the array of reflecting grooves is replaced by an array of reflecting metallic dots. The RDA has the principle advantage of being part of the same mask and *metallization as the interdigital transducers*, allowing single-stop fabrication. A linear FM filter was developed with a center frequency of 60 MHz, bandwidth of 20 MHz and differential time delay of 10 microsecond with less than 3 degrees of rms phase deviation from quadratic without phase compensating film showing that high performance pulse compression filters can be produced at low cost. G.Y.

N78-31286# Office National d'Etudes et de Recherches Aerospatiales, Paris (France).
INFLUENCE OF ACCELERATION ON SURFACE ACOUSTIC WAVE OSCILLATORS
Michel Valdois, Patrick Levesque, and Pierre Hartemann (Laboratoire Central de Rech. Thomson-CSF, Orsay, France) *In* AGARD Impact of Charge Coupled Devices and Surface Acoustic Wave Devices on Signal Process. and Imagery in Advanced Systems Jun. 1978 6 p refs In FRENCH; ENGLISH summary (For primary document see N78-31279 22-31)
Avail: NTIS HC A21/MF A01

The influence of acceleration on oscillators using a delay line or a resonator with surface acoustic waves was studied in the 0 - 30 g range. The surface wave oscillators were installed on a variable speed rotating arm. The piezoelectric substrates used were in quartz of ST and Y cut. Several directions of acceleration were experimented. The frequency shift due to acceleration is as a first approximation, a linear function of the acceleration magnitude. With a surface wave resonator made of *two transducers placed in a cavity defined* by two periodic reflecting networks, the maximum sensitivity is 48 Hz/g at 124 MHz for an acceleration direction to the propagation surface. Results show that the acoustic surface wave oscillators, in their present form, are more sensitive to acceleration than the volume wave oscillators. The ratio of relative sensitivity increase is of the order of 100. G.Y.

N78-31287# Laboratoire Central de Recherches Thomson-CSF, Orsay (France).
TUNABLE MAGNETOELASTIC SURFACE WAVE OSCILLATORS
G. Volluet *In* AGARD Impact of Charge Coupled Devices and Surface Acoustic Wave Devices on Signal Process. and Imagery in Advanced Systems Jun. 1978 11 p refs (For primary document see N78-31279 22-31)
Avail: NTIS HC A21/MF A01

A new technique for achieving the frequency control of SAW oscillators with an external magnetic field was experimented. Magnetoelastic Raleigh wave delay lines using ZnO transducers were fabricated with Gd-Ga Y I.G. epitaxial films grown on G G G. substrates. An important phase velocity shift was obtained as a function of an external biasing magnetic field through a magnetoelastic interaction. Feedback oscillators were implemented using this kind of delay lines. A frequency change up to 1650 ppm around 211.5 MHz and 1800 ppm around 339.5 MHz were obtained by sweeping a biasing magnetic field over a 70 Oe range. G.Y.

N78-31288# Allen Clark Research Centre, Towcester (England)
PERFORMANCE LIMITATIONS OF TWO PHASE CCD'S
V. A. Browne *In* AGARD Impact of Charge Coupled Devices and Surface Acoustic Wave Devices on Signal Process. and Imagery in Advanced Systems Jun. 1978 8 p refs (For primary document see N78-31279 22-31)
Avail: NTIS HC A21/MF A01

There are several different techniques available for achieving two-phase operation. These are discussed and compared. The performance of two-phase CCD's (charged coupled devices) *fabricated with a coplanar, N-channel*, double-level polysilicon gate process is described and compared between devices fabricated with stepped-oxide, implanted barriers and offset-gate structures. A comparison between surface and buried channel devices is also made. A basic three-phase charge transfer system was studied, and whilst such structures are simple in concept, they are difficult to operate. Performance limitations of a number of two-phase CCD structures when operating in both two-phase and *the uniphase mode* are discussed. Their performance is compared to the equivalent three-phase device. G.Y.

N78-31289# Edinburgh Univ. (Scotland). Dept. of Electrical Engineering
THE DESIGN AND DEVELOPMENT OF CCD PROGRAMMABLE TRANSVERSAL FILTERS AND CORRELATORS
J. Mavor and P. B. Denyer *In* AGARD Impact of Charge Coupled Devices and Surface Acoustic Wave Devices on Signal Process. and Imagery in Advanced Systems Jun. 1978 16 p refs (For primary document see N78-31279 22-31)
Avail: NTIS HC A21/MF A01

The potential of integrated circuit-based convolers for baseband operation is examined. The emphasis is on compact processor development with an eventual aim of a single chip, monolithic design suitable for a variety of signal processing applications. Trade-offs of serial and parallel configurations of convolers are considered together with their respective component requirements. Following a description of a Deltic serial processor (having a time-bandwidth product of 500) a study is made of the circuit elements of a particular realization of an integrated convoler in CCD/MOS technology. All aspects of the design are considered and the description is focussed around a prototype 64-stage convoler. The future of this approach is discussed and thought to be capable of 255 convolution points on a single chip. G.Y.

N78-31290# Rockwell International Corp., Anaheim, Calif.
A HYBRID SAW/CCD SIGNAL PROCESSOR
William H. Conway and Dirk R. Kloss (Army Electronic Warfare Lab., Fort Monmouth, N. J.) *In* AGARD Impact of Charge Coupled Devices and Surface Acoustic Wave Devices on Signal Process. and Imagery in Advanced Systems Jun. 1978 8 p refs (For primary document see N78-31279 22-31)
Avail: NTIS HC A21/MF A01

The combining of SAW and CCD technologies to produce a hybrid signal processor capable of performing bandwidth compression on signals of short time duration while maintaining their phase relationships is discussed. The devices used in fabricating a feasibility brassboard are described and test results influencing the design of such hybrid processors are presented. G.Y.

N78-31291*# Bell-Northern Research Ltd., Ottawa (Ontario)
A WIDE BANDWIDTH CCD BUFFER MEMORY SYSTEM
K. Siemens, R. W. Wallace, and C. R. Robinson *In* AGARD Impact of Charge Coupled Devices and Surface Acoustic Wave Devices on Signal Process. and Imagery in Advanced Systems Jun. 1978 9 p refs (For primary document see N78-31279 22-31)
(Contract NAS1-13507)
Avail: NTIS HC A21/MF A01 CSCL 09B

A prototype system was implemented to demonstrate that CCD's can be applied advantageously to the problem of low power digital storage and particularly to the problem of interfacing widely varying data rates. CCD shift register memories (8K bit) were used to construct a feasibility model 128 K-bit buffer memory system. Serial data that can have rates between 150 kHz and 4.0 MHz can be stored in 4K-bit, randomly-accessible memory blocks. Peak power dissipation during a data transfer is less than 7 W, while idle power is approximately 5.4 W. The system *features automatic data input synchronization with the recirculating* CCD memory block start address. System expansion to accommodate parallel inputs or a greater number of memory blocks can be performed in a modular fashion. Since the control logic does not increase proportionally to increase in memory capacity, the power requirements per bit of storage can be reduced significantly in a larger system. G.Y.

N78-31292# Bell-Northern Research Ltd., Ottawa (Ontario)
A MICROPROCESSOR CONTROLLED ELECTRICALLY PROGRAMMABLE TRANSVERSAL FILTER
A. Chowaniec, R. W. Wallace, M. A. Copeland (Carleton Univ., Ottawa), and Y. A. Haque (Carleton Univ., Ottawa) *In* AGARD Impact of Charge Coupled Devices and Surface Acoustic Wave Devices on Signal Process. and Imagery in Advanced Systems Jun. 1978 9 p refs (For primary document see N78-31279

Avail. NTIS HC A21/MF A01

A real time electrically programmable transversal filter which promises to have considerable potential for sampled analog data signal processing is described. Results obtained using the filter in combination with a microprocessor are presented. The filter is based on a novel functional multiplying structure in the standard silicon gate MOS process. The analog multiplication of signals is achieved by digitally selecting the application of controlled analog signal voltage on the semiconductor inversion layer side of an MOS capacitor - a process that is linear and free of signal interaction (crosstalk) between taps. A microprocessor is used to manipulate and load the tap data. A programmable filter of this type can find wide application in advanced signal processing systems and some discussion is presented on its applicability to areas as adaptive filtering for communications and matched filtering for spread spectrum modes. Author

N78-31293# AEG-Telefunken, Ulm (West Germany)

DESIGN AND PERFORMANCE OF SAW-RESONATORS AND RESONATOR-FILTERS

W. H. Haydl (Fraunhofer Gesellschaft, Freiburg), P. Hiesinger (Fraunhofer Gesellschaft, Freiburg), G. Kohlbacher, and P. Schmitt *In* AGARD Impact of Charge Coupled Devices and Surface Acoustic Wave Devices on Signal Process. and Imagery in Advanced Systems Jun. 1978 7 p refs (For primary document see N78-31279 22-31)

Avail: NTIS HC A21/MF A01

One-, two- and three-port SAW resonators on ST-quartz and YZ-lithium niobate were developed employing aluminum metallization. Investigations were carried out on the important parameters for the design of SAW resonators, such as the reflection coefficient, number of reflector elements, reflector and transducer placement, and terminating impedance. Out of the many possible different designs the most promising ones are described in detail: control of the center frequency, permanant trimming to the final frequency by sputtering of thin films and in situ measurement, electronic tuning by means of varactors, low loss, series operation of several devices giving up to 100 db sidelobe signal suppression, multimode operation, and oscillators with single- and multiple-mode resonators, respectively. G.Y.

N78-31294# Rome Air Development Center, Hanscom AFB, Mass.

SYSTEMS APPLICATIONS OF SAW FILTERS AND DELAY LINES

Paul H. Carr *In* AGARD Impact of Charge Coupled Devices and Surface Acoustic Wave Devices on Signal Process. and Imagery in Advanced Systems Jun. 1978 12 p refs (For primary document see N78-31279 22-31)

Avail: NTIS HC A21/MF A01

The applications that SAW (surface acoustic waves) filters and delay lines have to communications and radar systems are reviewed. The development of SAW resonators at frequencies up to 1 GHz is reported together with their promise for stabilizing precision oscillators. Operation directly at 1 GHz eliminates the multiplier chains required for conventional quartz oscillators. The use of miniature SAW transversal filters for banks of contiguous filters is shown to be important in reducing the size of fast frequency synthesizers and multiplexers for spread-spectrum communications applications. The design of a 9.1 microsecond delay line with all spurious echoes 70 db down is described together with its radar signal processing application. G.Y.

N78-31295# Motorola, Inc., Scottsdale, Ariz.

THE MONOLITHIC INTEGRATION OF SURFACE ACOUSTIC WAVE AND SEMICONDUCTOR CIRCUIT ELEMENTS ON SILICON FOR MATCHED FILTER DEVICE DEVELOPMENT

Fred S. Hickernell and Henry J. Bush *In* AGARD Impact of Charge Coupled Devices and Surface Acoustic Wave Devices on Signal Process. and Imagery in Advanced Systems Jun. 1978 13 p refs Prepared in cooperation with RADC, Griffiss AFB, N. Y. (For primary document see N78-31279 22-31) (Contracts F30602-74-C-0021; F30602-76-C-0134)

Avail: NTIS HC A21/MF A01

Work on the development of silicon-based monolithic programmable matched filter SAW devices capable of generating and processing binary code data is presented. Two programmable filters were designed, fabricated and tested using zinc oxide film transducers for surface acoustic wave generation, piezoresistive MOSFET taps for detection, and semiconductor logic elements for phase and amplitude control of the taps. The filters were developed at a carrier frequency of 100 MHz, with a 10 MHz bandwidth and a capability for generating and correlating 31-bit PN sequences. The developments serve to demonstrate the visibility of the monolithic integration of SAW and semiconductor elements, and permitted assessment of various aspects of the technology. G.Y.

N78-31296# Norges Tekniske Hoegskole, Trondheim. Dept. of Electrical Engineering

EXPERIMENTS AND ANALYSIS OF ACOUSTOELECTRIC MEMORY CORRELATORS

K. A. Ingebrigtsen, A. Ronnekleiv, and S. Stueflotten *In* AGARD Impact of Charge Coupled Devices and Surface Acoustic Wave Devices on Signal Process. and Imagery in Advanced Systems Jun. 1978 14 p refs (For primary document see N78-31279 22-31)

Avail: NTIS HC A21/MF A01

Progress in the development of acoustoelectric diode memory correlators is described. The fabrication technique is described in some detail and experimental results from devices using Schottky diodes and pn-diodes are given. This model describes several of the experimentally observed features in the recording process, of the storage, and of the correlation readout. The experiments suggest that the model needs improvements in the description of the recording process. G.Y.

N78-31297# Compagnie Generale de Telegraphie sans Fil, Paris (France). Div. des Activites Sous-Marines. Chemin des Travails.

CONVOLUTION AND CORRELATION MEMORY BY MEANS OF SURFACE ACOUSTIC WAVE DEVICES [CONVOLUTION ET CORRELATION A MEMOIRE A L'AIDE DE COMPOSANTS ACOUSTIQUES A ONDES DE SURFACE]

H. Gautier, C. Maerfeld, and P. Tournois *In* AGARD Impact of Charge Coupled Devices and Surface Acoustic Wave Devices on Signal Process. and Imagery in Advanced Systems Jun. 1978 14 p refs In FRENCH (For primary document see N78-31279 22-31)

Avail: NTIS HC A21/MF A01

A device with two inputs and one output capable of generating the convolution product of the two input signals is described, and a simple solution that utilizes counterdirective surface acoustic waves in support of information processing is studied.

Transl. by B.B.

N78-31298# TRW Defense and Space Systems Group, Redondo Beach, Calif.

LSI VIDEO COMPRESSION AND COMPUTATIONAL MODULES UTILIZING DIGITAL CHARGE COUPLED DEVICES

R. A. Allen, D. J. Spencer, and C. S. Miller *In* AGARD Impact of Charge Coupled Devices and Surface Acoustic Wave Devices on Signal Process. and Imagery in Advanced Systems Jun. 1978 10 p refs (For primary document see N78-31279 22-31) (Contract N00014-74-C-0068)

Avail: NTIS HC A21/MF A01

The techniques used in the design of LSI arithmetic arrays are described and is referred to as Digital Charge Coupled Logic (DCCL). An LSI Video Compression Module concept utilizing the DCCL technology is described, that compresses video data by interface transform coding. The design of the DCCL arithmetic and control chips are also described. In particular is the use of these two types of DCCL LSI chips in the realization of the Itakura analysis - synthesis algorithm for a linear predictive coding (LPC) using partial correlation (PARCOR) techniques. G.Y.

N78-31299# Allen Clark Research Centre, Towcester (England)

CHARGE COUPLED DEVICES WITH SIMPLIFIED DRIVE REQUIREMENTS

J. N. Gooding *In* AGARD Impact of Charge Coupled Devices and Surface Acoustic Wave Devices on Signal Process. and Imagery in Advanced Systems Jun. 1978 7 p refs (For primary document see N78-31279 22-31)

Avail: NTIS HC A21/MF A01

The capabilities of charge coupled devices make them attractive for a wide range of signal processing applications. However, their advantages are diminished if they need to be surrounded by a significant amount of support circuitry. To what extent this peripheral circuitry can be simplified if not eliminated is discussed. Two delay line designs are discussed in detail. In an audio delay line all the support circuitry can be integrated onto the CCD chip. Power considerations prevent this being done

at video frequencies. However, it is possible to reduce the video delay line drive requirements to a single phase clock drive - all other required waveforms, etc. being generated on chip. G.Y.

N78-31300# Forschungsinstitut fuer Funk und Mathematik, Werthoven (West Germany).
SAW FILTER APPLICATION FOR PHASED ARRAY RADAR
W. Sander and W. H. Haydl (Inst. fuer Angew. Festkorperphysik der Fraunhofer-Ges.). *In* AGARD Impact of Charge Coupled Devices and Surface Acoustic Wave Devices on Signal Process. and Imagery in Advanced Systems Jun. 1978 11 p. refs (For primary document see N78-31279 22-31)
Avail: NTIS HC A21/MF A01

Some peculiarities of the array system which influences the design of the filtering devices in the 1F-amplifier are given. The design, development, and fabrication of two types of SAW filters for the 1F-amplifier of the receiving array for a phased array radar (Electronically Steerable Radar) are discussed. Compared to conventional filters with lumped elements, these filters have some important merits. Their use represents one of the few applications where high quality mass-produced SAW devices were applied to improve the system performance. G.Y.

N78-31301# Societe Anonyme de Telecommunications, Paris (France).
MODELIZATION OF METAL INSULATING SEMICONDUCTOR DEVICES ON CgHgTe APPLICATION TO A CHARGE TRANSFER DEVICE FOR INFRARED IMAGERY [MODELISATION DE STRUCTURES METAL-ISOLANT-SEMICONDUCTEUR SUR Cd Hg Te APPLICATION AUX DISPOSITIFS A TRANSFERT DE CHARGE POUR IMAGERIE INFRAROUGE]
M. Sirieix, M. Garcia (Comm. a l'Energie Atomique, Grenoble), J. Farre (Lab. d'Automatique et d'Anal. des Systemes), and J. Simonne (Lab. d'Automatique et d'Anal. des Systemes). *In* AGARD Impact of Charge Coupled Devices and Surface Acoustic Wave Devices on Signal Process. and Imagery in Advanced Systems Jun. 1978 17 p. refs. In FRENCH (For primary document see N78-31279 22-31)
Avail. NTIS HC A21/MF A01

Elementary structural models of a matrice adapted to scanning by charge transfer are studied. This MIS element detects the infrared radiation and integrates created charges. These two functions lead to limitations that modify the conception of infrared systems. Performance predictions for the models were also made. The addressing and scanning modes of a bidimensional matrice are discussed. A comparison was made between charge injection devices and charge coupled devices, and possible choices for obtaining a true matrice was discussed. Transl. by B.B.

N78-31302# Rensselaer Polytechnic Inst., Troy, N. Y.
IRCCD IMAGING SENSORS: A REVIEW OF DEVICE OPTIONS
Andrew J. Steckl. *In* AGARD Impact of Charge Coupled Devices and Surface Acoustic Wave Devices on Signal Process. and Imagery in Advanced Systems Jun. 1978 15 p. refs (For primary document see N78-31279 22-31)
Avail: NTIS HC A21/MF A01

A review is presented of the many device options investigated for the development of integrated infrared focal plane arrays. With only one or two exceptions, the approaches developed are centered on the charge coupled device (CCD) concept or its close relative, the charge injection device (CID). Monolithic and hybrid IRCCD and IRCID device options are classified, discussed and compared. B.B.

N78-31303# Reticon Corp., Sunnyvale, Calif.
CCPD: THE OPTIMUM SOLID-STATE LINE SCANNER
Hsin-Fu Tseng and Gene P. Weckler. *In* AGARD Impact of Charge Coupled Devices and Surface Acoustic Wave Devices on Signal Process. and Imagery in Advanced Systems Jun. 1978 12 p. refs (For primary document see N78-31279 22-31)
Avail: NTIS HC A21/MF A01

Optimized solid state line scanners were developed and described. They offer many advantages for applications requiring high sensitivity, low noise, and spectral purity. Photodiodes are employed as the detector elements, thus assuring maximum quantum efficiency and a broad, smooth spectral response, both characteristic of a good silicon photodiode. A charge-transfer device is used to provide the low noise readout. The combination of photodiodes and analog shift register results in the optimum solid state line scanner. In addition, these devices contain antiblooming circuitry as well as output buffer amplifiers. B.B.

N78-31304# Compagnie Generale de Telegraphie sans Fil, Paris (France). Div. des Activities Sous-Marines Chemin des Travails
READING AND ACOUSTIC PROCESSING OF OPTICAL IMAGES [LECTURE ET TRAITEMENT ACOUSTIQUES D'IMAGES OPTIQUES]
H. Gautier, C. Maerfeld, and P. Tournois. *In* AGARD Impact of Charge Coupled Devices and Surface Acoustic Wave Devices on Signal Process. and Imagery in Advanced Systems Jun. 1978 11 p. refs. In FRENCH (For primary document see N78-31279 22-31)
Avail: NTIS HC A21/MF A01

The geometry of devices utilized in optical image readings as well as operation principles are summarized. It was shown how these devices effect the direct reading of an image. The benefits of the phenomena of photon integration under conditions of sensor arrangement in a network of integrated diodes was reviewed. The systems that utilize these networks were studied in detail due to the fact that they demonstrate the highest sensitivity. Various other proposals for image reading were also included. Transl. by B.B.

N78-31305# Army Electronics Command, Fort Monmouth, N. J.
APPLICATIONS OF A CHARGE COUPLED DEVICE SENSOR FOR NAP-OF-THE-EARTH HELICOPTER OPERATIONS
A. Kleider. *In* AGARD Impact of Charge Coupled Devices and Surface Acoustic Wave Devices on Signal Process. and Imagery in Advanced Systems Jun. 1978 16 p. refs (For primary document see N78-31279 22-31)
Avail: NTIS HC A21/MF A01

The geometric characteristic of a wire obstacle was conceptually integrated with the discrete elemental structure of a charge couple device (CCD). This quantized detector structure provides a means for formulating a wire obstacle warning system (WOWS) *utilizing advances in technology to arrive at a low cost system* for use by helicopters flying Nap-of-the-Earth (NOE). The WOWS employs a CCD detector array and other monolithic semiconductor devices to achieve small size, lightweight, and low cost. The video information is logically processed to provide a symbolic display of the range and location of the wire obstacle relative to the aircraft heading as well as an audio visual alarm for the pilot. The concept of single site activation (SSA) provides a means of achieving wire pattern recognition which removes the requirement of having a human observer in the detection recognition loops. B.B.

N78-31306# Plessey Radar Ltd., Havant (England)
A CCD DIGITAL IMAGE STORE
D. M. Balston and P. R. Samways. *In* AGARD Impact of Charge Coupled Devices and Surface Acoustic Wave Devices on Signal Process. and Imagery in Advanced Systems Jun. 1978 9 p. refs (For primary document see N78-31279 22-31)
Avail: NTIS HC A21/MF A01

A digital image store, based on CCD technology designed for an image processing system is described. The processing system, termed IDP 3000, was introduced to fulfill a requirement in the field of Earth Resource Surveying and the design of the *store reflects the requirements of the specific area application.* The requirements were introduced and the specific solution adopted is described. Particular attention is paid to the relationship with a standard 625 line TV signal. Each function available in the store is discussed and the method of implementation is summarized. An indication of the reliability of the store was given as well as a description of its application to simulator development. B.B.

N78-31307# AEG-Telefunken, Ulm (West Germany)
A CCD MEMORY CHIP FOR RADAR IMAGE PROCESSING
K. Rodde, E. Stein, and H.-J. Wulf. *In* AGARD Impact of Charge Coupled Devices and Surface Acoustic Wave Devices on Signal Process. and Imagery in Advanced Systems Jun. 1978 10 p. refs. Sponsored by the Federal Ministry of Research and Technology, the Federal Republic of Germany (For primary document see N78-31279 22-31)
Avail: NTIS HC A21/MF A01

Considerations for the design of a digital CCD memory are discussed. Starting from commercial CCD devices, the design

characteristics of a second generation CCD were derived. The economically feasible capacity and its dependency on the technology lead to the definition of performance parameters and the chip organization. A SPS organization was found most suitable and design considerations of SPS blocks are summarized. The overal design of a 32 kbit CCD is described. B.B.

N78-31308# Carleton Univ., Ottawa (Ontario).
ELECTRO-OPTICAL PROCESSING OF SIGNALS AND IMAGES

D. Roy, M. A. Copeland and C. H. Chan. *In* AGARD Impact of Charge Coupled Devices and Surface Acoustic Wave Devices on Signal Process and Imagery in Advanced Systems. Jun. 1978. 9 p. refs (For primary document see N78-31279 22-31)
Avail: NTIS HC A21/MF A01

The use of an LED/CCD structure to perform transversal filtering of electrical signals was demonstrated. The action of convolution is achieved by progressive summation as against the simultaneous summation of tap weighted signal samples as in the split electrode CCD filter. Summation is done in a given CCD potential well as it is first created and then progressively clocked to the output end of the device. The multiplications necessary in a convolution operation are obtained by means of an optical mask which controls the amount of light from a signal modulated LED reaching the various CCD electrodes. The two types of processing are described and experimental results are given. Discussions on performance limitations were also included. B.B.

N78-31309# General Electric Co., Schenectady, N. Y.
CHARGE INJECTION DEVICE (CID) HADAMARD PLANE PROCESSOR FOR IMAGE BANDWIDTH COMPRESSION

G. J. Michon, H. K. Burke, T. L. Vogeloong, and P. A. Merola. *In* AGARD Impact of Charge Coupled Devices and Surface Acoustic Wave Devices on Signal Process and Imagery in Advanced Systems. Jun. 1978. 5 p. Sponsored by AFAL, Wright-Patterson Air Force Base, Ohio (For primary document see N78-31279 22-31)
Avail: NTIS HC A21/MF A01

A charge injection device (CID) solid state video sensor capable of producing a Hadamard transform of the incident optical image was developed. The device can be operated so as to produce a normal video signal. In a second mode, the device produces four 1x4 Hadamard transforms in parallel. Minimal off-chip hardware is required to produce a 4x4 two-dimensional transform. This approach offers an opportunity to reduce the size and power requirements of on-board electronics in mini-RPV and guided weapon antijam video data link applications by performing the Transform processing function of the airborne encoderer directly on the image plane. Performance of the device was verified by completing the two dimensional transform of various images, performing the inverse transform, and displaying the resultant images. B.B.

N78-31310# Bell-Northern Research Ltd., Ottawa (Ontario).
A HIGH PERFORMANCE CCD LINEAR IMAGING ARRAY

A. A. Ibrahim, J. J. White, K. G. McQuhae, K. Y. Yu, D. Gallant, W. C. Bradley (Itek Corp., Lexington, Mass.), and D. W. Colvin (Itek Corp., Lexington, Mass.). *In* AGARD Impact of Charge Coupled Devices and Surface Acoustic Wave Devices on Signal Process. and Imagery in Advanced Systems. Jun. 1978. 10 p. (For primary document see N78-31279 22-31)
Avail: NTIS HC A21/MF A01

The development of high performance CCD linear images was highlighted. The imager was fabricated with two level polysilicon buried channel CCD process. Photocharge collected in the odd and even sensors are read out via two serial shift registers which are clocked synchronously. The novel design technique involved in synchronized clocking systems is described. Test results are described and include noise spectral density, MIF curves and transfer efficiency measurements. The measurement of noise performance shows considerable improvement in comparison to similar available images. Pictures taken using the imagers are shown. B.B.

N78-31311# Microwave and Electronic Systems Ltd., Newbridge (Scotland).
DEVELOPMENT AND APPLICATION OF A SAW CHIRP-Z TRANSFORMER

M. B. N. Butler. *In* AGARD Impact of Charge Coupled devices and Surface Acoustic Wave Devices on Signal Process. and Imagery in Advanced Systems. Jun. 1978. 10 p. refs. Sponsored in part by the Ministry of Defense (For primary document see N78-31279 22-31)
Avail: NTIS HC A21/MF A01

A development is reported in which the Chirp-z transform algorithm is truncated to perform spectral amplitude analysis. The basic process is described in relation to a unit giving in excess of one hundred resolved spectral lines with a resolution of 50kHz and a total processing time of 50 microseconds per data set. The displayed spectrum covers a dynamic range in excess of 36db (six bits) essentially linearly and without process induced spurious signals. The distinct applications of the unit are considered to a coherent microwave radar in which Doppler spectral analysis is employed and to signal analysis in a 10 micron wavelength laser wind velocity equipment. In both applications the high speed of the unit has proved to be particularly significant. B.B.

N78-31312# Raytheon Co., Bedford, Mass. Missile Systems Div.
THE CHIRP Z TRANSFORM WITH CCD AND SAW TECHNOLOGY

D. MacFall, J. Collins, Sclarretta, and A. Cappon. *In* AGARD Impact of Charge Coupled Devices and Surface Acoustic Wave Devices on Signal Process. and Imagery in Advanced Systems. Jun. 1978. 13 p. refs (For primary document see N78-31279 22-31)
Avail: NTIS HC A21/MF A01

The Chirp Z transform (CZT) is presented as an IF process that makes use of time compression and chirp pulse compression. This allows sampled signals to be stored in CCD memory for milliseconds or more, and Z transformed by the chirp filter in microseconds. A CZT spectrum analyzer therefore has extremely high throughput and the capability to process many channels with one processing element. Some applications require both magnitude and phase information. Configurations that achieve a linear complex output by removal of residual quadratic phase is shown, resulting in sidelobe levels that are independent of transform size. B.B.

N78-31313*# Texas Instruments, Inc., Dallas.
SPECTRAL ANALYSIS USING THE CCD CHIRP Z-TRANSFORM

W. L. Eversole, D. J. Mayer, P. W. Bosshart, M. Dewit, C. R. Howes, and D. D. Buss. *In* AGARD Impact of Charge Coupled Devices and Surface Acoustic Wave Devices on Signal Process. and Imagery in Advanced Systems. Jun. 1978. 19 p. refs (For primary document see N78-31279 22-31)
(Contract NAS1-14290, DAAB07-76-C-1386)
Avail: NTIS HC A21/MF A01

The charge coupled device (CCD) Chirp Z transformation (CZT) spectral analysis techniques were reviewed and results on state-of-the-art CCD CZT technology are presented. The CZT algorithm was examined and the advantages of CCD implementation are discussed. The sliding CZT which is useful in many spectral analysis applications is described, and the performance limitations of the CZT are studied. B.B.

N78-31314# Thomson-CSF, Malakoff (France).
APPLICATIONS OF PIEZOELECTRIC CONVOLUTERS TO RADAR SIGNAL PROCESSING [APPLICATIONS D'UN CONVOLUTEUR PIEZOELECTRIQUE AU TRAITEMENT DU SIGNAL RADAR]

P. Anthoward and T. Beauvais. *In* AGARD Impact of Charge Coupled Devices and Surface Acoustic Wave Devices on Signal Process and Imagery in Advanced Systems. Jun. 1978. 17 p. refs. In FRENCH (For primary document see N78-31279 22-31)
Avail: NTIS HC A21/MF A01

Piezoelectric convoluters are described along with relative interfaces. Examples of convoluter relationships with radar processing lines such as time of arrival measurement and signal identification, and processing of an outlet for a lateral synthetic radar antenna are given. Emphasis was placed on a comparison made between acoustic and numerical processing.
Transl. by B.B.

N78-31315# Lincoln Lab., Mass. Inst. of Tech., Lexington.
OPERATION OF SAW REFLECTIVE ARRAY PULSE COMPRESSORS IN A HIGH PERFORMANCE RADAR WITH MINUS 0.4 METER RANGE RESOLUTION

W. J. Ince, S. C. Cottrill (RCA, Marshall Islands), and P. Gelzinis (RCA, Marshall Islands). *In* AGARD Impact of Charge Coupled

Devices and Surface Acoustic Wave Devices on Signal Process. and Imagery in Advanced Systems Jun. 1978 16 p refs Sponsored in part by the US Army (For primary document see N78-31279 22-31)
(Contract F19628-76-C-002)
Avail: NTIS HC A21/MF A01

The application of L-band reflective array pulse compression devices with a time-bandwidth product of 5120 to a high resolution radar is described. This is believed to be the largest time bandwidth product for any reflective array compressor (RAC) in an operational system. The subject radar is the ALCOE, which is a C-band instrumentation tracking radar designed to provide precision trajectory and signature information on space vehicles. In its waveform inventory ALCOR has a wideband operating mode with a 512-MHz instantaneous bandwidth (0.4 meter range resolution) that permits resolution of the individual scattering centers of a target. Author

N78-31316# Southampton Univ. (England).
A NOVEL SIGNAL INTEGRATOR USING CCDs
C. P. Trayner, P. C. T. Roberts, R. G. Taylor (Admiralty Surface Weapons Establishment, Portsmouth, Engl.), J. D. E. Beynon, and G. G. Bloodworth *In* AGARD Impact of Charge Coupled Devices and Surface Acoustic Wave Devices on Signal Process. and Imagery in Advanced Systems Jun. 1978 12 p refs Sponsored by Ministry of Defense (For primary document see N78-31279 22-31)
Avail: NTIS HC A21/MF A01

The implementation of two types of CCD signal integrator using nonrecursive and recursive integration is described. In order to minimize the effects of transfer inefficiency, a parallel transfer scheme is employed in which information is sequentially gated into storage areas with an on chip tapped CCD register. Test devices are described that were used to investigate the proposed implementations and, in particular, the on chip addressing scheme. The results presented demonstrate the feasibility of the techniques and also show good agreement with the predicted performance. The data obtained from the test devices enabled a modified integrator to be designed, incorporating several improvements which are also described. B.B.

N78-31317# Thomson-CSF, Bagneux (France).
CCD DELAY LINES FOR THE PROCESSING OF A RADAR SIGNAL: APPLICATION TO AN MTI [LIGNE A RETARD DUTYPE CCD POUR TRAITEMENT DU SIGNAL RADAR APPLICATION A UN MTI]
J. L. Berger, D. Reneric (STTA, Paris), and R. Vanhove *In* AGARD Impact of Charge Coupled Devices and Surface Acoustic Wave Devices on Signal Process. and Imagery in Advanced Systems Jun. 1978 23 p refs (For primary document see N78-31279 22-31)
Avail: NTIS HC A21/MF A01

A delay line composed of two registers of 512 stages is described as well as the performance reliability of linear and dynamic transfer. A preliminary study of the filter properties for a moving target indicator is presented. Performance levels achieved with delay lines with 256 stages, circuits associated with delay lines necessary to compensate for the limits of charge coupled devices and temperature problems are also summarized.
Transl. by B.B.

N78-31318# Standard Telecommunication Labs. Ltd., Harlow (England).
A CCD DELAY LINE DOPPLER ANALYSER
J. D. Jackson, G. R. Adams, and J. S. Heeks *In* AGARD Impact of Charge Coupled Devices and Surface Acoustic Wave Devices on Signal Process. and Imagery in Advanced Systems Jun. 1978 8 p refs (For primary document see N78-31279 22-31)
Avail: NTIS HC A21/MF A01

A CCD spectrum analyzing filter which is compatible with the real time processing of Doppler radar signals is reported. The scheme is based on the coherent memory filter (CMF) principle and has the feature of a simple delay line. Experimental results are presented for a prototype system providing a 50-point transform and performance limits as determined by the fundamental parameters of the CCD. In an extension of the approach it is proposed to interface the analyzer with an analogue tapped delay line in order to effect both range and Doppler processing.
B.B.

N78-31319# Kaiserslautern Univ. (West Germany).
COMBINED ACQUISITION AND FINE SYNCHRONIZATION SYSTEM FOR SPREAD SPECTRUM RECEIVERS USING A TAPPED DELAY LINE CORRELATOR
W. P. Baier, M. Pandit, and H. Grammuller (Siemens AG, Munich) *In* AGARD Impact of Charge Coupled Devices and Surface Acoustic Wave Devices on Signal Process. and Imagery in Advanced Systems Jun. 1978 12 p refs (For primary document see N78-31279 22-31)
Avail: NTIS HC A21/MF A01

In direct sequencing spread spectrum communications systems a local PN generator must be synchronized with the PN code contained in the incoming signal at the receiver. A method of using a tapped delay line correlator not only for acquisition but also for tracking is presented. At the outset PN clock generators of high inherent stability and low relative drift at the transmitter and receiver are employed. The correlation peaks at the output of the tapped delay line correlator are used to set the receiver PN generator in phase with the received PN code. During the intervals of time between the correlation peaks the local PN generator runs freely. A system including the hardware realization based on this principle is presented. The salient theoretical results were checked by measurements. B.B.

N79-18094# Advisory Group for Aerospace Research and Development, Neuilly-Sur Seine (France).
OPERATIONAL MODELLING OF THE AEROSPACE PROPAGATION ENVIRONMENT, VOLUME 1 AND 2
Haim Soicher, ed. (Army Commun. Res. and Develop. Command) Nov. 1978 690 p refs In ENGLISH and FRENCH Meeting held at Ottawa, 24-28 Apr. 1978
(AGARD-CP-238 Vol. 1 AGARD-CP-238-Vol-2.
ISBN-92-835-0224-8) Avail: NTIS HC A99/MF A01

Prediction of ionospheric variability and response to natural disturbances is considered in terms of radio wave propagation through the ionosphere. Specific topics covered include the ionospheric environment, short and long term effects for high frequency radio communications, transionospheric propagation, solar terrestrial effects, the optical/infrared environment, tropospheric turbulence, and EHF propagation. For individual titles see N79-18095 through N79-18145.

N79-18095# National Oceanic and Atmospheric Administration, Boulder, Colo. Space Environment Lab.
IONOSPHERIC PREDICTION AND EXTRAPOLATION
Kenneth Davies *In* AGARD Operational Modelling of the Aerospace Propagation Environ. Vol. 1 and 2 Nov. 1978 19 p refs (For primary document see N79-18094 09-31)
Avail: NTIS HC A99/MF A01

Long term ionospheric predictions required for the design of radio circuits, selection of radio frequencies, power requirements, and antenna design and short term ionospheric predictions (forecasts) intended for use of station operators are discussed. It is shown that ionospheric prediction systems are adequate for the long term planning of frequency allocation on an international basis, and for the design of many long distance communications circuits on high frequencies as well as broad planning of navigation systems on very low frequencies and the design of broadcasting services on medium frequencies. Short term predictions are shown to be inadequate. Improved forecast services for civilian and military communicators are recommended in order to provide for alternative means of communication, to initiate or delay rescue operations, and to inform users of the cause of their transmission problems. J.M.S.

N79-18096# Air Force Global Weather Central, Offutt AFB, Nebraska
USER REQUIREMENTS OF AEROSPACE PROPAGATION ENVIRONMENT MODELLING AND FORECASTING
Richard L. Thompson *In* AGARD Operational Modelling of the Aerospace Propagation Environ., Vol. 1 and 2 Nov. 1978 7 p refs (For primary document see N79-18094 09-31)
Avail: NTIS HC A99/MF A01

Space environment forecasting activities of the Space Environmental Support System (SESS) of the Air Weather Service (AWS) are described including: (1) forecasting and specification of ionospheric variability; (2) forecasting and specification of solar flare and solar particle events; and (3) providing geomagnetic and solar indices to users for determining density variability. Customer requirements for support include forecasts with lead times ranging from hours to months, real-time notification of solar and geophysical events within minutes, forecasts tailored to specific user requirements, and detailed post-analysis studies. Specification and prediction models currently in operational use, the worldwide solar and geophysical observing network, and the

data handling and processing system are described. The development and present status of operational forecasting and skills in the areas of High Frequency propagation, vertical electron density profiles, total electron content, solar and geophysical indices, and solar radiation are discussed. Future military applications and use of space environment support are also discussed along with selected technologically deficient areas.
J.M.S.

N79-18097# Naval Ocean Systems Center, San Diego, Calif. EM Propagation Div.
REAL-TIME PROPAGATION ASSESSMENT
Ilan J. Rothmuller. *In* AGARD, Operational Modelling of the Aerospace Propagation Environ., Vol. 1 and 2, Nov. 1978, 9 p, refs. (For primary document see N79-18094 09-31)
Avail: NTIS, HC A99/MF A01

An environmental prediction and assessment system (EPAS), comprised of a variety of real t... sources of solar/geophysical data and a center which collects, processes, and selectively disseminates these data to regional propagation assessment terminals is described. Operational environmental models used in PROPHET, a real time assessment terminal, and PROPHET products are discussed. Results of testing the terminal and the EPAS concept in an operational environment are included.
J.M.S.

N79-18098# Norwegian Defence Research Establishment, Kjeller.
GEOPHYSICAL DISTURBANCE EFFECTS AND THEIR PREDICTABILITY
E. V. Thrane. *In* AGARD, Operational Modelling of the Aerospace Propagation Environ., Vol. 1 and 2, Nov. 1978, 18 p, refs. (For primary document see N79-18094 09-31)
Avail: NTIS, HC A99/MF A01

Different types of disturbances in the upper atmosphere which change its properties as a propagation medium for electromagnetic waves are reviewed. The possibility of predicting not their actual occurrence, but rather their effect on the atmosphere once they have occurred, is discussed. The review is based upon current knowledge of ionospheric and upper atmosphere physics, and concentrates on effects of importance to radio wave propagation. Both natural phenomena, such as magnetic storms, and man made disturbances are discussed.
J.M.S.

N79-18099*# Pennsylvania State Univ., University Park. Ionosphere Research Lab.
OPERATIONAL PHYSICAL MODELS OF THE IONOSPHERE
John S. Nisbet. *In* AGARD, Operational Modelling of the Aerospace Propagation Environ., Vol. 1 and 2, Nov. 1978, 6 p, refs. (For primary document see N79-18094 09-31)
(Grant: NGL-39-009-003)
Avail: NTIS, HC A99/MF A01, CSCL 04A

Global models of the neutral constituents are considered relevant to ion density models and improved knowledge of the ion chemistry. Information provided on the pressure gradients that control the wind system and the electric field systems due to balloon, satellite, and incoherent scatter measurements is discussed along with the implication of these results to the development of global ionospheric models. The current state of knowledge of the factors controlling the large day to day variations in the ionosphere and possible approaches for operational models are reviewed.
J.M.S.

N79-18100# Institut fuer Physikalische Weltraumforshung, Freiburg (West Germany).
INTENTIONS AND BUILD-UP OF THE INTERNATIONAL REFERENCE IONOSPHERE
K. Rawer, D. Bilitza, S. Ramakrishnan, and N. Sheikh. *In* AGARD, Operational Modelling of the Aerospace Propagation Environ., Vol. 1 and 2, Nov. 1978, 10 p, refs. (For primary document see N79-18094 09-31)
Avail: NTIS, HC A99/MF A01

The International Reference Ionosphere (IRI), a descriptive empirical model of the ionosphere, is discussed. The model describes the four plasma parameters, electron (plasma) density, electron and ion temperature, and ion composition. Geographic variations are indicated for the electron density profiles. The IRI is based on satellite observations rather than aeronomic theory.
J.M.S.

N79-18101# Stanford Univ., Calif. Radioscience Lab.
MODELING OF VLF DUCTS IN THE PLASMASPHERE
P. A. Bernhardt and C. G. Park. *In* AGARD, Operational Modelling of the Aerospace Propagation Environ., Vol. 1 and 2, Nov. 1978, 13 p, refs. (For primary document see N79-18094 09-31)
(Contract N00014-76-C-0689, Grant NSF ATM-74-20084)
Avail: NTIS, HC A99/MF A01

Numerical simulations of the ionosphere and protonsphere used to investigate diurnal and seasonal variations in magnetospheric plasma density enhancements capable of ducting VLF (whistler-mode) radio waves are described. It is shown that during winter and equinoxes, VLF ducts may extend down to 3000 km altitude at night, but usually terminate above 1800 km during the day. In summer, ducts terminate above 1000 km altitude at all local times. The duct termination height affects the angle-of-arrival, and the signal strength of whistler-mode waves received on the ground.
J.M.S.

N79-18102# Mitre Corp., Bedford, Mass.
SATELLITE-REFERENCE IONOSPHERIC PROPAGATION CORRECTION FOR USAF SPACETRACK RADARS
Nicholas M. Tomljanovich and Richard J. Long. *In* AGARD, Operational Modelling of the Aerospace Propagation Environ., Vol. 1 and 2, Nov. 1978, 12 p, refs. Sponsored by AFSC (For primary document see N79-18094 09-31)
Avail: NTIS, HC A99/MF A01

The tracking accuracy of space surveillance radars is limited by ionospheric propagation effects. Available correction procedures based on predictions from the monthly behavior of the ionosphere are inadequate to account for its short-term variability. A technique using Navy Navigation Satellite System (NNSS or TRANSIT) signals in near-real time to determine the actual short term behavior of the ionosphere was developed to support U.S. SPACETRACK radars. Since the existing constellation of 5 TRANSIT satellites provides worldwide coverage, ionosphere propagation errors for any UHF radar can easily be compensated with the correction technique using an off-the-shelf NNSS receiver and a minicomputer. A discussion of the concepts and implementation of the TRANSIT referenced correction technique are presented, followed by test results which show potential for a factor of 4 improvement over monthly average predictions. Results of tests conducted with an operational radar at a high latitude site during the summer of 1977 are also presented.
J.M.S.

N79-18103*# National Aeronautics and Space Administration, Goddard Space Flight Center, Greenbelt, Md.
IONOSPHERIC RANGE RATE EFFECTS IN SATELLITE-TO-SATELLITE TRACKING
Rodney B. Bent, Judy R. Lipofsky, Sigrid K. Llewellyn, and Paul E. Schmid. *In* AGARD, Operational Modelling of the Aerospace Propagation Environ., Vol. 1 and 2, Nov. 1978, 15 p, refs. *Prepared in cooperation with Atlantic Sci. Corp., Indialantic, Fla.* (For primary document see N79-18094 09-31)
(Contract NAS5-23899)
Avail: NTIS, HC A99/MF A01, CSCL 20N

Ionospheric range and range rate corrections in satellite-to-satellite tracking were investigated and the magnitude of errors that have to be considered for communications between satellites and related experiments was defined. The major causes of the sudden and sometimes large variations apparent in the ionospheric range and range rate corrections along the satellite arc are the geometric effects of the raypath and the curved ionosphere and the localized perturbations in electron density along the satellite to satellite line of sight. Ionospheric tracking errors are greatly effected by the following parameters, whose influence was thoroughly investigated: satellite height, height of maximum electron density, localized ionospheric perturbations and gradients, and electron density variations with diurnal, day-to-day, seasonal and solar cycle patterns. The results point to the need of using a sophisticated modeling approach incorporating daily solar data and where possible actual ionospheric measurements as update information. Simulations were performed for satellites at various heights, Apollo, Geos and Nimbus tracked by ATS-6, and in two different geometric configurations, coplanar and perpendicular orbits.
J.M.S.

N79-18104# Appleton Lab., Slough (England).
DEVELOPMENTS IN TECHNIQUES FOR PREDICTING HF SKY WAVE FIELD STRENGTHS
P. A. Bradley. *In* AGARD, Operational Modelling of the Aerospace Propagation Environ., Vol. 1 and 2, Nov. 1978, 12 p, refs. (For

primary document see N79-18094 09-31)
Avail: NTIS HC A99/MF A01

The roles of predictions in system planning, frequency management and frequency assignment are discussed. The need for a compromise between prediction complexity and accuracy is stressed with regard to available resources and uncertainties in current knowledge of the behavior of the ionosphere. It is concluded that no single prediction procedure can be optimum for all purposes. Alternative means of approach based on either an empirical fit to past measured field strength data or to allowances which take account of the separate physical factors known to be of importance are considered. Features of the latest prediction method of the CCIR are discussed and those areas where further studies are needed or improvements seem possible in the foreseeable future are examined. Consideration is given to models of the height distributions of electron concentration and methods of determining raypaths, the importance of ionospheric tilts and off-great circle propagation. Developments in the prediction of auroral absorption and of sporadic-E obscuration and reflection losses are described. The difficulties which are encountered for predictions at frequencies close to the maximum usable frequency are highlighted and the need for an above the MUF loss allowance is reviewed. Means of extending predictions to combine data for different propagation modes and to give assessments of the likelihood of multipath are also considered. J.M.S.

N79-18105# Directorate of Radio Technology, London (England)
STATISTICAL MODELLING OF HF LINKS
L. W. Barclay *In* AGARD Operational Modelling of the Aerospace Propagation Environ., Vol. 1 and 2 Nov. 1978 9 p refs (For primary document see N79-18094 09-31)
Avail: NTIS HC A99/MF A01

Prediction of the monthly median received signal/external noise ratio as a function of frequency and of the system characteristics is considered along with the prediction of the probability that a particular service grade will be achieved. Specific topics covered include: the upper frequency limit; signal to noise ratio; circuit reliability; time availability; service probability; long term probability; and multimode propagation. The value of probability predictions of circuit performance to the user is discussed. J.M.S.

N79-18106# Laboratoire d'Etude des Transmissions Ionospheriques, Cachan (France)
MODELING THE ATMOSPHERE IN PROBLEMS CONCERNING THE MANAGEMENT OF HF TRANSMISSION NETWORKS [MODELISATION DE L'IONOSPHERE DANS LES PROBLEMES DE GESTION DE RESEAUX DE TRANSMISSION HF]
C. Goutelard and J. Caratori *In* AGARD Operational Modelling of the Aerospace Propagation Environ., Vol. 1 and 2 Nov. 1978 24 p refs In FRENCH (For primary document see N79-18094 09-31)
Avail: NTIS HC A99/MF A01

Transmission parameters are determined by studying the relation between any two parts of a several thousand kilometer zone centered on a station. The method developed is based on the study of ionospheric models and takes into account the horizontal ionization gradients. The model chosen is discussed and compared with other models. Its use in measuring transmission parameters systematically is demonstrated. Measurements of so-called static parameters which permit determination of the parameters of an ionospheric model are discussed as well as the dynamic parameters which account for the speed of instantaneous variations. The combination of these measurements leads to a system of equations of state for the ionospheric model. The system of equations permits a mapping of propagation conditions at the interior of the zone and establishes predictions. The method is compared with other proposed methods; its limits are specified and its field of application is defined.
Transl. by A.R.H.

N79-18107# Max-Planck-Institut fuer Aeronomie, Katlenburg-Lindau (West Germany)
WINTER ANOMALY OF RADIO WAVE ABSORPTION AND D-REGION MODIFICATION
Hans-Ulrich Widdel *In* AGARD Operational Modelling of the Aerospace Propagation Environ., Vol. 1 and 2 Nov. 1978 18 p refs (For primary document see N79-18094 09-31)
Avail: NTIS HC A99/MF A01

Results of a quantitative investigation of winter anomalous radio wave absorption are discussed and causes of the phenomenon are suggested. A correlation analysis between local wind and radio wave absorption is presented along with a time history of the development of the winter anomalous state of the D region in terms of electron density profiles. Winter anomaly precursors and the parameter normalized absorption contribution are considered. The relationship between the normalized absorption contribution and the development of the winter anomalous state of the D region is discussed. J.M.S.

N79-18108# Max Planck-Institut fuer Aeronomie, Katlenburg-Lindau (West Germany)
VARIATION OF THE GREEN LINE OXYGEN AIRGLOW EMISSION RATE AS A PRECURSOR INDICATIVE OF WINTERTIME ABSORPTION ANOMALY OF HF RADIO WAVES
H. Lauche and G. Lange-Hesse *In* AGARD Operational Modelling of the Aerospace Propagation Environ., Vol. 1 and 2 Nov. 1978 5 p refs (For primary document see N79-18094 09-31)
Avail: NTIS HC A99/MF A01

Airglow emission of the E layer was observed from the ground at nighttime during the Winter Anomaly Campaign at Arenosillo, Spain, winter 1975/76. A comparison of these optical data with the HF waves ionospheric absorption values of the following day indicates that a special kind of variation of the airglow emission can be used as a precursor indicative for an increase of the ionospheric D region absorption on the following day. J.M.S.

N79-18109# Centre National d'Etudes des Telecommunications, Lannion (France)
CALCULATING THE MUF IN THE PRESENCE OF LARGE SCALE GRADIENTS [CALCUL DE LA MUF EN PRESENCE DE GRADIENTS DE GRANDE ECHELLE]
P. Gourvez and R. Hanbaba *In* AGARD Operational Modelling of the Aerospace Propagation Environ., Vol. 1 and 2 Nov. 1978 10 p refs In FRENCH (For primary document see N79-18094 09-31)
Avail: NTIS HC A99/MF A01

The extent to which large scale ionospheric gradients should be considered in computations for predicting the propagation of decametric waves is examined. The analytic method used consists of a rigorous calculation of the propagation across an ionosphere represented by a three dimensional model. Preliminary results concern high frequency propagation in the ionosphere at low magnetic latitudes.
Transl. by A.R.H.

N79-18110# Institute for Telecommunication Sciences, Boulder, Colo.
IONOSPHERIC PREDICTIONS: METHODS AND RESULTS
Charles M. Rush *In* AGARD Operational Modelling of the Aerospace Propagation Environ., Vol. 1 and 2 Nov. 1978 9 p refs (For primary document see N79-18094 09-31)
Avail: NTIS HC A99/MF A01

The techniques employed to forecast the ionosphere and radio propagation conditions on a short-term and long-term basis are described. These techniques range from the highly statistical approach such as given in CCIR REPORT 252-2 for estimating skywave field strength for radio waves at frequencies greater than 2.0 MHz to the application of basic physical principles to forecast the ionospheric response to a solar disturbance. The agreement between both short-term and long-term ionospheric prediction techniques with observations of various ionospheric/radio propagation parameters is described and methods for further improvement of the predictions are addressed. J.M.S.

N79-18111# Leicester Univ. (England). Dept. of Physics
REAL-TIME UPDATING OF MUF PREDICTIONS
T. B. Jones, C. T. Spracklen, and C. P. Stewart *In* AGARD Operational Modelling of the Aerospace Propagation Environ., Vol. 1 and 2 Nov. 1978 10 p refs (For primary document see N79-18094 09-31)
Avail: NTIS HC A99/MF A01

A real time prediction system which will update the prediction program according to the ionospheric conditions prevailing at the time when the MUF (or optimum working frequency) is requested is considered. A single station equipment is described which can evaluate the propagation conditions prevailing in a given region of the ionosphere and provide an

improved forecast for any particular path and frequency of interest J M S

N79-18112# Forschungsinstitut der Deutschen Bundespost Darmstadt (West Germany)

HF SHORT TERM FIELD STRENGTH PREDICTIONS AND THEIR AGREEMENT WITH OBSERVATIONS

Th Damboldt *In* AGARD Operational Modelling of the Aerospace Propagation Environ Vol 1 and 2 Nov 1978 12 p refs (For primary document see N79-18094 09-31)

Avail NTIS HC A99/MF A01

Daily HF field strength predictions for two European and three overseas paths based on solar-geophysical data, real time field strength measurements of distant HF-transmitters on 26 frequencies the geomagnetic variations indicated on a local magnetometer in real time the critical frequencies of the ionosonde at Lindau and solar observations from Wendelstein and geomagnetic observations from Wingst are discussed The distinctive feature of the predictions is that they are forecast in the form of a quality figure which is related to the daily expected field strength All paths are monitored on four or five frequencies and the daily quality figure for each path is obtained by calculating the mean of the 24 hourly values of the field strength of that frequency having the highest field strength for each of the individual hours This is done on the assumption that the optimum frequency would be used for communication This value does not agree with the mean of the field strength of the five frequencies *The quality figure in steps of* 0 1 (corresponding to 0 5 dB) is forecast for the above-mentioned 5 circuits on each workday before noon Reliability of the forecasts is considered J M S

N79-18113# Max-Planck Institut fuer Aeronomie Katlenburg-Lindau (West Germany)

MODELLING THE DIURNAL AND SEASONAL VARIATION OF MEDIUM SCALE TRAVELLING IONOSPHERIC DISTURBANCES

J Roettger *In* AGARD Operational Modelling of the Aerospace Propagation Environ Vol 1 and 2 Nov 1978 5 p refs (For primary document see N79-18094 09-31)

Avail NTIS HC A99/MF A01

The diurnal and seasonal variation of medium-scale traveling ionospheric disturbances (TID) observed in the equatorial region is Fourier analyzed The significant spectral components are used for modeling the occurrence of medium-scale TIDs The spatial resonance mechanism in the equatorial ionosphere can steepen the amplitudes of TIDs which then break up into ionospheric irregularities The nonlinear steepened TID pattern, giving rise to large-scale patches on the equatorial spread-F, is modeled by a Fourier series J M S

N79-18114# Air Force Geophysics Lab, Hanscom AFB, Mass

EQUATORIAL AND HIGH LATITUDE EMPIRICAL MODELS OF SCINTILLATION LEVELS

Jules Aarons, Eileen M MacKenzie (Emmanuel Coll), and Krishin Bhavnani (Logicon Inc Bedford Mass) *In* AGARD Operational Modelling of the Aerospace Propagation Environ Vol 1 and 2 Nov 1978 20 p refs (For primary document see N79-18094 09-31)

Avail NTIS HC A99/MF A01

By making measurements of scintillations from VHF and UHF beacons on synchronous satellites, it was possible to amass a data bank sufficient to obtain analytical models of average scintillation at high and equatorial latitudes The data base, obtained in collaborative studies with various observatories, consists of 15 minute scintillation indexes of 3 to 7 years of observations (differing for various stations) Observations were *made at Sagamore Hill, Massachusetts, Goose Bay Labrador* and Narssarssuaq, Greenland Equatorial data used was from Accra, Ghana and Huancayo, Peru For both high and equatorial latitudes forcing functions are time of day, day of the year, magnetic index and solar flux The resulting analytical models were validated with one additional set of data at sub-auroral and auroral latitudes but remain to be validated at equatorial latitudes J M S

N79-18115# Communications Research Centre Ottawa (Ontario) Dept of Communications

THE SEARCH AND RESCUE SATELLITE (SARSAT) SYSTEM PROJECT

H L Werstiuk and A E Winter *In* AGARD Operational Modelling *of the Aerospace Propagation Environ* Vol 1 and 2 Nov 1978 12 p refs (For primary document see N79 18094 09 31)

Avail NTIS HC A99/MF A01

The application of satellite technology as an aid to search and rescue (SAR) was studied The work included examination *of SAR requirements and the investigation of various system* concepts culminating in proof of concept experiments using the AMSAT *OSCAR satellites during 1975 and 1976 In the* experiments, signals from simulated Emergency Locator Transmitters (ELTs) were received by the polar orbiting OSCAR 6 satellite and relayed to a ground station at the Communications Research Centre (CRC) By the processing of Doppler information contained in this relayed signal, the position of the ELT could be determined with an accuracy of 5-15 km The experimental techniques and *earlier results obtained in the program are described* J M S

N79-18116# Communications Research Centre, Ottawa (Ontario) Dept of Communications

IONOSPHERIC EFFECTS ON THE DOPPLER FREQUENCY FOR A SEARCH AND RESCUE SATELLITE (SARSAT)

D B Muldrew and H G James *In* AGARD Operational Modelling of the Aerospace Propagation Environ Vol 1 and 2 Nov 1978 13 p refs (For primary document see N79 18094 09 31)

Avail NTIS HC A99/MF A01

The Doppler frequency shift of signals propagating from an Emergency Locator Transmitter (ELT) up to a search and rescue satellite (SARSAT) and down to a central station enables the *position of the ELT to be determined The Doppler frequency* shift is affected by the ionosphere Ionospheric effects are estimated for a proof-of concept SARSAT experiment using the AMSAT OSCAR-6 satellite and a central station at Ottawa For the downlink frequency of 30 MHz it is found that the daytime ionosphere with no horizontal gradients in electron density can change the Doppler frequency shift by a few hertz Horizontal gradients of electron density can have more effect on the Doppler frequency than the vertical distribution of density This is because the Doppler effect caused by the negative vertical density gradient in the topside ionosphere tends to cancel the Doppler effect caused by the positive gradient in the bottomside However, in the late afternoon, evening and nighttime large east-west troughs in the density distribution exist which can produce shifts of a few tens of hertz at 30 MHz J M S

N79-18117# Centre National d Etudes des Telecommunications, Lannion (France)

A STUDY OF IONOSPHERIC CONTENT AND SCINTILLATIONS RECEIVED FROM ATS-6 SIGNALS AT LANNION [ETUDE DU CONTENU PLASMAPHERIQUE ET DES SCINTILLATIONS A PARTIR DES SIGNAUX D'ATS-6 A LANNION]

R Eleury and J P Cornec *In* AGARD Operational Modelling of the Aerospace Propagation Environ Vol 1 and 2 Nov 1978 13 p refs In FRENCH, ENGLISH summary (For primary document see N79-18094 09-31)

Avail NTIS HC A99/MF A01

The amplitude and the phase of radio beacon signals received from ATS 6 were studied The ionospheric content and the total electron content are deduced respectively from measurements of Faraday rotation and group delay The plasmaspheric content is given by the subtraction of the former from the latter During magnetically quiet periods, the ratio N sub P/N sub T shows a nocturnal maximum, about 45-55 percent, and a daytime minimum at 10-15 percent The observations are fitted in an ionosphere-magnetosphere model The electronic density distribution is given in terms of the altitude for two seasons (winter and spring) Scintillations are more frequent and stronger in summer than in winter During summer they are also more frequent in daytime, *in connection with sporadic E-layers Finally, the dependence* of the index S4 on the frequency, the connection of scintillations with the magnetic activity and spread-F, and the recordings of isolated bubbles of irregularities are examined J M S

N79-18118# Centre National d'Etudes des Telecommunications, Lannion (France)

THE INFLUENCE OF THE IONOSPHERE ON THE PRECISION OF GEODETIC MEASUREMENTS OBTAINED BY ARTIFICIAL SATELLITE [INFLUENCE DE L'IONOSPHERE SUR LA PRECISION DES MESURES EN GEODESIE PAR SATELLITE ARTIFICIEL]

J Papet-Lepine *In* AGARD Operational Modelling of the Aerospace Propagation Environ Vol 1 and 2 Nov 1978 24 p *refs In FRENCH (For primary document see N79 18094 09-31)*

Avail NTIS HC A99/MF A01

The ionosphere can carry an error when a single radio frequency is used to determine the distance separating a satellite from an earth station at a given moment. Sometimes this error can be corrected by using ionospheric models and daily measurements of ionospheric parameters. No existing model is yet capable of attaining the exact precision required. However, the problem can be solved in real time by using the dispersive action of the ionosphere. By taking several judiciously chosen frequencies, and by combining the effects of each of them, a precision inferior to that required can be achieved. The orders of magnitude of residual errors caused by the ionosphere when at least two frequencies are used are discussed. Thus, it is assumed that errors of experimental measurements are of a magnitude very inferior to the precision required. Transl. by A.R.H.

N79-18119# Physical Dynamics, Inc., Bellvue, Wash.
A SIGNAL-STATISTICAL AND MORPHOLOGICAL MODEL OF IONOSPHERIC SCINTILLATION
E. J. Fremouw and C. L. Rino. *In* AGARD Operational Modelling of the Aerospace Propagation Environ., Vol. 1 and 2, Nov. 1978, 24 p, refs (For primary document see N79-18094 09-31)
(Contract F30602-75-C-0236, ARPA Order 2777)
Avail: NTIS HC A99/MF A01

A signal-statistical and morphological model of radio wave scintillation produced in the F layer was developed and committed to two user-oriented computer codes. The more extensive of the two codes, IONSCNT, contains a morphological model of irregular ionospheric structure and a two-component propagation routine that permits calculation of both focusing and diffractive scatter effects. The usual outputs of IONSCNT are first-order signal-statistical moments, including intensity and phase scintillation indexes. The auxiliary code, DIST, employs some of the results from IONSCNT as inputs and permits the user to calculate first-order probability distributions of phase and amplitude, including fade-margin curves. A second operation mode of IONSCNT permits calculation of second-order signal-statistical moments, namely the spatial and temporal autocorrelation functions for intensity and phase and the two-frequency correlation coefficient for intensity. The structural description included in IONSCNT is a three-dimensional statistical model that allows for elongation along the geomagnetic field and, in the case of irregularities poleward of the subauroral scintillation boundary, for elongation in a second dimension (along L shells). The spatial spectrum employed is a power law, having a one-dimensional form for electron density squared. Morphologically, the model is of average or representative conditions for a given latitude, time of day, season, and epoch of the solar cycle. J.M.S.

N79-18120# Army Communications Research and Development Command, Fort Monmouth, N.J.
CORRELATION AND PREDICTION OF TRANSIONOSPHERIC SIGNAL TIME DELAYS AT WIDELY SEPARATED LOCATIONS
Haim Soicher. *In* AGARD Operational Modelling of the Aerospace Propagation Environ., Vol. 1 and 2, Nov. 1978, 4 p, refs (For primary document see N79-18094 09-31)
Avail: NTIS HC A99/MF A01

Excess time delays of transionospheric radio signals introduce ranging errors in satellite navigation and radar systems, which are directly proportional to the total electron content (TEC) along the propagation path. Correlations of TEC values (based on linear regression analysis) at Fort Monmouth, NJ (40 18 N, 74 06 W), Richmond, FL (25 60 N, 80 40 W) are determined. The correlation analysis is performed at daily intervals for equinoctial and winter periods during the quiet phase of the solar cycle. Average regression lines obtained by the analysis are then used to try to determine TEC at Richmond, assuming the availability of TEC in Fort Monmouth. In most cases, the 'predicted' TEC was within one standard deviation of actual observed data. Author

N79-18121# National Oceanic and Atmospheric Administration, Boulder, Colo. Space Environment Lab.
SOLAR TERRESTRIAL ENVIRONMENT MONITORING AND FORECASTING AT THE NOAA, SPACE ENVIRONMENT LABORATORY, BOULDER, COLORADO
A. G. Jean, G. R. Heckman, and C. E. Hornback. *In* AGARD Operational Modelling of the Aerospace Propagation Environ., Vol. 1 and 2, Nov. 1978, 12 p, refs (For primary document see N79-18094 09-31)
Avail: NTIS HC A99/MF A01

A survey is given of the Space Environment Laboratory Data Acquisition and Display System (SELDADS) and of the forecasting and warning services provided by the Space Environment Services Center and the applications of these data to radio propagation in such areas as communications, navigation and surveillance. J.M.S.

N79-18122# Naval Research Lab., Washington, D.C. Center for Space Research
IONOSPHERIC DISTURBANCE FORECASTING THROUGH USE OF X-RAY AND EUV MEASUREMENTS FROM THE NRL SOLRAD SATELLITES
Robert W. Kreplin and Donald M. Horan. *In* AGARD Operational Modelling of the Aerospace Propagation Environ., Vol. 1 and 2, Nov. 1978, 14 p, refs (For primary document see N79-18094 09-31)
Avail: NTIS HC A99/MF A01

The spacecraft system, telemetry, and ground station which make possible real time dissemination of measurements of the temporal and spectral variability os solar X-ray, EUV, and particle emission for the prediction and assessment of ionospheric disturbances affecting military communications, surveillance, and navigation systems are described. The NRL developed X-ray sensors and data processing techniques are included. Applications of SOLRAD 2 measurements discussed include derivation of the solar X-ray spectral distribution, assessment of F region ionospheric disturbances, and prediction of periods of solar flare activity. J.M.S.

N79-18123*# Applied Physics Lab., Johns Hopkins Univ., Laurel, Md.
PREDICTION OF SOLAR ENERGETIC PARTICLE EVENT HISTORIES USING REAL-TIME PARTICLE AND SOLAR WIND MEASUREMENTS
E. C. Roelof and R. E. Gold. *In* AGARD Operational Modelling of the Aerospace Propagation Environ., Vol. 1 and 2, Nov. 1978, 13 p, refs, Sponsored in part by NASA and NSF (For primary document see N79-18094 09-31)
(Contracts AFGL-TR-76-0136, N00017-72-C-4401)
Avail: NTIS HC A99/MF A01 CSCL 03B

The comparatively well-ordered magnetic structure in the solar corona during the decline of Solar Cycle 20 revealed a characteristic dependence of solar energetic particle injection upon heliographic longitude. When analyzed using solar wind mapping of the large scale interplanetary magnetic field line connection from the corona to the Earth, particle fluxes display an approximately exponential dependence on heliographic longitude. Since variations in the solar wind velocity (and hence the coronal connection longitude) can severely distort the simple coronal injection profile, the use of real-time solar wind velocity measurements can be of great aid in predicting the decay of solar particle events. Although such exponential injection profiles are commonplace during 1973-1975, they have also been identified earlier in Solar Cycle 20, and hence this structure may be present during the rise and maximum of the cycle, but somewhat obscured by greater temporal variations in particle injection. J.M.S.

N79-18124*# Iowa Univ., Iowa City. Dept. of Physics and Astronomy
IPS ACTIVITY OBSERVED AS A PRECURSOR OF SOLAR INDUCED TERRESTRIAL ACTIVITY
W. M. Cronyn, S. D. Shawhan, J. J. Rickard, D. G. Mitchell, E. C. Roelof (APL, Laurel, Md.), and B. L. Gotwols (APL, Laurel, Md.). *In* AGARD Operational Modelling of the Aerospace Propagation Environ., Vol. 1 and 2, Nov. 1978, 17 p, refs (For primary document see N79-18094 09-31)
(Grant NGL-16-001-002, Contracts AFOSR NPP 75-157, N00017-72-c-4401, NOAA 04-3-022-289, Grant NSF ATM-73-06559)
Avail: NTIS HC A99/MF A01 CSCL 03B

A radio telescope designed to exploit the interplanetary scintillation (IPS) technique and locate, map, and track solar wind disturbances which result in geomagnetic disturbances, thereby providing a forecast capability, is described. Preliminary results from operation of the telescope include: (1) evidence for a precursor signal in the IPS activity with a 1-2 day lead time with respect to density enhancements which frequently give rise to geomagnetic activity; (2) detection of a spectral broadening signature which also serves as a precursor of geomagnetic activity; (3) out-of-the-ecliptic plasma density enhancements which were not detected by near-Earth, ecliptic plane spacecraft; (4) detection of 12 corotating density enhancements; (5) detection of over 80 sources which give detectable scintillation of which 45 have been used for detailed synoptic analysis and 9 for spectral analysis; and (6) measurement of 0-lag coefficient of 0.56 between density and IPS activity enhancements. J.M.S.

N79-18125# National Committee for Space Research, Haifa (Israel) Radio Observatory

PREDICTION OF GEOMAGNETIC DISTURBANCES BY INTERPLANETARY SCINTILLATION

Z Houminer *In* AGARD Operational Modelling of the Aerospace Propagation Environ Vol 1 and 2 Nov 1978 7 p refs (For primary document see N79-18094 09-31)

Avail NTIS HC A99/MF A01

Daily observations of the scintillation of a number of radio sources lying at widely separated positions are used to predict geomagnetic activity associated with large scale features of the solar wind By observing suitable sources lying to the east of the Sun it is possible to forecast up to six days in advance, geomagnetic storms associated with corotating solar wind streams Geomagnetic disturbances caused by interplanetary shock waves associated with solar flares may be predicted some 8 - 24 hours in advance, when using observations at UHF frequencies (300-400 Mhz) J.M.S

N79-18126*# Los Alamos Scientific Lab., N. Mex.

THE PREDICTION OF FAST STREAM FRONT ARRIVALS AT THE EARTH ON THE BASIS OF SOLAR WIND MEASUREMENTS AT SMALLER SOLAR DISTANCES

H Rosenbauer (Max-Planck-Inst fuer Aeronomie, Katlenburg-Lindau, W Ger.), R Schwenn (Max-Planck-Inst fuer Extraterrestrische Phys., Munich, W Ger.), and S J Bame *In* AGARD Operational Modelling of the Aerospace Propagation Environ., Vol 1 and 2 Nov 1978 5 p refs Sponsored by NASA and Ger Min for Res and Technol (For primary document see N79-18094 09-31)

Avail NTIS HC A99/MF A01 CSCL 03B

The problems involved in the prediction of the arrival of fast solar wind streams at the earth on the basis of measurements made by space probes in the region between 0.3 and 1 AU are discussed It is shown that arrival time predictions accurate to within a few hours that can be made at least as long as the large scale conditions on the Sun are relatively stationary as observed near the time of solar minimum However, the latitudinal extent of the respective high speed streams is found to be important for making quantitative predictions Coronal data sufficient for locating the sources of high speed streams can improve the precision of these predictions J.M.S.

N79-18127# Air Force Geophysics Lab., Hanscom AFB, Mass.

ATMOSPHERIC OPTICAL TRANSMISSION MODELLING AND PREDICTION SCHEMES

R. A. McClatchey and E. P Shettle *In* AGARD Operational Modelling of the Aerospace Propagation Environ., Vol. 1 and 2 Nov. 1978 24 p refs (For primary document see N79-18094 09-31)

Avail NTIS HC A99/MF A01

The optical modelling of the atmosphere requires a detailed knowledge of the physical and optical properties of the atmosphere including temperature, pressure and the distribution of molecules and aerosol contituents responsible for atmospheric extinction The major difficulty in dealing with the atmospheric aerosols is the large natural variability of their properties Work in modelling these properties is described The LOWTRAN code provides a moderately low spectral resolution atmospheric propagation model of both the atmospheric molecules and aerosols without extensive computer time Recent work in developing an atmospheric radiance version of LOWTRAN, and LASER which is a version of HITRAN including continuum absorption aerosol extinction is also discussed G.Y

N79-18128# Cologne Univ. (West Germany)

MODELLING THE TRANSFER OF RADIATION IN THE ATMOSPHERE

H J Jung, M Kerschgens, and E Raschke *In* AGARD Operational Modelling of the Aerospace Propagation Environ., Vol 1 and 2 Nov 1978 7 p refs (For primary document see N79-18094 09-31)

Avail NTIS HC A99/MF A01

The concept of radiative transfer is discussed by reference to computations of the radiative energy in the solar, infrared and microwave spectral range The radiation fields and spatial divergencies are dependent on the absorption, scattering and thermal emission by air molecules, aerosols, cloud and rain droplets Additional parameters which influence the radiation fields in the atmosphere are the reflection and emission properties of the ground G.Y

N79-18129# Elektronik-System G m b H., Munich (West Germany)

CALCULATION OF EXTINCTION AND SCATTERING IN THE WAVELENGTH RANGE 0.25 TO 15 MICRONS BY HYDROMETEORS AND FOR GENERAL GERMAN WEATHER SITUATIONS

W Eckl, H J Fluess, and H Hallwachs *In* AGARD Operational Modelling of the Aerospace Propagation Environ Vol 1 and 2 Nov 1978 10 p refs Prepared in cooperation with MBB, Munich, W Ger (For primary document see N79-18094 09-31)

Avail NTIS HC A99/MF A01

For system design and operational research purposes a computer program, KATTA, was written for the description of absorption and scattering of electromagnetic waves by hydrometeors (water droplets in rain, fog and clouds) The calculation is based upon the Mie theory and single scattering It is valid for Mie parameters up to 10,000 and includes the angular dependency of the scattering function The program is compatible with existing LOWTRAN codes For application of the integrated KATTA - LOWTRAN-code to European scenario detailed European atmospheric input data were used They contain statistical meteorological data and German significant weather map types including precipitation, fog and clouds The results show the variation of calculated atmospheric transmission for the different weather situation with and without precipitation G.Y

N79-18130# Cologne Univ (West Germany)

A BAROCLINIC MODEL FOR THE PREDICTION OF THE VERTICAL TEMPERATURE AND MOISTURE STRATIFICATION IN THE BAROCLINIC BOUNDARY LAYER

W Behnke *In* AGARD Operational Modelling of the Aerospace Propagation Environ., Vol 1 and 2 Nov 1978 7 p refs (For primary document see N79-18094 09-31)

Avail NTIS HC A99/MF A01

A baroclinic but otherwise horizontally homogeneous model of the planetary boundary layer, which considers instationarity, is used to compute the different influences of roughness and baroclinity on inversion height Computations are compared with the measurements of an acoustic echo sounder Author

N79-18131# Naval Research Lab., Washington, D. C.

A REVIEW OF THE NAVAL RESEARCH LABORATORY PROGRAM IN ATMOSPHERIC MEASUREMENTS AND APPLICATION TO MODELING: 1: PRECISION ATMOSPHERIC TRANSMISSION MEASUREMENTS AND MODEL COMPARISONS

J. A. Dowling, J. A. Curcio, S. T. Hanley, R. F. Horton, K. M. Haught, D. H. Garcia, A. Guttman, C. O. Gott, and W. L. Agambar *In* AGARD Operational Modelling of the Aerospace Propagation Environ., Vol 1 and 2 Nov 1978 4 p (For primary document see N79-18094 09-31)

Avail NTIS HC A99/MF A01

Extensive field measurements of atmospheric extinction at several infrared wavelengths were performed using procedures and facilities described in this paper Recent additions to these experiments include a high resolution Fourier transform spectrometer (FTS) and a gas filter correlation spectrometer (GFCS) which uses HDO as the filter gas The combination of laser extinction, FTS and GFCS measurements provide well characterized and precisely calibrated high resolution transmission spectra useful in comparisons to computational models Examples of comparisons between these data and line-by-line computer calculations for several spectral regions are presented and discussed G.Y

N79-18132# Naval Research Lab., Washington, D. C.

A REVIEW OF THE NAVAL RESEARCH LABORATORY PROGRAM IN ATMOSPHERIC MEASUREMENTS AND APPLICATION TO MODELING: 2: AEROSOL SIZE DISTRIBUTIONS FOR MODELING AND THE PREDICTION OF OPTICAL EXTINCTIONS

Gary L. Trusty and Thomas H. Cosden *In* AGARD Operational Modelling of the Aerospace Propagation Environ., Vol 1 and 2 Nov 1978 20 p refs (For primary document see N79-18094 09-31)

Avail NTIS HC A99/MF A01

In the winter of 1975 the Optical Radiation Branch of the Naval Research Laboratory was making outdoor, long-path, laser transmission measurements As part of that measurement program instruments were assembled which could monitor the aerosol that contributed to the laser extinction This paper gives a brief description of the resultant aerosol-monitoring mobile

laboratory in its present state of development and presents an overview of the many particle size distributions obtained in various locations in the last three years G Y

N79-18133# Army Electronics Research and Development Command, White Sands Missile Range, N Mex Atmospheric Sciences Lab

A MODELING PROGRAM FOR THE PREDICTION OF ATMOSPHERIC EFFECTS ON E-O SENSOR PERFORMANCE

Richard B Gomez *In* AGARD Operational Modelling of the Aerospace Propagation Environ., Vol 1 and 2 Nov 1978 12 p refs (For primary document see N79-18094 09-31)
Avail NTIS HC A99/MF A01

Both natural and battlefield induced adverse atmospheric conditions impose severe limitations on the performance and battlefield effectiveness of electro-optical (E-O) surveillance and weapons systems. There are limited programs in the U S and NATO which are addressing the effects of countermeasures (CM) smoke, natural atmospheric dust, fog, haze, rain and snow on E-O systems. The Atmospheric Sciences Laboratory has an ongoing atmospheric modelling program aimed at characterizing and predicting the effects of battlefield aerosols and gases on the effectiveness of E-O sensors. Details of this program and an overview of a supporting measurement work effort are described Author

N79-18134# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Oberpfaffenhofen (West Germany) Inst fuer Physik der Atmosphere

INTERPRETATION OF AIRBORNE MEASUREMENTS OF ATMOSPHERIC EXTINCTION AND IRRADIATING FLUXES IN GERMANY AND THE NETHERLANDS

H VonRedwitz, G H Ruppersberg, R Schellhase, and J Weidner *In* AGARD Operational Modelling of the Aerospace Propagation Environ Vol 1 and 2 Nov 1978 13 p refs (For primary document see N79-18094 09-31)
Avail NTIS HC A99/MF A01

In addition to the corresponding research in the OPAQUE (Optical Atmospheric Quantities in Europe) project the DFVLR (Deutsche Forschungs und versuchsanstalt Fur und Raumfahrt) carries out airborne measurements in the region between northern Germany, the Netherlands and southern Germany. Measuring flights are performed during a 2-year period at different times of the day for one week each month. The main attention therefore is set to interpretations in one hand standing in relation as close as possible to visibility problems in practice, and in the other hand allowing to be classified by meteorological routine parameters. Beside beam transmittance and path reflectance, the slant meteorological visibility range and in relation the slant detection range for visibility air to ground and ground to air seem to meet with this request under the prescribed conditions, as is shown in examples Author

N79-18135# Forschungsinstitut fuer Optik, Tiefbringen (West Germany)

THE INFLUENCE OF METEOROLOGICAL PARAMETERS ON ATMOSPHERIC TRANSMISSION AT 10.6 MICRONS (CO2-LASER RADIATION) AND 0.63 MICRONS (HeNe-LASER RADIATION) FROM MEASUREMENTS AND CALCULATIONS

J Abele, H Raidt, W Jessen, and R Kirschmer *In* AGARD Operational Modelling of the Aerospace Propagation Environ., Vol 1 and 2 Nov 1978 19 p refs (For primary document see N79-18094 09-31)
(Rept-1978/6) Avail NTIS HC A99/MF A01

Experimental and theoretical study on atmospheric transmission of HeNe and CO2 laser radiation in the photopic range is presented. A continuously operating transmissometer designed and developed in the institute measured the attenuation of the two wavelengths simultaneously and over a common path length. The laser transmissometer measurements in the photopic range were performed by commercial visibility meters. Results are compared with semiempirical formula, with deductions from Mie theory and with a model describing transmission through rain G Y

N79-18136# Naval Surface Weapons Center, White Oak, Md

ELECTRO-OPTICS SYSTEMS PERFORMANCE ANALYSIS IN SELECTED MARINE ENVIRONMENTS

Barry S Katz and Kenneth C Hepfer *In* AGARD Operational Modelling of the Aerospace Propagation Environ., Vol 1 and 2 Nov 1978 13 p refs (For primary document see N79-18094 09-31)
Avail NTIS HC A99/MF A01

In order to support electro-optics system planners, designers and users with probability of occurence information on surface marine propagation conditions, techniques were developed to convert large quantities of previously stored weather products to statistics of specific propagation parameters. Using a modified Monte Carlo approach that preserves correlations between meteorological parameters, these statistics are coupled to electro-optics system models in order to calculate the probability of performing various system tasks versus target range in a variety of marine locations. Optical systems in both visible and IR wavelength bands have been studied G Y

N79-18137# Aerospace Corp., Los Angeles, Calif

OPTICAL PHASE AND SCINTILLATION AT AMOS: COMPARISON BETWEEN OBSERVATION AND PREDICTION

H T Yura *In* AGARD Operational Modelling of the Aerospace Propagation Environ., Vol 1 and 2 Nov 1978 9 p refs (For primary document see N79-18094 09-31)
Avail NTIS HC A99/MF A01

Atmospheric turbulence has a significant impact on the performance of large aperture optical systems. A primary objective of an operational model of the aerospace propagation environment is to provide understanding for the system analyst to compute performance estimates under various operational conditions. To this end a comparison is presented between measured values of both stellar scintillation and optical phase coherence and the corresponding values predicted from a recent model of the atmospheric turbulence strength profile. Possible improvements with the turbulence model are discussed G Y

N79-18138# British Aerospace Dynamics Group, Bristol (England)

REAL TIME SIMULATION OF TURBULENT ATMOSPHERIC PROPAGATION

I D Lyow *In* AGARD Operational Modelling of the Aerospace Propagation Environ., Vol 1 and 2 Nov 1978 9 p (For primary document see N79-18094 09-31)
Avail NTIS HC A99/MF A01

Simulation of turbulent atmospheric propagation during the development of a tracker can reduce the amount of field trials necessary. A particular beacon/tracker system is described followed by the simulator requirement and its realization. The utilization of the simulator is described G Y

N79-18139# Rome Air Development Center, Griffiss AFB, N Y

TEMPERATURE TURBULENCE MEASUREMENTS AT AMOS

Donald W Hanson *In* AGARD Operational Modelling of the Aerospace Propagation Environ Vol 1 and 2 Nov 1978 7 p refs (For primary document see N79-18094 09-31)

Atmospheric temperature turbulence is created by random, small scale high frequency fluctuations in air. This turbulence degrades the performance of optical systems which image through the atmosphere. Extensive theory were developed which relates the propagation of light through the atmosphere to the temperature turbulence. Measurements of the temperature turbulence above Mount Haleakala on the island of Maui, Hawaii was made. The emphasis of these measurements was to measure vertical profiles of temperature turbulence, however the integrated value of the profiles was also measured. The measurement data was compared with existing models G Y

N79-18140# Institute for Telecommunication Sciences, Boulder, Colo

ATMOSPHERIC MEDIUM CHARACTERIZATION AND MODELLING OF EHF PROPAGATION IN AIR

H J Liebe and J D Hopponen (LMSC, Sunnyvale, Calif) *In* AGARD Operational Modelling of the Aerospace Propagation Environ., Vol 1 and 2 Nov 1978 19 p refs (For primary document see N79-18094 09-31)
Avail NTIS HC A99/MF A01

It is possible to predict the behavior of an EHF (frequencies up to 300 GHz) radio wave transversing a clear, inhomogeneous, nonturbulent atmosphere at various slant path angles theta. Molecular absorption spectra of major and minor air constituents cause frequency dependent signal attenuation, phase delay, ray bending, and medium noise. The interaction between radiation and air is expressed through a complex refractivity N. A tractable propagation model employs a spherically stratified atmosphere to be amenable to computer calculations of four integrals

cumulative attenuation, radio range, curved path length, and noise temperature due to upwelling and downwelling radiation. These integrals are evaluated by numerical integration applying the Romberg method to optimize computer time. Various aspects typical of EHF propagation are exemplified by results of specific cases. G.Y.

N79-18141# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (West Germany)

A COMPUTER MODEL DESCRIBING ATMOSPHERIC PROPAGATION OF MICROWAVES FROM 1 TO 300 GHz INCLUDING DETAILED ATMOSPHERIC CONDITIONS AND COMPARISON WITH EXPERIMENTAL DATA

H. J. Fluess *In* AGARD Operational Modelling of the Aerospace Propagation Environ., Vol. 1 and 2 Nov. 1978 15 p refs (For primary document see N79-18094 09-31)

Avail: NTIS HC A99/MF A01

For the frequency region from 1 to 300 GHz, a computer model was written describing the most important atmospheric effects on microwave propagation. The calculation of attenuation, scattering and refraction is based upon existing theoretical and experimental investigations and fundamental physical relations. Meteorological data evaluated from German significant weather map types were inserted into the model. These meteorological data include the probability of occurence, temperature, pressure and humidity profile, type and probability of precipitation and clouds. Based upon these data some basic results were obtained and compared with available data of the statistical US-model atmospheres. First results of experimental and theoretical propagation investigations are presented. G.Y.

N79-18142# Thomson-CSF, Levallois-Perret (France)

MODELLING TROPOSPHERIC CHANNEL DISTORTION [CARACTERISATION DE LA DISTORSION DU CANAL TROPOSPHERIQUE]

A. Marguinaud *In* AGARD Operational Modelling of the Aerospace Propagation Environ., Vol. 1 and 2 Nov. 1978 17 p refs In FRENCH (For primary document see N79-18094 09-31)

Avail: NTIS HC A99/MF A01

The preferred procedure for digital tropospheric scatter circuit at a frequency of 6 GHz is described. The experimental apparatus used permits time function measurements (100 times per second) of the atmospheric transfer function on the two channels of a diversified space. A second apparatus is used to obtain a rapid frequency sampling (8000 times per second) of the values of the amplitude and the delay of transmission. Measured values are registered on magnetic strips and processed by a computer. Measurements obtained over a period of approximately one year, at a distance of 140 km at 6 GHz on a 10 MHz band are summarized. In the case of numerical transmission assuming a distorted channel two procedures may be followed. The transfer function may be corrected and a demodulator adapted to a perfect channel used, or the signal received may be compared with different versions of estimated elementary signals after the signals have been demodulated. The second solution is always superior to the first because it takes into account the preceding and following signals. Transl. by A.R.H.

N79-18143# Institute for Telecommunication Sciences, Boulder, Colo. Office of Telecommunications

AEROSPACE PROPAGATION PREDICTION CAPABILITIES ASSOCIATED WITH THE IF-77 MODEL

M. E. Johnson and G. D. Gierhart *In* AGARD Operational Modelling of the Aerospace Propagation Environ., Vol. 1 and 2 Nov. 1978 14 p refs (For primary document see N79-18094 09-31)

Avail: NTIS HC A99/MF A01

The propagation model was incorporated into ten computer programs. These programs may be used to obtain a wide variety of computer-generated microfilm plots such as transmission loss versus path length and desired-to-undesired signal ratio at a receiving location versus the distance separating the desired and undesired transmitting facilities. Such capabilities are useful in estimating the service coverage of aerospace radio systems, and are currently being used to establish station separation requirements for VHF/UHF/SHF air navigation aids. This paper provides (1) a brief discussion of the IF-77 propagation model, (2) a summary of the prediction capabilities available, and (3) remarks concerning model validation work. G.Y.

N79-18144# Communications Research Centre, Ottawa (Ontario) Dept. of Communications

THE CRC VHF/UHF PROPAGATION PREDICTION PROGRAM: DESCRIPTION AND COMPARISON WITH FIELD-MEASUREMENTS

F. H. Palmer *In* AGARD Operational Modelling of the Aerospace Propagation Environ., Vol. 1 and 2 Nov. 1978 15 p refs (For primary document see N79-18094 09-31)

Avail: NTIS HC A99/MF A01

A computer-based propagation prediction program was developed which provides an accurate, easy-to-use means of predicting coverage areas for VHF and UHF systems, for the planning of radio links, both terrestrial and air/ground, and for use in electromagnetic compatibility analysis problems. A topographic data base enables detailed path-loss or field-strength calculations to be carried out in the Ottawa area by users who need only specify the transmitter and receiver parameters and define the area in which results are required. This data base can be extended to other areas of Canada. Comparisons of predictions with measured values of path-loss show that the detailed method of prediction is significantly better than statistical techniques and is the only method capable of identifying low signal areas in the shadows of terrain obstructions. G.Y.

N79-18145# Shape Technical Center, The Hague (Netherlands)

A STOCHASTIC MODEL OF RAIN ATTENUATION

T. Maseng and P. M. Bakken *In* AGARD Operational Modelling of the Aerospace Propagation Environ., Vol. 1 and 2 Nov. 1978 19 p refs (For primary document see N79-18094 09-31)

Avail: NTIS HC A99/MF A01

The model permits the expression of analytic relationships between parameters commonly used to describe the properties of interest for communication. The model utilizes a memoryless nonlinear device to transform attenuation and rain intensity into one-dimensional Gaussian stationary Markov process. Comparative results are presented. The analysis shows how the dynamic properties of rain attenuation should be measured to provide a complete characterization in the model. The application of the model to the statistical analysis of the performance of communication systems is illustrated. An advantage of the model is the simplicity with which it allows simulation of communication link performance under the influence of rain. Such simulations are of great interest for complex models of adaptive networks where several deteriorating effects, including finite response times, are given. G.Y.

N79-23236# Advisory Group for Aerospace Research and Development, Paris (France)

ADVANCED FABRICATION PROCESSES

Mar. 1979 258 p refs In ENGLISH and FRENCH Presented at the 47th Meeting of AGARD Struct. and Mater. Panel, Florence, 26-28 Sep. 1978

(AGARD-CP-256; ISBN-92-835-0227-2) Avail: NTIS HC A12/MF A01

The purpose of the specialists' meeting was threefold. Most importantly it was to elucidate on some specific high payoff new processing concepts selected from a cross-section of NATO nations. This broad base of coverage was invaluable in itself but also was intended to aid in steering the Structures and Materials Panel toward selection of specific new areas where data and information interchange in much greater depth would be beneficial. The third purpose was to promote a coupling of the fundamental research activities to more applied efforts. For individual titles, see N79-23237 through N79-23255.

N79-23237# Technische Hochschule, Aachen (West Germany).

APPLIED RESEARCH ON THE MACHINABILITY OF TITANIUM AND ITS ALLOYS

W. Koenig *In* AGARD Advan. Fabric. Processes Mar. 1979 10 p refs (For primary document see N79-23236 14-31)

Avail: NTIS HC A12/MF A01

Cutting materials with high toughness and good thermal conductivity were used. Small changes in cutting speed caused extremely high changes in tool life. To obtain maximum material removal rates, the feed should be selected as high as possible. In order to reduce wear, cooling was very important, especially the supply of sufficient quantities of cutting fluids. The analysis of the endmilling process resulted in recommendations to increase both productivity and accuracy. In grinding, the choice of wheels was restricted by the thermal and chemical properties of the titanium. Oxide abrasives were not used. Within the group of vitrified silicon carbide wheels, the wear was a matter of hardness. The super-abrasives, diamond and cubic boron nitride, gave considerable improvements in G-ratio. In general, oil has proved to be more suitable than water based coolants. J.A.M.

N79-23238# Katholieke Universiteit te Leuven (Belgium)
RESIDUAL STRESSES IN GRINDING
J. B. Peters, R. Snoeys, and M. Maris *In* AGARD Advan. Fabric Processes Mar. 1979 15 p
Avail: NTIS HC A12/MF A01

A theoretically and experimentally confirmed model gave temperature as a function of the grinding parameters and the thermal characteristics of the material. The role of thermal expansion, metallographic transformation, and mechanical forces, with respect to the value of the maximum stresses and the depth of the heat affected zone was considered. J.A.M.

N79-23239# Societe Nationale Industrielle Aerospatiale, Suresnes (France). Research and Engineering Lab.
EXPERIENCE WITH USING ADAPTIVE CONTROL IN MILLING [EXPERIENCE D'UTILISATION DE LA COMMANDE ADAPTATIVE EN FRAISAGE]
J. Y. Lhommet *In* AGARD Advan. Fabric. Processes Mar. 1979 4 p In FRENCH (For primary document see N79-23236 14-31)
Avail: NTIS HC A12/MF A01

A complete system of adaptive control which includes both the generation and modulation of advanced speed and which is widely used in the American aircraft industry was used to cut a number of high strength metals such as are used in various French aircraft. The FORTRAN program, which includes a logical part that defines the optimal technological conditions and a materials part which controls the force applied on the piece to be cut, is described. The speed of advance is perforated on the tape. Advantages of usin- the system are (1) protection of machinery and tools; (2) substantial reduction in cutting time; (3) reduction of program starting time and operating cost; and (4) elimination of decision of programmers and operations in determining the conditions for milling. Transl. by A.R.H.

N79-23240# Grumman Aerospace Corp., Bethpage, N.Y. Advanced Materials and Processes Development.
INNOVATIVE MANUFACTURING FOR AUTOMATED DRILLING OPERATIONS
Carl Micillo and John Huber *In* AGARD Advan. Fabric. Processes Mar. 1979 15 p (For primary document see N79-23236 14-31)
Avail: NTIS HC A12/MF A01

The major cost drivers in airframe fabrication were identified. In the assembly area, drilling for various fastening systems is described both from economic and quality aspects. The Five-Axis Automated Assembly Fixture addressed both labor intensity and reliability with minimal capital investment. The system can automatically locate the substructure of a part using a digital scanning process and form a precise map of the location of the parts. The digitized information was used to drill and countersink through skins and substructures without costly templates. The evolution of the system was followed from the development stage into production, and economic analyses and projections for aircraft structures at various learning curves and production rates are given, including the aluminum A-6E wing and A-10 horizontal stabilizer, and advanced composite B-1 horizontal stabilizer. J.A.M.

N79-23241# McDonnell Aircraft Co., St. Louis, Mo.
ION VAPOR DEPOSITED ALUMINUM COATINGS FOR IMPROVED CORROSION PROTECTION
E. R. Fannin *In* AGARD Advan. Fabric. Processes Mar. 1979 8 p refs (For primary document see N79-23236 14-31)
Avail: NTIS HC A12/MF A01

The corrosion resistant properties of metallic aluminum are well documented. However, commercial processes for the application of aluminum coatings, such as electroplating, spray metallizing, hot dipping, cladding, and others have severe limitations. Production equipment was recently developed for plating with aluminum by ion vapor deposition (IVD) without incurring many of the problems associated with these commercial processes. The coating was called Ivadize TM and provided outstanding corrosion protection. In addition, the coating can be used at temperatures up to 925 F (496 C); and the process does not cause hydrogen embrittlement. The coating and the coating process are nontoxic and do not contribute to the pollution of our environment. Because of its performance advantages, ion vapor deposited aluminum can be used in a wide range of applications, and is particularly effective as a replacement for cadmium coatings. J.A.M.

N79-23242# Royal Aircraft Establishment, Farnborough (England). Materials Dept.
AN EVALUATION OF COATINGS FOR STEEL AND TITANIUM ALLOY FASTENERS FOR AIRCRAFT APPLICATIONS
V. C. R. McLoughlin *In* AGARD Advan. Fabric Processes Mar. 1979 11 p refs (For primary document see N79-23236 14-31)
Copyright Avail: NTIS HC A12/MF A01

To evaluate their use as alternatives to cadmium on bolts, the properties of various coatings were examined. Judged by marine atmosphere exposure, the corrosion resistance of the coated bolts varied from excellent (cadmium and zinc plate) to negligible, their galvanic compatibility with aluminium alloy showed similar variations. The results of laboratory tests to evaluate these corrosion characteristics conflicted with the marine atmosphere tests. The measurement of the currents generated and weight losses which occurred in galvanic cells between the bolts and aluminum alloy electrodes is shown to be a useful and very rapid screening test for galvanic compatibility. The uniformity of the coatings was established metallographically and various properties of the coatings examined include fluid resistance, paint adhesion properties, electrical conductivity and resistance to thermal shock. The effect of the coatings on the fatigue properties and torque-tension characteristics of the bolts were also assessed. J.A.M.

N79-23243# Atomic Energy Research Establishment, Harwell (England). Materials Development Div.
PHYSICAL VAPOR DEPOSITION AND ION BEAM TECHNIQUES FOR SURFACE DURABILITY
J. P. Coad and N. E. W. Hartley *In* AGARD Advan. Fabric. Processes Mar. 1979 9 p refs (For primary document see N79-23236 14-31)
Avail: NTIS HC A12/MF A01

Two surface treatment processes under development at Harwell are described which make increasing use of the throwing power and versatility of ion beams. At low plasma discharge energies ionized atoms cause sputter cleaning of surfaces and enable fully dense and adherent coatings to be built up on complex industrial items. Ion implantation, in which the bombarding atoms are accelerated through typically 30 KV, causes the original surface to become heavily impregnated with ions. The reproducibility and relative ease of scaling up make both processes attractive for large volume automatic surface treatment, although the vacuum requirements for ion implantation are more stringent. Some examples taken from recent evaluations on components treated for corrosion and wear resistance in the aerospace and other industries are described. L.S.

N79-23244# Sherritt Gordon Mines Ltd., Fort Saskatchewan (Alberta).
METAL BONDED CARBIDES FOR WEAR RESISTANT SURFACES
L. F. Norris, V. Silins, M. Adamovic, and M. A. Clegg *In* AGARD Advan. Fabric. Processes Mar. 1979 12 p refs (For primary document see N79-23236 14-31)
Avail: NTIS HC A12/MF A01

Experiments were conducted to relate the wear resistance and matrix hardness of metal-refractory metal carbide coatings to the extent of dissolution of the refractory metal in the coating matrix during plasma spraying. Powders prepared by coating TiC, Cr3C2, TaC and WC with nickel or cobalt by hydrometallurgical processes were plasma sprayed in tests in which the heat input to the powder particles during spraying was varied. Increasing the heat input generally increased the amount of refractory metal in solution in the coating matrix as determined by microprobe analysis. The matrix microhardness generally increased with refractory metal content but the wear resistance of the coatings varied widely for the eight systems evaluated. It was concluded that the superior wear resistance of plasma sprayed coatings based on WC and Cr3C2 is not simply a consequence of extensive dissolution of the refractory metal in the coating matrix and must be related to a more complex interrelationship of hardness, toughness, density and metal-carbide bond strength. L.S.

N79-23245# Fiat Research Center, Orbassano (Italy).
SURFACE TREATMENTS BY HIGH POWER LASER ON NICKEL BASE SUPERALLOYS
D. Bacci and S. Tosto *In* AGARD Advan. Fabric. Processes Mar. 1979 10 p (For primary document see N79-23236 14-31)
Avail: NTIS HC A12/MF A01

Laser treatments are a powerful tool to perform surface treatments on materials These treatments allow to modify the surface structure of the sample, by changing some properties, to cladding or alloying, to make coatings or to treat coatings already performed by other methods The goodness of the results depends on many parameters, among them we mention the specific power, the interaction time and the shape of the treating spot for what concerns the laser, the thermal conductivity, the surface state and the nature of the material The laser treatment can be localized on the surface without affecting the bulk This characteristic, together with the reproducibility and rapidity of the treatments, make this technique an unique tool to confer new properties to the materials Examples of applications of the high power laser to the problem of the superalloys are given L S

N79-23246# Birmingham Univ (England) Dept of Mechanical Engineering

PLASTICITY MODELLING

G W Rowe and P Hartley *In* AGARD Advan Fabric Processes Mar 1979 12 p refs (For primary document see N79-23236 14-31)

Avail NTIS HC A12/MF A01

A brief review is given of some of the more common theoretical and experimental techniques used for the analysis of plasticity problems with particular reference to their application in metalworking processes Part One deals with the well known Slip Line Field and Upper Bound techniques but also discusses the more recent developments of these methods involving the use of computers Visioplasticity, Flow Function Theory and Variational Methods are also mentioned Recent improvements in the digital computer and the available facilities have led to the widespread use of the Finite Element Method Its application to metal-forming problems will also be discussed Part Two deals with experimental work which has largely been dominated by the Visioplasticity technique and simple experiments involving the use of model materials such as plasticine and soft metals A new technique that of using photoelastic models to predict *plastic deformation* is also discussed L S

N79-23247# Societe Nationale Industrielle Aerospatiale, Suresnes (France)

FUNDAMENTAL ASPECTS OF SUPERPLASTICITY WITH EXAMPLES OF INDUSTRIAL CONSTRUCTION USING TI-6AL-4V ALLOY [ASPECTS FONDAMENTAUX DE LA SUPERPLASTICITE EXEMPLES DE REALISATION INDUSTRIELLE EN ALLIAGE DE TITANE TI 6AL-4V]

E Budillon and J P Lechten (Metz Univ France) *In* AGARD Advan Fabric Processes Mar 1979 19 p refs In FRENCH (For primary document see N79 23236 14 31)

Avail NTIS HC A12/MF A01

In order to display superplastic behavior under precise conditions of temperature and rate of deformation a metal or alloy must have fine grain equiaxial structure This is especially the case for industrial sheets of Ti 6Al 4V alloys whose grain size is generally inferior at 10 microns The superplastic deformation of this alloy was determined by studying the coefficient m of the sensitivity of the constraint to the rate of deformation Some hemispherical and twisted pieces were heat formed by swelling nonwelded sheets or sheets welded by TIG Subject to accounting for the thinning caused by the deformation associated with hot forming, it is possible to hot form the pieces by better optimizing the fabrication scale and the tools used, as a function of the desired industrial application, particularly in aeronautical and space applications Transl by A R H

N79-23248# Pratt and Whitney Aircraft Group, West Palm Beach, Fla

RAPIDLY SOLIDIFIED POWDERS, THEIR PRODUCTION, PROPERTIES, AND POTENTIAL APPLICATIONS

A R Cox, J B Moore, and E C vanReuth (ARPA, Arlington, Va) *In* AGARD Advan Fabric Processes Mar 1979 11 p (For primary document see N79 23236 14 31)

(ARPA Order 3152)

Avail NTIS HC A12/MF A01

Forced convective cooling of superalloy powders generated by rotary atomization is a method (designated RSR) to produce bulk quantities of metal solidified at rates near 100000 to 1000000 K/sec The basic design concepts for the RSR process center about a high speed turbine driving a rotary disk which disintegrates a molten stream of metal into fine particles and accelerates them into an environment of high velocity, high mass flow helium quench gas More than 150 superalloy compositions were processed by the RSR process Typically, these alloy microstructures can be characterized as supersaturated solid solutions, of high incipient melt point, and near perfect chemical homogeneity The boundary limits within which alloying can be effectively achieved are beyond those defined for conventional processes Consolidation of particles and subsequent working operation, such as extrusion and forging, can be accomplished satisfactorily under parametric conditions normally used for superalloy processing Metallurgical and mechanical tests of superalloy compositions produced in the RSR manner indicate that the process offers advantages relative to alloy strengthening, microstructure stability at high temperatures, and resistance to environmental degradation L S

N79-23249# Canadian Westinghouse Co Ltd, Hamilton (Ontario) Turbine and Generator Div

HOT ISOSTATIC PROCESSING OF IN-738 TURBINE BLADES

G VanDrunen, J Liburdi, W Wallace, and T Terada *In* AGARD Advan Fabric Processes Mar 1979 12 p refs Prepared in cooperation with Natl Res Council of Can , Ottawa, Ontario (For primary document see N79-23236 14-31)

Avail NTIS HC A12/MF A01

The removal of casting defects by hot isostatic processing (HIP) benefits turbine designers with improved alloy utilization and turbine users with increased reliability A description is given of work performed with an investment cast nickel-base turbine blade alloy, IN-738 The effects of different HIP parameters on microstructures and mechanical properties were examined It was found that properly HIP processed blades exhibit improved stress rupture, fatigue and tensile properties compared to conventionally cast and heat treated material L S

N79-23250# Annawerk Keramische Betriebe G m b H , Roedental (West Germany) Ceranox Div

NET-SHAPE PROCESSING OF NON-OXIDE CERAMICS

Ernst Gugel *In* AGARD Advan Fabric Processes Mar 1979 16 p refs (For primary document see N79-23236 14-31)

Avail NTIS HC A12/MF A01

The possible fabrication methods for ceramic products, particularly, for nonoxide ceramics, are presented Special attenation is given to the shaping operation so that the unsintered preform is close to the final shape of the product The available fabrication methods are examined with particular attention to their ability to produce structural components M M M

N79-23251# Rockwell International Corp , Los Angeles, Calif Advanced Titanium Technology Div

CONCURRENT SUPERPLASTIC FORMING/DIFFUSION BONDING OF B-1 COMPONENTS

George W Stacher and Edward D Weisert *In* AGARD Advan Fabric Processes Mar 1979 10 p refs (For primary document see N79-23236 14-31)

Avail NTIS HC A12/MF A01

A process that combines both superplastic forming and diffusion bonding of titanium is discussed Trade studies using this technology in actual applications show that this combined process results in cost savings up to 60% when compared to conventional titanium construction methods, while also saving weight The evolution of these titanium fabrication methods came about because of the necessity to improve aircraft performance and reduce cost of ownership Applications include single-sheet formed parts, selectively formed and bonded hollow sections, and complex sandwich structure replacing multiple-piece assemblies and machined parts A total of 26 different titanium configurations were produced and installed on the B-1 Cost reductions and weight savings in all cases have averaged between 30 and 50% when compared to previous construction M M M

N79-23252# British Aerospace Aircraft Group, Bristol (England)

FABRICATION OF TITANIUM AT HIGH TEMPERATURES

S J Swadling *In* AGARD Advan Fabric Processes Mar 1979 17 p (For primary document see N79-23236 14-31)

Avail NTIS HC A12/MF A01

Forming techniques of titanium and titanium alloys are presented The applications of the technology in aircraft component manufacture is discussed Cost estimates and production methods are given M M M

N79-23253# Leybold-Heraeus G.m.b.H., Hanau/Main (West Germany)

PRODUCTION OF HIGH PURITY METAL POWDERS BY ELECTRON BEAM TECHNIQUES

H. Stephan, H. Schmitt, and R. Ruthardt. *In* AGARD Advan. Fabric. Processes Mar. 1979 11 p refs (For primary document see N79-23236 14-31)

Avail: NTIS HC A12/MF A01

The progress for the development and improvement of the electron beam rotating disk process and equipment is reported. The demands of quality and productivity, and the problems are presented. The limits of process and equipment and futural aspects are discussed. M.M.M.

N79-23254# Fiat Research Center, Orbassano (Italy).

HEAT TREATMENT OF P/M NICKEL-BASE SUPERALLOYS FOR TURBINE DISKS

P. L. Antona and A. Bennani. *In* AGARD Advan. Fabric. Processes Mar. 1979 20 p (For primary document see N79-23236 14-31)

Avail: NTIS HC A12/MF A01

The microstructure of a superalloy produced from pre-alloyed powder using the hot isostatic pressing process is presented. This superalloy makes subsequent heat treatment simpler and enables mechanical characteristics to be obtained which are comparable with superalloys produced using conventional technologies. M.M.M.

N79-23255# University Coll. of Swansea (Wales). Dept. of Metallurgy and Materials Technology.

FORMING METALS BY RAPID SOLIDIFICATION

A. R. E. Singer. *In* AGARD Advan. Fabric. Processes Mar. 1979 10 p refs (For primary document see N79-23236 14-31)

Avail: NTIS HC A12/MF A01

Three main techniques for forming useful products which benefit from rapid solidification are reviewed. They consist of: (1) extruding, forging, rolling or pressing rapidly solidified powder or splats; (2) solidifying molten metals by contact with a moving cold surface to produce tape or wire; and (3) spray forming on a cooled substrate or mould. Some of the important factors affecting the integrity of spray deposits and the properties of the subsequent spray formed products are discussed. Particular attention is directed to the effect of spray density in relation to substrate cooling on structure and mechanical properties, and the effect of residual oxygen. Information is given on the process variables involved in, and the properties produced by, spray casting, spray rolling, centrifugal spray forming, and spray forging. M.M.M.

N79-23264# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).

MILLIMETER AND SUBMILLIMETER WAVE PROPAGATION AND CIRCUITS

E. Spitz, ed. and Gerard Cachier, ed. Feb. 1979 519 p refs In ENGLISH and FRENCH. Presented at the 25th Meeting of the Electromagnetic Wave Propagation Panel, Munich, 4-8 Sep. 1978

(AGARD-CP-245. ISBN-92-835-0231-0) Avail: NTIS HC A22/MF A01

A broad view of the state of the art in solid state sources and detectors, and in associated circuit techniques and technologies is presented. Progress in power tubes, laser techniques and high power techniques is included. The system aspects are covered, including atmospheric propagation effects as well as specific problems in detection, telecommunications, and visualization. There will be an opportunity to discuss what future developments of the technology would be desirable and could be expected to cover the needs, especially in military applications. For individual titles, see N79-23265 through N79-23309.

N79-23265# Naval Research Lab., Washington, D. C.

THE POTENTIAL MILITARY APPLICATIONS OF MILLIMETER WAVES

Lawrence R. Whicker and Denis C. Webb. *In* AGARD Millimeter and Submillimeter Wave Propagation and Circuits Feb. 1979 6 p refs (For primary document see N79-23264 14-31)

Avail: NTIS HC A22/MF A01

The propagation characteristics of millimeter waves are reviewed considering effects of rain, clouds, and fog. The fundamental limitations of microwave, millimeter, and optical systems are discussed and the strengths and weaknesses of each class of systems are outlined. The most promising application areas for millimeter waves outlined. Applications for radar, communication, and electronic warfare are discussed. Additionally needed component research and development activities are considered. J.M.S.

N79-23266# Georgia Inst. of Tech., Atlanta. Radar and Instrumentation Lab.

ENVIRONMENTAL EFFECTS ON MILLIMETER RADAR PERFORMANCE

F. B. Dyer and N. C. Currie. *In* AGARD Millimeter and Submillimeter Wave Propagation and Circuits Feb. 1979 9 p refs (For primary document see N79-23264 14-31)

Avail: NTIS HC A22/MF A01

The effects of clutter and nonideal atmospheric conditions on the performance of millimeter radar systems are examined. A series of investigations of radar returns from land, sea, rain, and snow were performed to define the potential utility of millimeter waves to selected system applications. The data and supporting analyses include results for all of the commonly used radar operating frequencies between 9.5 GHz and 95 GHz. Average values were measured to develop frequency dependencies, and considerations were made of those factors such as polarization, amplitude distributions, and spectra which significantly impact the application of modern signal processing techniques to millimeter radar. J.M.S.

N79-23267# Thomson-CSF, Levallois-Perret (France).

THE MILLIMETER WIRELESS BEAM [FAISCEAU HERTZIEN MILLIMETRIQUE]

Jean Pierre Dehaene. *In* AGARD Millimeter and Submillimeter Wave Propagation and Circuits Feb. 1979 13 p In FRENCH (For primary document see N79-23264 14-31)

Avail: NTIS HC A22/MF A01

A portable transmitter-receiver capable of short distance analog (video) or numeric (2 Mbits/s) transmission in the 36 to 38 GHz frequency range is described. Transmission is essentially constituted by a GUNN oscillator with direct frequency modulation by a varactor coupled to its cavity. A Cassegrain antenna is used. The modulation of Walsh type 1 and 2 signals is dicussed. Transl. by A.R.H.

N79-23268# EMI Electronics Ltd., Wells (England)

REVIEW OF TWO DECADES OF EXPERIENCE BETWEEN 30 GHz AND 900 GHz IN THE DEVELOPMENT OF MODEL RADAR SYSTEMS

L. A. Cram and S. C. Woolcock. *In* AGARD Millimeter and Submillimeter Wave Propagation and Circuits Feb. 1979 15 p refs (For primary document see N79-23264 14-31)

Avail: NTIS HC A22/MF A01

The purposes, principles, and methods of radar scale modeling are discussed. Several different types of measuring radar which are in use for investigating different aspects of radar scattering are described. Interesting variations arise in these radars when adapted for use at sub-millimeter wavelengths where optical methods are used in component and system design. In any facility for collecting copious and diverse data, a foolproof organization is required to ensure that any erraneous data are recognized and rejected. The organization of data collection, and the processing and use of the data, are emphasized. The methods by which these data are simplified without loss of important reflection characteristics is discussed and examples of the results are presented. Finally, some indication is given of likely trends in future developments of the measuring radar equipment. J.M.S.

N79-23269# AEG-Telefunken, Ulm (West Germany)

MODEL SIMULATION OF TARGET CHARACTERISTICS AND ENGAGEMENT SITUATIONS EMPLOYING MILLIMETER WAVE RADAR SYSTEMS

W. Gabsdil and W. Jacobi. *In* AGARD Millimeter and Submillimeter Wave Propagation and Circuits Feb. 1979 9 p (For primary document see N79-23264 14-31)

Avail: NTIS HC A22/MF A01

Millimeter wave systems were used for model simulation measurements to determine the near field characteristics of complex targets. These data are used for system optimization, for the proof of system effectivity and are also used for quality control in the production of the systems. J.M.S.

N79-23270# EMI Electronics Ltd., Wells (England)

MICROWAVE HOLOGRAPHY: A DECADE OF DEVELOPMENT

L. A. Cram, G. W. Newberry, and K. C. Rossiter. *In* AGARD Millimeter and Submillimeter Wave Propagation and Circuits Feb. 1979 16 p ref (For primary document see N79-23264 14-31)

Avail: NTIS HC A22/MF A01

The advent of the laser as a source of coherent radiation within the optical spectrum regenerated interest in the techniques

of wavefront reconstruction or holography The equipment devised to operate at various frequencies ranging from 10 GHz to 140 GHz are described and typical results achieved are presented Reference is made to some of the components developed for use in the equipment J M S

N79-23271# AEG-Telefunken, Ulm (West Germany)
DESIGN AND PERFORMANCE OF 90 GHz RADIOMETER FRONT ENDS
H Barth and B Rembold *In* AGARD Millimeter and Submillimeter Wave Propagation and Circuits Feb 1979 5 p (For primary document see N79-23264 14-31)
Avail NTIS HC A22/MF A01

Results of prototype radiometer frontends at 90 GHz are described, using encapsulated whisker diodes The diodes were embedded in a commonly used reduced height waveguide, but in addition, a special fixture was allowed to move the diodes up and down in respect to the waveguide or to turn it This led to a very simple matching procedure The mixers were easy to balance LO-power was achieved using a 45 GHz Gunn-oscillator followed by a varactor-doubler The unit has a effeciency of 14 percent delivering an output power of about 10 mW at 90 GHz Including isolator losses (0 6 dB) and IF-noise figure (2 5 dB), the dsb noise figure of the entire front end was about 9 dB whereas the single mixers dsb noise figure was less than 4 dB J A M

N79-23272# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France)
A NEW COMPONENT FOR MILLIMETER SYSTEMS: THE FIELD EFFECT TRANSISTOR [UN NOUVEAU COMPOSANT POUR LES SYSTEMES MILLIMETRIQUES: LE TRANSISTOR A EFFET DE CHAMP]
J -L Teszner (Direction des Rech , Etudes et Tech France) *In its* Millimeter and Submillimeter Wave Propagation and Circuits Feb 1979 18 p refs In FRENCH (For primary document see N79-23264 14-31)
Avail NTIS HC A22/MF A01

The possiblity of using field effect transistors (FET) for systems operating above 35 GHz was investigated as well as the development of devices for the I and J bands The noise characteristics of gallium arsenide FET as determined in laboratory tests are discussed and the relative advantages of indium gallium arsenide and indium phosphide as candidate materials for millimeter devices are assessed Transl by A R H

N79-23273# Lille Univ (France) Centre Hyperfrequences et Semiconducteurs
STABLE MILLIMETER WAVE SOURCES BY AVALANCHE DIODE FREQUENCY MULTIPLICATION
P A Rolland, G Salmer, and E Constant *In* AGARD Millimeter and Submillimeter Wave Propagation and Circuits Feb 1979 21 p refs Sponsored by European Space Agency (For primary document see N79-23264 14-31)
Avail NTIS HC A22/MF A01

The main characteristics of avalanche frequency multipliers are presented Special attention was paid to the diode structure for operation from 25 to 100 GHz The design philosophy of multiplier circuit is given Data on the noise behavior of such multipliers are also presented Results obtained from a 7000 hours endurance test are given J A M

N79-23274# Alpha Industries, Inc., Woburn, Mass.
WIDE-BAND MECHANICALLY TUNABLE W-BAND (75-110 GHz) CW GUNN DIODE OSCILLATOR
John Ondria *In* AGARD Millimeter and Submillimeter Wave Propagation and Circuits Feb 1979 16 p refs (For primary document see N79-23264 14-31)
Avail NTIS HC A22/MF A01

Experimental results are presented for a wide band mechanically tunable CW Gunn diode oscillator in the 75 to 110 GHz range A variable height radial mode resonator emersed in full height WR-10 (0 100 x 0 050 in) rectangular waveguide produced a continuous tuning range of almost 20 GHz Corresponding output power of + 10 dBm + or - dB was obtained when an adjustable waveguide short, located approximately 5/4 lambda g behind the diode, was simultaneously optimized at each frequency The FM noise spectra for an oscillator tuned to 94 GHz was in agreement with recently published results typical measured noise deviation over the video range 0 to 2 kHz off the carrier frequency was less than 30 Hz rms, single sideband, referenced to a 1 Hz bandwidth at 1 kHz off carrier and exhibited a 1/f sub m dependency in this region The best CW results obtained thus far were an output power of + 18 3 dBm at 94 GHz with 1 27 percent conversion efficiency J A M

N79-23275# Allen Clark Research Centre, Towcester (England)
PARAMETRIC AMPLIFIER PUMP DESIGN
J J Purcell *In* AGARD Millimeter and Submillimeter Wave Propagation and Circuits Feb 1979 8 p ref (For primary document see N79-23264 14-31)
Avail NTIS HC A22/MF A01

Current developments are directed towards the demonstration of low noise performance at 94 GHz for such applications as coherent radar (LNR), space object imaging, reconnaissance and communications The use of cryogenic techniques to minimize the amplifier noise temperature is generally restricted to radio astronomy where expense, complexity, and reliability may be of secondary importance However, in military communications or civil systems, refrigeration is usually precluded and low noise is obtained by electronic cooling, by the use of high pump frequencies J A M

N79-23276# Hughes Aircraft Co., Torrance, Calif. Electron Dynamics Div.
HUGHES IMPATT DEVICE WORK ABOVE 100 GHz
H J Kuno and T T Fong *In* AGARD Millimeter and Submillimeter Wave Propagation and Circuits Feb 1979 2 p (For primary document see N79-23264 14-31)
Avail NTIS HC A22/MF A01

Recent progress in the IMPATT development above 100 GHz is discussed Both CW and pulsed oscillator results from 100 GHz to 240 GHz are presented The device processing, packaging and circuit techniques used in these developments are outlined J A M

N79-23277# Max Planck Institut fuer Radioastronomie, Bonn (West Germany)
DETERMINATION OF SCHOTTKY DIODE MIXER CONVERSION LOSSES IN THE SUBMM WAVELENGTH RANGE
H P Roeser, E Sauter, and G V Schultz *In* AGARD Millimeter and Submillimeter Wave Propagation and Circuits Feb 1979 6 p refs
Avail NTIS HC A22/MF A01

Optically pumped submm lasers have several submm laser lines with powers up to 30 *m* Watts suitable to drive a diode mixer to generate IF signals between 1 MHz and a few GHz The sensitivity of the diode mixers which were for heterodyne detection systems in the submm wavelength range was determined using HCN-lasers and optically pumped submm gas lasers between 41 7 microns and 1 217 microns The difference frequency (IF) signals were generated by mixing laser lines of two different submm lasers whose beams were combined by an optical dipleexer The beat signals were detected using a Schottky diode in an open structure mixer followed by a spectrum analyzer J A M

N79-23278# Max-Planck-Institut fuer Radioastronomie, Bonn (West Germany)
THE MOTTKY-DIODE: A NEW ELEMENT FOR LOW NOISE MIXERS AT MILLIMETER WAVELENGTHS
Nigel J Keen *In* AGARD Millimeter and Submillimeter Wave Propagation and Circuits Feb 1979 9 p refs (For primary document see N79-23264 14-31)
Avail NTIS HC A22/MF A01

Measurements are reported on a waveguide mixer at 115 GHz, employing a Schottky-barrier diode with an extremely thin epitaxial layer, so that it approximates a Mott-diode The single-sideband mixer noise temperature was less than 200 K when cooled to 20 K and pumped with only 150 microwatts of local oscillator power Room temperature noise performance of the diode approximated that of the normal Schottky-barrier except that the local oscillator power requirement was again significantly lower Initial measurements on this diode showed it to be robust and reliable, although somewhat more care was required when initially contacting the anode with the pointed whisker An analysis of the noise performance indicates that further improvements should be attainable by modifications in diode design, and that classical models for mixer noise generation require modification L S

N79-23279# Lincoln Lab., Mass. Inst. of Tech., Lexington.
ADVANCES IN GaAs SCHOTTKY DIODE SUBMILLIMETER HETERODYNE RECEIVERS AND RADIOMETERS
P E Tannenwald *In* AGARD Millimeter and Submillimeter

Wave Propagation and Circuits Feb 1979 9 p refs Sponsored by AF, Army Res Office NSF and DOE (For primary document see N79-23264 14-31)
Avail NTIS HC A22/MF A01

Radiometric sensitivity measurements were made on a quasi optical receiver in the spectral range 170 micrometers to 1 mm Using GaAs Schottky mixer diodes in a corner reflector configuration, a total system noise temperature of 9,700 K (DSB), or an NEP of 1 3 x 10 te the 19th power W/Hz, was obtained at 447 micrometers This same quasi-optical mixer was also used for the generation of tunable harmonic and side-band radiation suitable for submillimeter spectroscopic applications Planar, surface-oriented GaAs Schottky diodes were fabricated by means of photolithographic techniques in conjunction with ion implantation and proton bombardment High-order harmonic mixing and direct heterodyne mixing with lasers up to 761 GHz were achieved These planar diodes can be fabricated into array configurations by means of an integrated circuit approach L.S.

N79-23280# Bern Univ (Switzerland) Inst of Applied Physics
THE DEVELOPMENT OF SUBHARMONICALLY PUMPED MIXERS AT 230 GHz
K F Kuenzi and H Berger *In* AGARD Millimeter and Submillimeter Wave Propagation and Circuits Feb 1979 5 p refs (For primary document see N79-23264 14-31)
Avail NTIS HC A22/MF A01

The millimeter wave portion of the spectrum is becoming increasingly more important for many different applications such as short range telecommunications, high resolution radars and radiometry, etc. At shorter millimeter waves local oscillators for mixers in receivers are expensive and difficult to operate. The subharmonically pumped mixer is an attractive technique useable into the submillimeter region. Subharmonic mixers operate with local oscillators at a submultiple of the signal frequency and provide AM-noise suppression of the local oscillator Author

N79-23281# Observatoire de Paris (France). Lab. Primaire du Temps et des Frequences.
SUBMILLIMETER RECEIVERS: LOCAL OSCILLATORS AND MIXERS
J J Jimenez, P Plainchamp, A. Comeron, and A. Clairon *In* AGARD Millimeter and Submillimeter Wave Propagation and Circuits Feb. 1979 11 p refs (For primary document see N79-23264 14-31)
Avail NTIS HC A22/MF A01

With submillimetric (SUBMM) devices, lasers and mixers, the classical microwave techniques may be extended up to the SUBMM range. The best choice for the local oscillator seems to be the optically pumped FIR laser because of the high number of active lines, output power and frequency stability. For the last one, values as low as delta sub y (tau) = 2 x 10 to -13 power tau to the -1/2 power for tau less than or equal to 20 and a minimum measured value delta sub y (100 ms) = 2 x 10 to the -12th were obtained for the CH3OH pumped laser. For a high IF bandwidth, high multiplication order and high frequency operation, the classical mixers used in microwaves may be extended to the SUBMM as well as to the IR spectrum. Some of them have sensitivities to the quantum limit. Since an analysis of the optical wave propagation in the atmospheric for inclement weather operation has shown the useful windows on the SUBMM range, a SUBMM receiver appears to be very promising to operate in the battlefield on fog, rain and snow as active imaging system. L.S.

N79-23282# Naval Research Lab., Washington, D. C.
INTEGRATED-CIRCUIT MEDIA FOR MILLIMETER WAVE APPLICATIONS
Barry E. Spielman *In* AGARD Millimeter and Submillimeter Wave Propagation and Circuits Dec. 1979 8 p refs (For primary document see N79-23264 14-31)
Avail NTIS HC A22/MF A01

An overview and assessment are provided of the principal transmission media which are being considered for integrated-circuit millimeter-wave applications. The paper starts by describing the important problems which are encountered in circuit integration at millimeter wave frequencies, including high transmission line loss, dispersion and higher-order moding, insufficient availability of design data, factors affecting cost, and suitability of transmission lines for component implementation The principal transmission lines are compared with respect to: (1) unloaded Q; (2) the range of impedance levels which are offered; (3) the anticipated useful frequency range; (4) compatibility with solid state devices; (5) demonstrated utility for critical components like hybrids and filters; (6) availability of transitions to metal waveguide, need for mode suppression techniques; (7) availability of design data, and (8) other general considerations. The paper concludes with a summary of the outstanding features of these transmission media with particular attention to cost considerations and application areas L.S.

N79-23283# Aerospace Corp., Los Angeles, Calif.
ADVANCED TECHNOLOGY FOR THE MILLIMETER AND SUBMILLIMETER WAVE REGION
D T Hodges, M McColl, A H. Silver, and T S Hartwick *In* AGARD Millimeter and Submillimeter Wave Propagation and Circuits Feb 1979 9 p refs Sponsored by DOE and Office of Naval Res (For primary document see N79-23264 14-31)
Avail NTIS HC A22/MF A01

Recent research related to millimeter and submillimeter applications is summarized. The emphasis was on laser sources and wideband junction detectors, and highlights of work is presented on (1) developing CW laser sources that operate between 100 microns and 1 5 microns, (2) extending Schottky barrier mixer diode operation to THz frequencies, and (3) developing a new cryogenic variation of the Schottky diode. This latter device, called the super-Schottky diode, employs a superconducting contact to a heavily doped semiconductor, and is the most sensitive detector of microwave radiation Prospects for extending this record performance to NMMW frequencies are discussed. G Y

N79-23284# Airborne Instruments Lab., Melville, N Y
ADVANCED DEVICES AND COMPONENTS FOR THE MILLIMETER AND SUBMILLIMETER SYSTEMS
J. A. Calviello, J J. Taub, D I Bretzer, E H. Kraemer, and J L. Wallace *In* AGARD Millimeter and Submillimeter Wave Propagation and Circuits Feb 1979 25 p refs (For primary document see N79-23264 14-31)
Avail. NTIS HC A22/MF A01

Key topics are discussed related to low noise mixers, high efficiency multipliers, the use of quasi-optical techniques to reduce circuit losses, and the development of very high-Q devices applicable to the millimeter and submillimeter wavelengths In particular, the development of a highly reliable metalized GaAs Ta-Schottky barrier diode with native-oxide passivation is described. The zero bias cutoff frequency of these diodes is greater than 1000 GHz when measured accurately near 60 GHz with a zero bias junction capacitance near 0 1 pF This zero bias cutoff frequency is approximately twice the value for a comparable nonmetalized device. G Y

N79-23285*# Georgia Inst. of Tech., Atlanta Engineering Experiment Station.
CONCEPTS AND TECHNIQUES IN THE UTILIZATION OF MILLIMETER AND SUBMILLIMETER WAVES
J. H. Rainwater, R W. McMillan, and J. J. Gallagher *In* AGARD Millimeter and Submillimeter Wave Propagation and Circuits Feb 1979 24 p refs (For primary document see N79-23264 14-31) (Grant NsG-5012; Contract DAAK40-77-C-0047, Grant DAAG29-76-G-0280)
Avail. NTIS HC A22/MF A01 CSCL 20N

A millimeter-submillimeter transmitter and receiver system for propagation studies with an optically pumped laser as a source and a quasi-optical superheterodyne receiver is described Topics are discussed in the areas of extended microwave techniques, quasi-optical devices and methods, radiometry, and measurements of importance to spectroscopy and propagation Measurements obtained with operational systems are highlighted and their significance to physical questions and future system applications discussed M.M.M.

N79-23286# AEG-Telefunken, Ulm (West Germany).
ADVANCES IN mm-WAVE COMPONENTS AND SYSTEMS
B. Adelseck, H Barth, H. Hoffman, H. Meinel, and B. Rembold *In* AGARD Millimeter and Submillimeter Wave Propagation and Circuits Feb. 1979 17 p refs (For primary document see N79-23264 14-31)
Avail: NTIS HC A22/MF A01

An overview on state-of-art and availability of mm-wave semiconductors is presented Laboratory results are compared with the data of commercially available diodes New active and passive mm-wave components are discussed Examples of components demonstrated are high Q and high stable Gunn oscillators as well as swept IMPATT sources up to 90 GHz.

frequency converters as parametric up converters at 64 GHz, mixers at 35, 60, and 90 GHz, and doublers at 99 GHz. Fin-line components, such as detectors, PIN-attenuators and double-throw-switches are shown. M.M.M.

N79-23287# Thomson CSF, Orsay (France). Domaine de Corbeville

VARACTOR TUNED MILLIMETER WAVE OSCILLATOR IN THE PRETUNED MODULE TECHNOLOGY

Gerard Cachier and Jean Stevance. *In* AGARD Millimeter and Submillimeter Wave Propagation and Circuits, Feb. 1979. 6 p. refs. (For primary document see N79-23264 14-31)

Avail: NTIS HC A22/MF A01

The pretuned module (PTM), a new millimeter oscillator, is described. This device integrates, together with an IMPATT diode, all the elements for both internal matching and external radiation towards the utilization and facilitates the control of the oscillator. The PTM lends itself well to electronic tuning with a varactor diode. This is done by inserting two indentical modules in each broad wall of a retangular waveguide, one of them being polarized below the breakdown. A few percent tuning bandwidth can thus be obtained. M.M.M.

N79-23288# Hughes Aircraft Co., Canoga Park, Calif.

MICROSTRIP COMPONENTS FOR LOW COST MILLIMETER WAVES MISSILE SEEKERS

H. G. Oltman, D. M. Weems, G. M. Lindgren, and F. D. Walton. *In* AGARD Millimeter and Submillimeter Wave Propagation and Circuits, Feb. 1979. 9 p. ref. (For primary document see N79-23264 14-31)

Avail: NTIS HC A22/MF A01

The development of low cost photo-etched microstrip components and integrated circuits for missile seekers is reported. An antenna, hybrid and mixer are described suitable for incorporation into a single integrated circuit for either monopulse of sequential lobing seekers. Incorporation of all components into a single substrate offers advantages of direct incident radiation of IF conversion, no troublesome connectors between components, and accurate reproduction of the of the optimized circuit in production. The cost of developing the optimized circuit for the millimeter wave band (MMW) band is reduced by scaling the circuit in all details to a lower frequency and hence, larger size. Components for the MMW circuit described were designed, optimized, and then integrated and optimized at a 2:1 scale. The final MMW circuit was a photo-reduction of a photograph of the optimized integrated low frequency circuit. Author

N79-23289# GEC Hirst Research Centre, Wembley (England)

HYBRID-OPEN MICROSTRIP MIC TECHNOLOGY AT MILLIMETER WAVELENGTHS

T. H. Oxley. *In* AGARD Millimeter and Submillimeter Wave Propagation and Circuits, Feb. 1979. 9 p. refs. (For primary document see N79-23264 14-31)

Avail: NTIS HC A22/MF A01

The technological, fabrication, and performance features of the hybrid-open microstrip MIC design approach are discussed when applied to the superheterodyne type of receiver in the frequency range of 26 to 90 GHz. Gold microstrip circuits formed by thin film techniques, broadband waveguide feeders, non-reciprocal devices formed by embedding the ferrite disk in the dielectric substrate, and improved rugged construction gallium arsenide beam lead diodes provided the basis for the design of mixers and receivers in this frequency range. Special packaging techniques to provide a rugged construction to meet the requirements of military environments are described. A balanced mixer designed for the frequency range of 65 to 85 GHz with an overall noise figure of about 10 dB and an operation temperature ran-e of at least -55 C to +85 C provides a good example of the techniques employed and is discussed. The application of these features to provide rogged multi-circuit receivers operating at about 35 GHz is described. Such receivers combine several circuit functions on a single substrate including isocirculators, and provide an overall noise figure of about 8.0 dB. Author

N79-23290# Texas Univ. at Austin. Dept. of Electrical Engineering

QUASI-PLANAR DIELECTRIC WAVEGUIDE APPROACH FOR MILLIMETER-WAVE INTEGRATED CIRCUITS

Tatsuo Itoh. *In* AGARD Millimeter and Submillimeter Wave Propagation and Circuits, Feb. 1979. 14 p. refs.

(Grant DAAG29-77-G-0220)

Avail: NTIS HC A22/MF A01

A number of quasi planar techniques for millimeter-wave integrated circuits which become increasingly more attractive at higher frequencies is described. Many of these techniques resemble those used in optical integrated circuits. Operating principles of the quasi-planar waveguides employed in the present techniques are first described. Some passive components made of these waveguides are then presented. Current efforts toward developing novel active components and associated problems are discussed. Author

N79-23291# ERA Ltd., Leatherhead (England). RF Technology Centre

FEASIBILITY STUDIES OF INSULAR GUIDE MILLIMETER WAVE INTEGRATED CIRCUITS

M. J. Aylward and N. Williams. *In* AGARD Millimeter and Submillimeter Wave Propagation and Circuits, Feb. 1979. 11 p. refs. (For primary document see N79-23264 14-31)

Avail: NTIS A22/MF A01

A discussion on millimeter wave integrated circuits using a dielectric waveguide technology is reported. The characteristics of image line and related structures are described and their applicability to integrated circuits discussed. The structure chosen for these studies, insular guide, is a variant of image line and allows a relaxation in tolerances so that conventional laboratory fabrication techniques can be employed. The design of a range of components is reviewed and the development of a prototype integrated circuit, aimed at fully establishing the feasibility of the approach, is described. Author

N79-23292# Royal Military Coll. of Science, Shrivenham (England). Dept. of Electrical and Electronic Engineering

FEASIBILITY OF DESIGNING MILLIMETER PLANAR ANTENNA ARRAYS

P. S. Hall, C. Garrett, and J. R. James. *In* AGARD Millimeter and Submillimeter Wave Propagation and Circuits, Feb. 1979. 9 p. refs. (For primary document see N79-23264 14-31)

Avail: NTIS HC A22/MF A01

Types of low cost microstrip millimeter wave antennas having flat profiles which can be made conformal with the surface of missiles etc, are investigated. The antenna design is carried out using a computer design technique that recently proved successful up to 17 GHz; this process computes antenna gain, sidelobes, efficiency, etc prior to drawing the photographic mask, and the fundamental aspects of the technique are briefly noted. The design and subsequent performance of planar arrays using RT Duroid an alumina substrates at both 36 and 70 GHz is described and critically examined. It is concluded that microstrip antennas can be designed at millimeter wavelengths to achieve comparable performance to that microstrip antennas can be designed at millimeter wavelengths to achieve comparable performance to that obtained at lower frequencies, but that the precision with which th substrate can be manufactured and processed deter mines the actual performance obtained. G.Y.

N79-23293# Microwave Associates Ltd., Dunstable (England)

MILLIMETER PIN DIODE CONTROL DEVICES

M. L. Nyss. *In* AGARD Millimeter and Submillimeter Wave Propagation and Circuits, Feb. 1979. 8 p. (For primary document see N79-23264 14-31)

Avail: NTIS HC A22/MF A01

Work carried out on millimeter wave PIN diode control devices is reported. Circuit techniques that were developed to overcome the problem of stray parasitics limiting the performance of high frequency components are addressed. The components described operate in the reverse tuned mode in which low loss is achieved when the diode is forward biased and isolation is achieved when the diode is reverse biased. Packaged PIN diodes were used for frequencies up to 38 GHz and unpackaged devices for frequencies up to 79 GHz. G.Y.

N79-23294# Technische Universitaet, Brunswick (West Germany). Inst. fuer Hochfrequenztechnik

MILLIMETER PULSE MODULATION WITH LUMPED ELEMENT CIRCUITRY

E. Kpodzo, G. Begemann, and K. Schuenemann. *In* AGARD Millimeter and Submillimeter Wave Propagation and Circuits, Feb. 1979. 15 p. refs. (For primary document see N79-23264 14-31)

Avail: NTIS HC A22/MF A01

Both AM and PM pulse modulators are dealt with for millimeter waves using lumped element circuits. A circuit technique is described which utilizes evanscent mode resonators. In this technique, induction is represented by short sections of rectangular waveguide below cutoff, capacitance by obstacles in the

waveguide, such as capacitive screw or a thin sheet of dielectric. The diode imbedding is assumed to be a matching network. By applying a mathematical technique, a broader band performance was achieved compared to typical bandwidths of phase modulators in the Q-band region. A type of transmission modulator with a phase shift of 45 degrees was also developed with two diodes switching elements having a insertion loss of 0.5 dB.
G.Y.

N79-23295# Army Electronics Research and Development Command, Fort Monmouth, N. J.
PHASE CONTROL ELEMENTS FOR MILLIMETER WAVE SYSTEMS
R. W. Babbitt, R. A. Stern, L. R. Whicker, and C. W. Young, Jr. *In* AGARD Millimeter and Submillimeter Wave Propagation and Circuits Feb. 1979 16 p refs Prepared in cooperation with NRL (For primary document see N79-23264 14-31)
Avail: NTIS HC A22/MF A01

The state-of-the-art for two classes of ferrite phase shifters is discussed. Two development efforts are described which promise to improve the performance and reduce the cost of millimeter wavelength phase shifters. One program is concerned with the arc plasma spray process for fabricating ferrite toroids. Data for experiments at 35 GHz, 65 GHz are presented. The second program describes efforts to obtain nonreciprocal phase control elements which exhibit full waveguide bandwidths. Design and test data for a 26.5-40 GHz phase shifter is presented. G.Y.

N79-23296# Technische Universitaet, Brunswick (West Germany). Inst. fuer Hochfrequenztechnik.
AN OSCILLATOR-MULTIPLIER CIRCUIT FOR THE GENERATION OF MILLIMETER WAVES
L. Szabo and K. Schuenemann. *In* AGARD Millimeter and Submillimeter Wave Propagation and Circuits Feb. 1979 14 p refs (For primary document see N79-23264 14-31)
Avail: NTIS HC A22/MF A01

Theoretical and experimental investigations on a solid-state millimeter wave source are addressed, which combines a negative-resistance device (IMPATT diode or GUNN element) with a varactor diode in a common imbedding. Frequency generation and multiplication are thus performed in one circuit. The oscillator can be regarded as a two-frequency device, because the imbedding is designed to support only two frequencies: the fundamental and the desired harmonic wave. In comparison with an ordinary oscillator followed by a frequency multiplier, the new circuit shows no isolator between these two components.
G.Y.

N79-23297# Thomson-CSF, Boulogne-Billancourt (France).
RECENT PROGRESS AND FUTURE PERFORMANCES OF MILLIMETER-WAVE BWO'S
B. Epsztein. *In* AGARD Millimeter and Submillimeter Wave Propagation and Circuits Feb. 1979 11 p refs Sponsored by European Space Agency (For primary document see N79-23264 14-31)
Avail: NTIS HC A22/MF A01

Up to now, backward-wave oscillators were the most powerful and reliable millimeter wave generators. Among microwave tubes, they also reached the highest frequencies (840 GHz for a CSF tube, 1200 - 1300 GHz for a Russian tube). A modification of the slow-wave structure has resulted in a considerable increase in the electronic tuning range, having initially a few percent bandwidth, a tube operates now between 325 and 390 GHz, delivering more than 50 mW over most of the band and a narrow-band tube delivers more than 5 W at 280 GHz. Improvements are under way to reduce the weight and improve focusing.
G.Y.

N79-23298# AEG-Telefunken, Ulm (West Germany). Tubes and Subassemblies Div.
DEVELOPMENT OF A 5 WATT TRAVELLING WAVE TUBE FOR 60 GHz
N. Pranter. *In* AGARD Millimeter and Submillimeter Wave Propagation and Circuits Feb. 1979 9 p refs (For primary document see N79-23264 14-31)
Avail: NTIS HC A22/MF A01

For data transmission between geostationary communication satellites the frequency range from 54 GHz to 64 GHz is used. It is shown how frequency, output power, bandwidth, high efficiency and extremely long tube life determines the following main design parameters for a traveling wave tube: (1) perveance of the electron gun, (2) beam compression, (3) slow wave structure, (4) dimensions of the flow wave structure, and (5) collector. Thermal velocity spread of the beam electrons has great influence on the performance of the electron gun and the beam focusing system. A method to reduce this influence is described.
G.Y.

N79-23299# Ecole Polytechnique, Palaiseau (France). Lab. de Physique des Milieux Ionises
NEW HIGH POWER MICROWAVE SOURCES IN THE MILLIMETRIC RANGE
J. M. Buzzi, H. J. Doucet, P. Drossart, B. Etlicher, P. Haldenwang, H. Lamain, X. Mauchant, J. P. Marque, and C. Rouille. *In* AGARD Millimeter and Submillimeter Wave Propagation and Circuits Feb. 1979 16 p refs (For primary document see N79-23264 14-31)
Avail: NTIS HC A22/MF A01

Three processes of electromagnetic wave generation by intense pulsed relativistic electron beams are investigated: (1) The synchrotron maser, (2) the relativistic Doppler shift, and (3) the collective free electron laser. For the synchrotron maser instability, theoretical linear growth rate and threshold conditions are derived for annular beams in cylindrical waveguides. Experiments where the efficiency of the microwave generation reaches 10% with REB current of the order of 1 kA are presented and discussed. Frequency conversion of microwaves by Doppler shift using a relativistic beam front as a mirror is a possibility for the conversion of X-band radiation in the millimetric range. Conversion frequency from 9 GHz to 30 GHz was observed. The collective free electron laser also uses the relativistic Doppler shift for frequency conversion, but the mirror effect is obtained by Raman backscattering of the incident wave. The incident wave in the laboratory frame can be of zero frequency, i.e. a simple modulation of a static B field. Results of the preliminary investigations are presented.
Author

N79-23300# Naval Research Lab., Washington, D. C.
RELATIVISTIC ELECTRON BEAM INTERACTIONS FOR GENERATION OF HIGH POWER MILLIMETER AND SUBMILLIMETER WAVES
V. L. Granatstein, P. Sprangle, R. Parker, K. R. Chu, A. T. Drobot (Sci. Appl., Inc., McLean, Va.), L. Seftor, M. Read (JAYOR, Alexandria, Va.), and T. Coffey. *In* AGARD Millimeter and Submillimeter Wave Propagation and Circuits Feb. 1979 13 p refs (For primary document see N79-23264 14-31)
Avail: NTIS HC A22/MF A01

The use of relativistic processes in nonneutralized electron beams is discussed. The electron beams may be highly relativistic or only weakly relativistic, depending upon the mechanism and the objective. Two basic processes are considered: the electron cyclotron maser, and coherent scattering of electromagnetic radiation from relativistic electron beams. The first process exploits the fact that the electron cyclotron frequency is a function of the relativistic factor gamma of an electron beam. The second process (coherent scattering) is primarily an exploitation of the Lorentz transformations which come into play during the interaction of electromagnetic radiation with relativistic particles.
Author

N79-23301# Paris Univ., Orsay (France). Inst. d'Electronique Fondamentale
ANALYSIS OF OPTICALLY PUMPED CW (CONTINUOUS WAVE) FIR (FAR INFRARED) LASER EFFICIENCY
J.-M. Lourtioz, R. Adde, and J. Pontnau. *In* AGARD Millimeter and Submillimeter Wave Propagation and Circuits Feb. 1979 11 p refs Sponsored in part by Groupement de Rech. Coordonnees du CNRS (For primary document see N79-23264 14-31)
Avail: NTIS HC A22/MF A01

The different aspects of the FIR power optimization are presented and a simplified analytical expression of the FIR power is reported. The results show that output powers exceeding the milliwatt level are obtained over the whole FIR spectrum with simple devices and not too expensive materials; and a further increase in power efficiency may be expected with improved FIR resonator designs, a better frequency coincidence of the pump, and with more powerful CO2 lasers.
M.M.M.

N79-23302# Universite Catholique de Louvain (Belgium). Lab. de Telecommunications et d'Hyperfrequences
A SURVEY OF ATMOSPHERIC PROPAGATION RESEARCH EXPERIMENTS ON SLANT PATHS, IN THE BAND 18-40 GHz
A. S. VanderVorst. *In* AGARD Millimeter and Submillimeter Wave Propagation and Circuits Feb. 1979 17 p refs Sponsored

by European Space Agency (For primary document see N79-23264 14-31)
Avail: NTIS HC A22/MF A01

A study of the available literature is presented, resulting in a review of the present knowledge with respect to 15 to 40 GHz slant path propagation. Experiments are presented first by location in a decreasing order of complexity, then by subject: attenuation, depolarization, space diversity, and signal fluctuation. They are illustrated by key diagrams. A short compilation of sixteen survey papers is also presented. This bibliographic study has retained about one hundred references out of several hundred papers.
Author

N79-23303# Amt fuer Wehrgeophysik, Traben Trarbach (West Germany)
ATMOSPHERIC INFLUENCES ON THE MILLIMETER AND SUBMILLIMETER WAVE PROPAGATION
Karl Erdmann Fischer *In* AGARD Millimeter and Submillimeter Wave Propagation and Circuits Feb 1979 5 p refs (For primary document see N79-23264 14-31)
Avail: NTIS HC A22/MF A01

The millimeter and submillimeter wave propagation in the atmosphere are presented emphasizing with the problems arising at the attempt of parameterization and numerical prediction of the interference with radio systems in the above-mentioned frequency range from the influence exerted by the atmosphere. The various types of interaction of the millimeter and submillimeter wave propagation with the influence of the atmosphere and with their mathematical approach are discussed. The supply of meteorological input data for computing the effect caused by hydrometeors, by molecular absorption and mere refraction are presented. An account is given of the applicability of meteorological routine measurements to radio techniques as well as of special measurements of drop size distributions and precipitation intensities.
Author

N79-23304# Lignes Telegraphiques et Telephoniques, Conflans-Sainte-Honorine (France). Dept. Hyperfrequence
THE CONSTRUCTION OF TRANSMITTER RECEIVERS FOR LONG MILLIMETER WAVE TRANSMISSION SYSTEMS WITH APPLICATION TO THE STUDY OF RADIO WAVE CHARACTERISTICS IN THE PARIS AREA [REALISATION D'EQUIPEMENTS EMISSION RECEPTION POUR SYSTEMES DE TRANSMISSION AUX LONGUEURS D'ONDES MILLIMETRIQUES ET APPLICATION A L'ETUDE DES CARACTERISTIQUES RADIOELECTRIQUES DANS LA REGION PARISIENNE]
J. R. Mahieu and R. Devinne *In* AGARD Millimeter and Submillimeter Wave Propagation and Circuits Feb. 1979 7 p refs In FRENCH (For primary document see N79-23264 14-31)
Avail: NTIS HC A22/MF A01

The equipment constituting the intermediate and high frequency stages of various long millimeter wave transmission systems operating in the 30 to 110 GHz frequency range are described. A radioelectric liason constructed with such components was used to study wave propagation at 31 GHz following different atmospheric conditions near Paris. Results show that at this frequency transmission loss due to precipitation can be compensated for over a 5 km distance.
Transl. by A.R.H.

N79-23305# Physics Lab. RVO-TNO, The Hague (Netherlands).
RAIN ATTENUATION MEASUREMENTS AT 94 GHz: COMPARISON OF THEORY AND EXPERIMENT
W. P. M. N. Keizer, J. Snieder, and C. D. deHaan *In* AGARD Millimeter and Submillimeter Wave Propagation and Circuits Feb. 1979 9 p refs (For primary document see N79-23264 14-31)
Avail: NTIS HC A22/MF A01

Measurements were made of attenuation at 94 GHz caused by rain on a 935 m terrestrial path since October 1977. Simultaneously the raindrop size distribution was measured with a distrometer, together with the rainfall intensity recorded with three rapid response rain gauges spaced about 500 m apart along the propagation path. Using the actually measured raindrop size distribution and assuming spherical raindrops, the attenuation caused by rain was calculated with the aid of Mie's scattering theory for water spheres. The result is compared with the measured data. In case of uniform rainfall along the path a good agreement was observed between the measured and the calculated attenuation. The propagation link, the experimental results and the comparison between theory and measurement is presented. The decrease of antenna gain at 94 GHz due to water on a 1.2 m Cassegrain antenna is shown that for accurate propagation measurements it is absolutely necessary to equip the antennas with protective shelters.
S.E.S.

N79-23306# Admiralty Surface Weapons Establishment, Portsmouth (England)
MEASUREMENTS OF EFFECTIVE SEA REFLECTIVITY AND ATTENUATION DUE TO RAIN AT 81 GHz
R. J. Sherwell *In* AGARD Millimeter and Submillimeter Wave Propagation and Circuits Feb 1979 5 p refs (For primary document see N79-23264 14-31)
Avail: NTIS HC A22/MF A01

The results obtained with a link at 81 GHz established over a 5.6 km path close to the sea surface in S. England are described. The probablity of observing large values of specular reflection coefficient and the need for better data on which to predict the statistical behavior of attenuation at millimeter wavelengths with rainfall over maritime paths are discussed.
S.E.S.

N79-23307# British Columbia Univ., Vancouver. Dept. of Electrical Engineering
MEASUREMENT OF ATTENUATION DUE TO RAIN AT 74 GHz
M. M. Kharadly, J. D. McNicol, and J. B. Peters *In* AGARD Millimeter and Submillimeter Wave Propagation and Circuits Feb. 1979 16 p refs (For primary document see N79-23264 14-31)
Avail: NTIS HC A22/MF A01

The results of an experiment designed primarily to measure attenuation due to rain at 74 GHz are described. Emphasis is placed on comparisons between measured and theoretically predicted attenuation. The latter is based on measured as well as some widely-used drop-size distribution.
S.E.S.

N79-23308# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Wesseling (West Germany).
THE INFLUENCE OF THE ATMOSPHERE ON PASSIVE RADIOMETRIC MEASUREMENTS
J. Preissner *In* AGARD Millimeter and Submillimeter Wave Propagation and Circuits Feb 1979 14 p refs (For primary document see N79-23264 14-31)
Avail: NTIS HC A22/MF A01

The influence of the atmosphere on sensing the earth's surface by microwave radiometers in the frequency range from 10 GHz to 1000 GHz is discussed. The dominant influences (atmospheric gases, hydrometeors) are described. Attention is given to the so-called window frequencies in the range from 10 GHz to 400 GHz. A computer program was developed which determines, for any object on the ground, the brightness temperature as it is seen from an airborne sensor. The input required are the object parameters (physical temperature, reflectivity), parmeters of the atmosphere (e.g. temperature, pressure, humidity) and parameters of hydrometeors, flight height and sensor parameters (viewing angle, polarization, frequency). Statistical information about the atmospheric variables and the weather conditions, valid for the area of West Germany is incorporated in the program in order to compute probabilities that at a given flight height and for certain regions and times of the year objects (like woods, fields, roads, cars) is being detected. Some results of computation are given and compared qualitatively with some actual airborne measurements at 11 GHz, 32 GHz and 90 GHz which were carried out at the DFVLR in the last few years.
S.E.S.

N79-23309# Bern Univ. (Switzerland). Inst. of Applied Physics
ATMOSPHERIC SOUNDING USING MILLIMETER WAVE RADIOMETRY
F. F. Kuenzi, D. Meier, and A. Randegger *In* AGARD Millimeter and Submillimeter Wave Propagation and Circuits Feb 1979 4 p refs (For primary document see N79-23264 14-31)
Avail: NTIS HC A22/MF A01

Microwave radiometery is used to investigate the atmosphere by measuring thermal microwave radiometry is used to investigate the atmosphere by measuring thermal emission from molecular resonances. Information on a atmospheric temperature and composition is provided. A major advantage of this technique over comparable infrared methods is the capability of microwaves to penetrate clouds. Microwave instruments are used in satellites, aircrafts and ground based for investigations in meteorology (temperature, atmospheric water content) and atmospheric physics (composition of stratosphere and mesosphere).
S.E.S.

N79-24202# Advisory Group for Aerospace Research and Development, Paris (France).

RESEARCH AND DEVELOPMENT ACTIVITIES IN ITALY IN THE FIELD OF AEROSPACE STRUCTURES AND MATERIALS

L. Lazzarino (Pisa Univ., Italy) Mar. 1979 27 p. refs Presented at the 47th Meeting of the AGARD Structures and Mater. Panel, Florence, Italy, 25 Sep. 1978

(AGARD-R-675, ISBN-92-835-1315-0) Avail: NTIS HC A03/MF A01

The activities concerned with metallic and nonmetallic aerospace materials along with the fields of stress analysis, vibrations and aeroelasticity, fatigue and crack propagation, and particularly, interesting work aimed at resolving design problems and at facilitating the introduction of new technologies. The main facilities developed are indicated. M.M.M.

32 COMMUNICATIONS

Includes land and global communications, communications theory, and optical communications

For related information see also 04 Aircraft Communications and Navigation and 17 Spacecraft Communications, Command and Tracking

N77-22346# Advisory Group for Aerospace Research and Development, Paris (France)
NEW DEVICES, TECHNIQUES AND SYSTEMS IN RADAR
Feb 1977 591 p In ENGLISH, partly in FRENCH Presented at the Avionics Panel Symp The Hague, Netherlands, 14-15 Jun 1976
(AGARD-CP-197) Avail NTIS HC A25/MF A01

Progress in the development of radar systems such as devices that offer greater reliability, lower cost, and reduced space/weight demands are considered The topics covered include devices and modules, radar techniques, target, clutter, and propagation, and simulation and detection theory For individual titles, see N77-22347 through N77-22385

N77-22347# Royal Radar Establishment, Malvern (England)
SOLID STATE MICROWAVE AMPLIFIERS AND LOCKED OSCILLATORS FOR COHERENT RADAR TRANSMITTERS
I W Mackintosh, P W Braddock, M Dixon, R Genner, and R J Royds *In* AGARD New Devices, Tech and Systems in Radar Feb 1977 13 p refs (For primary document see N77-22346 13-32)
Avail NTIS HC A25, MF A01

The emphasis is on transmitter operation in the region 8 to 10 GHz and the components considered are IMPATT diode amplifiers and TRAPATT diode and LSA diode oscillators These components may be considered for use as driver stages to tube output stages or as transmitters in all solid state radars The potential role and present status of each of these devices is examined and their performance in terms of parameters relevant to radar transmitter operation is described Results are presented on IMPATT amplifiers with up to 6W CW power output and up to 20W peak power output over a 4 microns pulses TRAPATT oscillators capable of 10W peak power output over 5 microns pulses with high efficiency, and LSA oscillators with 1000W peak power output over 250 ns pulses Author

N77-22348# Mullard Research Labs., Red Hill (England)
A CHEAP LOW NOISE (2.5 dB) X-BAND AMPLIFIER
R E Pearson *In* AGARD New Devices, Tech and Systems in Radar Feb 1977 8 p refs (For primary document see N77-22346 13-32)
Avail NTIS HC A25/MF A01

Thin film techniques were applied to the design of a room temperature X-band amplifier to produce a unit which combines simplicity and low cost with the following performance frequency low X-band gain 15 dB bandwidth (3dB) 100 MHz, and noise figure 2.5 dB max The unit is, with the exception of the Ka band Gunn pump, constructed completely by thin film techniques, complete with temperature stabilization circuitry, it measures 50 mm x 60 mm x 20 mm and can weigh as little as 200 grams Bandwidths up to 500 MHz and noise figures as low as 1.9 dB were achieved Author

N77-22349# Laboratoires d'Electronique et de Physique Appliquee, Paris Limeil-Brevannes (France)
LOW NOISE TRANSISTOR AMPLIFIERS [AMPLIFICATEUR BAS BRUIT A TRANSISTORS F. E. T. au GaAs]
P Baudet, M Parisot, and R Veilex *In* AGARD New Devices, Tech and Systems in Radar Feb 1977 15 p refs In FRENCH (For primary document see N77-22346 13-32)
Avail NTIS HC A25/MF A01

A study of amplifiers for military use is presented The following are described and discussed (1) the application of components, (2) electrical characterization, (3) conception and application of the amplifier and (4) results Transl by B B

N77-22350# Varian Associates, Palo Alto, Calif
NEW ADVANCES IN RELIABILITY AND EFFICIENCY IN LIGHTWEIGHT TWTs
Robert Berry and Armand Staprans *In* AGARD New Devices Tech and Systems in Radar Feb 1977 16 p (For primary document see N77-22346 13-32)
Avail NTIS HC A25, MF A01

The most commonly used microwave power amplifier in recently developed airborne radars is the coupled-cavity traveling wave tube This tube is favored because of its large bandwidth high peak and average power capability, high gain, and good signal purity A number of recent developments were concerned with improvement of the special characteristics important for airborne use such as reliability efficiency small size and weight and simplicity of power supplies Recent developments and the various trade-offs for these areas are covered Author

N77-22351# EMI Varian Ltd., Hayes (England)
BROAD BAND MEGAWATT KLYSTROM AMPLIFIER UTILIZING AN OVERLAPPING-MODE-EXTENDED INTERACTION OUTPUT SECTION
D Perring, G Phillips, and M J Smith *In* AGARD New Devices, Tech and Systems in Radar Feb 1977 7 p refs (For primary document see N77-22346 13-32)
Avail NTIS HC A25/MF A01

A description of theory, design, and performance of an overlapping mode extended interaction output section for an S-band one megawatt pulsed klystron amplifier is reported The device has a broader bandwidth performance than the double tuned output version and a simpler construction than a hybrid tube The theoretical design predictions are compared with the practical results Author

N77-22352# AEG-Telefunken, Ulm (West Germany)
A HIGH POWER PIN DIODE PHASE SHIFTER IN X-BAND WAVEGUIDE
C H Hamilton *In* AGARD New Devices, Tech and Systems in Radar Feb 1977 13 p refs (For primary document see N77-22346 13-32)
Avail NTIS HC A25/MF A01

A new type of polarization phase shifter is described which was developed for a habour radar It employs the inherent reactance of the PIN diode in a loaded-line type structure to produce the desired phase shift Low impedance ridged waveguide and large volume diodes are used resulting in a design capable of considerably higher power handling capacity than has so far been reported for diode phase shifters in X-band At the same time, the advantages of fast switching and low temperature sensitivity compared with presently available ferrite phase shifters were retained Author

N77-22353# Lignes Telegraphiques et Telephoniques, Conflans-Sainte Honorine (France) Dept Hyperfrequence
NEW HYPERFREQUENCY EMISSION PLUG-IN UNIT - RECEPTION FOR MILLIMETER RADAR WAVES [NOUVEAUX SOUS ENSEMBLES HYPERFREQUENCE EMISSION - RECEPTION POUR RADARS AUX ONDES MILLIMETRIQUES]
B Chiron, J R Mahieu, and M Fache *In* AGARD New Devices, Tech and Systems in Radar Feb 1977 14 p In FRENCH (For primary document see N77-22346 13-32)
Avail NTIS HC A25/MF A01

The utilization of centimeter waves in microelectronic technology is discussed, which permits the suppression of coupling elements, the diminishing of tuning, and reduction of clutter A dielectric resonator in which the temperature is stabilized is examined Transl by B B

N77-22354# Royal Radar Establishment, Malvern (England)
A SURVEY OF THE USE OF SURFACE WAVE DEVICES IN RADAR SYSTEMS
J D Maines and E G S Paige *In* AGARD New Devices, Tech and Systems in Radar Feb 1977 13 p refs (For primary document see N77-22346 13-32)
Avail NTIS HC A25/MF A01

During the past decade, surface acoustic wave devices have emerged as important signal processing components which are particularly well suited to radar The range of components which were developed and their applications in radar were reviewed There were several significant achievements, most notable among them being the establishment of the use of SAW dispersive delay lines as the method for waveform generation and matched filtering in pulse compression systems Author

N77-22355# Lincoln Lab., Mass. Inst. of Tech., Lexington.
ANALOG MEMORY CORRELATORS FOR RADAR SIGNAL PROCESSING
Ernest Stern. *In* AGARD New Devices, Tech. and Systems in Radar Feb 1977 13 p refs Sponsored in part by the Army and ARPA (For primary document see N77-22346 13-32)
Avail: NTIS HC A25/MF A01

Acoustoelectric convolvers, memory correlators, and coherent integrators are being developed for spread-spectrum communication and radar systems. Performance details of each of these devices is given, and their potential utility for radars is assessed. Memory-correlators were realized which perform the functions of storing a reference waveform for a time-interval as long as 50 msec, and of cross-correlating subsequent signals with the stored reference. In a radar, a sample of the transmitted pulse is stored in the device, and radar echoes from targets subsequently correlate with a sample of the actual transmitted signal. Author

N77-22356# Siemens A.G., Munich (West Germany)
MTI-FILTERS USING SERIAL ANALOGUE MEMORIES
W. Kothmann. *In* AGARD New Devices, Tech. and Systems in Radar Feb 1977 10 p (For primary document see N77-22346 13-32)
Avail: NTIS HC A25/MF A01

An attempt was made to extend the attainable dynamic range of the filters for a given signal resolution by suitable modification of the transfer function, by splitting into subsystems and by suitably combining the subsystems with each other. By limiting the costly arithmetic units to the absolutely necessary, an endeavour was made to arrive at solutions with the minimum number of components, with low dissipations and maximum circuit transparency. By using recently developed technologies, attempts were made to obtain solutions requiring less space and less power with simultaneously increased filter operating speed. In this context, it was possible to increase the speed of A/D converters, which represent the weakest link in a digital MTI filter, and favorable solutions were found for the design of multipliers in the filter sections. Author

N77-22357# Selenia S.p.A., Rome (Italy).
A REAL-TIME FFT PROCESSOR FOR RADAR
A. Costanzi, S. Diouonzo, G. Galati, and P. Neri. *In* AGARD New Devices, Tech. and Systems in Radar Feb 1977 9 p refs (For primary document see N77-22346 13-32)
Avail: NTIS HC A25/MF A01

The general features of FFT (Fast Fourier Transform) algorithm are briefly exposed, and the behavior of an FFT processor in data filtering is summarized. The problems connected to FFT processing in pulse-Doppler radars are described. The FFT processor's prototype and its testing procedures are briefly described. Author

N77-22358# EMI Electronics Ltd., Feltham (England).
DIGITAL PROCESSING TECHNIQUES AND EQUIPMENT, A REVIEW
P. V. Coates. *In* AGARD New Devices, Tech. and Systems in Radar Feb. 1977 9 p refs (For primary document see N77-22346 13-32)
Avail: NTIS HC A25/MF A01

Advances in semi-conductor technology are continually opening new areas of application for digital systems. One of these areas is in the processing of video information derived from radar and other sensors prior to its display. The data format and the visual image are modified and synthetic information is inserted, either externally or internally generated, by the use of digital techniques. This enables an operator to obtain more useful information in a shorter time than was possible by displaying the image directly from the sensor output. Some of these techniques are described together with simple block diagrams of various equipment which perform this processing. A versatile digital equipment is described which uses a microprocessor to enable the single machine to be used to perform a wide variety of algorithms on the video outputs from many different sensors, in real time, by means of simple software modifications. Author

N77-22359# Shape Technical Center, The Hague (Netherlands)
DESIGN AND FIELD TESTING OF A DIGITAL AREA MTI-PLOT EXTRACTOR
J. Dekker. *In* AGARD New Devices, Tech. and Systems in Radar Feb 1977 15 p refs (For primary document see N77-22346 13-32)
Avail: NTIS HC A25/MF A01

A non-supervised non-parametric learning algorithm is described, which, incorporated in an automatic radar data extraction system, has the ability to maintain a given constant false rate in an a priori unknown and changing clutter and interference environment. The actual performance of a thus implemented extraction system is demonstrated by the results of operational field tests and by a series of long term extracted plot histories of recorded video signals from a variety of radar stations in Europe. Author

N77-22360# Lincoln Lab., Mass. Inst. of Tech., Lexington
MOVING TARGET DETECTOR, AN IMPROVED SIGNAL PROCESSOR
C. E. Muehe. *In* AGARD New Devices, Tech. and Systems in Radar Feb 1977 9 p refs (For primary document see N77-22346 13-32)
(Contracts F19628-76-C-0002, DOT-FA72WAI-242)
Avail: NTIS HC A25/MF A01

A three-year program directed toward radar improvements in an automated, air traffic control environment has successfully produced a practical radar signal processor which overcomes clutter effects and provides automatic acquisition and tracking of all aircraft within the radar antenna's field of view. The new digital processor, called the Moving Target Detector (MTD) was carefully evaluated, both theoretically and experimentally on an S-band Airport Surveillance Radar. The MTD radar exhibits a 50-dB improvement factor in ground clutter, a subweather visibility better than 12 dB, and complete elimination of second-time-around echoes. A ground clutter map gives the radar super- and intra-clutter visibility even on tangential aircraft (zero radial velocity). Author

N77-22361# Rome Air Development Center, Griffiss AFB, N.Y.
LOW ANGLE TRACKING TECHNIQUE
Kenneth C. Stiefvater. *In* AGARD New Devices, Tech. and Systems in Radar Feb 1977 21 p refs (For primary document see N77-22346 13-32)
Avail: NTIS HC A25/MF A01

The process enables the radar to track targets in elevation in the low-angle region between one beam width and the horizon. The technique uses the array facility to form two beams and a two-channel receiver system which forms the ratio of the signals from each beam. By design, this ratio is proportional to target elevation angle. The antenna patterns are designed to suppress the multipath signal energy, but residual image signal energy entering the receiver is processed with the target signal without degradation of system performance. This technique was implemented and tested on an overwater range using an aircraft as the test target to gather data and evaluate system performance under varying reflective surface conditions. The system operated at 5.5 MHz and used a 12-foot array aperture. Author

N77-22362# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Oberpfaffenhofen (West Germany)
RADAR CROSS SECTION ANALYSIS AND TARGET IMAGING FROM THE DOPPLER INFORMATION IN THE RADAR ECHO
G. Graf. *In* AGARD New Devices, Tech. and Systems in Radar Feb 1977 8 p refs (For primary document see N77-22346 13-32)
Avail: NTIS HC A25/MF A01

The Doppler frequency spectrum of the radar echo from a rotating target with high resolution yields the distribution of the scattering centers in a cross range direction. The relation between Doppler spectra and the location of the scattering centers on a target is discussed and the optimum aspect angle window (integration time) that yields optimum resolution in the spectrum is given. Some experimental results show that Doppler frequency analysis is a useful tool in the analysis of the scattering properties of complicated targets. Author

N77-22363# Thomson-CSF, Malakoff (France)
LATERAL BEAM RADAR UTILIZING A SYNTHETIC ANTENNA [RADAR A FAISCEAU LATERAL UTILISANT UNE ANTENNE SYNTHETIQUE]
J. Geruist. *In* AGARD New Devices, Tech. and Systems in Radar Feb 1977 15 p In FRENCH (For primary document see N77-22346 13-32)
Avail: NTIS HC A25/MF A01

Utilization of lateral beam radar to obtain a high resolution image is discussed. A chart of definition is provided to identify natural and artificial topographical details of the region an aircraft is flying over. Transl. by B.B.

N77-22364# Admiralty Surface Weapons Establishment, Portsmouth (England)

RADAR TRACK EXTRACTION SYSTEMS

A. L. C. Quigley, J. E. Holmes, and R. J. Tunnicliffe. *In* AGARD New Devices, Tech. and Systems in Radar, Feb. 1977, 19 p. refs (For primary document see N77-22346 13-32)

Avail: NTIS HC A25/MF A01

The main constituents of a largely automatic radar track while scan system are described. It contains a plot extractor, clutter map, stationary plot filter, and automatic tracking software. The system is designed to operate in high false alarm conditions without formation of false tracks. The clutter map is used to select the optimum video for processes by the plot extractor, which is of fairly conventional design using cell averaging CFAR and single level quantization. The plot extractor output has the majority of land clutter removed by the stationary plot filter and remaining plots are used in the formation and updating of tracks. The track updating algorithms are based on adaptive Kalman filters with various arithmetic simplifications for efficient computer processing. Author

N77-22365# AEG-Telefunken, Ulm (West Germany)

PLOT EXTRACTOR AND DATA PROCESSING EQUIPMENT FOR A MOBILE HIGH RESOLUTION 3D PENCIL-BEAM RADAR

Ing. Heinz Ebert. *In* AGARD New Devices, Tech. and Systems in Radar, Feb. 1977, 12 p. refs (For primary document see N77-22346 13-32)

Avail: NTIS HC A25/MF A01

The principle of sequential 3D scanning of the airspace by means of a pencil-beam antenna pattern, for reasons of complexity, is particularly suited for a highly mobile 3D air surveillance radar of high resolution. Advanced radar concepts of this type are using antennas with simultaneous electronic and mechanical beam scanning. For plot extraction, a procedure specially tailored to pencil-beam scanning and having the following basic features is used: (1) signal amplitude evaluation, (2) target detection within the elevation scan (sliding window), and (3) center azimuth determination by means of an associative processor. Author

N77-22366# ITT Gilfillan, Inc., Van Nuys, Calif.

TECHNIQUES FOR AUTOMATIC TARGET DETECTION IN SCANNING 3-D RADAR

D. E. Hammers. *In* AGARD New Devices, Tech. and Systems in Radar, Feb. 1977, 21 p. refs (For primary document see N77-22346 13-32)

Avail: NTIS HC A25/MF A01

Rigorous methods are presented for characterizing and analyzing sliding gate, automatic target detection functions for 3-D scanning radars. Established detection techniques do not accurately apply to this problem since they do not account for correlation properties associated with the sliding action of the gate in relation to the azimuth-elevation hit pattern. A typical approach considered Monte Carlo computer simulation to iteratively derive the best automatic target detection function. However, this method can incur excessive computer time and manhours if the model has not been initially derived in consideration of correlation properties of the sliding gate. Through a stochastic difference equations approach, it is shown that the desired detection function is a Markov process and, as such, it is systematically derived relative to maximizing target sensitivity relative to false alarm requirements. As a result, overall radar performance and implementation costs are quickly assessed, leaving the investigation of scan modulation losses and target location accuracy to the more extensive resources required by the process of simulation. Performance curves and design methodology are generated for some particular examples for various target models. Author

N77-22367# Thomson-CSF, Malakoff (France)

NON-PARAMETRIC TESTS APPLIED TO RADAR [TESTS NON-PARAMETRIQUES APPLIQUES AU RADAR]

R. Carre. *In* AGARD New Devices, Tech. and Systems in Radar, Feb. 1977, 7 p. In FRENCH (For primary document see N77-22346 13-32)

Avail: NTIS HC A25/MF A01

The use of nonparametric tests in treating radar permits the reception of a constant false alarm independent of the potency or form of distribution of clutter. Optical radar is sampled and numerically coded. Values are stored in a memory on four successive repetitions. The test consists of analyzing selected signals in a gliding window. Strong signals are compared to determine the presence of a target. Performances are compared with those during classic tests and show that independence from noise characteristics is acquired without loss of important information. Transl. by B.B.

N77-22368# Forschungsinstitut fuer Hochfrequenzphysik, Werthhoven (West Germany)

PROBLEMS OF ADAPTIVE SIDELOBE SUPPRESSION

G. Ries and K. Kruecker. *In* AGARD New Devices, Tech. and Systems in Radar, Feb. 1977, 11 p. refs (For primary document see N77-22346 13-32)

Avail: NTIS HC A25/MF A01

Investigations dealing with decorrelation effects in a suboptimal spatial filter for adaptive interference suppression are presented. Degradation caused by decorrelation is partly determined by the antenna configuration, partly by mismatch between the receiving channels. Additional degradation caused by the target signal and by correlator offset errors in the adaptive control loops are discussed, too. Results of a special experimental system are also given. Author

N77-22369# Royal Signals and Radar Establishment, Malvern (England)

PHASE COMPARISON MONOPULSE APPLIED TO SECONDARY SURVEILLANCE RADAR

Brian A. Wyndham. *In* AGARD New Devices, Tech. and Systems in Radar, Feb. 1977, 18 p. refs (For primary document see N77-22346 13-32)

Avail: NTIS HC A25/MF A01

Developments in future civilian Secondary Surveillance Radar (SSR) Systems are being aimed at increasing the amount as well as the integrity of information exchanged between the ground station and the interrogated aircraft, while reducing the actual interrogation rate to the minimum necessary for reliable performance. The ultimate reduction would be to a single interrogation made only in the expected direction of an aircraft. Such extreme measures reduce the overall interference problem and improve message reliability, but make it necessary to adopt some technique for azimuth measurement other than the sliding window plot extractor usually used. The simplest solution to the problem is the use of monopulse designed to yield off axis measurements of the azimuth of transponder signals. A brief discussion along with the results of the initial phase of the experiments aimed at comparing the performance of alternative processes are also reported. Author

N77-22370# Societe d'Etudes et de Constructions Electroniques, Paris (France)

IFF IDENTIFICATION IN ZONES WITH HIGHLY CONCENTRATED INTERROGATION [IDENTIFICATION IFF DANS LES ZONES A FORTE CONCENTRATION D'INTERROGATEURS]

F. X. Pruvot. *In* AGARD New Devices, Tech. and Systems in Radar, Feb. 1977, 10 p. refs. In FRENCH (For primary document see N77-22346 13-32)

Avail: NTIS HC A25/MF A01

The limitations of the secondary surveillance radar system are presented. Theoretical study of different configuration zones of a strong concentration of interrogators permits the approximate evaluation of the importance of perturbations affecting a given surveillance network. Some of the following are also discussed: (1) response rate of the responder, (2) failures, and (3) elementary treatment of responses. Transl. by B.B.

N77-22371# Manchester Univ. (England). Dept. of Electrical Engineering

THE CASCADE REALIZATION OF M.T.I. FILTERS WITH STAGGERED P.R.F. AND TIME VARIABLE WEIGHTS

H. W. Thomas and T. M. Abram. *In* AGARD New Devices, Tech. and Systems in Radar, Feb. 1977, 15 p. refs (For primary document see N77-22346 13-32)

Avail: NTIS HC A25/MF A01

Non uniform sampling is used in conjunction with time varying coefficients in M.T.I. filters to extend the first blind speed of the system, without degradation of the stopband. A z-transform matrix notation is introduced which leads to a concise representation of cascaded time varying filter sections. It is shown that the cascade realization has certain advantages in terms of sensitivity to arithmetic wordlength and a step-by-step design procedure for such filters is described. The design of each section is based on the determination of coefficients to locate zeros in the z-plane for optimum rejection of the clutter spectrum. Author

N77-22372*# Kansas Univ., Lawrence Remote Sensing Lab
POOR-RESOLUTION SATELLITE OBSERVATIONS OF RADAR RETURN FROM NORTH AMERICA, BRAZIL, AND THE OCEANS
Richard K. Moore, Arun Sobti (Motorola, Inc., Schaumburg, Ill.), and James D. Young (General Dynamics, Ft. Worth, Texas) *In* AGARD New Devices, Tech. and Systems in Radar Feb 1977 19 p refs (For primary document see N77-22346 13-32)
(Contracts NAS9-13331, NAS9-13642)
Avail: NTIS HC A25/MF A01

The 13.9 GHz radar scatterometer on Skylab produced statistics of radar returns from thousands of points in North America and Brazil, as well as from the oceans. The resolution cell of the system varied from about 11 km in diameter at vertical incidence to 20 by 30 km at 50 deg incidence. Although these cells are larger than the preprocessing cells to be expected from spacecraft synthetic-aperture radars, they are at least as comparable with such cells as are the observation cells when aircraft radars are used. Results are presented both in terms of composite statistics for North America, Brazil, and the oceans, and in terms of statistics for particular classes of terrain. Both vertical and horizontal polarization data are presented for the land, and cross-polarized measurements are presented as well as for the sea. Correlations are indicated for the returns at different angles and polarizations. Author

N77-22373# Physics Lab., RVO TNO, The Hague (Netherlands)
CHARACTERISTICS OF CLUTTER AND TARGETS AT X- AND KU-BAND
H. Sittrop *In* AGARD New Devices, Tech. and Systems in Radar Feb 1977 26 p refs (For primary document see N77-22346 13-32)
Avail: NTIS HC A25/MF A01

The radar backscatter of the sea per unit area, sigma 0, and the rms clutter velocity spread are described versus grazing angle and wind velocity by an experimental model. A thorough comparison is made with measurements and calculations. The obtained results justify the assumption that the model can be used in the so-called near grazing and in the plateau region. The two scatter mechanism of Bragg resonant capillary waves and small facets overlaying the shorter gravity waves is discussed. Characteristic ratios of sigma 0 are presented versus windvelocity. A multipath Radar Cross Section (RCS) approximation is given in a closed form and numerically, for a variety of target models and clusters. Optimum signal to clutter ratios are discussed for the detection of buoys by shipping-traffic. Characteristics of arbitrarily chosen target clusters are simulated and typical discrepancies between clutter and target scintillations are demonstrated. The influence of precession, nutation, and rotation on the radar backscatter, due to irregularities of a body of revolution, is shown. Results of dynamic, in flight, measurements and simulations based on static measurements are included. Clutter and target model application may contribute in finding an optimum combination of relevant and environmental parameters. Author

N77-22374# Malibu Research Associates, Santa Monica, Calif.
A REAL-TIME RADAR ENVIRONMENT SIMULATION
G. E. Pollen and J. F. Walker (Technol. Service Corp., Santa Monica, Calif.) *In* AGARD New Devices, Tech. and Systems in Radar Feb 1977 9 p refs (For primary document see N77-22346 13-32)
Avail: NTIS HC A25/MF A01

An approach to radar development and testing using real-time signal simulation was developed and successfully demonstrated in the development of a major phased-array radar system. The concept makes use of a real-time Radar Environment Simulation System (RESS) to serve as a test bed for the development and test of the host radar. The RESS generates target and clutter environment signal returns for insertion into the radar front-end video signal stream. The main feature of the RESS concept is its direct application of realistic target and clutter models to radar testing. Complex environmental models are used in an off-line general purpose computer to generate signal control tapes, which are used in an on-line, real-time signal simulation unit. The on-line system is interactive with the radar, i.e., it generates signal modulations due to beam scanning and transmitted waveform, in realtime on cue from the radar transmission. Target characteristics which are reflected in the RESS outputs signals include detailed prescribed trajectories, and RCS fluctuation models. Over 100 independent targets can be generated thus simulating a highly complex test environment. Clutter properties include spectral shapes, amplitude fluctuation, and spacial non-homogenities. Clutter types include ground, rain, and false targets. Author

N77-22375# Shape Technical Center, The Hague (Netherlands)
RECONSIDERATION OF THE TARGET DETECTION CRITERION BASED ON ADAPTIVE ANTENNA POLARIZATIONS
A. J. Poelman *In* AGARD New Devices, Tech. and Systems in Radar Feb 1977 14 p refs (For primary document see N77-22346 13-32)
Avail: NTIS HC A25/MF A01

The target detection problem is reconsidered taking into account the polarization state of the target backscattered and interference fields. Radar object backscattering in terms of its scattering matrix was reviewed. As the polarization state of an electromagnetic wave is a carrier of information, its employment may result in an improved target detection capability of the radar system, both in natural and man-made interference environments. Adaptive suppression of unwanted signals by means of proper matching of the antenna polarizations at transmit and receive is considered along with consequent improvement in average target signal power to average unwanted signal power ratio at the input of the detection receiver. As the adaptive schemes require significant digital processing, the applicability in particular in those areas, where a limited number of radar cells need to be treated simultaneously, e.g. in tracking radars, is studied. Author

N77-22376# Electronique Marcel Dassault, St. Cloud (France)
A METHOD FOR NUMERICALLY CALCULATING THE PROBABILITY OF DETECTING FLUCTUATING SIGNALS [METHODE DE CALCUL NUMERIQUE DE PROBABILITE DE DETECTION DE SIGNAUX FLUCTUANTS]
P. Blondy *In* AGARD New Devices, Tech. and Systems in Radar Feb 1977 9 p In FRENCH (For primary document see N77-22346 13-32)
Avail: NTIS HC A25/MF A01

The following methods for the calculation of probability detection were examined: (1) approximation by the Gram Charlier series; (2) inversion of the characteristic function by discrete Fourier transformation; and (3) inversion of the characteristic function by the calculation of residue. Transl. by B.B.

N77-22377# ITT Gilfillan, Inc., Van Nuys, Calif.
SIMULATION OF A RADAR TRACKING A GLINTING AIRCRAFT TARGET IN A MULTIPATH ENVIRONMENT
Jay H. Landreth *In* AGARD New Devices, Tech. and Systems in Radar Feb. 1977 23 p refs (For primary document see N77-22346 13-32)
Avail: NTIS HC A25/MF A01

Models of a radar, the target, and the terrain are developed for the Fresnel field range so that a radar designer can optimize a radar when tracking is required at short ranges near the ground. Those features of the radar that effect target information or the processing of it are part of the radar model. The target is assumed to be an ensemble of simple shaped scatterers while the roughness of the terrain is represented by a statistically rough surface and a slightly rough surface. A coherent time summation of the signals received from the direct and indirect signal paths are formed into a range facsimile of the real signal. A two channel receiver and processor were emulated to process the data. An application of the model was developed into a computer simulation in which a pencil beam radar employs three dimensional tracking. Author

N77-22378# Lincoln Lab., Mass. Inst. of Tech., Lexington
COHERENT INFRARED RADAR
Robert H. Kingston and Leo J. Sullivan *In* AGARD New Devices, Tech. and Systems in Radar Feb 1977 8 p refs Sponsored by ARPA (For primary document see N77-22346 13-32)
Avail: NTIS HC A25/MF A01

A coherent radar system operating at a wavelength of 10.6 micrometers or approximately 0.01 mm, using an ultra-stable CO2 laser oscillator and one kilowatt amplifier is described. Although limited to clear weather conditions, the high Doppler sensitivity, 2 kHz/cm/sec, and narrow beamwidth, 10 microradians result in extremely precise velocity and angle measurements. The critical components of the system are reviewed as well as the special properties and techniques peculiar to this wavelength region. The overall system is described as well as recent experiments utilizing the retroreflector-equipped GEOS-C satellite. Author

N77-22379# Compagnie Industrielle des Lasers (France)
LASER APPLICATIONS IN RADAR TECHNIQUES [APPLICATIONS DU LASER DANS LE DOMAINE DES TECHNIQUES RADAR]
P Trevoux *In* AGARD New Devices, Tech and Systems in Radar Feb 1977 10 p refs In FRENCH (For primary document see N77-22346 13-32)
Avail NTIS HC A25/MF A01

Laser applications are described for the following (1) guidance on a target indicated by a laser, (2) aircraft trajectory with automatic pursuit, and (3) the direction and the pursuit of low targets in the center of anti-aerial defense Transl by B B

N77-22380# Norden, Norwalk, Conn
MILLIMETER WAVE MONOPULSE TRACK RADAR
Lester H Kosowsky, Kenneth L Koester, and Robert S Graziano *In* AGARD New Devices, Tech and Systems in Radar Feb 1977 17 p refs (For primary document see N77-22346 13-32)
Avail NTIS HC A25/MF A01

A high accuracy millimeter wave monopulse radar was developed for use in high resolution tracking applications The system utilizes a real aperture millimeter wave antenna transmitting a medium power noncoherent narrow pulse An analysis of attenuation and backscatter in adverse weather conditions indicates that against a 10 square meter target, a range of 10 km may be obtained in clear air and 4 8 km in 4 mm/hr or rain A description of the system configuration is given together with currently available experimental data Accuracies of better than 1 0 mr were achieved Author

N77-22381# Forschungsinstitut fuer Funk und Mathematik, Werthoven (West Germany)
THE ELRA PHASED-ARRAY RADAR WITH AUTOMATIC PHASE ADJUSTMENT IN PRACTICE
G Hueschelrath and W Sander *In* AGARD New Devices, Tech and Systems in Radar Feb 1977 11 p refs (For primary document see N77-22346 13-32)
Avail NTIS HC A25/MF A01

The Electronic Steerable Radar system is described along with presently implemented parts First experimental results are also given Author

N77-22382# BDM Corp, Albuquerque, N Mex
WIDEBAND RADAR IMAGING AND SIGNAL PROCESSING ARRAY
Jiunn S Yu and David T Bailey *In* AGARD New Devices Tech and Systems in Radar Feb 1977 30 p refs (For primary document see N77-22346 13-32)
(Contracts F30602-73-C-0343, F30602-73-C-0110)
Avail NTIS HC A25/MF A01

Wideband coherent radar is capable of high-resolution target imaging Similar to synthetic aperture radars used in terrain mapping, the analytical formulation of space-object scattering and imaging are developed Three targets are selected to obtain their backscattering fields in computer simulation Complex signal and spectral densities are then used to perform the image-synthesis procedure based on the Woodward method Numerical examples are given to demonstrate resolution capability and image enhancement The dispersive radiation field of LP (Log-Periodic) antennas are also described, and the LP signal processing models based on the fractional bandwidth of radiating elements are examined Elemental transfer functions of narrow-band signals are developed to synthesize the overall broadband filter function for performing pulse compression Compression gains for signal energy density are derived using the LP-phase model Potential performance of combining the image synthesis and LP-signal processing are briefly discussed in terms of signal resolutions, frequency agility, and waveform diversity Author

N77-22383# Selenia S p A , Rome (Italy)
MULTIBEAM MONOPULSE ARRAY ANTENNA WITH INDEPENDENT ELEVATION BEAM SCANNING
B Palumbo and A Cucci *In* AGARD New Devices, Tech and Systems in Radar Feb 1977 21 p refs (For primary document see N77-22346 13-32)
Avail NTIS HC A25/MF A01

The antenna solution was chosen after a trade-off study and experimental verification of the achievable performances The antenna beams are independently s[illegible]ed in elevation and independent optimization of the sum and difference illumination distribution for high performance monopulse operation is provided Use is made of an RF matrix comprising a center dual series feed network for each beam Diode and ferrite phase shifters perform the scanning of the beams, each in its angular sector of the coverage elevation angle A set of stacked linear arrays of radiating elements, each fed by a power dividing network, in a planar array configuration, is utilized for the asimuthal beam forming Author

N77-22384# Royal Signals and Radar Establishment, Malvern (England)
SECONDARY RADAR FOR AIRFIELD GROUND MOVEMENT MONITORING
H N Griffiths *In* AGARD New Devices, Tech and Systems in Radar Feb 1977 19 p Sponsored in part by the Civil Aviation Authority (London) (For primary document see N77-22346 13-32)
Avail NTIS HC A25/MF A01

Secondary radar is used for the in-flight identification of aircraft An extension of the secondary radar technique is suggested for the identification and location of aircraft taxying on the airfield surface This has sufficient positional accuracy for use alone or for the labelling of a high definition primary radar display of airfield ground movements The results of trials on an airfield site are discussed and experiments to determine the effects of ground reflections and aircraft self screening are described with polar diagrams of selected aircraft Accurate position finding using trilateration is discussed Author

N77-22385# Norwegian Defence Research Establishment, Kjeller
RADAR WIND MEASUREMENT SYSTEM
S Rosenberg *In* AGARD New Devices, Tech and Systems in Radar Feb 1977 9 p ref (For primary document see N77-22346 13-32)
Avail NTIS HC A25/MF A01

An all solid state low power X-band radar for wind profile determination in the lower atmosphere is described Measurements of wind velocity and direction are made by tracking a balloon-borne corner-reflector Angle tracking is performed manually with the aid of the angle error signal which is presented on a liquid crystal display A Gunn oscillator/Impatt amplifier combination gives a 1 to 2 W output which is biphase modulated using Barker and modified Barker codes A correlation receiver with double IF is used, the active demodulation being performed in the second mixer Video integration is performed digitally by a microcomputer which also guides target acquisition and range tracking Author

N77-32377# Advisory Group for Aerospace Research and Development, Paris (France).
EM PROPAGATION CHARACTERISTICS OF SURFACE MATERIALS AND INTERFACE ASPECTS
H J Albrecht, ed (Forschungsges. fuer Angew Naturwiss. E. V.) Jun 1977 243 p refs Partly in ENGLISH and FRENCH Proceedings of Electromagnetic Wave Propagation Panel Specialists Meeting, Istanbul, 18-19 Oct. 1976
(AGARD-CP-208; ISBN-92-835-0196-9) Avail NTIS HC A11/MF A01

Electromagnetic wave propagation through the atmosphere and reflecting off the earth surface was examined. Surface characteristics, propagation in interface media, and global distribution of electromagnetic waves were considered. For individual titles, see N77-32378 through N77-32391.

N77-32378# Centre National d'Etudes des Telecommunications, Issy-les-Moulineaux (France).
ELECTROMAGNETIC PROPERTIES OF WATER, AT FREQUENCIES BELOW 1000 GHz, AS MET IN ITS VARIOUS FORMS AT THE SURFACE OF THE EARTH
P M Halley *In* AGARD EM Propagation Characteristics of Surface Mater. and Interface Aspects Jun. 1977 61 p refs In ENGLISH and FRENCH (For primary document see N77-32377 23-32)
Avail: NTIS HC A11/MF A01

In the harmonic condition, the application of a relatively simple theory provided satisfactory results. Both the harmonic and static theories were closely linked to a water molecule model which was folded strongly polar. The most widespread homogeneity on the earth's surface was the ocean. Its characteristics are quite well known up to 10 to the 12th power Hz. It was very opaque to electromagnetic waves. The polar ice caps were less homogeneous, with less well known characteristics up to 10 to the 11th power Hz only. Ice at low temperatures was less opaque to electromagnetic waves than the ocean. Author

N77-32379# Bundesanstalt fuer Geowissenschaften und Rohstoffe, Hannover (West Germany)
REVIEW PAPER: DETERMINATION OF THE EARTH'S RESISTIVITY BY SURFACE MEASUREMENTS
H. Flathe *In* AGARD EM Propagation Characteristics of Surface Mater. and Interface Aspects 1967 16 p refs (For primary document see N77-32377 23-32)
Avail: NTIS HC A11/MF A01

Analyzing a layered earth, regarding its resistivity distribution down to several hundred meters depth is no problem. This fact, often not well known in neighbor disciplines, is demonstrated, outlining the possibilities and limitations of the methods available. After a short introduction into the principle of geoelectrical sounding, practical results are shown by case histories from some selected parts of the world. The main conclusion is that low resistivities (< 50 ohm m) predominate at the surface even in arid areas and deserts. The reason for this surprising fact is the clay and saline component within the top layers. Author

N77-32380# Kansas Univ., Lawrence. Dept. of Electrical Engineering
ELECTROMAGNETIC WAVE PROPAGATION FROM SOURCES IN COMPOSITE MEDIA
Albert W. Biggs *In* AGARD EM Propagation Characteristics of Surface Mater. and Interface Aspects Jun. 1977 9 p refs (For primary document see N77-32377 23-32)
Avail: NTIS HC A02/MF A01

Space, ground, and surface wave expressions were developed for a four layer medium. The four layer medium consisted of an upper layer of air above a three layered earth. A horizontal electric dipole antenna was the source considered here. Boundary conditions and Fourier transforms were applied to the Hartz vector potential wave equations in each layer of the multilayer terrain. Integral expressions for the horizontal and vertical componets of the Hertz vector potential were found for each layer. The electric and magnetic fields are functions of the media parameters. Surface wave phenomena were observed for suitable combinations of layer parameters. In addition to material variations, the frequency and layer depths was also considered. Applications to buried thombic antennas and traveling wave antennas can be made with the preceding results. Square loop antennas were also synthesized. When arrays of buried horizontal antennas were examined, a frequency steerable antenna was developed. Author

N77-32381# Lille Univ. (France)
RECENT PROGRESS IN ELECTROMAGNETIC PROCESSES IN THE DETECTION OF HETEROGENEITIES [RECENTS PROGRES DANS QUELQUES PROCEDES ELECTROMAGNETIQUES DE DETECTION D'HETEROGENEITES]
M. Cauterman, P. Degauque, B. DeMoulin, and R. Gabillard *In* AGARD EM Propagation Characteristics of Surface Mater. and Interface Aspects Jun. 1977 15 p refs In FRENCH (For primary document see N77-32377 23-32)
Avail: NTIS HC A11/MF A01

Recent theoretical progress in the dipole-dipole method for detecting electrical resistivity anomalies is discussed. In the presence of an anomalie, an analog model is often used to interpret measurements. Because of the difficulties encountered, three-dimensional numeric models were developed which allow for the influence of the resistivity anomalie of whatever form, occuring in a semi-homogeneous medium. The solution is presented in a system of integral equations which verify the electromagnetic field at every point on the ground. By reduction to a matrix system, a numeric solution is obtained. The basic principles are explored and several problems used to illustrate the theory. Author

N77-32382*# Kansas Univ. Center for Research, Inc., Lawrence. Remote Sensing Lab.
VARIATIONS OF TEMPORAL, SPECTRAL AND ANGULAR RADAR BACKSCATTERING COEFFICIENT OF VEGETATION
Fawwaz T. Ulaby *In* AGARD EM Propagation Characteristics of Surface Mater. and Interface Aspects Jun. 1977 11 p refs (For primary document see N77-32377 23-32)
(Contracts NAS9-10261; NAS9-14052)
Avail: NTIS HC A11/MF A01

Results of an experimental program is reviewed which over the past five years has succeeded in documenting the variations of the radar backscattering coefficient of a variety of crop types as a function of time, signal frequency (1-18 GHz), angular range (nadir to 80 deg) and polarization (HH, VV and HV). The systems were the microwave active spectrometers (MAS); one MAS system covers the 1-8 GHz band and the other system covers the 8-18 GHz band. Each MAS system was mounted on a mobile truck-mounted boom and was operated by a computer controller. To date, these two systems have acquired over 3 million data points from agricultural crops, bare ground and trees. Author

N77-32383# AEG-Telefunken, Ulm (West Germany).
AN EMPIRICAL MODEL FOR AVERAGE SCATTERING CROSS SECTION COMPUTATIONS FOR LAND- AND SEA-SURFACES
W. Keydel *In* AGARD EM Propagation Characteristics of Surface Mater. and Interface Aspects Jun. 1977 15 p refs (For primary document see N77-32377 23-32)
Avail: NTIS HC A11/MF A01

There exists no physical explanation for the validity of the formula byt comparisons with measurements show that good agreements can be reached and that the formula can be used for clutter computations in case of different surfaces and over a wide frequency range. The model contains as special cases some different still existing models, Lamberts law for example. For a horizontal moving radar with a rotational symmetrical antenna, the stated model leads to simple solutions for the spectral density and the total power of the ground clutter. The spectra density can be expressed as a hypergeometric series. This model can be useful for comparative system analysis of different systems as well as for first clutter stimations in radar system design. Author

N77-32384# Polytechnic Inst. of New York, Farmingdale
GROUND WAVE PROPAGATION IN THE PRESENCE OF SMOOTH HILLS AND DEPRESSIONS
L. B. Felsen and A. Green *In* AGARD EM Propagation Characteristics of Surface Mater. and Interface Aspects Jun. 1977 13 p refs (For primary document see N77-32377 23-32)
(Grant DAHC04-75-G-0152)
Avail: NTIS HC A11/MF A01

To gain a better physical, as well as quantitative understanding of aspects of wave propagation on a concave surface, intensive studies were carried out on the simplest prototype configuration, *the interior of a perfectly* circular cylinder. These two dimensional field calculations, corresponding to excitation by an axial line source, are reviewed. A peculiarity of the cylindrical geometry was the presence, in addition to the whispering gallery modes, of a continuous guided mode spectrum which arises because of spurious reflections from the radial coordinate origin. Elimination of these spurious contributions leads to an asymptotic field representation in terms of an integral which can be manipulated so as to exhibit ray-optical contributions, whispering gallery mode contributions, a mixture of these, or a formulation containing a reduced canonical integral analogous to the Fock integral for convex surfaces. The most effective choice depends on the parameters of the problem. The results so obtained were generalized to apply to arbitrary concave surface shapes provided that the radius of curvature changes slowly over a wavelength interval. The validity of these variable-curvature solutions was been verified by comparison with exact calculations performed for a parabolic contour. Author

N77-32385# Saarland Univ., Saarbrucken (West Germany).
THE TRANSIENT RESPONSE OF A SLIGHTLY ROUGH DIELECTRIC SURFACE
K. J. Langenberg *In* AGARD EM Propagation Characteristics of Surface Mater. and Interface Aspects Jun. 1977 13 p refs (For primary document see N77-32377 23-32)
Avail: NTIS HC A11/MF A01

The source of the electromagnetic field is assumed to be a vertical electric dipole at height xi above the surface of the plane earth with arbitrary time varying moment. The problem of finding the transient field of this dipole when the earth is allowed to be slightly rough is solved by means of a perturbation analysis, repeated application of integral transforms, and their inversion on the base of Cogniard's method with the modification of de Hoop. Author

N77-32386# Deutsche Bundespost, Darmstadt (West Germany).
EFFECTS OF NOCTURNAL GROUND-BASED TEMPERATURE INVERSION LAYERS ON LINE-OF-SIGHT RADIO LINKS
L. Fehlhaber and H. G. Giloi *In* AGARD EM Propagation

Characteristics of Surface Mater. and Interface Aspects Jun. 1977 14 p refs (For primary document see N77-32377 23-32)
Avail: NTIS HC A11/MF A01

In radio relay systems, the variations of transmission loss caused by propagation effects, were of some importance. These variations occurred in the shape of slow fading and fast or multipath fading, mostly in nighttime. A model of the ground based inversion is presented, that explains the observed effects not only qualitatively but to some extent quantitatively, so that predictions of statistical parameters become possible. Author

N77-32387# Deutsche Versuchsanstalt fuer Luft- und Raumfahrt, Oberpfaffenhofen (West Germany).
EXPERIMENTAL RESULTS CONCERNING THE INFLUENCE OF WAVE PROPAGATION ON TELEMETRY DATA TRANSMISSION AT 230 MHz COMPARED WITH 2.3 GHz
G. V. Mayer *In* AGARD EM Propagation Characteristics of Surface Mater. and Interface Aspects Jun. 1977 9 p refs (For primary document see N77-32377 23-32)
Avail: NTIS HC A11/MF A01

The data transmission in the VHF and UHF band from surface vehicles to a fixed receiving station was studied by experiments in different kinds of terrain. In broadband systems, as used for telemetry, it was necessary to compare not only the received signal power, but also to add another criteria for the transmission quality, e.g. the bit error rate in digital systems. Thus a digital pulse code modulated data stream was simultaneously transmitted in both bands. The signal strength and the missed frame synchronization words of both data links were recorded on paper tapes for a quick look analysis. A magnetic type was produced for a computer comparison of each piece of information (bit) with the known transmitted bitpattern. The bit error rate per data frame of both systems was then correlated. Author

N77-32388# Italian Navy, Spezia.
SPECULATIONS ON MEDIA INTERFACES WITH INTERESTING ELF COMMUNICATIONS
Giorgio Tacconi (Genoa Univ.) *In* AGARD EM Propagation Characteristics of Surface Mater. and Interface Aspects Jun. 1977 10 p refs (For primary document see N77-32377 23-32)
Avail: NTIS HC A11/MF A01

Ionosphere, atmosphere, oceans, earth's crust, etc., represent, in the main, a set of layers with different electrical properties. The influences of structures and behaviors of different layers on ELF communications were examined; and some theoretical approaches to propagation were reviewed, taking into account certain methodologies assessed for a particular transmission channel, i.e. the acoustic channel. Author

N77-32389# Cologne Univ. (West Germany).
SATELLITE-BORNE MONITORING OF ATMOSPHERIC AND SURFACE CHARACTERISTICS AFFECTING THE PROPAGATION OF MICROWAVES IN THE TROPOSPHERE
E. Raschke *In* AGARD EM Propagation Characteristics of Surface Mater. and Interface Aspects Jun. 1977 4 p refs (For primary document see N77-32377 23-32)
Avail: NTIS HC A11/MF A01

Some possibilities were examined to observe and monitor on a global scale such atmospheric and surface properties which affect the propagation of microwaves in the troposphere. These are the fields of atmospheric temperature, moisture, pressure and also of precipitating clouds, the sea state, ice and snow cover, and the soil moisture. A manifold of satellite techniques was developed in the last years, primarily for meteorological applications. They may provide useful information for estimating the atmospheric transfer properties for the microwave region. However, the existence of the ducting inversion layers near the ground might be only indirectly deductable from them. Author

N77-32390# Ludwig-Maximilians-Universitat, Munich (West Germany). Inst. fuer Allgemeine und Angewandte Geophysik.
DISTRIBUTION OF ELECTRICAL RESISTIVITY ON CONTINENTAL AREAS
V. Haak, M. Beblo, and A. Berktold *In* AGARD EM Propagation Characteristics of Surface Mater. and Interface Aspects Jun. 1977 18 p refs (For primary document see N77-32377 23-32)
Avail: NTIS HC A11/MF A01

The electrical resistivity of the earth was investigated by several geophysical methods. The resistivity distribution in the uppermost kilometers on continental areas as inferred from such measurements turned out to be rather inhomogeneous. Generally a correlation between the distribution of resistivity and the distribution of the geological units as displayed on geological maps exists. Author

N77-32391# Paris Sud Univ., Orsay (France).
THE IMPORTANCE OF DIFFUSION AND DEPOLARIZATION OF ELECTROMAGNETIC WAVES BY THE GROUND IN PROBLEMS OF RETRODIFFUSION [CONSEQUENCES DE LA DIFFUSION ET DE LA POLARISATION DES ONDES ELECTROMAGNETIQUES PAR LE SOL DANS LES PROBLEMES DE RETRODIFFUSION]
C. Goutelard and J. L. Coatanhay *In* AGARD EM Propagation Characteristics of Surface Mater. and Interface Aspects Jun. 1977 18 p refs In FRENCH (For primary document see N77-32377 23-32)
Avail: NTIS HC A11/MF A01

Theoretical models for studying the diffusion of electromagnetic waves by the earth's surface were developed and experimentally verified. The effects of electromagnetic wave depolarization and diffusion on retrodiffusion were investigated. A theory for the formation of retrodiffusion echoes was developed and verified using measurements obtained simulataneously by a zenith probe and a retrodiffusion probe. Ionization profiles were measured and their spectra calculated and compared with the spectrum of the echoes obtained from the retrodiffusion probe. Good correlation between these results show the diffusion of electromagnetic waves by the earth's surface as well as by movements of the ionospheric layers. Author

N78-23318# Advisory Group for Aerospace Research and Development, Paris (France).
RECENT ADVANCES IN RADIO AND OPTICAL PROPAGATION FOR MODERN COMMUNICATIONS, NAVIGATION AND DETECTION SYSTEMS
Apr. 1978 270 p refs
(AGARD-LS-93, ISBN-92-835-1280-4) Copyright Avail: NTIS HC A12/MF A01

Ionospheric limitations and tropospheric effects which contribute to radio wave propagation problems are introduced, as well as the problems of coherent propagation and image reconstruction, incoherent propagation, and remote sensing, in optical systems. Other topics discussed include transmission-radiation difficulties, blooming, and LIDAR; incoherent optical propagation; effects of atmospheric properties; surface signatures, and the sea on infrared, ultraviolet, and microwave remote sensing, and radio wave scintillation effects on tracking and communication. For individual titles, see N78-23319 through N78-23330.

N78-23319# Forschungsinstitut fuer Optik, Tuebingen (West Germany).
INTRODUCTION TO OPTICAL PROBLEMS OF SYSTEMS
Dieter H. Hoehn *In* AGARD Recent Advan. in Radio and Opt. Propagation for Mod. Commun., Navigation and Detection Systems Apr. 1978 8 p refs (For availability see N78-23318 14-32)
Avail: NTIS HC A12/MF A01

The effects of atmospheric optical propagation on modern optical/optronical systems, as used for communications, navigation, and detection are discussed. With respect to the different types of systems (passive-active, imaging-nonimaging, coherent-incoherent) basic environmental effects, especially related to propagation are summarized, as affecting the general modules background target and propagation medium. These effects are related to the relevant atmospheric constituents. Meteorological aspects, e.g. the probability of certain propagation conditions or forecasting problems, are identified as essential for armament development and especially for the effective application of systems during military missions. Author

N78-23320# Forschungsinstitut fuer Optik, Tuebingen (West Germany).
PHYSICS OF INCOHERENT OPTICAL PROPAGATION
Dieter H. Hoehn *In* AGARD Recent Advan. in Radio and Opt. Propagation for Mod. Commun., Navigation and Detection Systems Apr. 1978 23 p refs (For availability see N78-23318 14-32)
Avail: NTIS HC A12/MF A01

Atmospheric optical effects are discussed as relevant to optical/optronical systems, i.e. atmospheric refraction and transmission. The basic relations for atmospheric absorption and scattering are presented. Effects of atmospheric molecules, aerosols, and hydrometeors are described for the wavelength range 0.3 micrometers to 15 micrometers. The general vision formula is presented together with remarks on atmospheric path radiance and on perception range modeling. The definition of visual range and maximum perception range, e.g. with respect

to thermal vision through the atmosphere is included. The project OPAQUE is mentioned as an example for the collection of data on atmospheric optical and infrared affects as relevant to the performance of optical/optronical systems and forecasting of the optical weather. Author

N78-23321# Rome Univ. (Italy)
PROPAGATION PROBLEMS RELATIVE TO LASER TRANSMISSION
Mario Bertolotti. *In* AGARD Recent Advan. in Radio and Opt. Propagation for Mod. Commun., Navigation and Detection Systems Apr. 1978 29 p refs (For availability see N78-23318 14-32)
Avail: NTIS HC A12/MF A01

Atmospheric transmission and scattering of monochromatic beams are considered. The effects of atmospheric turbulence are then described. Thermal blooming is discussed in cases of CW and pulse operation. Author

N78-23322# Air Force Geophysics Lab., Hanscom AFB, Mass. Space Physics Div.
INTRODUCTION TO RADIO WAVE PROPAGATION EFFECTS ON SYSTEMS
Jules Aarons. *In* AGARD Recent Advan. in Radio and Opt. Propagation for Mod. Commun., Navigation and Detection Systems Apr. 1978 6 p (For availability see N78-23318 14-32)
Avail: NTIS HC A12/MF A01

Refraction and absorption processes in the lower atmosphere at wavelengths below 3 cm at all angles of elevation are discussed. Ionospheric effects on radio wave propagation of major or minor significance are considered. Author

N78-23323# Leicester Univ. (England). Dept. of Physics.
HIGH FREQUENCY RADIOWAVE PROPAGATION IN THE IONOSPHERE
T. B. Jones. *In* AGARD Recent Advan. in Radio and Opt. Propagation for Mod. Commun., Navigation and Detection Systems Apr. 1978 16 p refs (For availability see N78-23318 14-32)
Avail: NTIS HC A12/MF A01

The effect of the ionosphere on the performance of a high frequency radio circuit is considered. Reflection at oblique incidence, multipath propagation, and maximum and lowest usable frequencies are discussed along with ground and ionospheric scatter. Methods of calculating the propagation parameters described include prediction from ionospheric models and ray tracing. A number of techniques for evaluating the complete channel response for improved system performance are discussed. J.M.S.

N78-23324# National Oceanic and Atmospheric Administration, Boulder, Colo. Space Environment Lab.
FORECASTING AND PREDICTION OF IONOSPHERIC PARAMETERS
Kenneth Davies. *In* AGARD Recent Advan. in Radio and Opt. Propagation for Mod. Commun., Navigation and Detection Systems Apr. 1978 29 p refs (For availability see N78-23318 14-32)
Avail: NTIS HC A12/MF A01

The effects of the ionosphere on the radio frequency spectrum are summarized. Long-term predictions and short-term forecasts of ionospheric conditions in the spatial, temporal, and frequency domains are considered along with the various techniques used in preparing predictions and forecasts. Short-term phenomena, such as solar flares, sudden ionospheric disturbances, polar cap events, and geomagnetic storms are treated. J.M.S.

N78-23325# Air Force Geophysics Lab., Hanscom AFB, Mass.
IONOSPHERIC EFFECTS ON SATELLITE NAVIGATION AND AIR TRAFFIC CONTROL SYSTEMS
J. A. Klobuchar. *In* AGARD Recent Advan. in Radio and Opt. Propagation for Mod. Commun., Navigation and Detection Systems Apr. 1978 11 p refs (For availability see N78-23318 14-32)
Avail: NTIS HC A12/MF A01

Major effects of the ionosphere on radio waves discussed include (1) time delays greater than the free space wave velocity, (2) polarization rotation of linearly polarized waves, (3) angular refraction or bending of the ray from a geometric straight line, and (4) phase advance of the carrier phase with respect to the free space phase scintillation. Various techniques of correcting for these effects are described. J.M.S.

N78-23326# Air Force Geophysics Lab., Hanscom AFB, Mass.
IONOSPHERIC SCINTILLATIONS: AN INTRODUCTION
Jules Aarons. *In* AGARD Recent Advan. in Radio and Opt. Propagation for Mod. Commun., Navigation and Detection Systems Apr. 1978 22 p refs (For availability see N78-23318 14-32)
Avail: NTIS HC A12/MF A01

Variations of amplitude, phase, polarization, and angle of arrival produced when the radio wave passes through electron density irregularities of the ionosphere are considered in terms of the effect on communications, navigation, and detection systems. Scintillation effects on UHF communications systems are described. J.M.S.

N78-23327# National Oceanic and Atmospheric Administration, Boulder, Colo. Space Environment Lab.
ARTIFICIAL MODIFICATION OF THE IONOSPHERE
Kenneth Davies. *In* AGARD Recent Advan. in Radio and Opt. Propagation for Modern Commun., Navigation and Detection Systems Apr. 1978 31 p refs (For availability see N78-23318 14-32)
Avail: NTIS HC A12/MF A01

Alteration of the ionosphere by radio and by chemical means is discussed from the point of view of the radio communicator. It is indicated that F-region modification provides a relatively secure means of communications because of the highly aspect sensitive characteristics of field-aligned scatter. Author

N78-23328# Leicester Univ. (England). Dept. of Physics.
THE PROPAGATION OF LOW AND VERY LOW FREQUENCY RADIOWAVES
T. B. Jones. *In* AGARD Recent Advan. in Radio and Opt. Propagation for Mod. Commun., Navigation and Detection Systems Apr. 1978 22 p refs (For availability see N78-23318 14-32)
Avail: NTIS HC A12/MF A01

The distinctive features of VLF and LF propagation are discussed and the specialized mathematical techniques necessary to calculate the propagation parameters are described. Examples of VLF and LF systems, the Omega and Loran C navigators, are considered. Some of the advantages and disadvantages of communications systems using these frequencies are noted. Author

N78-23329# Heriott-Watt Univ., Edinburgh (Scotland).
REMOTE SENSING
G. E. Peckham. *In* AGARD Recent Advan. in Radio and Opt. Propagation for Mod. Commun., Navigation and Detection Systems Apr. 1978 14 p refs (For availability see N78-23318 14-32)
Avail: NTIS HC A12/MF A01

The way in which emitted or reflected electromagnetic radiation is used to obtain information about the atmosphere, land, and sea is briefly described. The use of infrared scanners and radiometers on satellites to examine the land surface and properties of the atmosphere including temperature and composition, is considered. Author

N78-23330# Royal Norwegian Council for Scientific and Industrial Research, Kjeller. Remote Sensing Technology Programme.
TARGET DETECTION AND IDENTIFICATION METHODS BASED ON RADIO- AND OPTICAL WAVES
Dag T. Gjessing. *In* AGARD Recent Advan. in Radio and Opt. Propagation for Mod. Commun., Navigation and Detection Systems Apr. 1978 24 p refs (For availability see N78-23318 14-32)
Avail: NTIS HC A12/MF A01

Technological advances in the fields of microwave techniques, electrooptics, and computer technology are discussed in terms of application to target detection/identification systems. Increasing the target identification capability of these sensor systems is emphasized. Tunable lasers and IR heterodyne receivers are among the sensor systems described. Fundamental principles of target signature analysis are examined including the interaction between electromagnetic waves and geometrical objects, the interaction with molecules, and the influence of the motion pattern of the object on the frequency of the scattered electromagnetic wave. J.M.S.

N79-10299# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
ASPECTS OF ELECTROMAGNETIC WAVE SCATTERING IN RADIO COMMUNICATIONS
A. N. Ince, ed. (SHAPE Tech. Centre, The Hague). Sep. 1978 529 p refs partly in ENGLISH and FRENCH. Presented at the Electromagnetic Wave Propagation Panel Symp., Cambridge, Mass., 3-7 Oct. 1977
(AGARD-CP-244, ISBN-92-835-0219-1) Avail: NTIS HC A23/MF A01

The proceedings deal with the theory of scattering and reflection in the troposphere the ionosphere from meteor trails, and also scattering from ground environmental hazards such as hills trees and buildings In the propagation aspect the prediction of long and short term signal characteristics and the modeling and simulation of radio channels are included using scatter mode of propagation The proceedings also cover transmission and signal processing techniques for effective communications over such channels For individual titles see N79 10300 through N79 10333

N79-10300# Royal Norwegian Council for Scientific and Industrial Research Kjeller Remote Sensing Technology Programme

SCATTERING MECHANISMS AND CHANNEL CHARACTERIZATION IN RELATION TO BROAD BAND RADIO COMMUNICATION SYSTEMS

Dag T Gjessing *In* AGARD Aspects of Electromagnetic Wave Scattering in Radio Commun Sep 1978 15 p refs (For primary document see N79 10299 01 32)

Avail NTIS HC A23/MF A01

Many modern communication systems, such as systems making use of the spread spectrum mode, large synchronous time division multiplexing, and package switching in data transmission networks involving computers, were very sensitive to certain properties of the propagation medium (bandwidth, delay spectrum width etc) With these communication systems, some of the more important channel characterization parameters for circuits involving scattering by inhomogeneities in the tropospheric refractive index structure, by topographic irregularities or by rain were reviewed Some of the theoretical results, which were derived from first principles, were compared with experimental findings J A M

N79-10301# Brunel Technical Coll Bristol (England) Dept of Marine Electronics

ELECTRO MAGNETIC WAVE PROPAGATION IN AN INHOMOGENEOUS MEDIUM: A LABORATORY STUDY

W G Burrows *In* AGARD Aspects of Electromagnetic Wave Scattering in Radio Commun Sep 1978 23 p refs (For primary document see N79-10299 01 32)

Avail NTIS HC A23/MF A01

A physical modelling technique was used as an aid in the study of radio wave propagation in the troposphere The basic technique employed an optical model, scaled and constructed to represent a full size tropospheric radio system, where a coherent light beam was propagated through an inhomogeneous gaseous medium whose structures and properties might be considered to represent the real atmosphere The model was used, concurrently with the full scale system to conduct a number of investigations in an attempt to establish the significance of the time varying refractive index properties of the medium in relation to changes in the structure of the propagated beam at distances from the source Some of the many simple experimental studies are summarized to illustrate the value of the technique These results when compared with those obtained from the full scale system gave rise to the conclusion that the primary mechanisms of transhorizon propagation were associated with atmospheric structures in the lower region of the troposphere J A M

N79-10302# Saarland Univ, Saarbrucken (West Germany)

TROPOSPHERIC REFLECTION OF DIFFERENTLY POLARIZED TRANSIENT SIGNALS

K J Langenberg *In* AGARD Aspects of Electromagnetic Wave Scattering in Radio Commun Sep 1978 12 p refs (For primary document see N79-10299 01-32)

Avail NTIS HC A23/MF A01

The evaporation duct model was used, consisting of a discontinuous drop of the otherwise constant relative permittivity at the upper duct boundary The earth was assumed to be a perfect conductor and ideally plane The electrical field strength was determined at a fixed point within the duct layer, having chosen a certain polarization of the primary source, whose moment was allowed to vary arbitrarily in time The solution method was essentially based on the application of two functional transforms and Cagniard's method for their inversion J A M

N79-10303# Colorado Univ, Boulder

TROPOSCATTER APERTURE-MEDIUM COUPLING LOSS

C Lewin *In* AGARD Aspects of Electromagnetic Wave Scattering in Radio Commun Sep 1978 6 p refs (For primary document see N79-10299 01-32)

Avail NTIS HC A23/MF A01

Two basically different descriptions were given as to the cause of aperture coupling loss in tropospheric scatter systems nonplanar wavefront due to atmospheric irregularities, and a geometric effect due to the decrease of scattering properties with height within the common volume of the beams of the transmitter and receiver antennas The irregular wavefront explanation was examined and related to height-diversity concepts, and it was shown that the effect was determined by the angular spectrum of incoming rays, performance was related to the angle range and beam width In the explanation via the geometric effect, it was shown that increasing the antenna gain increased the on axis power but decreased the angular range over which energy was received The reduction in effective angular range was due to the same phenomenon as that giving rise to the loss due to the irregular phase fronts It was concluded that the two explanations really reduce to one and the same J A M

N79-10304# Forschungsinstitut fuer Hochfrequenzphysik, Werthhoven (West Germany)

STATISTICS OF TROPOSCATTER CHANNELS WITH RESPECT TO THE APPLICATIONS OF ADAPTIVE EQUALIZING TECHNIQUES

F Schmitt *In* AGARD Aspects of Electromagnetic Wave Scattering in Radio Commun Sep 1978 15 p refs (For primary document see N79-10299 01 32)

Avail NTIS HC A23/MF A01

Higher coherent bandwidth requirements for troposcatter communication channels may create serious problems due to the dispersion characteristics of troposcatter channels The multipath structure of such a channel is time variant Introduction of digital PCM techniques may allow for processing schemes which result in adaptively equalizing the transmission channel These processing schemes were based on the troposcatter channel characteristics The experiments were made at a frequency of 0,9 GHz with a bandwidth of 10 MHz The impulse response functions were measured at a rate of 10 per sec for one minute, followed by intermodulation measurements for one minute and then starting the cycle again J A M

N79-10305# General Electric Co, Syracuse, N Y

HF SCATTER FROM OVERDENSE METEOR TRAILS

George H Millman *In* AGARD Aspects of Electromagnetic Wave Scattering in Radio Commun Sep 1978 14 p refs (For primary document see N79-10299 01-32)

Avail NTIS HC A23/MF A01

The characteristics of HF radar reflections from overdense meteor ionization trails, having line densities greater than 10 to the 14th power electrons/m, are discussed Theoretical estimates were made of the radar cross sectional area, time duration, and the Doppler frequency shift of meteor echoes Utilizing experimental meteor data recorded at 32 MHz by Greenhow and Watkins (1964), extrapolations were made of the statistical variations of the cross sectional area, the echo duration, and the meteor echo rate for frequencies in the 6 MHz to 40 MHz band J A M

N79-10306# Raytheon Co, Wayland, Mass

TIME AND FREQUENCY SPREAD IN METEOR BURST PROPAGATION PATHS

M D Grossi and A Javed (Bell-Northern Res Ltd, Ottawa) *In* AGARD Aspects of Electromagnetic Wave Scattering in Radio Commun 1978 11 p refs (For primary document see N79-10299 01-32)

(Grant NOAA-04-4-158-16)

Avail NTIS HC A23/MF A01

Meteor burst propagation provided an intriguing medium for over-the-horizon intermittent communications at VHF, but was characterized by several undesirable properties that have severely limited, thus far, its application to links of practical relevance This channel, in addition to being intermittent, was also characterized by time variable multipath spread and Doppler spread Typically, in VHF links 100 to 1500 km long, the gain decreased by about 10 db after a few seconds from trail formation, the value of the multipath spread rose to a few microseconds, while Doppler spread was at most a few hertz Analog techniques did not prove fully suitable in the past for coping with this type of channel, and very few applications of meteor burst links were known to have reached practical implementation and operational use J A M

N79-10307# Air Force Geophysics Lab, Hanscom AFB, Mass

THE EVOLUTION OF SCATTERING EQUATORIAL F-REGION

IRREGULARITIES AND RESULTANT EFFECTS ON TRANS IONOSPHERIC RADIO WAVES

Herbert E Whitney, Jules Aarons, Jurgen Buchau, Edward J Weber, and J P McClure (Texas Univ at Dallas) *In* AGARD Aspects of Electromagnetic Wave Scattering in Radio Commun Sep 1978 11 p refs (For primary document see N79-10299 01-32)

Avail NTIS HC A23/MF A01

Results from a series of ground and airborne experiments are presented which describe spatial and temporal characteristics of equatorial F region irregularities and the effect of these irregularities on transionospheric radio propagation The experiments included UHF amplitude scintillation measurements from the WIDEBAND, MARISAT, and LES-9 satellites, and simultaneous ionospheric measurements from the AFGL Airborne Ionospheric Observatory and the Jicamarca Radar Observatory in Peru The results indicated a highly localized generation of the irregularities such that individual patches consisted of dense irregularities of the order of 10 - 100% of the ambient electron density The extent of each patch is of the order of 50-400 km east-west and at times greater than 1200 km in the north-south direction Within these regions small scale irregularities from several kilometers to as small as 3 meters often existed Once the patches were generated, they moved predominantly eastward with initial velocities of 50-150 meters per second

J A M

N79-10308# Illinois Univ at Urbana-Champaign Urbana Dept of Electrical Engineering

PULSE DELAY AND PULSE DISTORTION BY RANDOM SCATTERING IN THE IONOSPHERE

K C Yeh and C H Liu *In* AGARD Aspects of Electromagnetic Wave Scattering in Radio Commun Sep 1978 7 p refs (For primary document see N79-10299 01-32)

(Grant DAAG29-76-G-0286)

Avail NTIS HC A23/MF A01

The effects of the random scattering on the pulse delay and the pulse width were studied; this problem was mathematically formulated and solved All multiple scattering effects were taken into account except the backscattering The solutions are given in terms of many parameters which can be classified into three kinds signal parameters, ionospheric parameters, and irregularity parameters It was found that under certain conditions effects caused by random scattering can be more important than those caused by dispersion

J A M

N79-10309# Naval Ocean Systems Center, San Diego, Calif

THE ATMOSPHERIC SCATTER CHANNEL FOR OPTICAL COMMUNICATIONS OVER-THE-HORIZON

G C Mooradian, M Geller, R A Krautwald, and D Stephens *In* AGARD Aspects of Electromagnetic Wave Scattering in Radio Commun Sep 1978 11 p refs (For primary document see N79-10299 01-32)

Avail NTIS HC A23/MF A01

Measurements of the properties of an over-the-horizon optical propagation channel by scattering from normal marine atmospheric aerosols were made The signal loss of a 40 mile path for wavelengths in the blue green was nominally 100 db when the atmospheric visibility was greater than 10 miles This loss decreased by approximately 20 db for the near infrared at 1 06 micron When atmospheric ducting occurred, the path loss for both wavelength regions decreased by 20 db with accompanying severe scintillation The apparent angular source size was small less than 10 milliradians and there was no evidence of pulse dispersion for the 20 ns transmitted pulses for the 40 mile path The scattered beam was sharply peaked in the forward direction A model that was developed is in reasonable agreement with the data

J A M

N79-10310# CNR Inc Needham, Mass

RELATIONSHIP BETWEEN MODEM DEVELOPMENT AND CHANNEL CHARACTERIZATION

Phillip A Bello *In* AGARD Aspects of Electromagnetic Wave Scattering in Radio Commun Sep 1978 3 p (For primary document see N79 10299 01 32)

Avail NTIS HC A23/MF A01

The most effective approach to the development of optimum modulation and demodulation techniques for a specific class of channels involved a sequence of steps These steps included the measurement and modeling of channel characteristics to provide the basis for optimum modem design concepts and the utilization of channel simulators for the development, acceptance testing, and comparative evaluation of implemented modems prior to field testing

J A M

N79-10311# CNR Inc Needham, Mass

WIDEBAND LINE-OF-SIGHT CHANNEL SIMULATION SYSTEM

Phillip A Bello and H David Goldfein *In* AGARD Aspects of Electromagnetic Wave Scattering in Radio Commun Sep 1978 14 p refs (For primary document see N79 10299 01-32)

(Contract F30602 75-C-0242)

Avail NTIS HC A23/MF A01

The theoretical background, methods of implementation, and utility of a multipurpose wideband LOS (line-of sight) channel simulation system is described as a means for checking out wideband digital modems The system provided both a channel probing/channel playback capability and a synthetic stochastic channel simulation Simulated propagation media effects included both multipath due to refractive anomalies (refractive multipath) and scattering off the surface (surface multipath) The types of LOS channels handled by the system included airplane-airplane, ground-airplane, ground-ground, and airplane satellite In addition, the simulator allowed the introduction of controlled amounts of nonlinearity, phase jitter, and frequency offset The simulator operated at selectable IF frequencies of 70, 300, or 700 MHz At the two higher IF frequencies, signal bandwidths up to 100 MHz may be accommodated, while at 70 MHz, bandwidths up to 25 MHz may be handled

J A M

N79-10312# Laboratoire d'Etude des Transmissions Ionospheriques, Cachan (France)

ELECTROMAGNETIC SOUNDING TECHNIQUE USING SPECTRAL AND SPATIAL SAMPLING OF THE RECEPTION SIGNALS, APPLICATION TO THE STUDY OF INHOMOGENEITIES IN IONOSPHERIC PLASMA

C Goutelard, J L Caratori, and A Joisel *In* AGARD Aspects of Electromagnetic Wave Scattering in Radio Commun Sep 1978 22 p refs In FRENCH, ENGLISH summary (For primary document see N79-10299 01-32)

Avail NTIS HC A23/MF A01

The study of diffusion properties of ionospheric plasma was connected to inhomogeneities of free electrons density The inhomogeneous studies were carried out by different methods, using very sensitive measuring systems The backscatter sounding method necessitated important installations A sounding station, using this principle, was constructed Very accurate and precise measurements were readily obtained Frequency resolutions better than 0.01 Hz are usually reached although measurements points are separated by only 0.05 s Spatial resolutions were only limited by technological aspects This technique was used in backscatter ionospheric soundings and allowed low value inhomogeneities in ionospheric plasma to be revealed, as well as certain brief local changes such as ionized meteor trails

J A M

N79-10313# Laboratoire d'Etude des Transmissions Ionospheriques, Cachan (France)

APPLICATION OF BACKSCATTER TECHNIQUE TO IONOSPHERIC SHORT TERM PREDICTIONS

C Goutelard, J L Caratori, J L Coatanhay, and R Rolland *In* AGARD Aspects of Electromagnetic Wave Scattering in Radio Commun Sep 1978 16 p refs In FRENCH, ENGLISH summary (For primary document see N79-10299 01-32)

Avail NTIS HC A23/MF A01

A forecasting method based upon the use of the spectrals analysis of backscatter echoes and on the inversion of backscatter ionograms is described The inversion program, which made use of regression curves can easily be processed using a small computer The exploitation of the spectrals analysis of backscatter echoes allowed instantaneous measurement of dynamic parameters of the ionized layers and brought about a considerable increase in the probability of a link being well established Experimental results carried out on real cases show the validity of the method

J A M

N79-10314# Saarland Univ, Saarbrucken (West Germany)

CALCULATION OF THE SCATTERING CROSS-SECTION OF PERFECTLY CONDUCTING OR DIELECTRIC BODIES BY NUMERICAL OR PERTURBATIONAL METHODS

K-D Becker *In* AGARD Aspects of Electromagnetic Wave Scattering in Radio Commun Sep 1978 13 p refs (For primary document see N79-10299 01-32)

Avail NTIS HC A23/MF A01

For the calculation of the scattering cross section of perfectly conducting or dielectric cylinders of rough surfaces, two methods were used a numerical method, based on integral equation formalism, and a perturbational method The validity of the results based on these methods was examined in their

dependence on selected characteristic parameters. Also, the influence of these characteristic parameters on the far field cross section was studied. J A M

N79-10315# Kansas Univ., Lawrence. Remote Sensing Lab.
A SCATTER MODEL FOR LEAFY VEGETATION
A. K. Fung and F. T. Ulaby. *In* AGARD Aspects of Electromagnetic Wave Scattering in Radio Commun. Sep. 1978. 10 p. refs. (For primary document see N79-10299 01-32)
(Grant NSF ENG-75-03220; DAAG29-77-G-0075)
Avail: NTIS HC A23/MF A01

A model for vegetation scatter was developed, using the first order renormalization method. The vegetated medium was taken to be an inhomogeneous medium characterized by a random permittivity function with a cylindrically symmetric, fast decaying correlation function. The permittivity of the vegetation (taken to be a combination of water and some solid material) was estimated by mixing formula after de Loor (1968) and the permittivity of the vegetated medium (taken to be a combination of vegetation and air) was estimated. The backscattering coefficient from such a model was computed as a function of the incidence angle, frequency, and the moisture content of the vegetation. Comparisons were made with measured data from soybeans, alfalfa, and corn. J A M

N79-10316# British Aircraft Corp., Filton (England). Guided Weapons Div.
VHF PROPAGATION PREDICTION WITH PATH PROFILE METHODS
B. K. Lee. *In* AGARD Aspects of Electromagnetic Wave Scattering in Radio Commun. Sep. 1978. 11 p. refs. (For primary document see N79-10299 01-32)
Avail: NTIS HC A23/MF A01

Propagation prediction models applicable to VHF military type links in West Germany were derived. These related to a static base station located to give good area coverage. The initial stages of the work involved the measurement of propagation losses (and local signal variations) for 830 paths at 3 frequencies, and also the construction of a digitized topographic data base for the area considered. The latter enabled two dimensional path profiles with associated surface features (such as trees and buildings) to be rapidly produced between any two points within the data base area. The measured data were analyzed in conjunction with the associated path profiles to produce prediction models for both the median propagation loss and the local signal variations as functions of the path profile. The standard deviation of prediction error for the former was 7.3 db, while the average standard deviation for the signal distributions for the latter was 2.5 db. J A M.

N79-10317# Research Inst. of National Defence, Stockholm (Sweden).
MULTIPATH CHARACTERISTICS AT UHF IN RURAL IRREGULAR TERRAIN
Lars Ladell. *In* AGARD Aspects of Electromagnetic Wave Scattering in Radio Commun. Sep. 1978. 12 p. refs. (For primary document see N79-10299 01-32)
Avail: NTIS HC A23/MF A01

Extensive measurements were carried out in order to get a better knowledge concerning multipath characteristics in rural irregular terrain. These measurements were then used in a comparison with two different theoretical models, which were developed to find out the behavior of multipath propagation in different kinds of terrain. In a deterministic theoretical model, the field strength of a delayed wave component was calculated, assuming a given vertical reflection obstacle oriented for optimum reflection. From this model, the effects on multipath propagation by changing polarization, frequency or antenna height, may be assessed. By means of a Monte Carlo technique this deterministic model together with a statistical description of terrain characteristics were utilized to create a stochastic model. It was used for risk analysis of multipath propagation effects in different kinds of irregular terrain. J A M

N79-10318# Shape Technical Center, The Hague (Netherlands).
INTERCEPTION OF SIGNALS TRANSMITTED VIA METEOR TRAILS
A. N. Ince. *In* AGARD Aspects of Electromagnetic Wave Scattering in Radio Commun. Sep. 1978. 13 p. refs. (For primary document see N79-10299 01-32)
Avail: NTIS HC A23/MF A01

In order to test the vulnerability of meteor burst signals to interception and jamming, a 1000 km circuit between La Crau, near Toulon, France, and Staalduinen near The Hague, Netherlands, was monitored at five different locations. These were Harrogate in the UK, Saclay near Paris, Breisach near Freiburg, Santa Marinella near Rome, and Noordwijk, some 35 km from the terminal at Staalduinen. It was found that at Noordwijk, the same signal bursts were received as at the northern terminal 35 km away, and interception was practically total. At the other four locations interception was mainly due to the simultaneous occurrence of two meteor trails reflecting waves in different directions. The amount of information intercepted was on the average between 3 percent and 16 percent, but could occasionally be 100 percent due to sporadic E layer reflections. However, the experiments used a frequency of 36 MHz, by operating at 70 MHz or higher interception due to abnormal ionospheric propagation conditions could be virtually eliminated. J A M

N79-10319# Institute for Telecommunication Sciences, Boulder, Colo. Policy Res. Div.
TROPOSPHERIC STRATIFICATION AND ANOMALOUS PROPAGATION
Harold T. Dougherty and Burgette A. Hart. *In* AGARD Aspects of Electromagnetic Wave Scattering in Radio Commun. Sep. 1978. 9 p. refs. (For primary document see N79-10299 01-32)
Avail: NTIS HC A23/MF A01

The progress to date was summarized for predicting the enhanced fields that were encountered in a stratified atmosphere. The ducting conditions associated with supercritical refractivity gradients both aloft and at or near the surface were considered. As a basis for estimating the likelihood of these supportive conditions, the available information was surveyed. It was suggested that the access to computers and the availability of historical radiosonde data be exploited to map the pertinent characteristics of tropospheric layers on a worldwide basis to meet the interference prediction requirements of the telecommunications regulatory agencies. J A M

N79-10320# Shape Technical Center, The Hague (Netherlands).
A REVIEW OF SCATTER COMMUNICATIONS
A. N. Ince, I. M. Vogt, and H. P. Williams. *In* AGARD Aspects of Electromagnetic Wave Scattering in Radio Commun. Sep. 1978. 31 p. refs. (For primary document see N79-10299 01-32)
Avail: NTIS HC A23/MF A01

Six distinct forms of scatter communication were reviewed, namely ionoscatter, meteorscatter, field aligned scatter, troposcatter, chaff or needles, and a short range scatter from using ultraviolet radiation. A summary was provided in the form of a figure giving typical values of the frequencies and distances involved, together with the multipath and frequency spreads and typical scatter losses. Each type of scatter communication is discussed briefly, though because of the greater importance of troposcatter systems this form is dealt with at some length. It was pointed out that troposcatter predictions were still subject to errors in the path loss of 10 db or more, and that a better knowledge is required of the effect of climatic conditions. A neglected type of scatter communication was meteor burst which offers a simple solution to the transmission of a few telegraph channels for distances of up to 2000 km. J A M

N79-10321# Defense Communications Engineering Center, Reston, Va.
DESIGN CONSIDERATIONS FOR DIGITAL TROPOSCATTER COMMUNICATIONS SYSTEMS
J. L. Osterholz. *In* AGARD Aspects of Electromagnetic Wave Scattering in Radio Commun. Sep. 1978. 15 p. refs. (For primary document see N79-10299 01-32)
Avail: NTIS HC A23/MF A01

The performance of digitized voice channels under fading conditions was measurably different than the performance of conventional analog voice channels under the same conditions. Therefore the applicability of existing analog transmission link and system design criteria to the design of a digital transmission system was negligible. Performance criteria were proposed for digitized voice channels which more accurately reflect the expected temporal distribution of channel outages given the fading statistics of the troposcatter channel. Measured data is presented along with a digital troposcatter channel model which effectively bounds voice channel outage statistics on digital troposcatter links and relates these statistics to link design parameters such as link signal to noise ratio, multipath dispersion, and diversity configuration. J A M

N79-10322# Marconi Communication Systems Ltd., Chelmsford (England).

LEVEL CONTROL IN TROPOSPHERIC SCATTER SYSTEMS
B S Skingley *In* AGARD Aspects of Electromagnetic Wave Scattering in Radio Commun Sep 1978 8 p refs (For primary document see N79-10299 01-32)
Avail NTIS HC A23/MF A01

The methods used to implement the various level control techniques are described along with design criteria for setting various critical parameters and for establishing specific approaches It was noted that receive level-control alone was sufficient to enable the filters to be effective in minimizing interference into any given link from other systems Temperature control was also required to minimize interference A method is described whereby both systems can be implemented to gain the advantages of both J A M

N79-10323# Shape Technical Center, The Hague (Netherlands)
THE PERFORMANCE OF METEOR-BURST COMMUNICATIONS AT DIFFERENT FREQUENCIES
D W Brown and H P Williams *In* AGARD Aspects of Electromagnetic Wave Scattering in Radio Commun Sep 1978 26 p refs (For primary document see N79-10299 01-32)
Avail NTIS HC A23/MF A01

The phenomenon of propagation via meteor trails is reviewed, and the STC meteor burst communication system, COMET, which used ARQ and diversity reception to provide several telegraph channels on a 1000 km path is described Results of extensive testing of COMET at frequencies near 40 and 100 MHz are presented Signal level statistics, as well as burst length and interval statistics are included for both frequencies The traffic capacity of the COMET system at the two frequencies was compared, based on extensive trials, using simple yagi antennas and transmitter powers of 200 W and 2000 W at 40 and 100 MHz respectively Reasons for the observed dependance were developed and it was due primarily to the physics of meteor propagation, rather than to inefficiencies in the COMET system Two possible applications of a COMET system, a low capacity jamming resistant circuit and a reliable orderwire for an HF system, are briefly discussed and suggested circuit parameters set out J A M

N79-10324# California Microwave, Inc., Fullerton.
COMMUNICATIONS VIA METEOR TRAILS
Frank J Sites *In* AGARD Aspects of Electromagnetic Wave Scattering in Radio Commun Sep 1978 21 p refs (For primary document see N79-10299 01-32)
Avail NTIS HC A23/MF A01

The state-of the-art of meteoric communications, basic meteoric conditions, system engineering implications, and why these developments constitute a departure from, or provide unique applications of, current technology were addressed A brief historical development was provided and followed by an explanation of the nature, availability, and radio characteristics of meteor trails Such material included justified propagation-availability models, availability improvement techniques, optimization of radio system provisions, and other new information It was shown that a departure from conventional bistatic paths, point-to-point practices, and brute force techniques promoted a host of unique and intriguing system possibilities J A M

N79-10325# Shape Technical Center, The Hague (Netherlands)
PROPAGATION MEASUREMENTS ON THE ACE-HIGH TROPOSCATTER SYSTEM
A N Ince and I M Vogt *In* AGARD Aspects of Electromagnetic Wave Scattering in Radio Commun Sep 1978 22 p refs (For primary document see N79-10299 01-32)
Avail NTIS HC A23/MF A01

To predict the propagational reliability of the ACE High troposcatter system, extensive measurements were carried out over a period of two years (1963-1965) on several links which were selected to typify geographical and meteorological conditions in the system The measurement program consisted of (1) long term measurements of the transmission loss on seven links, one in Norway, two in Germany, and four in the Mediterranean and (2) measurement of the multipath intermodulation noise on five links J A M

N79-10326# CNR, Inc., Needham, Mass
A REVIEW OF SIGNAL PROCESSING FOR SCATTER COMMUNICATIONS
Phillip A Bello *In* AGARD Aspects of Electromagnetic Wave Scattering in Radio Commun Sep 1978 23 p refs (For primary document see N79-10299 01-32)
Avail NTIS HC A23/MF A01

The state-of the-art in effective communications techniques was reviewed for fading multipath distorted radio links The system function parameters of important radio links were defined, and the relationship between the values of these parameters and the selection of appropriate modulation and demodulation techniques is discussed Reliable communication over fading dispersive channels required the utilization of diversity communications In addition to the conventional forms of diversity, such as space, frequency, angle, and polarization, advanced communication techniques make use of signal diversity which existed in the signal structure of the received digital modulation waveform by virtue of the time and frequency selectivity of the channel Utilization of modem and coding techniques to exploit signal diversity is discussed and error rate curves presented J A M

N79-10327# Fernmeldetechnisches Zentralamt, Darmstadt (West Germany)
MAXIMUM USABLE BANDWIDTH AND FREQUENCY DIVERSITY IN TROPOSCATTER COMMUNICATION
R Valentin *In* AGARD Aspects of Electromagnetic Wave Scattering in Radio Commun Sep 1978 10 p refs (For primary document see N79-10299 01-32)
Avail NTIS HC A23/MF A01

Measurements concerning the maximum usable bandwidth, as well as the frequency distance necessary for frequency diversity, were performed on a 420 km tropospheric scatter path A carrier frequency of 1.89 GHz and two side bands with variable frequency spacing up to 4 MHz were transmitted The received scatter-mode signals referring to the three different frequencies were correlated by means of an electronic correlator It was possible to obtain the frequency correlation function, which determined the maximum usable bandwidth and the frequency diversity spacing. Author

N79-10328# GEC-Marconi Electronics Ltd., Chelmsford (England) Research Labs
TROPOSCATTER ANGLE DIVERSITY IN THEORY AND PRACTICE
M W Gough, G C Rider, and R Larsen *In* AGARD Aspects of Electromagnetic Wave Scattering in Radio Commun Sep 1978 14 p refs (For primary document see N79-10299 01-32)
Avail NTIS HC A23/MF A01

Background work on the behavior of angle diversity in the troposcatter mode is briefly reviewed, together with some important applications Favorable predictions of angle diversity behavior, based on established theory and limited experimental validation, have encouraged confirmatory trials on an established oversea troposcatter link temporarily adapted for angle diversity working Trials at the U K terminal involved simultaneous comparison between a reference dual (angle/space) diversity system and optimized angle diversity systems involving horizontally splayed beams and latterly vertically splayed beams The horizontally offset system yielded channel cross correlations and post-combiner relative efficiencies, well in keeping with theoretical prediction, while the vertically offset system performed significantly better than predicted J A M

N79-10329# Mitre Corp., Bedford, Mass
AN EXPERIMENTAL PROGRAM LEADING TO DEVELOPMENT OF A TACTICAL DIGITAL TROPOSCATTER SYSTEM
A Sherwood, S Wenglin, and J Wick *In* AGARD Aspects of Electromagnetic Wave Scattering in Radio Commun Sep 1978 16 p refs (For primary document see N79-10299 01-32)
Avail NTIS HC A23/MF A01

An extensive test program was undertaken to characterize the multipath nature of tactical troposcatter links The data was used to prepare the design specifications for the AN/TRC-170 troposcatter terminals A performance prediction technique was derived which considers the variability in path loss and multipath spreading and the effect of this variability on modem performance to predict the usable range of this equipment J A M

N79-10330# Defense Communications Engineering Center, Reston, Va
PROPAGATION MEASUREMENTS ON A TRANSALPINE OVER-THE-HORIZON PATH
J L Osterholz, P T Nielsen, E Pusone, and I M Vogt *In* AGARD Aspects of Electromagnetic Wave Scattering in Radio Commun Sep 1978 17 p refs Prepared in cooperation with Shape Tech Center, The Hague (For primary document see N79-10299 01-32)

Avail NTIS HC A23/MF A01

Results of propagation measurements on a transhorizon UHF path are presented. The path was a 287 km forward scatter link between southern Germany and northern Italy, traversing the Swiss Alps. Measurements were carried out during the period January to June 1977. The results illustrate the large variation in propagation characteristics caused by a diurnally fluctuating mixture of troposcatter and diffraction propagation. Received signal level predictions, based on a detailed topographic analysis of the test link, and measured data were shown to be in reasonable agreement. Frequent periods of rapid fading attributed to aircraft passage through the scatter volume were noted, and data were presented which characterizes aircraft passage events, according to their signal level and differential delay profiles. J.A.M.

N79-10331# Laboratoire d'Etude des Transmissions Ionospheriques, Cachan (France)

USE OF PSEUDO-ORTHOGONAL CODES IN RANDOM MULTIPATH CHANNELS

F. Chavand, M. Gindre, and C. Goutelard. *In* AGARD, Aspects of Electromagnetic Wave Scattering in Radio Commun., Sep. 1978, 23 p, refs. In FRENCH, ENGLISH summary (For primary document see N79-10299 01-32)

Avail NTIS HC A23/MF A01

Use of pseudo-orthogonal codes allowed an increase in bit rate while a very low error ratio was guaranteed. Pseudo-orthogonal codes classification and codes construction algorithms were considered. These codes were used in multipath ionospheric channel transmissions. Errors in a particular path, caused by interference of the other propagation modes, were corrected by the redundancy introduced by pseudo orthogonal codes. J.A.M.

N79-10332# CNR, Inc., Needham, Mass.

MLT-1: AN EXPERIMENTAL MODEM FOR TROPOSCATTER COMMUNICATIONS USING MAXIMUM LIKELIHOOD SEQUENCE ESTIMATION AND ERROR-CORRECTION CODING

David Chase and Phillip A. Bello. *In* AGARD, Aspects of Electromagnetic Wave Scattering in Radio Commun., Sep. 1978, 14 p, refs. (For primary document see N79-10299 01-32)

(Contract F30602-74-C-0133)

Avail NTIS HC A23/MF A01

A new high speed troposcatter digital modem, designated MLT-1, is discussed. This modem combined coding and modulation and achieved unprecedented reliability by exploiting the scatter properties of this channel to achieve in-band time and frequency diversity. Experimental results for a tactical single diversity troposcatter modem operating at uncoded data rates of 4.6 Mb/s and a coded data rate of 2.3 Mb/s are presented. Author

N79-10333# Shape Technical Center, The Hague (Netherlands)

AN EXPERIMENTAL MODEM FOR HF CHANNELS USING SPREAD-SPECTRUM AND BLOCK ENCODING

R. E. Schemel and A. N. Ince. *In* AGARD, Aspects of Electromagnetic Wave Scattering in Radio Commun., Sep. 1978, 5 p, refs. (For primary document see N79-10299 01-32)

Avail NTIS HC A23/MF A01

An experimental program was developed to investigate the performance of a spread spectrum HF modem, designed to combat multipath and interference effects. The design of a prototype system is outlined, and performance results are discussed. The features of the modem included automatic synchronization, diversity operation, provision for an ARQ mode, and more elaborate coding methods. J.A.M.

N79-27385# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France)

AEROSPACE PROPAGATION MEDIA MODELLING AND PREDICTION SCHEMES FOR MODERN COMMUNICATIONS, NAVIGATION, AND SURVEILLANCE SYSTEMS

May 1979, 208 p, *refs*, *AGARD Lecture Ser. held at London*, 4-5 Jun. 1979, Boulder, Colo., 14-15 Jun. 1979

(AGARD-LS-99, ISBN 92-835-1322-3) Avail NTIS HC A10/MF A01

Modelling and prediction schemes of the aerospace radio and optical propagation environment based on media characterization have become essential to meet requirements of operational accuracies in communication, navigation, and surveillance in military and civilian systems. The lectures included the following topics: (1) general modelling and prediction schemes, (2) aerospace (atmosphere, ionosphere, and the space environment) media-characterization, (3) short- and long-term prediction techniques across the RF and optical spectrum and agreement with observational data, (4) detection and communications through scattering channels, (5) adaptability of prediction techniques to radio and optical communication, navigation and surveillance systems operating in the aerospace environment, and (6) effects of geophysical disturbances on the state of the media and their predictability. For individual titles, see N79-27386 through N79-27393.

N79-27386# Appleton Lab., Slough (England)

PROPAGATION AT MEDIUM AND HIGH FREQUENCIES. 1: PRACTICAL RADIO SYSTEMS AND MODELLING NEEDS

P. A. Bradley. *In* AGARD, Aerospace Propagation Media Modelling and Prediction Schemes for Mod. Commun., Navigation, and Surveillance Systems, May 1979, 21 p, refs. (For primary document see N79-27385 18-32)

Avail NTIS HC A10/MF A01

The principal phenomena associated with ground wave and sky wave propagation at MF and HF are discussed. Particular consideration is given to transmission loss and coverage range, the dependence on ground-reflection properties, the state of the ionosphere and the earth's magnetic field. Regular temporal changes depending on time of day, season and solar activity, together with short term fading are noted. The importance of antenna design in system operation is emphasized. Practical usage of the MF and HF bands is illustrated. Propagation parameters susceptible to modelling were reviewed, followed by an examination of requirements for long-term propagation models for system design, frequency allocation, and assignment. Short-term models are shown to be of potential value for frequency management, but the logistic difficulties of producing and disseminating results from these models are emphasized. J.A.M.

N79-27387# Institute for Telecommunication Sciences, Boulder, Colo. Performance Predictions and Model Development Group

TRANSIONOSPHERIC RADIO PROPAGATION

Charles M. Rush. *In* AGARD, Aerospace Propagation Media Modelling and Prediction Schemes for Mod. Commun., Navigation, and Surveillance Systems, May 1979, 28 p, refs. (For primary document see N79-27385 18-32)

Avail NTIS HC A10/MF A01

The effects of the earth's ionized atmosphere on radio waves that propagate through the ionosphere are reviewed. Emphasis is placed on transionospheric radio propagation systems and how their operational performance is impacted by the structure of, and changes in the structure of the ionosphere. The normal ionosphere leads to refraction and slowing down of radio waves that propagate through it. This refraction and slowing down varies as the ionosphere itself varies. Irregularities in the ionospheric electron density can impart fluctuations or scintillations onto radio waves that pass through the irregularities. The morphological behavior of the ionospheric characteristics pertinent to transionospheric systems, as well as actual observations of these characteristics are discussed in terms of impact on system performance. Models that were developed to represent these characteristics under conditions of varying geophysical activity were also considered. J.A.M.

N79-27388# Air Force Geophysics Lab., Hanscom AFB, Mass.

MODELLING OF THE VISIBLE/INFRARED PROPAGATION ENVIRONMENT

Robert A. McClatchey. *In* AGARD, Aerospace Propagation Media Modelling and Prediction Schemes for Mod. Commun., Navigation, and Surveillance Systems, May 1979, 14 p, refs. (For primary document see N79-27385 18-32)

Avail NTIS HC A10/MF A01

The pertinent atmospheric properties of temperature, pressure and constituent distribution are discussed. The AFGL atmospheric absorption line parameters compilation will then be described with emphasis on the accuracy of the data base and its application to high resolution propagation modelling. The necessity to deal with molecular continuum absorption and its relationship to absorption line formation are discussed. Knowledge and application of aerosol optical properties to the development of aerosol models are presented. Finally, the LOWTRAN atmospheric transmission model is described with emphasis on its accuracy, its applicability and its limitations. J.A.M.

N79-27389# Cologne Univ. (West Germany)

THE TRANSFER OF ELECTROMAGNETIC RADIATION IN THE TURBULENT ATMOSPHERE

E. Raschke. *In* AGARD, Aerospace Propagation Media Modelling and Prediction Schemes for Mod. Commun., Navigation, and Surveillance Systems, May 1979, 10 p, refs. (For primary document see N79-27385 18-32)

Avail NTIS HC A10/MF A01

The principle properties of the terrestrial atmosphere are reviewed up to an altitude of about 50 km, with inclusion of general principles of theoretical models for the calculation of its motion fields. This is followed by a description of the transfer of electromagnetic radiation in the turbulent atmosphere and a brief outline of the general radiative transfer theory. J.A.M.

N79-27390# Massachusetts Inst. of Tech., Cambridge. Dept. of Electrical Engineering and Computer Science.

OPTICAL COMMUNICATION AND DETECTION THROUGH OPTICAL SCATTERING CHANNELS

Robert S. Kennedy. *In* AGARD Aerospace Propagation Media Modelling and Prediction Schemes for Mod. Commun., Navigation, and Surveillance Systems. May 1979. 10 p. refs. (For primary document see N79-27385 18-32)

(Contract DAAG29-77-C-0048, Grant NSF ENG-78-21603)

Avail NTIS HC A10/MF A01

The following were considered: (1) the effects of multiple scattering upon received signals, (2) the impact of these effects upon the performance of systems that were designed to operate in the absence of scattering, and (3) the essential features of systems that are best able to operate through channels in which the propagation is dominated by multiply-scattered radiation. A plausible, but incomplete, statistical model for the aperture field was introduced. The changes in the qualitative feature of the field with increasing scatter is reviewed. The performance degradation that systems designed for clear weather operation suffer in the face of increased scatter was noted as a prelude to a deeper discussion of the essential features and performance of systems that were designed to operate in multiple scattering atmospheres. J.A.M.

N79-27391# Norwegian Defence Research Establishment, Kjeller.

GEOPHYSICAL DISTURBANCE EFFECTS ON THE STATE OF THE PROPAGATION MEDIUM AND THEIR PREDICTABILITY

E. V. Thrane. *In* AGARD Aerospace Propagation Media Modelling and Prediction Schemes for Mod. Commun., Navigation, and Surveillance Systems. May 1979. 24 p. refs. (For primary document see N79-27385 18-32)

Avail NTIS HC A10/MF A01

Different types of disturbances in the upper atmosphere can change its properties as a propagation medium for electromagnetic waves. The most important of these disturbances are reviewed along with the possibility of predicting, not their actual occurrence, but rather their effect on the atmosphere once they have occurred. The review is based upon current knowledge of ionospheric and upper atmosphere physics, and concentrates on effects of importance to radio wave propagation. Both natural phenomena, such as magnetic storms, and man-made disturbances are discussed. J.A.M.

N79-27392# Appleton Lab., Slough (England).

PROPAGATION AT MEDIUM AND HIGH FREQUENCIES. 2: LONG AND SHORT-TERM MODELS

P. A. Bradley. *In* AGARD Aerospace Propagation Media Modelling and Prediction Schemes for Mod. Commun., Navigation, and Surveillance Systems. May 1979. 43 p. refs. (For primary document see N79-27385 18-32)

Avail NTIS HC A10/MF A01

Procedures for the long-term estimation of sky-wave signal strengths at MF and HF as proposed by the CCIR are discussed. At MF an empirical fit to past measured signal data was used. Particular consideration was given to modelling the increased losses at auroral latitudes and the excess polarization-coupling loss on some-latitude paths. Sea-gain-enhancement allowances are also presented. Models at HF are shown to involve a detailed representation of the state of the ionosphere, idealized height distributions of electron concentration, an approximate means of raypath determination and separate allowances for the different factors contributing to the transmission loss. The degree of agreement with observational data achieved was illustrated for both frequency bands. The CCIR models for atmospheric, man-made and galactic noise were reviewed and examples presented of computer-based calculations. The use of statistical day-to-day signal and noise variability statistics to provide system performance estimates at HF was indicated. J.A.M.

N79-27393# Norwegian Defence Research Establishment, Kjeller.

PROPAGATION OF LONG RADIO WAVES IN THE EARTH'S ENVIRONMENT

E. V. Thrane. *In* AGARD Aerospace Propagation Media Modelling and Prediction Schemes for Mod. Commun., Navigation, and Surveillance Systems. May 1979. 26 p. refs. (For primary document see N79-27385 18-32)

Avail NTIS HC A10/MF A01

The antenna problem is discussed, then the propagation of the long waves in the waveguide formed by the earth's surface and the lower ionosphere is treated. Some of the most important computational methods available for predicting phase and amplitude of long waves are briefly described. The penetration of long waves into the sea is of importance for submerged vessels, and the physical principles of such penetration will be given some attention. The most important application of long waves is probably for navigation purposes. The major VLF and LF navigation systems in use will be described and their accuracy and limitations discussed. J.A.M.

N79-30454# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).

STRATEGIES FOR AUTOMATIC TRACK INITIATION

S. J. Rabinowitz, ed. (Mitre Corp., Bedford, Mass.). Jun. 1979. 230 p. refs. In ENGLISH and FRENCH. Presented at the Avionics Panel Specialists' Meeting, Monterey, Calif., 16-17 Oct. 1978. (AGARD-CP-252, ISBN-92-835-0236-1) Avail: NTIS HC A11/MF A01

The subjects of extraction of targets from clutter, automatic track initiation, and automatic tracking are covered. The application of various techniques to individual two dimensional and three dimensional radars, nets of two dimensional and three dimensional radars, and experimental phased array radars are presented. For individual titles, see N79-30455 through N79-30473.

N79-30455# Admiralty Surface Weapons Establishment, Portsdown (England).

AN AUTOMATIC TRACKING SYSTEM BASED ON THE STATIONARY PLOT FILTER

R. J. Tunnicliffe. *In* AGARD Strategies for Autom. Track Initiation. Jun. 1979. 22 p. refs. (For primary document see N79-30454 21-32)

Avail NTIS HC A11/MF A01

The design of an automatic tracking system applicable to shipborne non-moving target indicator radars is considered. The system is based on the stationary plot filter (SPF), which cancels stationary and slow moving detections and also provides data for both control of the first threshold and adaption of the track confirmation rules. The design of the system is discussed, with the emphasis on the SPF. Some experimental results are presented, which show how the performance of the filter is affected by the values of its parameters and also compares the performance of the SPF based approach with that of the more conventional moving target indication. J.M.S.

N79-30456# Lincoln Lab., Mass. Inst. of Tech., Lexington.

AUTOMATED TRACKING FOR AIRCRAFT SURVEILLANCE RADAR SYSTEMS

R. M. ODonnell and C. E. Muehe. *In* AGARD Strategies for Autom. Track Initiation. Jun. 1979. 16 p. refs. (For primary document N79-30454 21-32)

(Contracts DOT-FA72WAI-242, DOT-FA-TQ-679, F19628-78-C-0002)

Avail NTIS HC A11/MF A01

An improved moving target detector (MTD) (a digital signal processor) was designed, constructed and tested which successfully rejects all forms of radar clutter while providing reliable detection of all aircraft within the coverage of the radar. Testing on both terminal and enroute surveillance radars is reported. This processor was integrated with automatic tracking algorithms to give complete rejection of ground clutter, heavy precipitation, and angels (birds). J.M.S.

N79-30457# Forschungsinstitut fuer Funk und Mathematik, Werthoven (West Germany).

BEAM STEERING AND SIGNAL PROCESSING WITH A PHASED ARRAY RADAR SYSTEM FOR AUTOMATIC TRACK INITIATION

Eberhard Hanle. *In* AGARD Strategies for Autom. Track Initiation. Jun. 1979. 12 p. refs. (For primary document see N79-30454 21-32)

Avail NTIS HC A11/MF A01

The relations between the main system functions search, acquisition, and tracking and their radar counterparts detection, interference reduction, and position finding of an experimental radar system (ELRA) are explained. For automatic track initiation a lot of radar tasks with different parameters are handled partly simultaneously and partly sequentially which demands

various kinds of data transfer between the radar antennas and the tracking computer It is pointed out that the radar physics and the tracking process require a variable integration time for optimum signal processing dependent on the target range, direction, and estimated cross section and on the information from a clutter map and that adaptive clutter suppression and jammer cancellation can be included with modest reduction of the efficiency The demand for a high detection probability and location accuracy and limitations in power and time with long-range surveillance systems are overcome by a multiple-beam concept using interlaced transmit-receive processing J M S

N79-30458# Shape Technical Center, The Hague (Netherlands) Command Control and Systems Div

DESIGN CONSIDERATIONS FOR RADAR TRACKING IN CLUTTER

H. B. Driessen *In* AGARD Strategies for Autom. Track Initiation Jun 1979 14 p refs (For primary document see N79-30454 21-32)

Avail: NTIS HC A11/MF A01

The performance of an automatic tracking logic in a mixed environment of false and real plots is studied The problem is investigated with Monte Carlo simulation The investigation is a sensitivity analysis for five important parameters (1) radar detection probability, (2) clutter density, (3) smoothing parameters, (4) gate size, and (5) maximum number of consecutive misses The results are applicable to the design of a tracking logic of an automatic air traffic control system J M S

N79-30459# Plessey Radar Ltd., Addlestone (England)

SOME ASPECTS OF MULTI-RADAR TRACKING

A. R. Morley and A. S. Wilsdon *In* AGARD Strategies for Autom. Track Initiations Jun 1979 14 p ref (For primary document see N79-30454 21-32)

Avail: NTIS HC A11/MF A01

Three different aspects of a multi-radar simulation study aimed at determining the best tracking organization and algorithms are presented The first aspect is that of tracking groups of aircraft which are not all individually resolvable Simulation showed that a manually defined quadrilateral enclosing the aircraft could be used for filtering the formation while tracking was performed by evaluating the centroid of the group and tracking it as a single entity In any tracking system height is required primarily for tactical reasons, but in a multi-radar tracking system it is also required for the co-ordinate conversion of the measured plot position to the common tracking plane There is therefore an additional requirement to produce accurate height information in order to improve the tracking performance The height accuracy can, in general, be improved by height filtering A possible algorithm is described The implications of uncoupling the multi-radar Kalman filter are considered in terms of tracking performance It is shown that under certain circumstances the tracking performance is considerably degraded when an uncoupled Kalman filter is implemented A R H

N79-30460# Elektronik-System G m b H., Munich (West Germany)

ALGORITHMS FOR SIMULTANEOUS AUTOMATIC TRACK INITIATION IN MULTIPLE RADAR NETWORKS

Karl Brammer, Franz Herzmann, Albert Kainzinger, and Norbert Knoppik *In* AGARD Strategies for Autom. Track Initiation Jun 1979 17 p refs (For primary document see N79-30454 21-32)

Avail: NTIS HC A11/MF A01

In a system which uses tracking facilities of equal authority collocated at every radar station, redundant communication links between the stations provide a failure tolerant data exchange capability Algorithms are described which lead to a unique system track for a target entered into the system by several radar sensors while each of the collocated tracking facilities starts an individual track by pooling radar information from its own sensor and from neighboring sensors seeing the same target The functions of automatic multiradar track initiation and management for echo targets are illustrated by some simulation results Extension of the algorithms to strobe tracking and triangulation is outlined A R H

N79-30461# General Research Corp., Santa Barbara, Calif.

A NETTING APPROACH TO AUTOMATIC RADAR TRACK INITIATION, ASSOCIATION, AND TRACKING IN AIR SURVEILLANCE SYSTEMS

Gary W. Deley *In* AGARD Strategies for Autom. Track Initiation Jun 1979 10 p ref (For primary document see N79-30454 21-32)

Avail: NTIS HC A11/MF A01

One of several promising concepts for netting radars in a tactical air surveillance system employs track while scan radars having scan periods of from 4 to 12 seconds Such scan periods are too long to yield an acceptably high probability of automatic association of measurements with tracks when the surveillance region contains many highly maneuverable targets As presented, the radars overcome this limitation by being connected into a non-hierarchical net over which measurement data is pooled In the system concept described, most targets will be seen by twenty or more radars If all radars able to see a target shared the resulting data with the entire system, the communications bandwidth required would be excessive To avoid this problem, an algorithm was devised that dynamically selects a 'best' subset of the system's radars to track each target, thus, simultaneously achieving a high probability of correct association (and hence of maintaining track) while requiring reasonable communications bandwidths This performance is achieved without centralized control The concept was verified using a detailed computer simulation called TACRAN (Tactical Air Control Radar Net), some simulation results are presented A R H

N79-30462# Societe Industrielle des Nouvelles Techniques Radioelectriques et de l'Electrique Francaise, Asnieres

PRIMARY AUTOMATIC TRACKING RADAR IN A MILITARY APPROACH AND ASSEMBLY CENTER [POURSUITE AUTOMATIQUE RADAR PRIMAIRE DANS UN CENTRE D'APPROCHE ET DE RECUEIL MILITAIRE]

A. Poch *In* AGARD Strategies for Autom. Track Initiation Jun 1979 5 p In FRENCH (For primary document see N79-30454 21-32)

Avail: NTIS HC A11/MF A01

Automatic tracking radar in a military center is confronted with problems related to both the environment and to operational exploitations Special algorithms, adapted in an extremely short time are used to process targets developing in dense zones at low altitudes, by performing the following functions (1) constituting a moving map supported in real time by recognized plots of the coverage, (2) rapid automatic initiation on plots at contact, beginning from a self adaptive criteria, as a function of the creation zone in the radar coverage assembly zone, landing/takeoff zone, surveillance zones, (3) associating contact-targets, considering the correct conditions for approach, fixed echoes, atmospheric clutter, speed, and the performance and location of very disparate targets, and(4) the automatic, real time adaptation, of related parameters as a function of the development of targets accelerations, decelerations, turning, and lack of radar detection These algorithms are incorporated into a compact program and used on a minicomputer

Transl. by A R H

N79-30463# Communications Research Centre, Ottawa (Ontario). Communications Dept.

ANALYSIS OF SECOND AND THIRD ORDER STEADY STATE TRACKING FILTERS

A. W. Bridgewater *In* AGARD Strategies for Autom. Track Initiation Jun 1979 11 p refs Sponsored by the Dept. of Natl. Defence, Ottawa, Ontario (For primary document see N79-30454 21-32)

Avail: NTIS HC A11/MF A01

In a multi-target environment the heavy processing load on even the most powerful radar tracking systems makes it necessary to sacrifice theoretical optimality for practical feasibility in the tracking process One approach is to adopt sub-optimal methods for track estimation using steady state adaptive alpha-beta and alpha-beta-gamma filters which are derived from the Kalman filter and which combine good track-following ability, ease of adaptation to changes in the tracking conditions, and low computational cost A theoretically-derived functional relationship between the set of gain coefficients and a system parameter which quantifies the current tracking conditions permits a rapid and near optimal response to any changes in those conditions An economical means is developed to incorporate this adaptive feature in a tracking system Coordinate transformation techniques are described and other aspects of practical implementation of this type of tracking filter are also examined A R H

N79-30464# Forschungsinstitut fuer Funk und Mathematik, Werthoven (West Germany)

AUTOMATIC TRACK INITIATION FOR A PHASED ARRAY RADAR USING A CLUTTER MAP

Wilhelm Fleskes *In* AGARD Strategies for Autom. Track Initiation Jun 1979 11 p refs (For primary document see N79-30454 21-32)

Avail: NTIS HC A11/MF A01

A statistical method for track validation was introduced which uses a sequential likelihood ratio test procedure. The test discriminates between tracks of the wanted objects and false tracks on the basis of the target detection probability and the local false alarm probability. The latter is estimated for each search plot in a clutter map which is a list of stored clutter echos. The map is updated in real time and the list organization technique provides a set of converging volumina containing the estimation point so that nonparametric estimates can be obtained by testing on uniformity. Core memory and computing time requirements allow real time operation in a multipurpose computer programmed in higher level language. M.M.M.

N79-30465# Forschungsinstitut fuer Funk und Mathematik, Werthoven (West Germany)
SOFTWARE STRUCTURE AND SAMPLING STRATEGY FOR AUTOMATIC TARGET TRACKING WITH A PHASED ARRAY RADAR
G. vanKeuk. *In* AGARD Strategies for Autom. Track Initiation Jun. 1979 13 p refs (For primary document see N79-30454 21-32)
Avail: NTIS HC A11/MF A01

The software system used for multi-target tracking in the experimental phased array system under construction at the FFM is described as well as the introduction on the application to Kalman filters for tracking maneuvering targets. In contrast of the situation with conventional radars, the additional degree of freedom to adapt the scan period on the estimated lack of information with regard to each individual track is analyzed for the electronically steerable radar case. A sampling strategy is developed and analyzed that minimizes the tracking frequency considering the shape of the detection probability within a tracking beam pointing towards the predicted target position. Adapting the scan interval a constant track accuracy in space can be achieved taking the various dynamical and geometrical restrictions into consideration. An optimal spatial extension of this uncertainty volume can then be derived. As the sampling frequency of course also depends on the assumed maneuvering capabilities of the target under track, the extension of the optimal uncertainty volume depends only on the beam splitting ratio of the used monopulse angle finding technique. M.M.M.

N79-30466# Forschungsinstitut fuer Funk und Mathematik, Werthoven (West Germany)
THE FORMATION TRACKING PROCEDURE FOR TRACKING IN DENSE TARGET ENVIRONMENT
G. Bimas. *In* AGARD Strategies for Autom. Track Initiation Jun. 1979 11 p refs (For primary document see N79-30454 21-32)
Avail: NTIS HC A11/MF A01

The strategy of formation tracking presented is characterized by the substitution of raid tracks for single target tracks. The raid tracks are correlated and updated by plot-clusters. The formation track consists of one central track and several marginal tracks containing the whole information about the mean cinematical behavior and the spatial extension of the tracked formation. Special investigations were directed to the following problems: formation track initiation, formation track evolution, decision and control procedures with regard to formation track splitting, and formation track junction. The efficiency of formation tracking can be demonstrated by a few one dimensional examples of appropriate airspace situations. M.M.M.

N79-30467# Mitre Corp., Bedford, Mass.
PERFORMANCE OF AUTOMATIC TRACK INITIATION LOGIC IN SPECIFIC TARGET ENVIRONMENTS
G. E. Lindeberg, A. S. Margulies, and P. A. Smyton. *In* AGARD Strategies for Autom. Track Initiation Jun. 1979 10 p refs (For primary document see N79-30454 21-32)
(Contract F19628-78-C-0001)
Avail: NTIS HC A11/MF A01

Two generalized analytical computer models were developed to provide data for a parametric assessment of various ATI algorithms which attempt to replicate the surveillance operator's judgmental processes. One model was used to investigate the initiation of tracks on actual targets and the other was used to determine the track initiation performance based only upon false reports. This performance dichotomy is valid for the anticipated NAEW target environment. It was concluded that there are several ATI algorithms which would yield satisfactory performance. Even within this set of acceptable algorithms, however, some criteria provide enhanced performance in initiation of true targets at the expense of a relatively larger number of false track initiations and there are others for which the converse is true. The level of false target reports per scan, the expected target speeds, and the speed with which real targets are initiated are all significant factors in the construction of the ATI feature and their ramifications are discussed in detail. M.M.M.

N79-30468# Naval Research Lab., Washington, D. C.
INITIATION OF TRACKS IN A DENSE DETECTION ENVIRONMENT
J. D. Wilson and G. V. Trunk. *In* AGARD Strategies for Autom. Track Initiation Jun. 1979 18 p refs (For primary document see N79-30454 21-32)
Avail: NTIS HC A11/MF A01

In a dense detection environment present track-while-scan algorithms are expected to introduce false tracks when processing is performed on a scan-by-scan basis. The maximum likelihood solution involving all detections on all scans is formulated and evaluated for the initiation problem. While the maximum likelihood method cannot be implemented because of the enormous computational requirements, it provides a standard to which more implemental algorithms (such as a raid detector) can be compared. M.M.M.

N79-30469# Federal Aviation Administration, Washington, D. C.
AUTOMATIC RADAR TRACKING IN TERMINAL AIR TRAFFIC CONTROL FACILITIES
Hugh G. McEvoy. *In* AGARD Strategies for Autom. Track Initiation Jun. 1979 7 p refs (For primary document see N79-30454 21-32)
Avail: NTIS HC A11/MF A01

A radar tracking system was developed for use in the terminal area. The extractor is referred to as a Sensor Receiver and Processor (SRAP). It detects both primary radar and secondary radar targets and correlates the two for transmission to the central computer. The primary radar extractor portion of the SRAP employs a rank order quantizer as the first detector so that quantizing of signals is done on a non-parametric basis. The device also employs a dynamic correlation measurement technique to produce a tight clutter false alarm control. The automatic radar terminal system 3 computer program was modified to accept data already azimuthally correlated between primary and secondary signals. Author

N79-30470# Royal Netherlands Navy, Den Helder (Netherlands).
EXPERIENCE WITH AUTOMATIC TRACKING SYSTEMS OF THE ROYAL NETHERLANDS NAVY
Leo Stigter. *In* AGARD Strategies for Autom. Track Initiation Jun. 1979 7 p (For primary document see N79-30454 21-32)
Avail: NTIS HC A11/MF A01

The problems encountered and the experience gained with automatic tracking systems for the modern frigates of the Royal Netherlands Navy are described. The on board data handling system DAISY (digital automated information processing system) was studied. R.E.S.

N79-30471# Litton Systems, Inc., Van Nuys, Calif. Data Systems Div.
THE REMOTE RADAR TRACKING STATION
Frank P. Hiner, III. *In* AGARD Strategies for Autom. Track Initiation Jun. 1979 8 p refs (For primary document see N79-30454 21-32)
Avail: NTIS HC A11/MF A01

The development of the remote radar tracking station (RRTS) is described. The capabilities of the RRTS are discussed in detail. R.E.S.

N79-30472# IBM France S. A., Paris
BASIC CONCEPTS OF RADAR DATA PROCESSING IN THE STRIDA
G. Grolleron and A. Clanet. *In* AGARD Strategies for Autom. Track Initiation Jun. 1979 4 p (For primary document see N79-30454 21-32)
Avail: NTIS HC A11/MF A01

Radar data processing in STRIDA is carried out by three types of processing: (1) extraction (which digitalizes, extracts and filters radar information), (2) tracking (which elaborates and updates the group of tracks for each radar), and (3) merging (which enables the establishment of a general air traffic chart). These functions are entirely automatic and are implemented in the different network centers. The process of initiation and update of tracks is performed in two steps: firstly, at a mono-radar level, and then, at a multi-radar level. This technique gives the

advantage of limiting the number of false tracks while being sure of creating every new track. It also enables the establishment of a general air traffic chart by dynamically choosing the best radar detection for each track. R E S

N79-30473# Hughes Aircraft Co., Fullerton, Calif. System Analysis Section

ESTABLISHMENT OF AIR DEFENSE SENSOR REQUIREMENTS FOR AUTOMATIC AIRCRAFT TRACKING

Martin Dana *In* AGARD Strategies for Autom. Track Initiation Jun. 1979 10 p (For primary document see N79-30454 21-32) Avail: NTIS HC A11/MF A01

The functional relationship between air defense requirements and the capabilities of the target acquisition, tracking, identification, threat evaluation and weapon assignment, and weapon subsystems was investigated. Some alternative methods for assessing quantitatively the relationship between total air defense system performance and the performance of the individual subsystems are discussed. A detailed analytic model of system versus subsystem performance was derived. The sensor and sensor processing related functions--that is, acquisition, tracking, identification and acquisition of designed targets by fire control radars--were emphasized in the derivation. Although the communication subsystem is a vital element of an integrated air defense system, communications was not considered except to note that a system which can transmit the required information to and from the command and control subsystem without excessive delays due to traffic and queueing problems is required. R E S

N79-31458# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France)

DIGITAL COMMUNICATIONS IN AVIONICS

Heinz Lueg, ed. (Technische Hochschule Aachen, West Ger.) Jun. 1979 456 p refs In ENGLISH and FRENCH Presented at the Avionics Panel Symp., Munich, 5-9 Jun. 1978 (AGARD-CP-239 ISBN-92-835-0242-6) Avail: NTIS HC A20/MF A01

The technology of digital communications is addressed. Communications between air and/or ground terminals and relay communications, both satellite-borne and air-borne, improvement of communication in the case of multipath transmission by means of spectrum techniques, echo cancelling, or pulse compression, and improvement of jam resistance by means of power balance are among the topics discussed. Spread spectrum techniques, error protection coding, and cost effective improvements in performance in the presence of noise and interference are also considered. For individual titles, see N79-31459 through N79-31496.

N79-31459# Defense Communications Agency, Washington, D.C.

THE IMPACT OF DIGITIZATION ON MILITARY COMMUNICATIONS

Irwin L. Lebow *In* AGARD Digital Commun. in Avionics Jun. 1979 16 p refs (For primary document see N79-31458 22-32) Avail: NTIS HC A20/MF A01

The U. S. Defense Communications System (DCS) subsystems which provide switched services and dedicated transmission are described. It is shown that a second-generation system with the common theme of digitization to improve secure voice capability is designed to maximize interoperability with tactical, civil, and allied secure voice systems. This system is based upon a common user secure voice system, AUTOSEVOCOM 2, used in conjunction with dedicated satellite transmission employing transportable terminals for robustness. J M S

N79-31460# Centre d'Essais en Vol, Bretigny-sur-Orge (France)

TECHNICAL AND OPERATIONAL ASPECTS OF TELECOMMUNICATIONS IN AERONAUTICS [LES ASPECTS TECHNIQUES ET OPERATIONNELS DES TELECOMMUNICATIONS EN AERONAUTIQUE]

Carlier Maurice *In* AGARD Digital Commun. in Avionics Jun. 1979 4 p In FRENCH (For primary document see N79-31458 22-32) Avail: NTIS HC A20/MF A01

The principle information requirements for air defense stations are reviewed and constraints peculiar to telecommunications in aeronautics are examined. Solutions to aircraft communication problems developed since the end of World War 2 are assessed as well as the need for a communication system to provide for navigation, identification, and anticollision functions. Such a time division multiple access system will supply numerical information in messages of short duration, use a large frequency band, synchronize all participants in the network, and access each participant during a determined time, at regular intervals or periods. A R H

N79-31461# *Carleton Univ., Ottawa (Ontario) Dept. of Systems* Engineering and Computing Science

A NOVEL APPROACH TO THE DESIGN OF AN ALL DIGITAL AERONAUTICAL SATELLITE COMMUNICATION SYSTEM

M. E. Ulug *In* AGARD Digital Commun. in Avionics Jun. 1979 16 p refs (For primary document see N79-31458 22-32) Avail: NTIS HC A20/MF A01 CSCL 17B

The design of an all digital aeronautical satellite communication system based on the transparent intelligent network (TI-NET) is described. The novel features of the system, namely a 9.6 kb/s ground to aircraft link which provides a TDMA operation and the statistical multiplexing of the encoded voice and data were experimentally tried out using 12-14 GHz satellite link between Carleton University, in Ottawa, Canada and the NASA AMES Research Center in Palo Alto, California using Hermes (CTS) satellite. Other unique features of the system are the trading off of the satellite up-down delay with the packet formation delay, multi-polling and multiaddressing capability, and the complete transparency to the user's protocol. In addition, the system has a turn around time of 22.5 ms which is most useful in making quick changes in the polling sequence as well as producing fast re-transmissions. A polling algorithm which meets the particular needs of the aircraft in high, medium and low density areas is described. The terrestrial network connecting the communication centers and ground stations in North America is also discussed and its associated interfaces and protocols are defined. It is believed that the proposed system will result in a more efficient use of the communication channels, greater immunity against noise, and a less complex airborn computer with smaller memory. Although the system design is based on a set of hypothetical traffic data, the model can be readily modified to perform at a higher or lower traffic level. In this connection another system using a 4.8 kb/s ground-aircraft link is described and its performance compared with that of the proposed model. J M S

N79-31462# Communications Research Centre, Ottawa (Ontario)

CENSAR TDMA: CENTRALIZED SYNCHRONIZATION AND RANGING FOR TIME-DIVISION MULTIPLE ACCESS

Peter P. Nuspl *In* AGARD Digital Commun. in Avionics Jun. 1979 8 p refs (For primary document see N79-31458 22-32) Avail: NTIS HC A20/MF A01

Experiments in synchronization for time division multiple access systems for satellite communications are discussed. The basic principles of the new synchronization ranging concept called CENSAR and the technological requirements are covered. Hardware and software features of the implementation are described and the results are discussed. A major result is that this open-loop synchronization method is feasible with guard times of less than 30 ns. J M S

N79-31463# Eurocontrol Agency, Maastricht (Netherlands)

A DIGITAL COMMUNICATION SYSTEM AS GATEWAY BETWEEN ADJACENT COMPUTERIZED AIR TRAFFIC CONTROL CENTRES

M. Baum *In* AGARD Digital Commun. in Avionics Jun. 1979 14 p refs (For primary document see N79-31458 22-32) Avail: NTIS HC A20/MF A01

A practical approach to improve data communication between adjacent computerized air traffic control centers is described. The applied concept is communication procedure conversion by which systems with incompatible transmission procedures can communicate with each other via a gateway system. Procedure conversion meets the basic requirement which is not to intervene in the functioning of the involved local networks and not to require modifications of locally used procedure envelopes. The transit function is realized by conversion of the procedure specific message type and priority on one hand and of address information on the other hand. A flexible table mechanism is chosen instead of fixed coding. Outstanding problems are an efficient link failure processing and an envisaged attachment of a circuit switching function to the message switching principle. J M S

N79-31464# California Univ., Los Angeles. Dept. of System Science

A MARKOV MODEL FOR NONLINEAR CHANNELS WITH MEMORY AND SOME APPLICATIONS

Ezio Biglieri (Politecnico di Torino, Italy) *In* AGARD Digital Commun. in Avionics Jun. 1979 9 p refs Sponsored in part by ONR (For primary document see N79-31458 22-32)
Avail: NTIS HC A20/MF A01

A Markov chain model is proposed for the analysis of bandlimited and possibly nonlinear, digital communication channels. The fundamental feature of this approach is its analytical tractability, as well as its flexibility. From this model several results can be obtained in a relatively straightforward way. An application considered is the evaluation of the signal power spectrum at the channel output. The bandwidth occupancy, and hence the interference among adjacent channels, in a multiple-user communication situation subject to spectrum spread due to a nonlinearity (a typical example occurs in digital satellite communication systems) is evaluated. As another application, the structure of the optimum (maximum likelihood sequence) receiver for a channel modeled in this way is derived, and a Viterbi algorithm is set up for the demodulation of a digital signal.
J.M.S.

N79-31465# Massachusetts Univ., Amherst. Dept. of Electrical and Computer Engineering
STATE OF THE ART OF ERROR CONTROL TECHNIQUES
Jack Keil Wolf *In* AGARD Digital Commun. in Avionics Jun. 1979 12 p refs (For primary document see N79-31458 22-32)
(Grant AF-AFOSR-2601-74)
Avail: NTIS HC A20/MF A01

A survey of error control techniques for achieving reliable transmission over noisy communication channels is presented. Both binary and nonbinary codes are considered. Block codes and tree codes are described along with their decoding algorithms. The parameters of the most frequently utilized codes are given. Finally, the performance of such codes are considered for an additive Gaussian noise channel with and without Rayleigh fading.
J.M.S.

N79-31466# Communications Research Centre, Ottawa (Ontario). Dept. of Communications
FORWARD ERROR-CORRECTION FOR THE AERONAUTICAL SATELLITE COMMUNICATIONS CHANNEL
Alan Sewards, Leo Beaudet, and Hassan Ahmed *In* AGARD Digital Commun. in Avionics Jun. 1979 14 p refs Prepared in cooperation with Miller Commun. Systems Ltd., Kanata, Ont.
(For primary document see N79-31458 22-32)
Avail: NTIS HC A20/MF A01

The problems caused in an L-band aeronautical satellite communications channel by ocean surface multipath are identified. It is shown that data messages transmitted over the channel exhibit unacceptably high error rates under typical conditions. Channel characteristics and techniques for reducing the error rate are discussed, leading to the choice of a diffuse threshold decodable convolutional forward error correcting code. Two implementations of coder/decoders for this code are described, one using standard IC logic, and the other a Z-80A microprocessor. Results of tests of the IC coder/decoder with noise, data error bursts, and a system simulator are quoted, which show that the codec performed as expected and is capable of reducing the error rate to 0.00001 or better.
J.M.S.

N79-31467# Manchester Coll. of Science and Technology (England). Dept. of Electrical Engineering and Electronics.
AN EXPERIMENTAL EVALUATION OF INTERLEAVED BLOCK CODING IN AERONAUTICAL HF CHANNELS
Brian Hillam and Geoffrey F. Gott *In* AGARD Digital Commun. in Avionics Jun. 1979 4 p refs Sponsored by the Ministry of Defence (For primary document see N79-31458 22-32)
Avail: NTIS HC A20/MF A01

Results obtained from the application of forward error correcting block codes to a 75 baud frequency shift keyed data transmission system, operating in aeronautical hf channels are presented. Six different binary cyclic codes were tested, using detailed error structures obtained from point-to-point link tests. In an attempt to randomize error bursts, which arise because of fading and interference on the channel, interleaving of the codeword bits was employed, using several different degrees of interleaving for each code.
J.M.S.

N79-31468# Standard Elektrik Lorenz A.G., Stuttgart (West Germany)
AN ASYNCHRONOUS DATA TRANSMISSION SYSTEM WITH LOW ERROR PROBABILITY FOR THE SETAC LANDING AID
Wolfgang Beier *In* AGARD Digital Commun. in Avionics Jun. 1979 5 p (For primary document see N79-31458 22-32)
Avail: NTIS HC A20/MF A01

A serial code which is used in the TACAN compatible landing aid SETAC is described. Its features are optimized for the expected error rate and types of errors as well as for the data transmission rate and the accepted error rate after correction.
R.E.S.

N79-31469# Technische Hogeschool, Eindhoven (Netherlands). Dept. of Electrical Engineering
ON THE PERFORMANCE OF A MAXIMUM LIKELIHOOD DECODER FOR CONVOLUTIONAL CODES
J. P. M. Schalkwijk *In* AGARD Digital Commun. in Avionics Jun. 1979 7 p refs Sponsored by the Netherlands Organ. for the Advan. of Pure Res. (For primary document see N79-31458 22-32)
Avail: NTIS HC A20/MF A01

A method of evaluating the event error probability for maximum likelihood decoding of convolutional codes is presented. To illustrate this method calculations were carried through for the simple rate 1/2 convolutional code generated by an encoder. Similar calculations were performed for the standard constraint length upsilon = 2 code with connection polynomials 1 + D2, and 1 + D + D2.
R.E.S.

N79-31470# Kent Univ., Canterbury (England). Electronics Labs
DIGITAL COMMUNICATIONS USING SOFT-DECISION DETECTION TECHNIQUES
P. G. Farrell, E. Munday, and N. Kalligeros *In* AGARD Digital Commun. in Avionics Jun. 1979 19 p refs (For primary document see N79-31458 22-32)
Avail: NTIS HC A20/MF A01

The history of soft-decision techniques is briefly reviewed and the potential advantages of using such techniques are outlined. The experimental implementations of soft-decision schemes are described and evaluated. The results of some studies of quite simple block soft-decision decoding schemes are presented. Then a practical implementation of a data transmission system incorporating full minimum-distance soft-decision decoding is described. The system is based on a transparent product block code, with interleaving, and is suitable for use of HF, VHF and UHF channels. The results of tests on simulated and real channels are presented and commented on. It was concluded that efficient operation of data transmission systems with channel (redundant) coding is impossible without soft-decision detection, particularly in non-Gaussian environments.
R.E.S.

N79-31471# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Oberpfaffenhofen (West Germany). Inst. of Communication Technology
THEORETICAL LIMITS ON CHANNEL CODING UNDER VARIOUS CONSTRAINTS
B. G. Dorsch and F. Dolainsky *In* AGARD Digital Commun. in Avionics Jun. 1979 12 p refs (For primary document see N79-31458 22-32)
Avail: NTIS HC A20/MF A01

Theoretical limits on coding under some fundamental constraints of practical schemes were calculated, which were not taken into account in Shannon's absolute limit for Gaussian noise. First channel capacity (zero error probability with codes of infinite length) was considered for finite rate codes (finite energy per symbol, finite bandwidth), binary input and quantized output signals. Then the influence of finite length and finite error probability on the theoretical limits of coding was investigated for three decoding philosophies (maximum likelihood decoding, bounded minimum distance decoding and decoding with an optimum fixed threshold). It was found that the performance of practical coding schemes under certain constraints should be compared to these limits rather than the absolute Shannon limit.
R.E.S.

N79-31472# Ruhr Univ., Bochum (West Germany). Inst. fuer Elektronik
AN ERROR-RATE MEASUREMENT SET-UP OPERATING AT 1 GBIT/S
Ulrich Wellens *In* AGARD Digital Commun. in Avionics Jun. 1979 12 p refs (For primary document see N79-31458 22-32)
Avail: NTIS HC A20/MF A01

An error rate measurement set-up is described which directly operates at information rates near 1 Gbit/s. The transmitter delivers pseudo random sequences which are generated by high speed base coupled logic gates working in conjunction with two delay lines. In the error rate detector the bit stream, transmitted via the communications system under test, was compared with

a reference bit stream from the transmitter in an exclusive gate. The discovered error bits were registered in a counter chain and divided by the total number of bits transmitted during an adjustable measurement time. The accuracy achieved with this equipment was better than 10 to the -9th power. Two application examples in utilizing the measurement set up are described. In one of these the error rate versus the input signal power of a coaxial cable transmission path was determined. The other application was concerned with a special problem in an optical transmission system. RES

N79-31473# FGAN, Wachtberg-Werthhoven (West Germany)
INTRODUCTORY NOTES ON PROPAGATION EFFECTS AND RELATED ASPECTS
H. J. Albrecht. *In* AGARD, Digital Commun. in Avionics, Jun. 1979, 3 p. (For primary document see N79-31458 22-32)
Avail: NTIS, HC A20/MF A01

Fundamental information on propagation media is presented as a basis for subsequent papers which review the more detailed problem areas and illustrate typical applications. Comments on the trend in relevant research and development are also included. RES

N79-31474# Siemens A.G., Munich (West Germany)
PROPAGATION EFFECTS ON DIGITAL COMMUNICATION IN AVIONICS (REVIEW PAPER)
Ernst Lampert. *In* AGARD, Digital Commun. in Avionics, Jun. 1979, 15 p. refs (For primary document see N79-31458 22-32)
Avail: NTIS, HC A20/MF A01

The different modes of electromagnetic wave propagation and their relevancy in avionics were investigated. The relevant propagation modes are then discussed in terms of frequency from the HF band to EHF region. Satellite communication was also discussed. RES

N79-31475# Northeastern Univ., Boston, Mass.
MODELLING OF PROPAGATION ASPECTS OF DIGITAL COMMUNICATION SYSTEMS
H. R. Raemer. *In* AGARD, Digital Commun. in Avionics, Jun. 1979, 11 p. refs (For primary document see N79-31458 22-32)
Avail: NTIS, HC A20/MF A01

Propagation considerations important in modelling of digital communication systems are reviewed. Nearly the entire radio frequency spectrum is covered. The following topics are briefly discussed: (1) basic channel modelling theory concepts; (2) systems analysis and design as it relates to propagation; and (3) the two channels, troposcatter and satellite-ground. RES

N79-31476# Royal Aircraft Establishment, Farnborough (England). Radio and Navigation Dept.
PERFORMANCE PREDICTIONS AND TRIALS OF A HELICOPTER UHF DATA LINK
R. M. Harris. *In* AGARD, Digital Commun. in Avionics, Jun. 1979, 17 p. refs (For primary document see N79-31458 22-32)
Avail: NTIS, HC A20/MF A01

A combination of theoretical and experimental studies conducted in order to estimate the bit error rate performance of a digital communication system are reviewed. The system is proposed for the transmission of binary digital data over dedicated simplex UHF radio links between helicopters and between helicopters and ships. Initial predictions of system performance were based on known characteristics of some helicopter installed systems and classical treatment of multipath radio wave propagation over a smooth sea. The probability of achieving a particular grade of service was considered as the arithmetical product of several independent statistical parameters. Some of these were related to the temporal and spatial variability of radio wave propagation, others reflected the almost random orientation of the aircraft under operational conditions affecting the signal received via the aircraft's radiation pattern. A method of statistical analysis based on approximate Gaussian frequency distribution functions was applied to the experimental data. Performance predictions are presented in terms of time availability for selected bit error rates. RES

N79-31477# Air Force Geophysics Lab., Hanscom AFB, Mass.
NEW INSIGHT INTO IONOSPHERIC IRREGULARITIES AND ASSOCIATED VHF/UHF SCINTILLATIONS
J. Buchau, E. J. Weber, and H. E. Whitney. *In* AGARD, Digital Commun. in Avionics, Jun. 1979, 26 p. refs (For primary document see N79-31458 22-32)
Avail: NTIS, HC A20/MF A01

Using a new all-sky photometer and airborne/ground based sounding the large scale structure of equatorial irregularity regions responsible for VHF/UHF scintillations was determined. Field aligned electron density depletions of 1200 km north-south extent develop after sunset in the bottomside of the equatorial ionosphere and move towards the east at approximately 100 m/sec. The lifetime of these depletions is several hours. They are the seat of irregularities (scale sizes meters to kilometers) which extend from the bottomside to 800 km height. They occur single or in groups and result in scintillations of traversing signals. At arctic latitudes the irregular F-region ionization resulting from soft particle precipitation is often associated with auroral forms. These forms were made visible with the all-sky photometer and scintillation events observed on VHF/UHF were related to the observed features. Airborne scintillation measurements at the equator show strong dependence of the fading rate on aircraft heading a result of eastward drift of the irregularities. Ground based measurements show that space diversity and time diversity are effective means to operate under strongly scintillated conditions. RES

N79-31478# Technische Universitaet Braunschweig (West Germany).
MULTIPATH PROPAGATION MEASUREMENT BY DOPPLER TECHNIQUE
P. Form, R. Springer, H. Bothe, and K. Klein. *In* AGARD, Digital Commun. in Avionics, Jun. 1979, 23 p. refs. Prepared in cooperation with DFVLR, Brunswick (For primary document see N79-31458 22-32)
Avail: NTIS, HC A20/MF A01

Some microwave landing system features are discussed with respect to the multipath propagation. For illustration of specific multipath effects a Doppler shift measurement technique with high angle resolution is presented which needs simple antennas and equipment and offers easy interpretation. MMM

N79-31479# Transportation Systems Center, Cambridge, Mass.
A CHANNEL SIMULATOR FOR L-BAND SATELLITE-MOBILE COMMUNICATIONS
Peter D. Engels. *In* AGARD, Digital Commun. in Avionics, Jun. 1979, 10 p. refs (For primary document see N79-31458 22-32)
Avail: NTIS, HC A20/MF A01

A laboratory simulator which enables the characterization of any variety of experimental modems in the presence of simulated multipath and noise is described. Such a procedure is advantageous in cost savings, repeatability, and comprehensiveness. MMM

N79-31480# Technische Universitaet, Brunswick (West Germany). Inst. fuer Nachrichtentechnik.
INVESTIGATION ON INFORMATION ERROR CAUSED BY TRAFFIC LOADING IN APPROACH AND LANDING SYSTEMS
Wolfgang Skupin. *In* AGARD, Digital Commun. in Avionics, Jun. 1979, 15 p. (For primary document see N79-31458 22-32)
Avail: NTIS, HC A20/MF A01

For the evaluation of a required approach and landing systems with statistical interrogation ALSSI serving capacity, a traffic model was developed. This model is based on the operational requirements and gives a defined standard traffic volume for a ALSSI. For investigating the reply efficiency and the accuracy of an ALSSI several methods can be employed. By means of probability calculations the reply efficiency can be determined with comparatively low expense. For the determination of the accuracy it is useful to carry out real world system tests with a test a/c. Because of less expense the traffic load is simulated with these tests by pulse generators. More flexibility can be achieved by employing a software simulation. For this a computer model of the traffic loading has to be installed as well as a computer model of the system to be investigated. Some results achieved by employing these methods are presented. MMM

N79-31481# Rome Air Development Center, Griffiss AFB, N.Y.
NEW DEVICES FOR DIGITAL COMMUNICATIONS IN AVIONICS
F. I. Diamond, H. J. Bush, and J. A. Graniero. *In* AGARD, Digital Commun. in Avionics, Jun. 1979, 9 p. refs (For primary document see N79-31458 22-32)
Avail: NTIS, HC A20/MF A01

Technological advances in microelectronics to improve capabilities and reduce complexity of digital communication systems in the aircraft industry are assessed. MMM

N79-31482# California Univ., San Diego, La Jolla
TRANSFORM DOMAIN PROCESSING FOR DIGITAL COMMUNICATION SYSTEMS USING SURFACE ACOUSTIC WAVE DEVICES
L. B. Milstein, D. R. Arsenault, and P. Das *In* AGARD Digital Commun. in Avionics Jun. 1979 16 p refs Prepared in cooperation with Rensselaer Polytech. Inst. (For primary document see N79-31458 22-32)
(Grant DAAG29-77-G-0205)
Avail: NTIS HC A20/MF A01

A surface acoustic wave receiver is presented. This device is light and small enough to be used on board aircraft and can receive continuous time-digital signals accurately and securely. The detection of digital signals in the presence of Gaussian noise and interference using this device is studied. M.M.M.

N79-31483# California Univ., Los Angeles. Dept. of System Science
AN ANALYSIS OF THE ERROR PROBABILITY OF AN ALL DIGITAL DETECTOR
Sam Reisenfeld and Kung Yao *In* AGARD Digital Commun. in Avionics Jun. 1979 13 p refs Sponsored by the ONR (For primary document see N79-31458 22-32)
Avail: NTIS HC A20/MF A01

Several analytical approaches are taken to evaluate the error probability of a digital communications system with a detector implemented as a digital signal processor. A binary hypothesis problem over an AWGN channel, where the receiver consists of a low-pass filter, a sampler, a dynamic range scaling device, an A/D converter, a digitally implemented integrate-and-dump filter, and a threshold device is considered. The digital processing for the receiver is done with fixed-point arithmetic. Exact error probability expressions are given for cases of overflow and no overflow in the integrate-and-dump filter. Approximate expressions for P sub e, which depend upon approximations of the moments of the quantization error, are obtained. The P sub e expressions are derived as functions of E sub b/n sub o, the number of bits in the integrate-and-dump filter output, the number of samples per binary symbol, and the dynamic range scaling factor. Numerical examples illustrating the above analytical approaches are given. M.M.M.

N79-31484# Johann-Wolfgang-Goethe-Universitat, Frankfurt am Main (West Germany). Inst. fuer Angewandte Physik.
ASPECTS OF SOURCE ENCODING
Dietrich Wolf *In* AGARD Digital Commun. in Avionics Jun. 1979 6 p refs (For primary document see N79-31458 22-32)
Avail: NTIS HC A20/MF A01

After some general remarks on the concepts of source encoding some illustrative examples of actual interest are presented. In particular, recent results on source models of bandpass-limited speech signals, on optimum quantization of nonGaussian random sources, on data compression encoding schemes for speech and television signals are discussed. Author

N79-31485# Johann-Wolfgang-Goethe-Universitat, Frankfurt am Main (West Germany). Inst. fuer Angewandte Physik.
PROBLEMS IN COMBINING SOURCE AND CHANNEL CODING
Hans Juergen Matt *In* AGARD Digital Commun. in Avionics Jun. 1979 12 p refs (For primary document see N79-31458 22-32)
Avail: NTIS HC A20/MF A01

Some problems in combining source and channel coding are discussed. By the example of DPCM coded video signals the effects of channel errors were analyzed to see how these effects could be minimized. An adaption strategy for source- and channel codecs is proposed based on the fact that channel decoders are particulary suited to correct small numbers of errors occurring with high probability so that greater numbers of errors occurring less frequently are left to the source decoder for reconstruction. For protection of the compressed signals a low cost tri-state channel code is proposed and its performance is outlined. Finally, the problem of optimizing a transmission system as a whole is shown to be a variational problem relating the cost of the system to the signal quality (distortion) produced at the receiver. Its solution leads to a cost-distortion function which may include all relevant parameters of the transmission system's components. M.M.M.

N79-31486# Technische Universitaet, Hanover (West Germany). Lehrstuhl fuer Theoretische Nachrichtentechnik und Informationsverarbeitung
SEGMENTATION OF PICTURES INTO CHANGING AND MOVING PARTS FOR FRAME REPLENISHMENT CODING TECHNIQUES
Juergen Klie *In* AGARD Digital Commun. in Avionics Jun. 1979 10 p refs (For primary document see N79-31458 22-32)
Avail: NTIS HC A20/MF A01

A method is described which allows the segmentation of a video signal in changing and unchanging parts. The segmentation is done by comparing the average absolute value of five adjacent frame-to-frame differences to a threshold of 1.2/256. The segmentation algorithm detects only those frame areas which have changed their information visibly. This is done for a mimimum number of picture elements by using relatively long clusters, which in turn increases the bit rate reduction for conditional replenishment coders. In addition to the segmentation of the frame in changing and unchanging areas, a method is explained which allows an exact distinction between moving areas and uncovered background. This can be used for instance for the purpose of bit rate reduction by adapting the spatial sampling frequency to the reduced spatial resolution in the moving areas which depends on the velocity. Author

N79-31487# Rensselaer Polytechnic Inst., Troy, N. Y. Electrical and Systems Engineering
STATE OF THE ART IN DIGITAL SIGNAL PROCESSING WITH APPLICATIONS TO MULTIPLE ACCESS SYSTEMS
Lester A. Gerhardt *In* AGARD Digital Commun. in Avionics Jun. 1979 9 p refs (For primary document see N79-31458 22-32)
Avail: NTIS HC A20/MF A01

Advanced developments and trends in the fields of digital signal processing and digital communications were reported. The effects of microprocessors and minicomputers in this development were addressed. The availability of new devices, device technology, and directions are summarized with respect to the emphasis on speed. A discussion of CDM, CDMA, SSMA, and TDMA was reported. The Joint Tactical Information Distribution System was described as a system concept. M.M.M.

N79-31488# Thomson-CSF, Gennevilliers (France). Div. Telecommunications.
THE TELEGRAPH MODEM AT SPREAD SPECTRUM [MODERN TELEGRAPHTIQUE A ETALEMENT DE SPECTRE]
D. Brisset and G. Auger *In* AGARD Digital Commun. in Avionics Jun. 1979 7 p refs In FRENCH (For primary document see N79-31458 22-32)
Avail: NTIS HC A20/MF A01

A modem for spread spectrum telegraphy was included in the design of an experimental satellite communication station and is being evaluated the Symphonie satellite. The information transmitted is in a telegraphic rhythm at 75 bits/s, using a differential coding followed by a PSK bi-phase modulation. The spectrum spread is achieved in a band of several tens of MHz by means of PN sequence at elevated rhythm. In relation to other multiple access techniques, (FDMA, TDMA, without frequency) the advantages of this transmission of the SSMA type are multiple access without requiring centralized management of the network, discretion, resistance to interference, and reduced complexity of equipment involved in ground stations and onboard the satellite. On the other hand, the capacity for transmission is inferior to that of other modes of multiple access. Transl. by A.R.H.

N79-31489# Technische Hochschule, Aachen (West Germany). Inst. fuer Elektrische Nachrichtentechnik
THE PERFORMANCE OF CODE DIVISION MULTIPLEXING WITH PULSE POSITION MODULATION
Juergen Lindner *In* AGARD Digital Commun. in Avionics Jun. 1979 11 p refs (For primary document see N79-31458 22-32)
Avail: NTIS HC A20/MF A01

Pulse position modulation (PPM) is considered for code division multiplexing (CDM) in order to find attractive alternatives to PCM for the transmission of analog data over a CDM system. The relations between the output signal to interference ratio, the number of users and the bandwidth on the channel are calculated and an attempt is made to optimize the binary sequences used as carrier functions. Binary sequences are presented having autocorrelation functions (ACF) which are relatively good approximations to the optimal ones. By means of some known results it is shown that the crosstalk properties, given by the crosscorrelation functions (CCF) of the binary sequences, are fixed. The characteristics of CDM/PPM and

CDM/PCM are compared and, a PPM receiver is presented leading to low cost and effort necessary for the implementation of a CDM/PPM system for speech transmission. One very attractive feature is the absence of any synchronization within the system, similar to frequency division multiplexing with AM and incoherent reception, but with the properties of CDM and the resulting advantages in some applications. A.R.H.

N79-31490# Lincoln Lab., Mass. Inst. of Tech., Lexington.
A TERMINAL ACCESS CONTROL SYSTEM FOR FLEETSAT
Steven L. Bernstein. *In* AGARD, Digital Commun. in Avionics, Jun. 1979, 9 p, refs. Sponsored by Navy (For primary document see N79-31458 22-32)
Avail: NTIS, HC A20/MF A01

The terminal access control system (TACS) utilizes time division multiple access (TDMA) to derive several circuits from each of the several 25 kHz wide frequency channels available. Access to these circuits is controlled in real-time by a master control station according to user demand; thus TACS is an example of a demand assigned multiple access (DAMA) system. The access control techniques and efficiency of performance is described. In order to verify system performance predictions, a master control station and mobile platform subscriber unit were constructed and used in an extensive test program. A.R.H.

N79-31491# Mitre Corp., Bedford, Mass.
IMPLEMENTING JTIDS IN TACTICAL AIRCRAFT
David R. McMillan. *In* AGARD, Digital Commun. in Avionics, Jun. 1979, 13 p (For primary document see N79-31458 22-32)
Avail: NTIS, HC A20/MF A01

The implementation of a high capacity, secure, jam-resistant time division multiple access information system for providing integrated communications, navigation, and identification capabilities is discussed. Major characteristics of the joint tactical information distribution system (JTIDS) in tactical aircraft are summarized and relevant elements of the JTIDS program plan are highlighted. The context for specific requirements to be satisfied with aircraft installations are established in terms of operational functions, sources and sinks of information which support those functions, and current information distribution systems and man-machine interfaces which mechanize the transfer to and from tactical aircraft and their crews. The relative benefit of JTIDS over present solutions to operational information needs is established in this context. An overview of key elements of the tactical aircraft implementation challenge is included. A.R.H.

N79-31492# *Rome Air Development Center, Griffiss AFB, N.Y.*
TDMA FOR RELAYED COMMUNICATIONS
D. L. Baerwald. *In* AGARD, Digital Commun. in Avionics, Jun. 1979, 11 p, refs (For primary document see N79-31458 22-32)
Avail: NTIS, HC A20/MF A01

The use of time division multiple access (TDMA) as a means of sharing the available communication resources of a communication relay, either orbital or otherwise elevated is discussed. The different forms of time-shared communications are reviewed and the impact of TDMA operation on other aspects of the communications system's performance such as flexibility, interoperability, anti-jam capability, and equipment economics is examined. A breadboard TDMA/ANSAR (Adaptive Null Steering Array Relay) system is described. The relay provides both temporal and spatial adaptive processing to maximize the ratio of recognized desired energy to unrecognized interfering energy. It performs the processing on a pulse-to-pulse basis as each user accesses it during an assigned time slot. In the system developed, each modem synchronizes its clock with that of the relay. This is critical to the rapid processing required of the relay. A.R.H.

N79-31493# Societe le Materiel Telephonique, Boulogne-Billancourt (France).
A NETWORK OF DIGITAL RADIO COMMUNICATION BY TIME DIVISION DUPLEXING [RESEAU DE RADIOCOMMUNICATION NUMERIQUE EN DUPLEX TEMPOREL]
J. Lautier. *In* AGARD, Digital Commun. in Avionics, Jun. 1979, 11 p, In FRENCH (For primary document see N79-31458 22-32)
Avail: NTIS, HC A20/MF A01

Until the present, the establishment of digital duplex radioelectric links required the use of two frequencies, one for transmission and the other for reception. Time division duplexing now permits the use of a single carrier frequency which automatically provides for transmission at one time and for reception at another. The user, however, can speak and listen simultaneously. The delta modulation used for digitization is particularly adapted to digitizing communication.
Transl. by A.R.H.

N79-31494# Ruhr Univ., Bochum (West Germany). Inst. fuer Elektronik
A MULTI-GBIT/S RZ-FORMAT DIODE MULTIPLEXER
Udo Barabas. *In* AGARD, Digital Commun. in Avionics, Jun. 1979, 13 p, refs (For primary document see N79-31458 22-32)
Avail: NTIS, HC A20/MF A01

A clocked multiplexer circuit was realized which provided 4.48 Gbit/s, 5 Gbit/s, and 7.84 Gbit/s output-pulse streams for PCM type input tributaries at 1.22 Gbit/s, 0.25 Gbit/s, and 1.22 Gbit/s, respectively. The circuit employed essentially modified ultra-broadband hybrid tees, step-recovery diodes, and GaAs Schottky-barrier diodes. Output voltages up to 2 V were obtained across a load of 50 omega. The pulse of the output pulses was approximately 100 ps. Author

N79-31495# Rome Air Development Center, Griffiss AFB, N.Y.
A 16 Kb/s MODEM FOR SECURE VOICE SERVICE OVER NARROWBAND ANALOG CHANNELS
Richard A. Northrup, T. R. Losson, D. D. McRae, and F. A. Perkins. *In* AGARD, Digital Commun. in Avionics, Jun. 1979, 13 p, refs. Prepared in cooperation with Harris Corp., Melbourne, Fla. (For primary document see N79-31458 22-32)
Avail: NTIS, HC A20/MF A01

The development, testing, and planned applications of the 16 Kbps modem which operates over unconditioned 4 kHz voice frequency channels are discussed. The modem transmitter/receiver, automatic equalizer, and unique stored program processor are described as well as their operation in both the training mode and data transmission mode. A comprehensive test program of the model operating at both 16 and 8 Kbps over the worldwide dialed-up circuits of the U.S. automatic voice network (AUTOVON) is described along with a summary of the test results. Based upon the successful test performance, planned applications for the modem are inexpensive 16 Kbps continuous variable slope delta moculation (CVSD) secure digital voice transmission, and the 8 Kbps transmission of high quality data or imagery over dialed-up narrowband circuits. An alternate secure digital voice application is 32 Kbps CVSD, whereby a biplexer device splits the 32 Kbps into two 16 Kbps streams for transmission by the 16 Kbps modem over two separate channels. A.R.H.

N79-31496# Politecnico di Torino (Italy). Inst. di Elettronica e Telecommunicazioni.
DOUBLE DIFFERENTIAL PSK SCHEME IN THE PRESENCE OF DOPPLER SHIFT
Mario Pent. *In* AGARD, Digital Commun. in Avionics, Jun. 1979, 11 p, refs (For primary document see N79-31458 22-32)
Avail: NTIS, HC A20/MF A01

A double differentially coherent demodulation scheme (DDPSK) is proposed for digitally phase modulated signals. Its performance is theoretically independent on slow carrier frequency fluctuations and this result is obtained by means of a very simple and reliable structure. The theoretical analysis of the ideal DDPSK shows that, in the absence of carrier frequency shift, it suffers a penalty of about 4 dB with respect to the conventional DCPSK demodulation scheme. Since the potential applications of such a demodulation scheme are in the field of the air-to-air or air-to-ground data links, a comparative analysis was made with respect to the conventional DCPSK in the presence of a carrier frequency shift, and the conditions are derived (in terms of carrier frequency, relative speed and information rate) under which the DDPSK performs better. Author

N80-19345# Advisory Group for Aerospace Research and Development, Paris (France).
TERRAIN PROFILES AND CONTOURS IN ELECTROMAGNETIC WAVE PROPAGATION
Albert W. Biggs, ed. (Kansas Univ., Lawrence). Dec. 1979, 378 p, refs. Presented at the Specialist Meeting of the Electromagnetic Wave Propagation Panel, Spatind, Norway, 10-14 Sep. 1979
(AGARD-CP-269; ISBN-92-835-1345-2) Avail: NTIS, HC A17/MF A01

The propagation problems which are connected with terrain profiles and contours were addressed. Specifically examined were theoretical aspects, methods of digital terrain mapping, and terrain effects on antenna characteristics. For individual titles, see N80-19346 through N80-19371.

N80-19346# Middle East Technical Univ., Ankara (Turkey) *Electrical Engineering Dept*

THE EFFECTS OF STRATIFIED GROUND ON CHARACTERISTICS OF THE INVERTED L ANTENNA

Edip Niver (Polytechnic Inst. of N.Y., Brooklyn) and Altunkan Hizal *In* AGARD *Terrain Profiles and Contours in Electromagnetic* Wave Propagation Dec 1979 13 p refs (For primary document see N80-19345 10-32)

Avail: NTIS HC A17/MF A01

Characteristics of an inverted L antenna over a homogeneous moist ground, a poor ground, and a two layered ground consisting of a frozen layer of earth above a moist earth are studied numerically using an integral equation formulation. The feed of the antenna is elevated from the base of the antenna to avoid the discontinuity in the current at the feed and to increase the accuracy of the reflection coefficient approximation used in the formulation. The current distributions are calculated by solving a *Hallen's type integral equation. The input admittance and radiation* patterns are calculated as a function of the length of the horizontal section. The results show that the inverted L antenna studied possesses useful impedance and radiation characteristics. Author

N80-19347# Communications Research Centre, Ottawa (Ontario)

THE EFFECTS OF RE-RADIATION FROM HIGH-RISE BUILDINGS AND TRANSMISSION LINES UPON THE RADIATION PATTERN OF MF BROADCASTING ANTENNA ARRAYS

John S. Belrose, W. Lavrench (Nat. Res. Council, Ottawa), J. G. Dunn (Nat. Res. Council, Ottawa), C. W. Trueman (Concordia Univ., Montreal), and S. J. Kubina (Concordia Univ., Montreal) *In* AGARD Terrain Profiles and Contours in Electromagnetic Wave Propagation Dec 1979 11 p refs (For primary document see N80-19345 10-32)

Avail: NTIS HC A17/MF A01

Results of experimental measurements employing antenna modeling techniques on the re-radiation from model high rise buildings and power lines, are presented. It is found that high rise buildings are resonant in the middle of the MF broadcast band and that buildings located ten or more wavelengths (3 kilometers) from the MF broadcasting array could affect the far field pattern. It is shown that high voltage power transmission line towers, the connecting sky wires, and their image in the ground form loops which are resonant within the braodcast band. A long power line is a system of over coupled, staggered tuned loops, and if the resonant frequency of the power line is that of a nearby broadcast station, the effects of re-radiation on the pattern of the MF broadcast antenna is large. Numerical modeling by the method of moments is in agreement with experiment although it is difficult to calculate the re-radiation from extended structures like power lines. The experimental and numerical modeling represent worst case situations, since the 'earth' is *perfectly conducting and the structures employed are either* insulated from or connected to it. J.M.S.

N80-19348# Mitre Corp., Bedford, Mass.

SURFACE FIELDS AND RADIATION PATTERNS OF A VERTICAL ELECTRIC DIPOLE OVER A RADIALLY VARYING GROUND SYSTEM

C. Teng and R. J. King (Wisconsin Univ., Madison) *In* AGARD Terrain Profiles and Contours in Electromagnetic Wave Propagation Dec 1979 p 4-1 - 4-19 refs (For primary document see N80-19345 10-32)

(Grant NSF ENG-75-16174)

Avail: NTIS HC A17/MF A01

The EM propagation over and radiation from radially varying ground systems are studied by numerical methods using the compensation theorem integral formulation. The source is taken to be a vertical electric dipole (VED) situated either on or above an azimuthally symmetric plane ground system having an assumed surface impedance profile which can vary arbitrarily in the radial *direction. Particular attention is given to conventional HF radial* wire systems laid on both well and poorly conducting earth, and to HF ground systems near a sloping beach. For one section, radial wire ground systems, the radiation patterns are found to *be independent of increasing radial length if the magnitude of* the composite surface impedance is within 90% of the surface impedance of the underlying ground. It is also found that the radially varying feature tends to suppress high-angle lobes which *are otherwise present with highly conducting ground systems,* especially if the surrounding ground is poorly conducting. Suitable combinations of VED height, and the length and number of radials tend to enhance the low angle radiation, as does the use of compound radial wire systems. A land-sea beach on which the water depth gradually increases is shown to have little effect on the radiation pattern compared to that for an abrupt coastline. J.M.S.

N80-19349# *Saarland Univ., Saarbrucken (West Germany)*

TERRAIN EFFECTS ON LOG-PERIODIC ANTENNA CHARACTERISTICS USING THE SINGULARITY EXPANSION METHOD

K. D. Rech and K. J. Langenberg *In* AGARD *Terrain Profiles* and Contours in Electromagnetic Wave Propagation Dec 1979 20 p refs (For primary document see N80-19345 10-32)

Avail: NTIS HC A17/MF A01

A vertical log-periodic directional antenna (LPDA) is investigated with singularity expansion method in free space over a lossy ground and over a perfectly conducting halfspace using Nortons approximation for the Sommerfeld integrals. The influence of the feedingnetwork and of *the mutual coupling of the elements* as well as the influence of antenna thickness on the natural resonances is studied. The modes of the LPDA are presented and the current in frequency and time domain is computed in free space. Dependent on the ground parameters and the antenna height the pole migration in the complex frequency plane is shown and the appropriate modes are determined. Starting from the free space current distribution the transient fields of the vertical LPDA over ground are computed for various ground parameters and antenna heights. J.M.S.

N80-19350# Institute for Telecommunication Sciences, Boulder, Colo.

THEORIES OF GROUND WAVE PROPAGATION OVER MIXED PATHS

R. H. Ott *In* AGARD Terrain Profiles and Contours in Electromagnetic Wave Propagation Dec 1979 9 p refs (For primary document see N80-19345 10-32)

Avail: NTIS HC A17/MF A01

A review is given of some common techniques for predicting the field of a dipole transmitter over an irregular, inhomogeneous terrain profile. The effects of the atmosphere are not included except to modify the degree of 'earth bulging' by the appropriate earth's radius. Some of the topics included are: (1) the impedance boundary condition, (2) the integral equation and mode-match methods for field strength predictions, for a simple knife-edge obstacle on a spherical earth, (3) the double-knife-edge diffraction formula for field strength predictions, and (4) the fields of dipoles in layered media for calculating the transmission through forest-covered and vegetated media. Author

N80-19351# Polytechnic Inst. of New York, Farmingdale. Dept. of Electrical Engineering

HIGH-FREQUENCY SIGNAL PROPAGATION AND SCATTERING IN GUIDING CHANNELS

L. B. Felsen *In* AGARD Terrain Profiles and Contours in Electromagnetic Wave Propagation Dec 1979 7 p refs (For primary document see N80-19345 10-32)

Avail: NTIS HC A17/MF A01

The Earth's environment contains pro: agation channels wherein waves can be guided because of the presence of transverse boundaries or transverse refractive index gradients. By a new approach, high frequency guiding by a single concave surface or by the boundary of an inhomogeneous surface duct is analyzed in terms of a judiciously chosen combination of rays and modes. In essence, the modes account for the cumulative effect of those rays that have experienced a great many reflections on the boundary. This hybrid formulation is appealing in that it requires far fewer rays and far fewer modes than if the field representation involves rays only or modes only, as has been customary. By an extension of the theory, it is shown that the hybrid method can also be applied to channels wherein guiding occurs between multiple transverse boundaries. Here, modes near cutoff can represent efficiently all those rays that have made many excursions between the channel walls. As an illustration, results are presented for a parallel plane waveguide excited by a line source. J.M.S.

N80-19352# Institute for Telecommunication Sciences, Boulder, Colo.

GROUND WAVE PROPAGATION OVER IRREGULAR, INHOMOGENEOUS TERRAIN: COMPARISONS OF CALCULATIONS AND MEASUREMENTS AT FREQUENCIES FROM 121 kHz TO 50 MHz

R. H. Ott *In* AGARD Terrain Profiles and Contours in

Electromagnetic Wave Propagation Dec 1979 10 p refs (For primary document see N80-19345 10-32)
Avail NTIS HC A17/MF A01

A method for calculating the ground wave field over irregular, inhomogeneous terrain was developed and comparisons with alternative analytical methods were made for idealized terrain profiles like concave parabolas, sea-land-sea paths, and single Gaussian ridges. The computer algorithm implementing an integral equation (called PROGRAM WAGNER) uses linear interpolation to represent the terrain height versus distance and a surface impedance which also varies with distance. The transmitting antenna height is arbitrary and is included in the integral equation formulation whereas the height of the receiving antenna is treated approximately by modifying the surface field at the observation point by an effective height-gain function. Comparisons of observed field strength measurements for several paths with field strength predictions based on PROGRAM WAGNER are given for frequencies ranging from 20 kHz to 50 MHz. Although most of the comparisons show encouraging agreement, the 20 mHz comparisons over an extremely rugged path in the Colorado Mountains provided a challenge for the algorithm. J.M.S.

N80-19353# Technical Univ. of Denmark, Lyngby. Electromagnetics Inst.

AN EXPERIMENTAL STUDY OF SURFACE WAVE PROPAGATION ON A LOW PERMITTIVITY MEDIUM

J. Appel-Hansen and R. J. King. *In* AGARD Terrain Profiles and Contours in Electromagnetic Wave Propagation Dec. 1979 4 p refs. Prepared in cooperation with Wisconsin Univ., Madison (For primary document see N80-19345 10-32)
Avail: NTIS HC A17/MF A01

It is experimentally shown that a surface wave having d to the minus 2 power dependence can propagate on a medium having a dielectric constant near unity, when excited by a low-gain source near the interface. This occurs for both parallel and perpendicular polarization. Author

N80-19354# Norsk Marconi A.S., Oslo.

MULTIPATH ANALYSIS OF ILS GLIDE PATH

T. Breien. *In* AGARD Terrain Profiles and Contours in Electromagnetic Wave Propagation Dec. 1979 10 p refs (For primary document see N80-19345 10-32)
Avail: NTIS HC A17/MF A01

A major problem with instrument landing system slide path is the dependence of the signal quality upon site conditions. Unwanted scattering from the surroundings causes error in the guidance signal. A new method to analyze the problem is described. For practical use, the surroundings are modeled as a set of plane wedges. The scattering from each wedge is analyzed using uniform theory of diffraction (UTD), which assumes smooth, sharp and perfectly conducting wedges. Theoretical and practical work was carried out to study the influence of finite conductivity, surface roughness and round edges on the scattered signal. The conclusion is that for most glide path surroundings, UTD gives adequate accuracy. An effective UTD computer program for analysis of glide path performance was developed. Comparisons between computed and measured results show good agreement. R.E.S.

N80-19355# Air Force Avionics Lab., Wright-Patterson AFB, Ohio.

AIRBORNE MEASUREMENTS OF ELECTROMAGNETIC WAVE REFLECTIONS FROM LAND AND SEA WATER

Allen L. Johnson. *In* AGARD Terrain Profiles and Contours in Electromagnetic Wave Propagation Dec. 1979 17 p refs (For primary document see N80-19345 10-32)
Avail: NTIS HC A17/MF A01

Multipath fading caused by terrain reflections can disrupt an airborne communication or navigation system. The severity of the multipath is dependent upon the antenna illumination factor, surface reflection coefficient, and the divergence of the reflected signal. Airborne measurements were used to verify that severe multipath is regularly encountered over water when the aircraft is communicating with a satellite at a low elevation angle. Techniques which can reduce the multipath fading effect include the use of directive antennas, circular polarization and diversity techniques. R.E.S.

N80-19356# Nebraska Univ., Lincoln. Electrical Engineering Dept.

SCATTERED RADIATION FIELDS FROM ROUGH SURFACES FULL WAVE SOLUTIONS

Ezekiel Bahar. *In* AGARD Terrain Profiles and Contours in Electromagnetic Wave Propagation Dec. 1979 12 p refs (For primary document see N80-19345 10-32)
Avail: NTIS HC A17/MF A01

Full wave solutions are derived for the scattered radiation fields from rough surfaces with arbitrary slope and electromagnetic parameters. These solutions bridge the wide gap that exists between the perturbational solutions for rough surfaces with small slopes and the quasi optics solutions. Thus, it is shown for example, that for good conducting boundaries the backscattered fields which are dependent on the polarization of the incident and scattered fields at low frequencies, become independent of polarization at optical frequencies. These solutions are consistent with reciprocity, energy conservation and duality relations in electromagnetic theory. Since the full wave solutions account for upward and downward scattering, shadowing and multiple scatter is considered. Applications to periodic structures and random rough surfaces are also presented. Author

N80-19357# Saarland Univ., Saarbrucken (West Germany).

THEORETICAL ASPECTS OF TRANSIENT RADIATION AND SCATTERING IN LOSSLESS TWO MEDIUM HALF SPACES

M. Doebrich and K. J. Langenberg. *In* AGARD Terrain Profiles and Contours in Electromagnetic Wave Propagation Dec. 1979 14 p refs (For primary document see N80-19345 10-32)
Avail: NTIS HC A17/MF A01

A vertical transient multipole is situated at the height X_1 above a plane boundary separating two dielectric loss-less halfspaces. The potential of the primary and reflected field was evaluated by means of Fourier and Laplace transforms, their inversion was performed on the base of Cagniard's method. The relation between the Fourier integral representation and the generalized Sommerfeld integrals for multipoles is shown. R.E.S.

N80-19358# Deutsche Bundespost, Darmstadt (West Germany).

THEORETICAL DISTRIBUTION FUNCTIONS OF MULTIPATH PROPAGATION AND THEIR PARAMETERS FOR MOBILE RADIO COMMUNICATION IN QUASI-SMOOTH TERRAIN

R. W. Lorenz. *In* AGARD Terrain Profiles and Contours in Electromagnetic Wave Propagation Dec. 1979 16 p refs (For primary document see N80-19345 10-32)
Avail: NTIS HC A17/MF A01

Due to the superposition of many partial waves arriving from different directions, the field strength received by a mobile antenna is an intensely fluctuating function of space. For the planning of radio service areas, the statistical distribution of the amplitudes should be known to improve frequency efficiency. Three statistical distributions were considered: the Weibull distribution, the Nakagami-m-distribution and the mixture of Rayleigh and log-normal distributions. Formulas are given for the determination of the distribution parameters from measurements. For the choice of the best distribution, three different methods are discussed. Results from measurements in quasi-smooth terrain in the 450-mHz-range are presented. R.E.S.

N80-19359# Deutsche Welle, Cologne (West Germany).

ON THE INFLUENCE OF SURFACE STATISTICS, GROUND MOISTURE CONTENT AND WAVE POLARIZATION ON THE SCATTERING OF IRREGULAR TERRAIN AND ON SIGNAL POWER SPECTRA

K. J. Hortenbach. *In* AGARD Terrain Profiles and Contours in Electromagnetic Wave Propagation Dec. 1979 23 p refs (For primary document see N80-19345 10-32)
Avail: NTIS A17/MF A01

The scattering properties of different types of terrain were investigated making visible the shape and fine structure of the effective scattering area by plotting contours of constant average scattered power density on the main scattering plane. Computations and comparisons were carried out for Gaussian and actual roughness statistics, different polarizations, and moisture content of the ground. It is shown that the effective scattering area exhibits a detailed fine structure which is most complex when the angle of the incident radiation is near the pseudo-Brewster angle. This structure modifies the radiation patterns of antennas operating above irregular terrain as well as the signal characteristics. The power density spectrum of a signal transmitted or received by an aircraft flying over irregular terrain generally becomes spread due to the scattering process. The shape of the resulting spectrum depends on the orientation of the velocity vector of the aircraft relative to the scattering area and on its structure. It is also shown that the shape of the resulting spectrum

has a fine structure and can be highly asymmetrical relative to the frequency of the directly incident wave which is verified experimentally R E S

N80 19360*# Massachusetts Inst of Tech , Cambridge
THEORETICAL MODELLING AND EXPERIMENTAL DATA MATCHING FOR ACTIVE AND PASSIVE MICROWAVE REMOTE SENSING OF EARTH TERRAIN
J A Kong, L Tsang, M Zuniga, R Shin, J C Shiue, and A T C Chang *In* AGARD Terrain Profiles and Contours in Electromagnetic Wave Propagation Dec 1979 8 p refs Prepared in cooperation with NASA Goddard Space Flight Center Greenbelt, Md (For primary document see N80-19345 10-32)
Avail NTIS HC A17/MF A01 CSCL 20N

Two theoretical models were developed to characterize terrain media a random medium with a variance, a horizontal correlation length, and a homogeneous dielectric containing discrete scatterers The earth terrain is modelled as layers of such scattering media bounded by air above and half-space below Matching the theoretical results with experimental data collected from vegetation and snow-ice fields shows that (1) for observation angles near nadir, rough surface effects are important, (2) for snow-ice field the horizontal correlation length is greater than the vertical correlation length whereas for vegetation field their relative sizes depend on the types of vegetation, (3) the vertically polarized backscattering cross-section is always larger than the horizontally polarized backscattering cross-section for half-space scattering media, (4) for snow field displaying diurnal change, a three-layer model including a thin top layer caused by sunlight illumination must be used, and (5) for a random medium with equal horizontal and vertical correlation lengths, the measured data can also be matched with a corresponding discrete scatterer model K L

N80-19361# British Aerospace Dynamics Group, Bristol (England)
SOME OF THE PROBLEMS IN DIGITAL TERRAIN MODEL CONSTRUCTION
G B Thersby *In* AGARD Terrain Profiles and Contours in Electromagnetic Wave Propagation Dec 1979 9 p (For primary document see N80-19345 10-32)
Avail NTIS HC A17/MF A01

Aspects of terrain which may effect electromagnetic wave propagation are identified Arguments for and against accurate terrain modelling are presented from the point of view of both the user and the software designer Two possible approaches to digital terrain modelling are outlined as examples and the problems associated with each are discussed The problems associated with producing a data base which is efficient in terms of computer storage and access times and which comprehensively models the terrain and associated data necessary for advanced propagation prediction modelling techniques are discussed K L

N80-19362# Missouri Univ -Rolla Electrical Engineering Dept
AZIMUTH BEAMWIDTH EFFECT ON RADAR SENSED TERRAIN HORIZON PROFILES
Gordon E Carlson and Paul W Sapp *In* AGARD Terrain Profiles and Contours in Electromagnetic Wave Propagation Dec 1979 13 p refs (For primary document see N80-19345 10-32)
Avail NTIS HC A17/MF A01

A method is presented for smoothed horizon generation The mathematical model used computes elevation angle measurements for a phase-monopulse radar by considering a number of individual scattering points within the antenna beamwidth at the horizon range Simplification of the mathematical model permits rapid generation and thus reasonable computer costs Example smoothed horizons are shown and errors due to mathematical model simplification are analyzed The smoothed horizon generation method is applied to the simulation analysis of a horizon checkpointing system Results indicate that good position identification can be achieved with relatively wide azimuth beamwidths K L

N80-19363# German Military Geophysical Office, Traben-Trarbach (West Germany)
BIOLOGICAL AND GEOPHYSICAL FACTORS OF ELECTROMAGNETIC WAVE PROPAGATION AND THEIR USE IN DIGITAL DATA BANKS
Ekkehard R Kuesters *In* AGARD Terrain Profiles and Contours in Electromagnetic Wave Propagation Dec 1979 8 p refs (For primary document see N80-19345 10-32)
Avail NTIS HC A17/MF A01

The development of a radar clutter data bank containing data about elevation and soil cover for the whole Federal Republic of Germany is discussed The different categories of soil cover are to be correlated with their specific effects on the propagation of electromagnetic waves The greatest problems in this respect arise with deciduous forest and farmland because of the phenological changes that take place during the year A phenological observation net was established to obtain data Since it was impossible to ascertain data for each grid field, a coarse subdivision of the Federal Republic of Germany was made into regions that are homogeneous with respect to the phenological events Because of the influence of hydrometeors on electromagnetic wave propagation, the data bank also contains data about the altitude, vertical extension, frequency of occurrence, and drop spectra of the major cloud types K L

N80-19364# Lincoln Lab , Mass Inst of Tech , Lexington
PREDICTION OF RADAR COVERAGE AGAINST VERY LOW ALTITUDE AIRCRAFT
John R Delaney and M Littleton Meeks *In* AGARD Terrain Profiles and Contours in Electromagnetic Wave Propagation Dec 1979 15 p refs (For primary document see N80-19345 10-32)
Avail NTIS HC A17/MF A01

A model was developed for the effects of propagation on radar coverage accounting for refraction, diffraction, and reflection The model was applied to digitized terrain data for three sites, one with relatively hilly terrain, one with relatively smooth terrain, and one with mixed terrain Results show that approximating the radar coverage by the potential target locations within line of sight can be quite misleading Results also show that the coverage of lower frequency radars can be better than that of higher frequency radars in terrain where diffraction is the dominant phenomena Moreover, the coverage of lower frequency radars in reflection-dominated terrain can be quite satisfactory if sufficient power is transmitted The results of a field experiment confirm that the model correctly combines the effects of diffraction and reflection K L

N80-19365# Joint Radio Committee of the Nationalised Power Industries, London (England)
RADIO NETWORK AND RADIO LINK SURVEYS DERIVED BY COMPUTER FROM A TERRAIN DATA BASE
C E Dadson *In* AGARD Terrain and Contours in Electromagnetic Wave Propagation [illegible] 1979 17 p refs (For primary document see N80-19345 10-32)
Avail NTIS HC A17/MF A01

A method of deriving calculations for the coverage area of mobile radio networks using a computer and a topographical data base is described The topographical data base was manually produced from providing 800,000 height reference points at 0 5 kilometer intervals for England, Wales, and Scotland excluding Highlands and Islands Path profiles are produced by the computer and calculations are provided for each 0 5 km point over the survey area, which can be up to a maximum of 90 km square The computer requires the user to input details of the base station transmitter location, antenna height, radiated power, and type of antenna K L

N80-19366# Communications Research Centre, Ottawa (Ontario)
VHF/UHF PATH-LOSS CALCULATIONS USING TERRAIN PROFILES DEDUCED FROM A DIGITAL TOPOGRAPHIC DATA BASE
F H Palmer *In* AGARD Terrain Profiles and Contours in Electromagnetic Wave Propagation Dec 1979 11 p refs (For primary document see N80-19345 10-32)
Avail NTIS HC A17/MF A01

A digital topograhic data base comprising some 150,000 sq km of southern Ontario was established to allow terrain profiles profiles to be constructed automtically The profiles, together with a variety of terrain surface cover information also derived from the data base, are used in the calculation of path loss, signal strength, and signal to noise ratios for various types of VHF/UHF systems These calculations incorporate a number of additional factors necessary to achieve good agreement between predicted and measured path losses, including the effects of various types of terrain surface cover and of multiple, nonisolated obstacles Comparisons of predictions and measurements made over a wide variety of terrain types indicate that rms prediction errors of 4 to 5 bd can be achieved in the VHF/UHF bands K L

N80-19367# Genoa Univ. (Italy)
ELECTRIC FIELD COMPONENTS IN PRESENCE OF A SEA-SEA BOTTOM INTERFACE AT ELF
Giorgio Tacconi *In* AGARD Terrain Profiles and Contours in Electromagnetic Wave Propagation Dec 1979 7 p refs Sponsored in part by the Italian National Research Council, Genoa (For primary document see N80-19345 10-32)
Avail NTIS HC A17/MF A01

A conceptual theoretical recall as well as a collection of computed curves of the electric field rho component E sub phi, and relative phase versus distance, for a selection of bottom depths and frequencies, in the sea are presented. Such theoretical exercise is validated by some experimental results also presented in this paper. R.C.T.

N80-19368# Technical Univ. of Denmark, Lyngby. Electromagnetics Inst.
RADAR ALTIMETER MEASUREMENTS
Flemming Thomsen *In* AGARD Terrain Profiles and Contours in Electromagnetic Wave Propagation Dec 1979 11 p refs (For primary document see N80-19345 10-32)
Avail NTIS HC A17/MF A01

A theoretical method for calculating the output signal of a satellite radar altimeter as a function of time was developed for ice and snow covered areas. Satellite altimeters were applied by the Skylab S-193, the GEOS 3 and the SEASAT experiments. Pulse limited altimeters with pulse lengths between 10 and 100 nanoseconds were reviewed. The transmitted pulse was assumed to be rectangular. When the skin depth of the radiation was great, compared to the spatial width of the transmitted pulse, the subsurface material gave considerable contributions to the total echo. Considering altimeter measurements of snow and fresh water ice surfaces, we find skin depths ranging from 10 to several hundred meters. R.C.T.

N80-19369*# National Aeronautics and Space Administration, Washington, D. C.
A LASER PROFILOMETER FOR DIGITAL TERRAIN MAPPING
Bernard Rubin and Michael W. Fitzmaurice *In* AGARD Terrain Profiles and Contours in Electromagnetic Wave Propagation Dec 1979 11 p refs (For primary document see N80-19345 10-32)
Avail NTIS HC A17/MF A01 CSCL 20N

A preliminary design of a space-based decimeter accuracy ranging instrument is described along with the ranging subsystem, the pointing subsystem, and attitude reference. The measurement capabilities including ranging accuracy, the signal-to-noise ratio for water, ice, and solid Earth, footprint size, and atmospheric effects are defined and the overall system with its advantages and disadvantages are summarized. R.C.T.

N80-19370# Standard Elektrik Lorenz A.G., Pforzheim (West Germany)
AN EXPERIMENTAL INVESTIGATION OF MULTI-PATH SCATTERING AT L-BAND
P. Lewis *In* AGARD Terrain Profiles and Contours in Electromagnetic Wave Propagation Dec 1979 24 p refs (For primary document see N80-19345 10-32)
Avail NTIS HC A17/MF A01

The scattering effect responsible for large errors in the azimuth bearing measurements obtained with a 1 GHz monopluse receiver on a particular site when the source occupied different positions near the top of a distant hill was investigated. The received field distribution on a horizontal line of length 32 m directly in front of the monopulse antenna was sampled by a travelling probe antenna and recorded holographically. Computer processing of the hologram realised essentially a series of filtering operations to reconstruct sections of the field distribution (assuming 2 dimensional propagation in empty space) at different distances in front of the receiver, which were printed out as amplitude and phase plots. These images revealed the scattering mechanism, which included a ground reflected wave diffracted between two buildings. The reflection coefficient was in reasonable agreement with theoretical predicitons. A computer model of the scattering mechanism served both to confirm the interpretation of the experimental data and to investigate the effects of different components of the multi path field on the monopulse receiver. Maximum bearing errors to the order of 0.2 beamwidths were found. R.C.T.

N80-19371# Deutsche Bundespost, Darmstadt (West Germany)
DIFFRACTION PHENOMENA DURING MULTIPATH FADING
H. G. Gilor *In* AGARD Terrain Profiles and Contours in Electromagnetic Wave Propagation Dec 1979 14 p refs (For primary document see N80-19345 10-32)
Avail NTIS HC A17/MF A01

The measured electrical field strength height profiles at a receiving station located near a forest were verified. The experiments were performed on A 40-km link which operated at 9 GHz was investigated. The receiving aerial was set up on an elevator which moved up and down a 40-m tower. Electrical field strength height profiles were recorded with fade depths up to 26 dB. R.C.T.

N80-19372# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France)
SPECIAL TOPICS IN HF PROPAGATION
Vincent J. Coyne, ed. (RADC, Griffiss AFB, N.Y.) Nov 1979 595 p refs In ENGLISH and FRENCH Symp. held in Lisbon, 28 May - 1 Jun. 1979
(AGARD-CP-263, ISBN-92-835-0253-1) Avail NTIS HC A25/MF A01

The state-of-knowledge of HF propagation as it applies to communication, surveillance, and other systems contemplated or presently in use is presented in 49 papers. Topics cover operational considerations, modeling of ionospheric parameters, high latitude ionospheric effects, propagation through irregularities, remote sensing and ocean surveillance tunnel transmission and surface waves, and equipment considerations. For individual titles, see N80-19373 through N80-19419.

N80-19373# Royal Aircraft Establishment, Farnborough (England)
THE ROLE OF HF IN AIR-GROUND COMMUNICATIONS: AN OVERVIEW
B. Burgess *In* AGARD Spec. Topics in HF Propagation Nov 1979 6 p refs (For primary document see N80-19372 10-32)
Avail NTIS HC A25/MF A01

High frequency radio is a prime means for beyond line-of-sight air-ground communications and will remain as such into the foreseeable future, complementing Satellite communications where this latter system is employed. Various aspects that make up an HF communciations system and the contribution that they make to the overall system performance are reviewed. The needs of the modern user in the use of HF communications are considered with emphasis on the changing requirements on the HF link that the use of digital communications brings. Error rate performance, avoidance of interference, HF prediction techniques for Northern latitudes, and the role of channel evaluation techniques are addressed in order to acquaint the research worker with the status and trends in airborne HF communications and to indicate where further work may profitably be undertaken to eventually improve system performance. A.R.H.

N80-19374# Royal Aircraft Establishment, Farnborough (England). Radio and Navigation Dept.
HF COMMUNICATION TO SMALL LOW FLYING AIRCRAFT
N. M. Maslin *In* AGARD Spec. Topics in HF Propagation Nov 1979 13 p refs (For primary document see N80-19372 10-32)
Avail NTIS HC A25/MF A01

HF (2-30 mHz) radio communication is a principal means of beyond line of sight communication to aircraft. There are particularly serious problems for the small aircraft. Many factors degrade the overall received signal-to-noise ratio both at the ground and in the aircraft. To achieve satisfactory results, careful consideration should be given not only to the terminal radio equipment but also to the long term geographic planning and to the management of the frequencies to be used over mobile HF links. The worst HF communication problems occur for a short range air-ground sky-wave link at night which requires frequencies at the low end of the HF band. Working over a longer range link increasing the 'optimum working frequency', thus avoiding the poor antenna efficiencies and generally reducing external noise levels. It is shown that good frequency management, ground antenna directivity and the use of a number of geographically separated remote receiving stations are vital in providing satisfactory communications reliability to the small aircraft.
Author

N80-19375# Army Avionics Research and Development Activity, Fort Monmouth, N. J. Communication and Sensor Div.
MODERN HF COMMUNICATIONS FOR LOW FLYING AIRCRAFT
John F. Brune and Bernard V. Ricciardi *In* AGARD Spec.

Topics in HF Propagation Nov 1979 15 p refs (For primary document see N80-19372 10-32)
Avail NTIS HC A25/MF A01

An application of the HF propagation phenomenon that can provide relatively short range, reliable, terrain independent communications is described It has been shown that communications out to ranges of 50 km under varying terrain conditions, to and from low flying aircraft, is an extremely difficult problem especially for air mobile tactical forces The US Army under the Nap-of-the-Earth Communications (NOE Comm) System program conducted extensive tests and analysis using the HF media for tactical communications with low-flying aircraft The use of the near vertical-incidence skywave (NVIS) portion of the HF channel for aircraft communications is described The HF-SSB radio systems have the capability of operating in either a ground wave or NVIS mode For the NVIS mode, the energy is directed vertically to the ionosphere and returned to the surface of the earth The NVIS mode provides umbrella type coverage Because of NVIS propagation, HF SSB systems with appropriate antennas have the capability of providing communications coverage out to ranges greater than 50 km in any type of terrain The NVIS mode is terrain independent The characteristics of the HF NVIS mode are considered and the features required of a modern HF radio system to make efficient and practical utilization of the already overcrowded HF band are noted A R H

N80-19376# Barry Research Corp, Sunnyvale Calif
REAL-TIME ADAPTIVE HF FREQUENCY MANAGEMENT
Robert B Fenwick and Terence J Woodhouse *In* AGARD Spec Topics in HF Propagation Nov 1979 14 p (For primary document see N80-19372 10-32)
Avail NTIS HC A25/MF A01

In 1972 the United States Air Force began a program aimed at improving tactical HF communications The approach involved measurement in real time of the important unknowns propagation, noise and spectrum occupancy and adapting operating frequencies in real time to the conditions measured A potential problem with this approach is causing harmful interference to other spectrum users An exercise called TROPHY DASH III was conducted to assess the ability of a particular technique to permit real time selection of frequencies while yielding acceptably low interference TROPHY DASH III results are viewed as significant First, in spite of extensive notification of other spectrum users negligible interference was reported Based upon these results, real-time adaptive sharing of the HF spectrum in the tactical theater appeared both valid and feasible for a limited number of high-priority users, and procurement of the AN/TRQ-35(V) Tactical Frequency Management System was authorized Author

N80-19377# Royal Aircraft Establishment, Farnborough (England) Radio and Navigation Dept
ASSESSMENT OF HF COMMUNICATIONS RELIABILITY
N M Maslin *In* AGARD Spec Topics in HF Propagation Nov 1979 12 p refs (For primary document see N80-19372 10-32)
Avail NTIS HC A25/MF A01

The concept of circuit reliability for an HF sky-wave link is discussed Its frequency dependence is considered together with the relationship to the median received signal-to-noise ratio for a given HF circuit The importance of a study of this kind is the ability to be able to quantify changes that could be made for an HF circuit, in terms of reliability improvements, and hence to make decisions of the cost effectiveness of increasing transmitter power, antenna efficiencies, directional antenna design A R H

N80-19378# Forschungsinstitut der Deutschen Bundespost, Darmstadt (West Germany)
COMPARISON OF MEASURED AND PREDICTED MUF'S AT A REMOTE LOCATION
Th Damboldt *In* AGARD Spec Topics in HF Propagation Nov 1979 6 p refs (For primary document see N80-19372 10-32)
Avail NTIS HC A25/MF A01

The times at which the signals are received first and last by ionospheric propagation during the diurnal cycle define the times where the frequency of the transmitted signal is equal to the path MUF (maximum usable frequency) Values of these transition times are taken from the field-strength records of a path from England to Germany and then compared with the predicted values A further comparison is made between the observed MUF transition times and the ionogram critical frequencies at the approximate path mid-point, i e de Bilt in Holland for the above mentioned path Good agreement is obtained between the ionogram critical frequencies and the measured MUF s It is suggested that information obtained from signal strength records can lead to substantial improvements in MUF predictions This is of considerable importance since operational requirements usually exist for real-time situations and not for the average conditions computed by prediction programmes A R H

N80-19379# Mission Research Corp Santa Barbara, Calif
AUGMENTATION OF HF PROPAGATION
T J Barrett *In* AGARD Spec Topics in HF Propagation Nov 1979 13 p refs (For primary document see N80-19372 10-32)
Avail NTIS HC A25/MF A01

It appears that chemical releases might be employed to scatter communication signals for limited critical periods This technique is an augmentation to be used in the event of an emergency or an apparent emergency The technique, while short-lived does provide communication coverage over vast areas (approximately 3000 mile range) In a nuclear environment, the chemical ion cloud allows the use of VHF transmissions, rather than HF, thus greatly reducing blackout durations Assessing the nuclear environment provides information to avoid blackout caused by beta particle ionization and allows choice of optimum cloud location This technique does not replace any current communication system but does provide a way to maintain communications for a few minutes which might otherwise be blacked out for hours Potential applications of this technique include communication with NATO, fleets, subforces, SAC and other tactical communications Author

N80-19380# General Electric Co, Syracuse, N Y
TROPOSPHERIC EFFECTS ON HF PROPAGATION
George H Millman *In* AGARD Spec Topics in HF Propagation Nov 1979 14 p refs (For primary document see N80-19372 10-32)
Avail NTIS HC A25/MF A01

An evaluation is made of the effect of tropospheric refractive bending on the propagation of HF radio waves The index of refraction in the troposphere is modeled in terms of the CRPL Reference Refractivity Atmosphere-1958, while the index of refraction in the ionosphere is defined in terms of the transverse *ordinary mode of propagation*, the electron density being represented by a Chapman model Ray tracings are performed based on the assumption that the propagation media are stratified into layers of constant refractive index The ground scatter distance and the true and virtual reflection heights are calculated as a function of surface refractivity and various electron density profiles The relationship between radar range and target-ground distance is also examined The existence of long range propagation paths beyond 4500 km for specific tropospheric and ionospheric conditions is discussed Author

N80-19381# National Oceanic and Atmospheric Administration, Boulder, Colo Space Environment Lab
TOWARD GLOBAL MONITORING OF THE IONOSPHERE IN REAL TIME BY A BOTTOMSIDE NETWORK: THE GEOPHYSICAL REQUIREMENTS AND THE TECHNOLOGICAL OPPORTUNITY
J W Wright and A K Paul *In* AGARD Spec Topics in HF Propagation Nov 1979 21 p refs (For primary document see N80-19372 10-32)
Avail NTIS HC A25/MF A01

Various aspects of a proposed ionospheric sounding network are discussed This network is composed of modern digital ionosondes that are fully computer-interactive These ionosondes could provide vertical incidence and oblique incidence ionograms signal amplitude, direction of arrival information and polarization The advantages of such a network of sophisticated ionosondes are outlined J M S

N80-19382# Polytechnic Inst of New York Farmingdale Dept of Electrical Engineering
HYBRID RAY-MODE FORMULATION OF *TROPOSPHERIC* PROPAGATION
S H Cho, C G Migliora, and L B Felsen *In* AGARD Spec Topics in HF Propagation Nov 1979 15 p refs (For primary document see N80-19372 10-32)
Avail NTIS HC A25/MF A01

A method of analyzing radio propgation using a combination of ray and mode theory is addressed Using as an illustration the propagation of radio waves in an elevated tropospheric duct the emphasis is given to how the hybrid ray mode approach

could be readily applied to a number of different propagation related problems across the frequency spectrum J M S

N80-19383# *Centre National d Etudes des Telecommunications*, Lannion (France)
THE INFLUENCE OF IONOSPHERIC MODELS ON CALCULATIONS OF DECAMETRIC WAVE PROPAGATION [INFLUENCE DES MODELES D'IONOSPHERE SUR LES CALCULS DE PROPAGATION DES ONDES DECAMETRIQUES]
R Fleury and P Gourvez *In* AGARD Spec Topics in HF Propagation Nov 1979 14 p refs In FRENCH, ENGLISH summary (For primary document see N80-19372 10-32)
Avail NTIS HC A25/MF A01

The ionospheric F2 layer critical plasma frequency foF2 is one key geophysical parameter among those involved in HF wave propagation This means that the efficiency of numerical methods available for HF waves propagation simulation (e g , ray tracing) is greatly limited by the uncertainties inherent to the foF2 input models Observed planetary distributions of monthly median foF2 and those calculated by current models which give values of error bars on foF2 are compared systematically Further, an accurate ray tracing method used with F2-region models in which foF2 is perturbed in amounts equal to typical values of its error bars helps to assess the influence of these error bars on HF waves propagation results A R H

N80-19384# Illinois Univ at Urbana-Champaign, Urbana Dept of Electrical Engineering
METHODS OF DETERMINING IONOSPHERIC STRUCTURE FROM OBLIQUE SOUNDING DATA
R E DuBroff, N Narayana Rao, and K C Yeh *In* AGARD Spec Topics in HF Propagation Nov 1979 16 p refs (For primary document see N80-19372 10-32)
Avail NTIS HC A25/MF A01

The problem of determining ionospheric conditions from swept frequency oblique backscatter ionograms is considered Emphasis is given to the methods developed to obtain an estimate of the equivalent electron density profile that results from the inversion of backscatter measurements J M S

N80-19385# Naval Research Lab , Washington, D C Communication Sciences Div
THE GEOMORPHOLOGY OF THE HF BREAKTHROUGH PHENOMENON
John M Goodman *In* AGARD Spec Topics in HF Propagation Nov 1979 13 p refs (For primary document see N80-19372 10-32)
Avail NTIS HC A25/MF A01

The morphological behavior of HF radio waves that propagate through the ionosphere and are observed at satellite levels is described Using realistic models the types of information about the ionospheric structure that could be deduced from satellite measurements of ground based HF signals of HF noise sources are studied J M S

N80-19386# Institut fuer Astrophysik und Extraterrestrische Forschung, Bonn (West Germany)
COUPLING BETWEEN THE NEUTRAL AND IONIZED UPPER ATMOSPHERE DURING DISTURBED CONDITIONS
G W Proelss *In* AGARD Spec Topics in HF Propagation Nov 1979 14 p refs (For primary document see N80-19372 10-32)
Avail NTIS HC A25/MF A01

Classical ground based ionospheric data coupled with satellite observation are used to unravel the problems associated with understanding the dynamics of the ionosphere during a geomagnetic storm It is indicated that the Earth s ionized atmosphere cannot be understood and predicted in the absence of comparable knowledge about the neutral atmosphere J M S

N80-19387# Ionospharen-Institut Breisach (West Germany)
BASIC FINDINGS HELPFUL FOR IONOSPHERIC PREDICTIONS
E Harnischmacher and K Rawer *In* AGARD Spec Topics in HF Propagation Nov 1979 10 p refs (For primary document see N80-19372 10-32)
Avail NTIS HC A25/MF A01

The day-to-day fluctuations in the ionospheric parameters and how they appear tied to lunar includences are considered In addition, the apparent planetary influences on the observed behavior of the F2 region critical frequency is discussed J M S

N80-19388# Centre National d Etudes des Telecommunications Lannion (France)
ON DETERMINING THE MAXIMUM USABLE FREQUENCY (MUF) [SUR LA DETERMINATION DE LA MUF CLASSIQUE]
R Hanbaba *In* AGARD Spec Topics in HF Propagation Nov 1979 9 p refs In FRENCH (For primary document see N80 19372 10 32)
Avail NTIS HC A25/MF A01

Calculation of the highest frequency at which radio waves can be propagated by ionospheric reflection between two given points is generally based on a representation of the propagation mode by a rectilinear path between the ground and the points in the ionosphere By adopting Bradley and Dudeney s quasi parabolic model of variation with the altitude of the electric concentration, analytical expression can be obtained for the length of the ionospheric leap the MUF, and the elevation angle of the radio path However, for practical applications, it is necessary to use as simple a method as possible A 'manual' method for determining the MUF and the elevation angle of the radioelectric path is presented Transl by A R H

N80-19389# Air Force Geophysics Lab , Hanscom AFB, Mass
CHARACTERISTICS OF THE HIGH LATITUDE IONOSPHERE PRODUCED BY AURORAL PARTICLE PRECIPITATION
James A Whalen *In* AGARD Spec Topics in HF Propagation Nov 1979 12 p refs (For primary document see N80-19372 10-32)
Avail NTIS HC A25/MF A01

The general domains of the high lattidue ionosphere are described How these domains relate in space and time to general magnetospheric domains and how these relations aid the understanding of high frequency propagation in the high latitudes is discussed R E S

N80-19390# Institute for Telecommunication Sciences, Boulder, Colo
PERSPECTIVE ON THE PREDICTION OF AURORAL ABSORPTION
Vaughn Agy *In* AGARD Spec Topics in HF Propagation Nov 1979 16 p refs (For primary document see N80-19372 10-32)
Avail NTIS HC A25/MF A01

Methods for the calculation of the effects of auroral absorption on high frequency (HF) communication circuits (or HF radar) are briefly described The riometer is discussed in detail as the best method for establishing an adequate data base for the prediction of auroral absorption effects on HF communication circuits The reasons to explain why, after 25 years of riometer measurement, there is still no adequate data base are reviewed Questions remain about the geographic distributions, the temporal variations, and the relationships with polar cap absorption on one hand, and with magnetospheric substorms on the other These questions are stated and briefly examined R E S

N80-19391# Communications Research Centre, Ottawa (Ontario) Dept of Communications
DIRECTION AND DOPPLER CHARACTERISTICS OF MEDIUM AND LONG PATH HF SIGNALS WITHIN THE NIGHT-TIME SUB-AURORAL REGION
R W Jenkins, E L Hagg, and L E Montbriand *In* AGARD Spec Topics in HF Propagation Nov 1979 18 p refs Sponsored in part by AFGL (For primary document see N80-19372 10-32)
Avail NTIS HC A25/MF A01

During 1976, the large receiving array near Ottawa was used to record high frequency (HF) transmissions from a USAF Geophysics Laboratory aircraft 2000 km away over the northwest Atlantic on four evening flights Geomagnetic conditions ranged from quiet to active Signals from individual array elements were separately recorded, and later analyzed to provide the Doppler shift and direction of the signal Also used were oblique ionograms recorded on the aircraft for a similar path The F-mode maximum usable frequencies (MUF) were below 5 MHz for the major portions of all evening flights However, several weaker modes were observed to be present at much higher frequencies They were examined for their potential utility in extending HF communications and surveillance It is concluded that the Sporadic-E and skip-distance-focussed ground-sidescatter modes present an opportunity for limited HF operations in the subauroral region during evening hours, when very low F-mode MUF's would otherwise make such operations impossible R E S

N80-19392# Rome Air Development Center, Hanscom AFB, Mass

RECENT ADVANCES IN HF PROPAGATION SIMULATION
Terence J Elkins *In* AGARD Spec Topics in HF Propagation Nov 1979 17 p refs (For primary document see N80-19372 10-32)
Avail NTIS HC A25/MF A01

The recent developments in high frequency propagation simulation are summarized Practical applications of the developments are discussed R E S

N80-19393# James Cook Univ of North Queensland, Townsville (Australia) Dept of Physics
TRANSEQUATORIAL PROPAGATION THROUGH EQUATORIAL PLASMA BUBBLES: DISCRETE EVENTS
M L Heron *In* AGARD Spec Topics in HF Propagation Nov 1979 10 p refs (For primary document see N80-19372 10-32)
Avail NTIS HC A25/MF A01

Recent results from the Jicamarca radar facility and satellite-borne plasma density probes have provided the general characteristics of rising depletions in the evening ionospheric plasma over the equator The depletions are not spherical bubbles but extend along the magnetic field lines so that their feet are always in the lower F region The bubbles are driven by E x B fields Generally they move with the background ionosphere horizontally towards the east at about 125 m/s, but often they have a vertical component as well A propagation model was developed, which uses the observed characteristics of the bubbles to predict radio wave guiding along the depleted tubes The numerical model is set up to calculate power, Doppler shift, elevation and azimuth at the receiver of a transequatorial transmitter receiver pair of stations The numerical model was successfully evaluated in terms of a few observations of transequatorial propagation events R E S

N80-19394# Max-Planck-Institut fuer Aeronomie, Katlenburg-Lindau (West Germany)
THE PHENOMENOLOGY OF TRANSEQUATORIAL RADIO PROPAGATION UNDER SPREAD-F CONDITIONS
J Roettger *In* AGARD Spec Topics in HF Propagation Nov 1979 9 p refs (For primary document see N80-19372 10-32)
Avail NTIS HC A25/MF A01

Three special phenomena of transequatorial propagation are described (1) the frequency dependence of off-great-circle path points to steep horizontal gradients of ionization, caused by the spatial resonance effect in the postsunset equatorial F region, (2) the small scale irregularities of the equatorial spread F which are generated at the steep gradients give rise to strong amplitude fluctuations of transequatorial signals, (3) the upward rising depletions of ionization can duct and scatter very high frequency signals over distances of more than 6000 km Author

N80-19396# Max-Planck-Institut fuer Aeronomie, Katlenburg-Lindau (West Germany)
DETECTION, RANGING AND DRIFTSPEED MEASUREMENTS OF EQUATORIAL IONOSPHERIC IRREGULARITIES BY MEANS OF AIRGLOW OBSERVATIONS
G Lange-Hesse and H Lauche *In* AGARD Spec Topics in HF Propagation Nov 1979 7 p refs (For primary document see N80-19372 10-32)
Avail NTIS HC A25/MF A01

Measurements of the emission rate distribution of the red oxygen line lambda 630 nm in the night airglow with a panorama photometer at Tsumeb, Namibia show the occurrence of distinct airglow irregularities in the equatorial region These irregularities are associated with irregularities in the electron density of the ionospheric F2-layer and show a nearly constant eastward drift with a average speed of about 100 m/s The drift to the east is superimposed by an irregular movement to the south and north with a speed of about 200 m/s and more R E S

N80-19396# Leicester Univ (England) Dept of Physics
HF WAVEFRONT IRREGULARITIES OBSERVED ON A LARGE APERTURE RECEIVING ARRAY
T B Jones and E C Thomas *In* AGARD Spec Topics in HF Propagation Nov 1979 11 p refs (For primary document see N80-19372 10-32)
Avail NTIS HC A25/MF A01

The wavefronts of HF signals received on a large receiving array are investigated for a range of propagation conditions The array consists of seven vertical elements spaced in a minimum redundancy configuration The phase and amplitude on each element are measured and the whole array scanned every 0.1 sec Signals received via ground waves and sky waves are investigated The curvature of the wave front of the ground wave signals enables the location of the transmitter to be determined The sky wave signals exhibit a wide variety of disturbance features An attempt is made to relate these to the corresponding reflections in the ionosphere K L

N80-19397# Army Communications Command, Fort Huachuca, Ariz
A SPORADIC E PREDICTION TECHNIQUE
Miles A Merkel and Roberto Rubio *In* AGARD Spec Topics in HF Propagation Nov 1979 8 p refs Prepared in cooperation with Atmospheric Sciences Lab, White Sands Missile Range, N Mex (For primary document see N80-19372 10-32)
Avail NTIS HC A25/MF A01

A Sporadic E assessment technique was developed and implemented on electronic computer to facilitate computations and comparisons with experimental data Very good agreement was found with the data in the mid-latitudes Recommendations are made for approaches which should improve the accuracy and reduce computer run time K L

N80-19398# Rome Air Development Center, Hanscom AFB, Mass Electromagnetic Sciences Div
SCATTER INJECTION/DUCTED MODE HF RADAR
Gary S Sales *In* AGARD Spec Topics in HF Propagation Nov 1979 10 p refs (For primary document see N80-19372 10-32)
Avail NTIS HC A25/MF A01

An extended range HF radar that uses Earth detached propagation modes to minimize losses was developed for detecting missile induced ionospheric perturbations The ability of artificially generated irregularities to facilitate the injection/ejection of HF signals into ducted modes was studied theoretically K L

N80-19399# Instituto Nacional de Meteorologia e Geofisica Lisbon (Portugal)
IONOSPHERIC EFFECTS OF A SOLAR ECLIPSE IN THE CAPE VARDE ISLANDS [EFFETS IONOSPHERIQUES D'UNE ECLIPSE SOLAIRE DANS LES ILES DU CAP VERT]
A S Mendes, F Bertin, P Vila, and J Papet-Lepine *In* AGARD Spec Topics in HF Propagation Nov 1979 4 p refs In FRENCH, ENGLISH summary Prepared in cooperation with Centre National d'etudes Telecommunications Issy-les-Moulineaux (France) (For primary document see N80-19372 10-32)
Avail NTIS HC A25/MF A01

The installation of two ionosondes at SAL (Cape Verde Islands) and at Ascension Island (conjugate point to SAL) as well as three polarimeters at SAL, DAKAR and BATHURST (Gambia) in addition to the permanent ionosonde in DAKAR made it possible to detect various ionospheric effects of the eclipse The passage of the entire eclipse at supersonic speed seems to have produced a gravity wave front due to the cooling The simultaneous foF2 and total electron content minima determine the initial time for the passage of a gravity-wave-like wake with a velocity around 250 ms/1 and whose fundamental period is 18 mn The ionospheric electric field perturbation is due to the ionization loss in the E region dynamo in a cylindrical region of 500 km radius As a result of the upper F region 10 45 to 11 00 UT without any ionization loss at these levels A thermospheric contraction flux appearing 20 mn after the eclipse maximum as well as a forced thermal diffusion flux were also noted The results were essential for interpreting the more complex variations observed at subtropical and equatorial stations A R H

N80-19400# Birmingham Univ (England)
GROUND-WAVE AND SKY-WAVE SEA-STATE SENSING EXPERIMENTS IN THE UNITED KINGDOM
E D R Shearman, W A Sandham, E N Bramley, and P A Bradley *In* AGARD Spec Topics in HF Propagation Nov 1979 11 p refs Prepared in cooperation with the Science Research Council, Slough (England) (For primary document see N80-19372 10-32)
Avail NTIS HC A25/MF A01

The use of gound wave MF/HF radar and sky wave HF radar for sensing wave characteristics and surface currents was studied Ground wave experiments revealed a marked dependence of echo amplitude on sea state for 77 m waves as a function of the wind dependent long wavelength cut-off of the sea spectrum The 0.01 Hz Doppler resolution employed permitted identification of island and ship echoes with ships being tracked out to a 210 km range Using synthetic aperture technique, wave directional features were established and correlated with wind data A sky wave radar project involving on-line digital

processing was initiated for daily monitoring of the North Atlantic at ranges from 1 000 3 000 km over a 60 deg arc Comparisons are reported of radar deduced surface wind directions and magnitudes with those measured in oceanographic vessels An extension of the statistical theory used in the analysis of radar spectra is presented K L

N80-19401# Toulouse Univ (France)
SEA-STATE DIRECTIONAL SPECTRA OBSERVED BY HF DOPPLER RADAR [ESTIMATION DU SPECTRE DIRECTIONNEL DES VAGUES PAR RADAR DECAMETRIQUE COHERENT]
P Broche *In* AGARD Spec Topics in HF Propagation Nov 1979 12 p refs In FRENCH, ENGLISH summary (For primary document see N80-19372 10-32)
Avail NTIS HC A25/MF A01

The principal elements used in describing the sea surface, and the fundamental phenomena implied in the backscattering of the electromagnetic waves by this surface are reviewed Results of experiments performed with a ground-wave HF Doppler radar are presented and compared with a sea-truth supplied by conventional oceanographic means Two points are stressed the estimation of the wind direction, by measuring the ratio of the amplitudes of the two Bragg lines in the doppler spectrum of the backscattered H F wave, and the estimation of the dominant frequency in the sea-state spectrum and of the significant height of the waves by measuring the cut-off frequencies which are present on both sides of the Bragg lines A R H

N80-19402# SRI International Corp , Menlo Park, Calif
DEVELOPMENT OF HF SKYWAVE RADAR FOR REMOTE SENSING APPLICATIONS
Taylor W Washburn, Lawrence E Sweeney, Jr , James R Barnum, and Walter B Zavoli *In* AGARD Spec Topics in HF Propagation Nov 1979 17 p refs (For primary document see N80-19372 10-32)
Avail NTIS HC A25/MF A01

The capabilities of HF radar are discussed along with radar techniques and propagation management tools used to maximize radar performance Methods are described for inferring radar sensitivity from cluster to noise measurements, minimizing interference problems in the crowded HF spectrum, and using the swept frequency continuous wave signal format to separate small moving targets from clutter and observe fine details within the clutter itself K L

N80-19403# SRI International Corp , Menlo Park, Calif
HF SKYWAVE RADAR ESTIMATES OF THE TRACK, SURFACE WIND AND WAVES OF HURRICANE ANITA
Joseph W Maresca, Jr and Christopher T Carlson *In* AGARD Spec Topics in HF Propagation Nov 1979 13 p refs Presented at the Conf on Coastal Eng , Hamburg, West Germany, Aug 1978 (For primary document see N80-19372 10-32)
Avail NTIS HC A25/MF A01

The track of Hurricane Anita and the intensity of the surface wind and waves throughout the storm were estimated from high frequency skywave radar sea echo Doppler spectra measurements made over 3000 km away from the storm Twenty-one maps of the surface wind direction within 250 km of the eye were generated A track was computed from estimates of the hurricane center made from each wind direction map Spatially averaged hurricane wind-speed, wind-direction, and wave-height radar estimates were compared to point measurements made at NDBO buoys and by reconnaissance aircraft Agreement was within the nominal measurement accuracy of all the sensors Comparison of point current measurement made nearly 290 km apart during Anita by the radar and moored open-ocean current meters show reasonable agreement These experiments indicate that during a hurricane, HF skywave radar can provide operational surface data that are as accurate as the more recognized in-situ measurements K L

N80-19404# SRI International Corp , Menlo Park, Calif
OCEAN SWELL PARAMETERS FROM NARROW-BEAM HF RADAR SEA ECHO
Belinda Lipa and Donald Barrick *In* AGARD Spec Topics in HF Propagation on Nov 1979 12 p refs Prepared in cooperation with NOAA Wave Propagation Lab , Boulder, Colo (For primary document see N80-19372 10-32)
Avail NTIS HC A25/MF A01

Inversion methods are described for studying the HF radar sea-echo Doppler spectra, giving parameters of the ocean wave spectrum in the important long wavelength region Radar spectra exhibiting very narrow spikes in the higher order structures adjacent to the first order lines are indicative of ocean swell with a single dominant wavelength, it is shown how to interpret such a radar spectrum to give swell period direction and rms waveheight When the higher-order echo peaks are more spread in frequency, a simple model for the swell yields a closed-form expression for the four second-order swell peaks parameters identifiable from this model, in addition to swell rms height, direction, and dominant period, include the angular spread and frequency spread of the swell Finally, when the swell Doppler peaks are quite spread, it is shown how to use integral inversion to give Fourier coefficients of the ocean-wave spectrum as a function of ocean wavelength At a given wavelength these coefficients are interpreted in terms of a cardioid model for the angular distribution to give the mean wave direction and the angular spread In normal surface-wave experiments, the major source of error or noise is the random surface height of the sea, the resulting statistics of the radar spectrum, are described and the propagation of uncertainty to the derived ocean parameters is traced M G

N80-19405# Colorado Univ at Boulder Cooperative Inst for Research in Environmental Sciences
PRINCIPLES OF HF COMMUNICATION IN TUNNELS USING OPEN TRANSMISSION LINES AND LEAKY CABLES
James R Wait, David A Hill, and David B Seidel *In* AGARD Spec Topics in HF Propagation Nov 1979 4 p refs (For primary document see N80-19372 10-32)
Avail NTIS HC A25/MF A01

The concept that electromagnetic waves can be guided by tunnels is covered It is shown that the frequency must be greater than some cut-off value that typically is of the order of 50 MHz When the tunnel contains axial conductors, the situation is changed dramatically, and there is no cut-off as such, although wave-guide type modes also propagate at the higher frequencies J M S

N80-19406# Universite Catholique de Louvain (Belgium) Laboratoire de Telecommunications et d'Hyperfrequences
MODE CONVERTERS FOR HF TUNNELS TRANSMISSION
P Delogne *In* AGARD Spec Topics in HF Propagation Nov 1979 14 p refs (For primary document see N80-19372 10-32)
Avail NTIS HC A25/MF A01

Leaky feeder techniques used to guide electromagnetic waves in tunnels are discussed These systems are based on the coupling of the coaxial or bifilar mode with the monofilar mode In contrast with the principle of continuous leaky feeders one can use discrete mode converters spaced along a nonleaky cable After an analysis of the general properties of mode converters, a detailed description of various types is given selective and wideband annular-slot converters for coaxial cables, leaky section, selective and wideband converters for two-wire lines M G

N80-19407# Queens Univ., Kingston (Ontario) Dept of Electrical Engineering
LEAKY COAXIAL CABLES FOR OBSTACLE DETECTION AND CONTINUOUS ACCESS GUIDED COMMUNICATIONS
N A M Mackay, J C Beal, D J Gale, and J L Mason *In* AGARD Spec Topics in HF Propagation Nov 1979 11 p refs (For primary document see N80-19372 10-32)
Avail NTIS HC A25/MF A01

Leaky coaxial cables utilized for continuous access guided communications and as a guiding medium in an obstacle detection scheme called guided radar are discussed Techniques for predicting the performance of leaky cable installations in a variety of configurations are examined A two cable resonantor test allows the coupling effectiveness of different designs to be measured in the laboratory in free space and the presence of different surrounding environments A theoretical treatment is developed based upon coupled transmission line theory This theoretical cavity is extended to simulate a full scale guided

N80-19408# California Univ Livermore Lab
DEFINITION OF SUBSURFACE FEATURES BY ELECTRICAL PROBING
R J Lytle *In* AGARD Spec Topics 1979 7 p refs (For primary

AD-A092 125 ADVISORY GROUP FOR AEROSPACE RESEARCH AND DEVELOPMENT--ETC F/G 15/7
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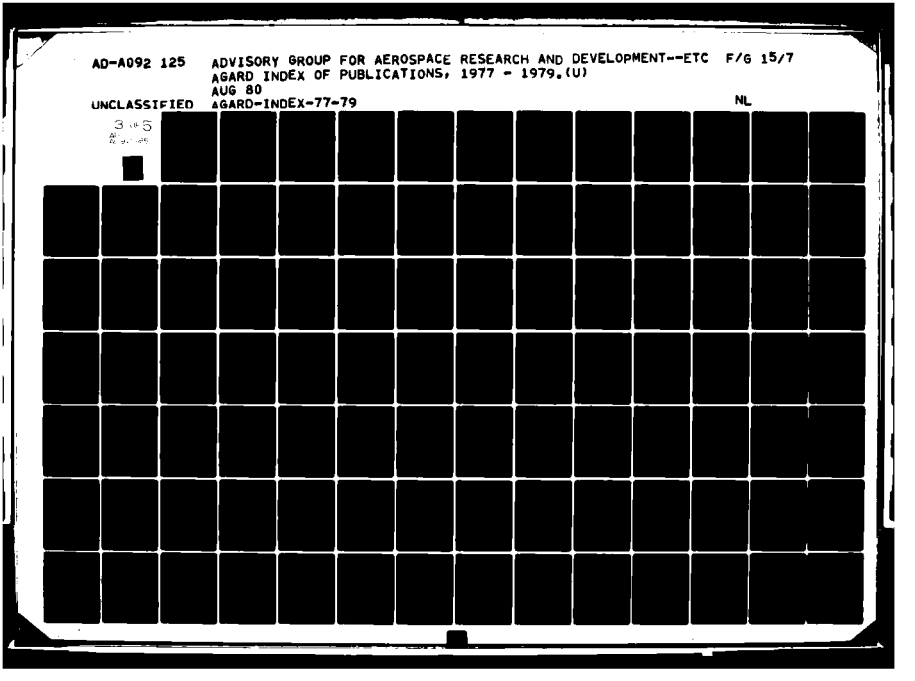

(Contract W-7405-eng-48)
Avail: NTIS HC A25/MF A01

An overview of advances in near surface geophysical probing is presented. Mathematical studies are covered as well as laboratory and controlled in-situ experiments. Developments in instrumentation, data processing, and data interpretation are included. J.M.S.

N80-19409# Lille Univ. (France). Dept. Electronique.
EXPERIMENTAL RESULTS ON THE FREE PROPAGATION OF UHF WAVES IN TUNNELS [RESULTATS EXPERIMENTAUX CONCERNANT LA PROPAGATION LIBRE DES ONDES UHF DANS LES TUNNELS]
P. Degauque, P. Mangez, B. Demoulin, and B. Gabillard *In* AGARD Spec. Topics in HF Propagation Nov. 1979 16 p refs In FRENCH (For primary document see N80-19372 10-32)
Avail: NTIS HC A25/MF A01

In mine passageways and generally in certain tunnels, it can be useful to establish radio communication over several hundred meters, if possible, with the aid of portable equipment. For this purpose radio communication in the high frequency range (400 MHz to 1 GHz) appears interesting. In fact, in this frequency band, the length of the wave is small enough in relation to the dimensions of the passage so that the dominant modes to be propagated correspond to rays which are reflected under grazing incidence. In this case, only a small amount of energy is lost by refraction on the walls. The loss obtained for different types of tunnels is presented. The case of rectilinear tunnels are considered first, and the influence of transverse geometry of the passageway and the roughness of the walls is demonstrated. Supplementary losses undergone by the wave when the tunnel contains one or more curves are also discussed.
Transl. by A.R.H.

N80-19410# Institute for Telecommunication Sciences, Boulder, Colo.
EXCITATION OF THE HF SURFACE WAVE BY VERTICAL AND HORIZONTAL APERTURES
James R. Wait and David A. Hill *In* AGARD Spec. Topics in HF Propagation Nov. 1979 11 p refs (For primary document see N80-19372 10-32)
Avail: NTIS HC A25/MF A01

An exposition of the normal mode approach to ground wave propagation is presented. This formulation is adapted to the solution of the surface wave excitation problem. The principal end result is the residue series representation for the vertical electric field over a spherical earth when excited by either a vertical or a horizontal antenna. The derivation incorporates the essential features of prior analyses without becoming embroiled in the mathematical niceties of branch cuts and intricate and tricky deformation of integration contours in the complex wave number planes. J.M.S.

N80-19411# Liege Univ. (Belgium). Inst. Physique.
EFFECTIVE USE OF NATURAL MODES IN VHF AND UHF TUNNEL PROPAGATION
L. Deryck *In* AGARD Spec. Topics in HF Propagation Nov. 1979 15 p refs (For primary document see N80-19372 10-32)
Avail: NTIS HC A25/MF A01

An experimental study of the electromagnetic wave propagation in various tunnels, at frequencies between 1 MHz and 1,000 MHz is presented. The results obtained provide a better understanding of natural propagation mechanisms in underground galleries containing no transmission line. The analysis of these results reveals the existence of a cutoff frequency and a strong correlation between the propagation characteristics and the transverse dimensions of the tunnel. Further experiments are made in tunnels where a transmission line is used as a waveguide; they show under what conditions the natural modes can be useful in this case. These modes can advantageously replace the so-called monofilar mode which is generally used for coupling between the transmission line and the mobile transceivers. Experimental checking shows that when using a well adapted transmission line, exploitation of natural propagation can greatly reduce the cost of the line installation without reducing its performance. Author

N80-19412# Institute for Telecommunication Sciences, Boulder, Colo.
COMPARISON OF LOOP AND DIPOLE ANTENNAS IN LEAKY FEEDER COMMUNICATION SYSTEMS
David A. Hill and James R. Wait *In* AGARD Spec. Topics in HF Propagation Nov. 1979 9 p refs (For primary document see N80-19372 10-32)
Avail: NTIS HC A25/MF A01

The mutual impedance between electric and/or magnetic dipoles in a circular tunnel containing a leaky coaxial cable was derived for arbitrary dipole positions. For the usual case of large dipole separation, the bifilar mode approximation was used to compute the mutual impedance and associated transmission loss. For typical cable parameters, a broad minimum in transmission loss was found in the range from 2 to 10 MHz. In this frequency range, the transmission loss was slightly less for magnetic dipoles (loops) than for electric dipoles. R.C.T.

N80-19413# Colorado Univ. at Boulder. Cooperative Inst. for Res. in Environmental Sciences.
MODE CONVERSION BY TUNNEL NON-UNIFORMITIES IN LEAKY FEEDER COMMUNICATION SYSTEMS
David B. Seidel and James R. Wait *In* AGARD Spec. Topics in HF Propagation Nov. 1979 9 p refs (For primary document see N80-19372 10-32)
Avail: NTIS HC A25/MF A01

Using an idealized theoretical model, the inadvertent mode conversion between the bifilar and monofilar modes in a tunnel that contains a braided coaxial was investigated. The tunnel was allowed to have various kinds of lateral nonuniformities such as changes of wall conductivity and permittivity. Results indicate that such effects are very important in understanding leaky feeder systems. R.C.T.

N80-19414# James Cook Univ. of North Queensland, Townsville (Australia). Physics Dept.
A MOBILE HF IMPULSE SOURCE LOCATOR
M. L. Heron *In* AGARD Spec. Topics in HF Propagation Nov. 1979 9 p refs (For primary document see N80-19372 10-32)
Avail: NTIS HC A25/MF A01

A noise pulse locator designed to meet the needs of research into the structure of tropical cyclone (hurricane) systems but which may be easily adapted to storm location and tracking applications is described. The principle and instrumentation of the noise pulse locator are discussed. The resolution, errors, and limitation of the equipment as deployed on an Orion aircraft are estimated and the areas of application and adaption of the instrument are noted. R.C.T.

N80-19415# Technology for Communications International, Mountain View, Calif.
A NEW COMPUTER-CONTROLLED HIGH FREQUENCY DIRECTION-FINDING AND TRANSMITTER LOCATING SYSTEM
R. L. Tanner *In* AGARD Spec. Topics in HF Propagation Nov. 1979 13 p refs (For primary document see N80-19372 10-32)
Avail: NTIS HC A25/MF A01

A direction finding and transmitter locating system is described. The following capabilities are evaluated: the ability to operate against very short duration signals with high accuracy; the ability against short range, high angle sky wave signals; single station locator capability; critical siting requirements, adaptability to automatic netting of a multistation system; and requirements for trained technical personnel. R.C.T.

N80-19416# Lowell Univ., Mass. Center for Atmospheric Research.
DIGITAL ON-LINE PROCESSING AND DISPLAY OF MULTIPARAMETER HF TRANSMISSION DATA
K. Bibl and B. W. Reinisch *In* AGARD Spec. Topics in HF Propagation Nov. 1979 9 p refs (For primary document see N80-19372 10-32)
Avail: NTIS HC A25/MF A01

Amplitude, phase, angle of arrival, polarization, frequency shift and signal travel time of a radio wave are simultaneously measured as functions of time and frequency in a new digital ionosonde, the Digisonde 128PS. For the study of the structure and motions of the ionosphere and its influence on Over-the Horizon detection systems, on sea-state measurements, on direction and location finding methods and on communication systems a selection of the measurable parameters is recorded and displayed in real time with the necessary resolution. Two main modes of operation are described, the ionogram mode using a Maximum Amplitude scheme for data compression and the Doppler-Drift Mode using preselected frequencies and range bins of data compression. Author

N80-19417# Communications Research Centre, Ottawa (Ontario). Dept. of Communications.

NEW TECHNOLOGY TO IMPROVE HF CIRCUIT RELIABILITY AND AVAILABILITY FOR REMOTE REGIONS
J. S. Belrose and L. R. Bode *In* AGARD Spec. Topics in HF Propagation Nov. 1979 11 p refs (For primary document see N80-19372 10-32)
Avail: NTIS HC A25/MF A01

The research and development underway at the Communications Center, Ottawa, is described along with that in Canadian Industry. Topics discussed include: (1) trail-remote camp radio communications, (2) antennas for base station and trail use, (3) HF-SSB Transceiver, and (4) SSB tone decoder. F.O.S.

N80-19418# *Surrey Univ., Guildford (England).*
ELECTRICALLY SHORT HF AERIAL SYSTEMS
M. N. Sweeting and Q. V. Davis *In* AGARD Spec. Topics in HF Propagation Nov. 1979 21 p refs (For primary document see N80-19372 10-32)
Avail: NTIS HC A25/MF A01

The communications efficiency of electrically short HF aerials in a tactical field environment remains unacceptably poor. Some of results from a detailed, practical study of the problem, performed at full-scale are described and the effect on the aerial performance of several factors shown by the experiments to be important but not previously sufficiently recognized are discussed. F.O.S.

N80-19419# *Rohde and Schwartz, Munich (West Germany).*
RADIO-LINK COMPUTATIONS OPTIMIZE PATTERN SHARING OF SHORTWAVE ANTENNAS
A. Stark *In* AGARD Spec. Topics in HF Propagation Nov. 1979 17 p refs (For primary document see N80-19372 10-32)
Avail: NTIS HC A25/MF A01

Statistical data were obtained from forecast printouts to produce frequency-dependent, optimized values for the elevation angles of the radiation maximum and for the vertical beamwidths. R.C.T.

X80-72172# Advisory Group for Aerospace Research and Development, Paris (France).
TECHNIQUES FOR SUPPRESSION OF RADARS ASSOCIATED WITH SAMs, EXECUTIVE SUMMARY, VOLUME 1 (U)
Jan. 1977 60 p This document is not available from the NASA STI Facility. All requests must be directed to AGARD Hq.
(AGARD-AR-91-Vol-1, AASC-Study-7) NATO Secret report

Various techniques expected to be available in the 1980's for the suppression of radars associated with surface to air missiles are examined for the purpose of reducing the vulnerability of NATO aircraft to SAMs. Two basic means of suppression are emphasized namely by destruction or by neutralization. Neutralization covers the aspects of surveillance, target tracking, missile tracking, missile guidance, fuse, and availability status. In the area of destruction, weapon guidance systems are evaluated with attack variables such a range, warhead weight, and type of attack. A survey is included on future enemy SAMs and electronic intelligence. A model for performing tradeoff comparisons between the two means of suppression is described. J.M.S.

X80-72173# Advisory Group for Aerospace Research and Development, Paris (France).
ARTIFICIAL MODIFICATION OF PROPAGATION MEDIA (U)
H. J. Albrecht, ed. Jun. 1977 16 p Meeting held at Brussels, 26-29 Apr. 1976 This document is not available from the NASA STI Facility. All requests must be directed to AGARD Hq.
(AGARD-CP-192-Suppl) NATO Restricted report

Limiting propagation criteria, optimum methods of modification, and efficiency of changing propagation media as a function of means employed are addressed. The anthropogeneous changes to the Earth's atmosphere as a propagation medium are examined in three topic areas: modification of nonionized media; of ionized media by e.m. waves; and of ionized media by chemical substances. In addition to the recognition of the state-of-the-art and the predominant directions of progress, the stimulation of propagation-oriented modification projects is considered. J.M.S

X80-72174# Advisory Group for Aerospace Research and Development, Paris (France).
TECHNIQUES FOR SUPPRESSION OF RADARS ASSOCIATED WITH SAMs, MAIN REPORT AND APPENDICES, VOLUME 2 (U)
Jul. 1978 214 p This document is not available from the NASA STI Facility. All requests must be directed to AGARD Hq.
(AGARD-AR-91-Vol-2) NATO Secret report

Various techniques expected to be available in the 1980's for the suppression of radars associated with surface to air missiles with the purpose of reducing the vulnerability of NATO aircraft to SAMs are presented. The two basic means of suppression, namely by destruction or by neutralization are considered. M.M.S.

X80-72175# Advisory Group for Aerospace Research and Development, Paris (France).
COMMUNICATIONS WITH LOW FLYING AIRCRAFT BEYOND THE HORIZON (U)
Jul. 1978 34 p This document is not available from the NASA STI Facility. All requests must be directed to AGARD Hq.
(AGARD-AR-117) NATO Confidential report

Techniques are identified and studied which would give some capability of communications between a ground station and an aircraft flying at low altitudes beyond line of sight. The techniques identified include: classical HF skywave communications, use of satellite communications operating at UHF; use of manned aircraft as a relay aircraft; using RPVs as relays, and meteor burst communications. A.W.H.

X80-72176# Advisory Group for Aerospace Research and Development, Paris (France)
COMMUNICATIONS DEVICES SUPPORTING AIR WARFARE WITH REDUCED SUSCEPTIBILITY TO JAMMING, INTERCEPT, AND LOCATION DETERMINATION, EXECUTIVE SUMMARY, VOLUME 1 (U)
Aug. 1979 64 p This document is not available from the NASA STI Facility. All requests must be directed to AGARD Hq.
(AGARD-AR-120-Vol-1) NATO Secret report

The susceptibility of most communications systems supporting aerospace operation to jamming, intercept, and direction finding is discussed. Various countermeasures available to reduce the susceptibility of the communication systems during combat operations are examined. The following topics are considered: communication requirements supporting air warfare activities, equipment and systems description; electronic warfare considerations, parametric identification of system susceptibility to intercept, local determination, and jamming, system concept analysis; and parametric estimate of trend and cost effectiveness. A.W.H.

X80-72177# Advisory Group for Aerospace Research and Development, Paris (France)
SUPPRESSION OF DETECTION AND GUIDANCE SYSTEMS, OTHER THAN RADAR, ASSOCIATED WITH SAMs AND GUIDED BOMBS, EXECUTIVE SUMMARY, VOLUME 1 (U)
Aug. 1979 46 p This document is not available from the NASA STI Facility. All requests must be directed to AGARD Hq.
(AGARD-AR-121-Vol-1) NATO Secret report

The application of countermeasures to EO/IR guidance systems used in threats posed by Surface to Air Missiles (SAMs) Air to Surface Missiles (ASMs) and guided bombs was considered. A survey was made of such basic considerations as equipment usage, technology descriptions, atmospheric physics and human capabilities. Official estimates of the current and future threat were augmented with additional technically feasible threat possibilities. Possible means of countermeasures (CM) e.g. shielding, obscuration, camouflage, passive and active decoys, jamming, were reviewed and countermeasure applicability and implementation matrices were prepared relating the SAM and ASM/guided bomb threats to the physical possibilities of the different means of CM and to possible CM hardware implementation. In order to demonstrate the dependence of CM effectiveness upon the mission and target type, seven exemplary scenarios were considered for SAM and ASM operations and value judgements on CMs were made for each scenario. Specific recommendations in research and development related to the various phases of the study are given. R.C.T.

34 FLUID MECHANICS AND HEAT TRANSFER

Includes boundary layers; hydrodynamics; fluidics; mass transfer; and ablation cooling

For related information see also *02 Aerodynamics* and *77 Thermodynamics and Statistical Physics.*

N77-22442# Advisory Group for Aerospace Research and Development, Paris (France).
COMPUTATIONAL FLUID DYNAMICS
Apr 1977 170 p refs
(AGARD-LS-86) Avail NTIS HC A08/MF A01

Fluid dynamic research is reviewed, including finite element methods for fluid flow calculations and for solving partial differential equations. Numerical treatment of turbulence modelling and Navier-Stokes equations are also considered, along with relaxation methods for time dependent conservation equations. For individual titles, see N77-22443 through N77-22448.

N77-22443# Maryland Univ Baltimore County, Baltimore. Dept. of Mathematics
THE FOUNDATION AND DEVELOPMENT OF THE FINITE ELEMENT METHOD TO SOLVE PARTIAL DIFFERENTIAL EQUATIONS OF FLUID MECHANICS
A. K. Aziz and S. Leventhal (Naval Surface Weapons Center, White Oak, Md.) *In* AGARD Computational Fluid Dyn. Apr. 1977 25 p refs (For primary document see N77-22442 13-34)
Avail NTIS HC A08/MF A01

The mathematical theory is given beginning with the variational formulation of a problem. The three basic steps in the finite element method are discussed: (1) the subdivision of the domain, (2) the definition of the elements to approximate the unknown functions, and, (3) the forming of the algebraic system for the unknown coefficients. Application of the finite element method to two problems in fluid mechanics is also given. The first of these problems is boundary layer flow, and the other is transonic flow. Author

N77-22444# Naval Ship Research and Development Center, Bethesda, Md. Numerical Mechanics Div.
RECENT ADVANCES IN THE NUMERICAL TREATMENT OF THE NAVIER-STOKES EQUATIONS
Hans J. Lugt *In* AGARD Computational Fluid Dyn. Apr. 1977 17 p refs (For primary document see N77-22442 13-34)
Avail NTIS HC A08/MF A01

Some recent developments in finite difference methods for the solution of the Navier-Stokes equations are discussed. Emphasis is placed on the computational difficulties encountered at and near bounding surfaces and in situations of high body acceleration. Physical and numerical aspects of initial and boundary conditions are considered, along with their influence on the solutions. Slip and nonslip boundary conditions, their occurrence in reality, their significance in flow modeling, and their effect on the generation and decay of vortices and vorticity are discussed. Recent studies of higher order approximations and the treatment of boundaries of arbitrary shape by body-fitted coordinate systems are pointed out. The interpretation of time dependent viscous flows in various reference frames is difficult and necessitates the careful analysis of velocity and vorticity fields. This is demonstrated for flow separation vortices, and rotating bodies. Author

N77-22445*# National Aeronautics and Space Administration Ames Research Center, Moffett Field, Calif.
NUMERICAL TURBULENCE MODELING
Morris W. Rubesin *In* AGARD Computational Fluid Dyn. Apr. 1977 37 p refs (For primary document see N77-22442 13-34)
Avail NTIS HC A08/MF A01

The underlying bases and developments in two techniques of detailed turbulence modeling are described where the flow is treated in the Eulerian sense, and one technique where the Lagrangian motions of vortices are followed. First a technique is described for solving the single-point statistically averaged conservation equations. The Reynolds stresses that appear in these equations are evaluated by solving supplemental differential equations which contain terms that are modeled. A sequence of increasingly complex, but also increasingly general, modeling equations is described and computations based on these equations are compared with experimental data. The hierarchy of models described terminates with equations for the individual components of the Reynolds stress tensor. The second Eulerian technique approach to turbulence modeling is the direct numerical simulation of turbulent fields. In this approach, all three dimensional eddies between a predetermined range of sizes are computed in time within a specified volume of flow. Present day computers require a tradeoff between the size of the volume that can be considered and the degree of resolution of the turbulent eddies. Techniques of modeling the smallest eddies are described that permit enlarging the volume, or Reynolds number, that can be considered. Author

N77-22446# Von Karman Inst. for Fluid Dynamics, Rhode-Saint-Genese (Belgium)
RELAXATION METHODS FOR TIME DEPENDENT CONSERVATION EQUATIONS IN FLUID MECHANICS
H. J. Wirz *In* AGARD Computational Fluid Dyn. Apr. 1977 49 p refs (For primary document see N77-22442 13-34)
Avail NTIS HC A08/MF A01

Iterative methods in general are characterized. The successive application of a method led to a state, which is invariant with respect to further iterations (convergence); this invariant state (which will be identified with the steady state for our purpose) was independent of the choice of the initial guess (unicity). Since only a limited amount of iteration steps were carried out, the question of accuracy of the solution (error estimation) was considered. This problem was independent of the reliability of the discrete model being used to represent the continuous conservation equation. It is desirable and crucial for the success of the application of an iterative method, that the process converges as fast as possible to the invariant state (rate of convergence) using a minimum amount of operations per iteration step. Author

N77-22447# Bristol Univ. (England). Dept. of Engineering Mathematics.
FLOW REPRESENTATION, INCLUDING SEPARATED REGIONS, USING DISCRETE VORTICES
R. R. Clements *In* AGARD Computational Fluid Dyn. Apr. 1977 20 p refs (For primary document see N77-22442 13-34)
Avail NTIS HC A08/MF A01

The kinematic properties of fluid motion were utilized to determine the motion of the line vortices and the evolution of the flow field is inferred from this motion. Two dimensional, axisymmetric and fully three dimensional flows were treated by such methods, the complexity and duration of the computations increasing. One of the interesting aspects of the method is the various means which its users have developed for the incorporation of solid boundaries into the flow field. Two dimensional complex potential flow theory and the surface source/sink method have both been used in a variety of contexts. Many computations have involved imbedded solid objects of a nature such that the vorticity creating boundary layers separate from the object to create separated shear layers in the flow, and it is to the treatment of these separated layers that the method is applied. The various models of the connection between the shear layers and the discrete vortices form another most interesting aspect of the subject. Author

N77-22448# Paris V Univ. (France)
SOME FINITE ELEMENT METHODS IN FLUID FLOW
R. Temam *In* AGARD Computational Fluid Dyn. Apr. 1977 15 p refs (For primary document see N77-22442 13-34)
Avail NTIS HC A08/MF A01

Some finite element methods are described which were recently introduced for the computation of viscous and inviscid incompressible flows. Some finite element methods of the displacement type are discussed which apply to viscous flows, with emphasize on a linear nonconforming finite element. The principle of the weak (or variational) formulation for the Stokes and Navier Stokes equations and their Galerkin finite element discretization are considered. Author

N77-33478# Advisory Group for Aerospace Research and Development, Paris (France).
PHYSICAL VULNERABILITY OF AIRCRAFT DUE TO FLUID DYNAMIC EFFECTS
D. B. Anthony (Naval Weapons Center, China Lake, Calif.) Jul. 1977 80 p refs
(AGARD-AR-106) Avail NTIS HC A05/MF A01

The problem of predicting the structural response to external blast was summarized. Important details of a spherical charge

in free air as it interacts with rigid surfaces were studied. The use of impulse momentum for calculating structural response and the approximation of a uniformly distributed impulse on the surface in question are approximations and are experimentally justified. Author

N78-14316# Advisory Group for Aerospace Research and Development, Paris (France).
LAMINAR-TURBULENT TRANSITION
Oct. 1977 380 p refs In ENGLISH and FRENCH Presented at the Fluid Dyn. Panel Symp., Lyngby, Denmark, 2-4 May 1977
(AGARD-CP-224; ISBN-92-835-0204-3) Avail: NTIS HC A17/MF A01

Stability theory and prediction methods applied to fluid dynamic processes in laminar-transitional flows are presented. For individual titles, see N78-14317 through N78-14344.

N78-14317*# Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
TRANSITION PREDICTION AND LINEAR STABILITY THEORY
Leslie M. Mack *In* AGARD Laminar-Turbulent Transition Oct. 1977 22 p refs (For availability see N78-14316 05-34)
(Contract NAS7-100)
Avail: NTIS HC A17/MF A01 CSCL 20D

Linear stability theory is used in computing the amplitude ratio for other than two-dimensional instability waves. The wave motion is obtained from the ray equations of kinematic wave theory, and the amplitude ratio by simply integrating the spatial amplification rate of the parallel flow theory along a ray. Both the temporal and spatial theories are examined for two- and three-dimensional incompressible and two-dimensional compressible boundary layers. The dispersion relation is most directly obtained with the temporal theory, but the magnitude and direction of the group velocity have to be computed to give the spatial amplification rate, and then only approximately. The spatial theory gives the spatial amplification rate directly, but only after the direction of the group velocity is known. Transition prediction methods, divided into amplitude-density and amplitude methods, are discussed. Author

N78-14318# National Maritime Inst., Teddington, (England).
SERIES REPRESENTATION OF THE EIGENVALUES OF THE ORR-SOMMERFELD EQUATION
M. Gaster *In* AGARD Laminar-Turbulent Transition Oct. 1977 12 p refs (For availability see N78-14316 05-34)
Avail: NTIS HC A17/MF A01

A series representation of the relation that links the eigenvalues of the Orr-Sommerfeld equation is developed. This enables the complex frequency parameter to be expressed as a double series in terms of the Reynolds number and wave number, both of which are treated as complex variables. The complex coefficients arising in this series are determined by contour integration for the case of the Blasius boundary layer profiles. A non-linear transformation is applied to the partial summations formed from the series in order to improve the convergence, and so to enable predictions of high accuracy to be made from only a few terms. Eigenvalues calculated by this technique are compared with those obtained directly from the Orr-Sommerfeld equation. The power of the technique is demonstrated by various graphical displays of the amplification contours for both temporal and spatial modes. Author

N78-14319# Stuttgart Univ. (West Germany) Inst. Fuer Aerodynamik und Gasdynamik.
FINITE AMPLITUDE STABILITY OF PLANE PARALLEL FLOWS
Thorwald Herbert *In* AGARD Laminar-Turbulent Transition Oct 1977 10 p refs (For availability see N78-14316 05-34)
Avail NTIS HC A17/MF A01

The equilibrium states of periodic finite amplitude motions in a plane channel are studied by a perturbation method for calculating the Landau constants, and by direct iterative solution of the differential equations resulting from Fourier decomposition of the secondary flow. According to a comparison of numerical results, the neglect of higher order terms in the amplitude restricts the use of the Landau method to almost neutral disturbances. The results of the iterative method indicate moderate convergence of the Fourier series. In all approximations, however, the equilibrium states form a connected neutral surface with a non-linear Reynolds number of about half the value obtained from the linearized theory. Some aspects of the secondary instability with respect to three-dimensional disturbances are discussed as well as the application of the iterative method to the combined Poiseuille-Couette flow and plane Couette flow. Author

N78-14320# Aerospace Corp., Los Angeles, Calif.
NUMERICAL INVESTIGATION OF NONLINEAR WAVE INTERACTION IN A TWO-DIMENSIONAL BOUNDARY LAYER
John W. Murdock and Thomas D. Taylor *In* AGARD Laminar-Turbulent Transition Oct. 1977 8 p refs Sponsored in part by ONR (For availability see N78-14316 05-34)
(Contract F04701-76-C-0077)
Avail: NTIS HC A17/MF A01

A spectral method is used to solve the unsteady, two-dimensional flow over a flat plate in the Reynolds number range of transition. The physical problem considered is the propagation of large amplitude (nonlinear) Tollmien-Schlichting waves in a boundary layer. The solutions are generally in qualitative agreement with nonlinear stability theories in that: (1) nonlinear effects can be destabilizing; (2) the growth/decay behavior of the primary mode is changed only slightly by nonlinear effects, and (3) the second temporal harmonic is usually a second spatial harmonic. There are, however, regions in the flow in which both (1) and (3) are not true. Details of the solution in such a region are given to illustrate the complex nonlinear wave interactions possible in a boundary layer. Author

N78-14321# Leeds Univ. (England). Dept. of Applied Mathematical Studies.
NONLINEAR INSTABILITY OF FREE SHEAR LAYERS
P. Huerre *In* AGARD Laminar-Turbulent Transition Oct. 1977 12 p refs In ENGLISH; FRENCH summary (For availability see N78-14316 05-34)
Avail: NTIS HC A17/MF A01

Nonlinear stability characteristics of a two dimensional free shear layer are determined for temporally growing waves of small amplification rate. The amplitude equation governing the growth of the disturbances is derived by making use of the method of multiple scales. It is then found that the finite amplitude response strongly depends on the nature of the flow in the critical layer. For low initial fluctuation levels, the critical layer is known to be viscous and nonlinear, and the wave amplitude ultimately reaches a saturation value, as described by the Stuart-Watson equation. For higher fluctuation levels however, the critical layer is purely nonlinear and the instability waves are amplitude modulated so that no equilibrium value is ever reached. The initial amplification rate and mode shape are found to be very sensitive to the magnitude of the initial disturbance. Author

N78-14322*# Virginia Polytechnic Inst. and State Univ., Blacksburg. Dept. of Engineering Science and Mechanics.
NONPARALLEL STABILITY OF BOUNDARY LAYERS WITH PRESSURE GRADIENTS AND SUCTION
William S. Saric and Ali Hasan Nayfeh *In* AGARD Laminar-Turbulent Transition Oct. 1977 21 p refs In ENGLISH; FRENCH summary (For availability see N78-14316 05-34)
(Grant NsG-1255)
Avail: NTIS HC A17/MF A01 CSCL 20D

An analysis is presented for the linear nonparallel stability of boundary layer flows with pressure gradients and suction. The effect of the boundary layer growth is included by using the method of multiple scales. The present analysis is compared with those of Bouthier and Gaster and the roles of the different definitions of the amplification rates are discussed. The results of these theories are compared with experimental data for the Blasius boundary layer. Calculations are presented for stability characteristics of boundary layers with pressure gradients and nonsimilar suction distributions. Author

N78-14323# California State Univ., Long Beach. Dept. of Mechanical Engineering.
STABILITY CALCULATIONS FOR A ROTATING DISK
Tuncer Cebeci and Herbert B. Keller (Calif. Inst. of Technol., Pasadena) *In* AGARD Laminar-Turbulent Transition Oct. 1977 9 p refs (For availability see N78-14316 05-34)
(Contract N00014-76-C-0927)
Avail: NTIS HC A17/MF A01

Solutions are obtained for the governing layer and stability equations for a rotating disk by using an efficient numerical method. The stability calculations utilize Stuart's J-profiles in the solution of the Orr-Sommerfeld equation and provide good agreement with Brown's numerical predictions of neutral stability

curve. Preliminary calculations when applied to determine the number or vortices on a rotating disk agree reasonably well with experimental data and clearly demonstrate the expected improvements due to the inclusion of viscosity. Author

N78-14324# Southampton Univ. (England). Dept. of Aeronautics and Astronautics.

THE STABILITY OF AXIAL FLOW BETWEEN CONCENTRIC CYLINDERS TO ASYMMETRIC DISTURBANCES

R. Mahadevan and G. M. Lilley. *In* AGARD Laminar-Turbulent Transition Oct. 1977 10 p refs (For availability see N78-14316 05-34)

Avail: NTIS HC A17/MF A01

The linear hydrodynamic stability for the axial flow between concentric circular cylinders has been investigated for both axisymmetric and asymmetric disturbances superposed on the mean flow. A step-by-step integration procedure has been chosen to solve the linearized disturbance equations. The neutral stability curves in the vicinity of minimum critical Reynolds number are obtained for various radius ratios and for azimuthal wave numbers from 0 to 4. The results show that the axisymmetric mode does not give the lowest critical Reynolds number for all radius ratios and also indicates the importance of the first azimuthal mode ($n = 1$) for small radius ratios. Author

N78-14325# Case Western Reserve Univ., Cleveland, Ohio.

STABILITY OF HEATED LAMINAR BOUNDARY LAYERS IN WATER

A. J. Strazisar and E. Reshotko. *In* AGARD Laminar-Turbulent Transition Oct. 1977 9 p refs Sponsored in part by ONR (For availability see N78-14316 05-34)

Avail: NTIS HC A17/MF A01

The stability of heated laminar boundary layers on a flat plate has been studied in a low turbulence water tunnel. The disturbances were introduced by a vibrating ribbon and measurements of the response were made using temperature compensated hot-film anemometry. Neutral stability and spatial growth characteristics measured for uniform wall temperatures up to 8 F above the free stream temperature show agreement with theoretically predicted trends. Disturbance growth rates and the band of amplified disturbance frequencies both decreased as wall heating was increased. Disturbance growth rates for step changes in wall temperature are minimal when the step is located approximately at the minimum critical point of the unheated plate. Author

N78-14326# Princeton Univ., N. J. Dept. of Aerospace and Mechanical Sciences.

INSTABILITY AND TRANSITION IN AXISYMMETRIC WAKES

F. R. Hama, L. F. Peterson, S. C. DelaVeaux, and D. R. Williams. *In* AGARD Laminar-Turbulent Transition [date] 8 p refs Sponsored in part by NSF (For availability see N78-14316 05-34)

Avail: NTIS HC A17/MF A01

Axisymmetric wakes created by bodies of revolution of a varity of bluntness, at a fixed body-diameter Reynolds number of 3600, are studied. The first wake producing body is a streamlined model with a sharp trailing tip of NACA 0006 cross-sectional shape, on which no separation takes place, and the second is a prolate spheroid with an enclosed recirculation region, which nevertheless does not break away. The experiment is performed in a running water channel, the hot-film anemometry being the principal technique. In both cases the basic oscillation at the beginning of the wake is that of 1 Hz component. In the wake of the streamlined body, this component acquires a reasonable helical mode as the stability theory considers, and an ensuing 2 Hz component is amplified quickly and dominates the instability and final breakdown. Behind the blunt prolate spheroid, on the contrary, the 1 Hz component dominates. In both cases, the dominating mode of oscillation, i.e., the 2 Hz component in the former and the 1 Hz in the latter, is identified to be a heavily squashed helical mode, which may be regarded as merely a side-to-side oscillation, and appears to play a decisive role in the breakdown. Author

N78-14327# Stuttgart Univ. (West Germany). Inst. fuer Aerodynamik und Gasdynamik.

THE INCOMPRESSIBLE FLUID MOTION DOWNSTREAM OF TWO-DIMENSIONAL TOLLMIEN SCHLICHTING WAVES

Franz Xaver Wortmann. *In* AGARD Laminar-Turbulent Transition Oct. 1977 8 p refs (For availability see N78-14316 05-34)

Avail: NTIS HC A17/MF A01

Detailed flow field measurements were made of the natural deformation of two-dimensional Tollein waves in a water tunnel. The waves were stimulated by a vibrating ribbon and amplified to ten to thirteen wave lengths. The spanwise position of the breakdown was not fixed by any roughness in the test section. The results indicate for the incipient transition a three dimensional structure composed by the basic flow and longitudinal counterrotating sheets of vorticity which are inclined downstream and overlap each other like roof shingles. Author

N78-14328# Centre d'Etudes et de Recherches, Toulouse (France)

EXPERIMENTAL ANALYSIS AND CALCULATION OF THE ONSET AND DEVELOPMENT OF THE BOUNDARY LAYER TRANSITION

Daniel Arnal, Jean-Claude Juillen, and Roger Michel. *In* AGARD Laminar-Turbulent Transition Oct. 1977 18 p refs In FRENCH; ENGLISH summary (For availability see N78-14316 05-34)

Avail: NTIS HC A17/MF A01

Transition of an incompressible boundary layer, with zero pressure gradient and low free-stream turbulence, is studied. Mean velocity, turbulence and Reynolds shear stress profiles are presented. The development of the wave is clearly shown until the turbulent spots appear. The intermittency phenomenon is studied by conditional sampling of the hot-wire signal. The comparison with calculation results obtained by resolution of a set of transport equations shows a good agreement for the mean characteristics of the flow; discrepancies observed for the turbulent quantities evolution are due to the intermittency phenomenon. Author

N78-14329# Stuttgart Univ. (West Germany). Inst. A fuer Mechanik.

NUMERICAL SIMULATION STUDIES OF TRANSITION PHENOMENA IN INCOMPRESSIBLE, TWO-DIMENSIONAL FLOWS

H. Fasel, H. Bestek, and R. Schefenacker. *In* AGARD Laminar-Turbulent Transition Oct. 1977 8 p refs (For availability see N78-14316 05-34)

Avail: NTIS HC A17/MF A01

Preliminary results of stability and transition studies are discussed which were obtained by employing an implicit finite difference method for the solution of the complete Navier-Stokes equation. The reaction of a flat plate boundary to periodic disturbances of finite amplitude is studied in order to gain insight into the nonlinear, two dimensional development of the transition process. In another effort the numerical model is applied to the investigation of stability and transition in plane Poiseuille flow with special consideration of nonlinear, spacewise disturbance amplification. The effects of a single roughness element (backward-facing step) on stability and transition in a boundary layer flow are also considered. Author

N78-14330# Aix-Marseilles Univ. (France). Inst. de Mecanique Statistique de la Turbulence.

SOME MEASUREMENTS IN THE TRANSITIONAL SUPERSONIC WAKE OF A TRANSVERSE CIRCULAR CYLINDER WITH EMPHASIS ON THE EFFECT OF EXTERNAL NOISE

H. Bumage and J. Gaviglio. *In* AGARD Laminar-Turbulent Transition Oct. 1977 11 p refs In ENGLISH; FRENCH summary (For availability see N78-14316 05-34)

Avail: NTIS HC A17/MF A01

The transition of the wake of a circular cylindar at M = 2.3 has been investigated in a low turbulence wind tunnel in which the stagnation pressure can be varied. The influence of the noise radiated by the nozzle walls boundary layers has been observed, and two possible mechanisms of interaction between the wake and the sound field are proposed. One is a fluttering motion on the viscous laminar wake due to a random motion of the stagnation and separation lines of the cylinder, the other is a direct interaction between the sound field and the verticity and entropy gradients in the laminar wake which has been shown to generate vorticity fluctuations. Methods, based on the interpretation of the hot wire anemometer signal, are proposed and justified to locate the statistical mean position of an initial, intermediate and final stage of transition, for a given Reynolds number. Author

N78-14331# University of Southern Calif., Los Angeles. Dept. of Aerospace Engineering.

THE COUPLING BETWEEN FREESTREAM DISTURBANCES, DRIVER OSCILLATIONS, FORCED OSCILLATIONS, AND STABILITY WAVES IN A SPATIAL ANALYSIS OF A BOUNDARY LAYER

Harold L. Rogler *In* AGARD Laminar-Turbulence Transition Oct. 1977 15 p (For availability see N78-14316 05-34) (Grants AF-AFOSR-3094-76; AF-AFOSR-2577-74)
Avail: NTIS HC A17/MF A01

Freestream disturbances are represented by arrays of rectangular vortices, oscillating sheets of vorticity, and irrotational fluctuations which propagate along with various speeds and wavenumbers. These disturbances interact inviscidly with a boundary layer which is represented by two layers of uniform vorticity and which has the same derivative of the mean velocity at the wall, the same displacement thickness, and the same momentum thickness as a Blasius layer. This layer begins at the leading edge and extends downstream with uniform thickness; upstream of the leading edge, the mean flow is uniform. Vorticity fluctuations convecting into the layer have their wavenumber increased, phase speed decreased, position above the wall increased, and frequency unchanged. Additional fluctuations then arise because the vorticity of the boundary layer is rearranged by the unsteady convection. Three fluctuations are found inside the boundary layer: (1) the driver oscillations which are the freestream disturbances modified by the shearing flow and/or the wall; (2) the forced oscillations with the same wavenumbers and phase speeds as the driver; and (3) the natural oscillations or eigenmodes with wavenumbers and phase speeds generally different from, but frequency the same as, the driver. Author

N78-14332# Centre d'Etudes et de Recherches, Toulouse (France).
TRANSITION OF A BOUNDARY LAYER SUBJECTED TO AN OSCILLATION OF THE EXTERNAL FLOW
Jean Cousteix, Robert Houdeville, and Ardre Desopper *In* AGARD Laminar-Turbulent Transition Oct. 1977 12 p refs In FRENCH, ENGLISH summary (For availability see N78-14316 05-34)
Avail: NTIS HC A17/MF A01

Laminar-turbulent transition of an oscillating boundary layer at 37 Hz is studied. The successive stages of the transition are experimentally studied by measurements of turbulent kinetic energy and of turbulent shear stress. Control of the intermittency phenomenon by the frequency of the external flow was observed. Onset and development of waves disturbing the laminar regime were followed by the formation of turbulent patches which are first localized and which occupy the whole cycle further downstream. Author

N78-14333# Laboratoire d'Aerothermique du C.N.R.S., Meudon (France).
THE INFLUENCE OF A PERIODIC WALL DEFORMATION ON THE DEVELOPMENT OF NATURAL INSTABILITIES LEADING TO A TRANSITION [INFLUENCE D'UNE DEFORMATION PERIODIQUE DE PAROI SUR LE DEVELOPMENT DES INSTABILITES NATURELLES CONDUISANT A LA TRANSITION]
Pierre Gougat and Francoise Martin *In* AGARD Laminar-Turbulent Transition Oct. 1977 9 p refs In FRENCH (For availability see N78-14316 05-34)
Avail: NTIS HC A17/MF A01

The natural instabilities which occur in the laminar boundary layer of a deformable wall are constituted by a series of intermittent waves. A spectral analysis of these fluctuations reveals the frequencies and coefficients of amplifications of natural instabilities are identical to those predicted by the stability theory. A deformation of the wall does not change the structure of the phenomena, it merely introduces a degree of exterior velocity which provokes an amplification or attenuation of the instabilities. The effect of a static deformation of the wall on the formation and amplification of boundary layer instabilities was studied in relation to the gradient of exterior speed. Transl. by A.R.H.

N78-14334# California Univ., Los Angeles
THE EFFECT OF WALL HEATING UPON TRANSITION IN WATER BOUNDARY LAYERS
Steven J. Barker and Carl Jennings (Autonetics, Anaheim, Calif.) *In* AGARD Laminar-Turbulent Transition Oct. 1977 9 p refs Sponsored in part by DARPA. Prepared in cooperation with Poseidon Research, Los Angeles, Calif. (For availability see N78-14316 05-34)
Avail: NTIS HC A17/MF A01

The stabilization of water boundary layers by wall heating is considered. Linear stability theory coupled with the e to the ninth transition criterion has predicted transition Reynolds numbers of greater than 200 million for a flat plate boundary layer over a heated wall. The boundary layer develops on the inside of a cylindrical tube 10.2 cm in diameter and 6.1 m in length. Heat is applied to the tube by electrical heaters on the outside wall. The location of transition is determined by local heat flux measurements or by a hot film anemometer at the downstream end of the tube. With no wall heat, a transition Reynolds number of 10 million was obtained in the tube boundary layer. As heat is added to the wall, the experimental results agree well with the theory up to a 10 F overheat. At higher overheats the measured transition Reynolds numbers are well below the predictions. The highest transition Reynolds number obtained was 42 million at an overheat of 35 F. Author

N78-14335# Technische Hogeschool, Delft (Netherlands). Dept. of Aerospace Engineering
TRANSITION, PRESSURE GRADIENT, SUCTION, SEPARATION AND STABILITY THEORY
J. L. Vaningen *In* AGARD Laminar-Turbulent Transition Oct. 1977 15 p refs (For availability see N78-14316 05-34)
Avail: NTIS HC A17/MF A01.

A semi-empirical method is presented for the prediction of transition in two-dimensional incompressible flows with pressure gradient and suction. Included is the case of the laminar separation bubble where transition is preceded by laminar separation. The method employs linear stability theory to calculate the amplification factor sigma for unstable disturbances in the laminar boundary layer (sigma is defined as the natural logarithm of the ratio between the amplitude of a disturbance at a given instant or position to the amplitude at neutral stability). It is found that at the experimentally determined transition position the calculated amplification factor for the critical disturbances attains nearly the same value (about 10) in many different cases for flows with low free stream turbulence levels. An attempt is made to include the effects of higher free stream turbulence levels by allowing the critical amplification factor to decrease with increasing free stream turbulence. Author

N78-14336# Cranfield Inst. of Technology (England). Aerodynamics Div.
LEADING EDGE TRANSITION ON SWEPT WINGS
D. I. A. Poll *In* AGARD Laminar-Turbulent Transition Oct. 1977 11 p refs (For availability see N78-14316 05-34)
Avail: NTIS HC A17/MF A01

The behavior of the swept wing attachment line boundary layer has been studied experimentally. Two dimensional trip wires and turbulent flat plate boundary layers have been used as sources of disturbance and a wide range of conditions has been covered, ensuring that the results are directly applicable to full scale flight situations. Simple criteria have been deduced and those allow the state of the attachment line boundary layer to be determined for a given geometry and free stream conditions. The validity of some of the principal results has been extended to high Mach numbers for the adiabatic wall case. Sample calculations show that most of the present generation of civil aircraft have turbulent attachment lines in the cruise condition. Although some benefit may be gained by a removal of root disturbances and the maintenance of a smooth leading edge the tolerable roughness heights are so small that it seems unlikely that turbulence can be prevented without some form of boundary layer suction. Author

N78-14337# Rolls-Royce Ltd., Derby (England). Dept. of Turbine Aerodynamics and Blade Cooling Research
ENGINEERING PREDICTIONS OF TRANSITIONAL BOUNDARY LAYERS
A. E. Forest *In* AGARD Laminar-Turbulent Transition Oct. 1977 19 p refs (For availability see N78-14316 05-34)
Avail: NTIS HC A17/MF A01

A procedure is described for the prediction of transitional boundary layers occurring, for example, on turbomachinery blading. The method attempts to combine rapidity with the inclusion of the dominant influences affecting these flows. In consequence, a highly empirical approach has to be adopted. Some of the relationships employed are preliminary and schematic, nevertheless fair agreement with a range of data is obtained. The complexity of the flow conditions on a modern gas turbine rotor blade is demonstrated. Author

N78-14338# Physical Sciences, Inc., Woburn, Mass.
ON THE APPLICATION OF SECOND-ORDER CLOSURE MODELS TO BOUNDARY LAYER TRANSITION
Michael L. Finson *In* AGARD Laminar-Turbulent Transition Oct. 1977 6 p refs (For availability see N78-14316 05-34)

(Contract F44620-74-C-0022)
Avail: NTIS HC A17/MF A01

Second-order closure models offer several potential advantages for the study and prediction of boundary layer transition. The required closure approximations can be formulated to represent an adequate physical description of the transition process. A five equation model is presented for fluctuating variables. It is argued that adequate closure techniques are available for the production, dissipation, and diffusion terms. Improved closure schemes are suggested, and a model is also presented for the manner by which surface roughness elements disturb the boundary layer. Calculations have been obtained for two by-pass situations where the initial fluctuation levels are relatively high, due either to free stream turbulence or surface roughness, and the results are in reasonable agreement with wind tunnel observations on flat plates. Author

N78-14339# Ecole Centrale de Lyon, Ecully (France).
A METHOD FOR PREDICTING BOUNDARY LAYER TRANSITION [METHODE DE PREDICTION DE LA TRANSITION DE LA COUCHE LIMITE]
C. Mari and J. Mathieu *In* AGARD Laminar-Turbulent Transition Oct. 1977 9 p refs In FRENCH; ENGLISH summary (For availability see N78-14316 05-34)
Avail: NTIS HC A17/MF A01

The method is based on recent works by McDonald about the transition in the boundary layer. In addition to momentum and total enthalpy equations, an integral equation for turbulent kinetic energy is taken into account. The numerical scheme is based in a semi-linear implicit method due to Patankar Spalding on the first hand, and on an iterative approach on the other hand. This choice was mostly guided by the short computing time used (5 to 6 sec. on CDC 7600). Author

N78-14340# ARO, Inc., Arnold Air Force Station, Tenn. Propulsion Wind Tunnel Facility.
A SURVEY OF TRANSITION RESEARCH AT AEDC
Jack D. Whitfield and N. Sam Dougherty, Jr. *In* AGARD Laminar-Turbulent Transition Oct. 1977 20 p refs Sponsored by AEDC (For availability see N78-14316 05-34)
Avail: NTIS HC A17/MF A01

Experimental research on transition Reynolds numbers conducted in a large number of ground test facilities is surveyed. Facilities surveyed included primary wind tunnels used for aerodynamic testing at subsonic, transonic, supersonic, and hypersonic conditions. Measurements have been made on cones and planar bodies, flat plates and hollow cylinders. The primary motivation for this research spanning nearly 25 years has been to verify the adequacy of the facilities to simulate flight conditions. This necessarily entailed the study of free stream disturbances in wind tunnels and the role these disturbances play in altering transition Reynolds number which must be considered when scaling Reynolds number sensitive data. Author

N78-14341# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Goettingen (West Germany). Inst. fuer Stroemungsmechanik.
AN EXPERIMENTAL STUDY OF BOUNDARY LAYER TRANSITION ON A SLENDER CONE AT MACH 6
P. Krogmann *In* AGARD Laminar-Turbulent Transition Oct. 1977 12 p refs (For availability see N78-14316 05-34)
Avail: NTIS HC A17/MF A01

Experimental results of an investigation conducted in a Ludwieg tube wind tunnel are presented. Transition was detected by means of local heat transfer rate measurements, and transition behavior on a 5 deg half-angle cone was investigated for different unit Reynolds numbers, temperature ratios and different angles of attack. In a range of unit Reynolds numbers from U/v = 100,000 to 5 x 100,000 transition Reynolds numbers were independent of unit Reynolds number. A variation of the wall to stagnation temperature ratio had no effect on transition. Small variations of angle of attack strongly affected transition, such that transition was promoted on the leeward surface and delayed on the windward surface. Author

N78-14342# *Institut de Mecanique des Fluides de Marseille* (France)
THREE-DIMENSIONAL BOUNDARY LAYER TRANSITION ON A YAWED 7.5 DEG SHARP CONE AT MACH 6
Annie Korsia and Jacques F. Marcillat *In* AGARD Laminar-Turbulent Transition Oct. 1977 10 p refs Sponsored by ONERA (For availability see N78-14316 05-34)
Avail: NTIS HC A17/MF A01

Boundary layer surveys and limiting streamlines at the wall pattern have been used for transition detection. Some examples of results obtained around a 7.5 deg sharp cone placed at angle of attack in a supersonic stream (M = 5) are presented. A simple new method of transition detection is reported that is based on the use of limiting streamlines at wall visualizations and that gives the picture of the boundary layer including the transition development from iso-Mach number contours. Author

N78-14343*# National Aeronautics and Space Administration, Langley Research Center, Langley Station, Va.
PROGRESS IN THE DEVELOPMENT OF A MACH 6 QUIET TUNNEL
I. E. Beckwith, J. B. Andere, P. C. Stainback, W. D. Harvey, and A. J. Srokowski *In* AGARD Laminar-Turbulent Transition Oct. 1977 14 p refs (For availability see N78-14316 05-34)
Avail: NTIS HC A17/MF A01 CSCL 20D

Various techniques to control and reduce radiated noise and the application of these techniques to a 1/2-meter Mach 5 quiet tunnel are reviewed. Measurements in a small scale nozzle have shown that the upstream part of the supersonic wall boundary layer could be maintained laminar up to Reynolds numbers of nearly 4 x 1 million based on the test region length upstream of the nozzle exit. Turbulent noise levels in this test region were then reduced by an order of magnitude. To maintain low noise levels at higher Reynolds numbers, laminar flow noise shields are required. Data are presented for shields that consist of small diameter rods alined nearly parallel to the entrance flow with small gaps between the rods for boundary layer suction. Analysis and data presented on the noise shielding and reflection characteristics of flat plates and a rod-wall test panel indicate that freestream turbulent noise can be reduced by 70 to 90 deg at high Reynolds numbers. Performance estimates for the 1/2-meter tunnel are based on these results. Author

N78-14344# National Research Council of Canada, Ottawa (Ontario).
NON-OBTRUSIVE DETECTION OF TRANSITION REGION USING AN INFRA-RED CAMERA
David J. Peake, Arthur J. Bowker, Stephen J. Lockyear, and Freda. Ellis *In* AGARD Laminar-Turbulent Transition Oct. 1977 17 p refs (For availability see N78-14316 05-34)
Avail: NTIS HC A17/MF A01

A Mach 3.85, high Reynolds Number flow in a 5 x 5-inch blowdown wind tunnel was used to determine the region of natural transition on a flat model, by recording the infrared emission from the plate surface. The respective chord and span dimensions of the plate were 7.5 and 5.0 inches, and a bakelite insulator was incorporated as the test surface. The tests were conducted with an airfoil stagnation temperature close to atmospheric (33 C.). The recovery temperatures at the plate surface thus derived from the infra-red camera measurements, for the case of negligible heat transfer and pressure gradient, defined the extent of transition. The more conventional transition diagnostic techniques utilizing sublimation patterns, a surface pitot tube and surface hot-film gauges, supported the infrared measurements. Author

N78-18374# Advisory Group for Aerospace Research and Development, Paris (France).
APPLICATIONS OF NON-INTRUSIVE INSTRUMENTATION IN FLUID FLOW RESEARCH
X. Bouis Dec. 1977 11 p ref In FRENCH Translation was announced as N77-11221
(AGARD-AR-112) Avail: NTIS HC A02/MF A01

A symposium was held to discuss and study in detail utilization techniques. Emphasis was placed on exact methods of flow measurement, and shorttime response applied to transonic, supersonic and hypersonic turbulent flows. Other topics of discussion were some of the following: (1) development stages of measuring techniques; (2) problems that these techniques can solve in external aerodynamics, turbomachinery, and flow with chemical reactions; (3) laser utilization; (4) Raman anti-Stokes diffusion; and (5) infrared emission and mathematical application of interferometry. Transl. by B.B.

N78-27382# Advisory Group for Aerospace Research and Development, Paris (France).
TECHNICAL EVALUATION REPORT OF THE FLUID DYNAMICS PANEL SYMPOSIUM ON LAMINAR-TURBULENT TRANSITION
Mark V. Morkovin (Illinois Inst. of Technol., Chicago) Jun. 1978

18 p refs Symp held at Lyngby, Denmark, 2-4 May 1978 (AGARD AR-122, ISBN-92-835-1283-9) Avail: NTIS HC A02/MF A01

The AGARD Fluid Dynamics Panel organized a three day symposium on laminar-turbulent transition to review the progress achieved during the last ten years and to bring to light the still unsolved problems. There were a total of twenty-nine papers presented in five sessions. The list of these papers heads the references at the end of the report. A second section of this report presents various considerations for evaluating theoretical and experimental analyses of the transition phenomena with particular concern to the improvement of methods for calculating (transition) onset and development on which emphasis was focused in the Call for Papers by the Program Committee. The subsequent sections then offer evaluative comments concerning individual papers and related groups of papers, primarily from the point of view of the specialist in the given subfield. G.Y.

N78-28397# Advisory Group for Aerospace Research and Development, Paris (France).

THREE DIMENSIONAL AND UNSTEADY SEPARATION AT HIGH REYNOLDS NUMBERS

Feb. 1978 244 p refs In ENGLISH and FRENCH Presented at Rhode-Saint-Genese, Belgium, 20-24 Feb. 1978 Amended version of N78-18375

(AGARD-LS-94; ISBN-92-835-0210-8) Avail: NTIS HC A11/MF A01

The present state of knowledge of three dimensional flows which contain regions of quasi-steady separation is reviewed including numerical methods for investigating such flows. The effect of three dimensional separating flows on the design and performance prediction of aircraft is emphasized. For individual titles, see N78-28398 through N78-28410.

N78-28398# Office National d'Etudes et de Recherches Aerospatiales, Paris (France).

PRESENTATION OF THE SUBJECT

M. Sirieix *In* AGARD Three Dimensional and Unsteady Separation at High Reynolds No. Feb. 1978 16 p refs (For primary document see *N78-28397 19-34*)

Avail: NTIS HC A11/MF A01

A brief overview of the lecture series is given. Flow visualization is used to describe three dimensional or unsteady separated flow. Various causes of separated flow are listed. The effects of separated flow on various aircraft configurations are discussed. J.M.S.

N78-28399# Avions Marcel Dassault-Breguet Aviation, Saint-Cloud (France).

BOUNDARY SEPARATION PROBLEMS FACED BY AIRCRAFT DESIGNERS [LES PROBLEMES DE DECOLLEMENTS POSES A L'AVIONNEUR]

Pierre Perrier In AGARD Three Dimensional and Unsteady Separation at High Reynolds No. Feb. 1978 11 p refs In FRENCH (For primary document see N78-28397 19-34)

Avail: NTIS HC A11/MF A01

Various forms of boundary separation problems in relation to quality flight performance and aircraft design were studied. Experimental methods to resolve these problems were analyzed in detail. Transl. by B.B.

N78-28400# Office National d'Etudes et de Recherches Aerospatiales, Paris (France).

NUMERICAL SOLUTION OF VISCOUS-INVISCID INTERACTION PROBLEMS IN TWO-DIMENSIONAL COMPRESSIBLE FLOWS BASED ON THE NAVIER-STOKES EQUATIONS

Henri Viviand In AGARD Three Dimensional and Unsteady Separation at High Reynolds No. Feb. 1978 21 p refs In FRENCH; ENGLISH summary (For primary document see N78-28397 19-34)

Avail: NTIS HC A11/MF A01

A review is presented of the approach based on the numerical solution of the Navier-Stokes number compressible flows. This global approach involves two distinct problems: on the one hand the numerical solution of the equations used, and on the other hand turbulence modeling to close the system of the averaged Navier-Stokes equations for the case of compressible separated flows. The validity of turbulence models is tested through comparisons between numerical prodictions anp experimental results. A general presentation of the problems and of the results which have been obtained is given. The essential features of the numerical methods and of the turbulence models which have been used are discussed. J.M.S.

N78-28401# Office National d'Etudes et de Recherches Aerospatiales, Paris (France).

VISCID-INVISCID INTERACTION METHODS FOR TWO-DIMENSIONAL FLOWS, INCLUDING SEPARATION AND SHOCK WAVES

Jean-Claude LeBalleur *In* AGARD Three Dimensional and Unsteady Separation at High Reynolds No. Feb. 1978 24 p refs In FRENCH, ENGLISH summary (For primary document see N78-28397 19-34)

Avail: NTIS HC A11/MF A01

Various methods which predict viscous flow when the Reynolds number is large enough for the inviscid approximation to be applied in the flow field are reviewed. Various approaches used to approximate the Navier-Stokes equations are outlined including rational asymptotic methods both for weak and singular boundary layer interactions; truncated Navier-Stokes equations; numerical matching at large distance of boundary layer regions, viscid-inviscid patching in the vicinity of boundary layers according to the strong interaction of the interacting boundary layer concept; and simplified methods with empirical models of separation. Emphasis is placed on progress achieved with the interacting boundary layer methods. The degree of rationality, the inclusion of separated bubbles, the upstream influence in supersonic flows, and the progress achieved in making this approach a practical tool for various inviscid codes, subsonic, transonic, or supersonic are among the factors considered. J.M.S.

N78-28402*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

PHENOMENOLOGICAL ASPECTS OF QUASI-STATIONARY CONTROLLED AND UNCONTROLLED THREE-DIMENSIONAL FLOW SEPARATIONS

David J. Peake *In* AGARD Three Dimensional and Unsteady Separation at High Reynolds No. Feb. 1978 52 p refs (For primary document see N78-28397 19-34)

Avail: NTIS HC A11/MF A01 CSCL 20D

Quasi-steady three dimensional separated flows about bodies of large fineness ratio operating at large angles of incidence or yaw are discussed. The general character of the three dimensional attached boundary layer, the concept of limiting streamlines, and the physics of three dimensional separation and reattachment are among the factors considered. Specific examples are given. The advantages of swept, sharp edges that generate controlled (or fixed) three dimensional flow separations on a vehicle, due to the qualitatively unchanging flow field developed throughout the range of flight conditions, are emphasized. J.M.S.

N78-28403*# National Aeronautics and Space Administration Ames Research Center, Moffett Field, Calif.

INTRODUCTION TO UNSTEADY ASPECTS OF SEPARATION IN SUBSONIC AND TRANSONIC FLOW

W. J. McCroskey *In* AGARD Three Dimensional and Unsteady Separation at High Reynolds No. Feb. 1978 8 p refs (For primary document see N78-28397 19-34)

Avail: NTIS HC A11/MF A01 CSCL 20D

Unsteady flow phenomena are reviewed with emphasis on separated flow in the subsonic and transonic regimes. Specific topics discussed include external flows past bluff bodies, unsteady separation on slender bodies, and internal flows. J.M.S.

N78-28404# Royal Aircraft Establishment, Bedford (England).

PREDICTION OF THE SEVERITY OF BUFFETING

D. G. Mabey *In* AGARD Three Dimensional and Unsteady Separation at High Reynolds No. Feb. 1978 30 p refs (For primary document see N78-28397 19-34)

Avail: NTIS HC A11/MF A01

The influence of buffeting criteria on the choice of wing loading for fighter and transport aircraft is discussed. Wings are classified in terms of flow separations and buffeting. Wind tunnel model tests used to predict aircraft buffeting are described with emphasis on the importance of using wind tunnels with low levels of flow unsteadiness. Factors measured in the model tests include: unsteady wing-root strain in the first bending mode; unsteady pressure across the surface; and unsteady responses. Alternative methods of determining buffet onset are also considered. J.M.S.

N78-28405*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

SOME UNSTEADY SEPARATION PROBLEMS FOR SLENDER BODIES

W. J. McCroskey *In* AGARD Three Dimensional and Unsteady

Separation at High Reynolds No. Feb. 1978 11 p refs (For primary document see N78-28397 19-34)
Avail: NTIS HC A11/MF A01 CSCL 20D

The unsteady Kutta-Joukowski condition, dynamic stall on oscillating airfoils, and unsteady shock wave-boundary layer interaction are discussed. Emphasis is placed on developing reliable prediction techniques and suppression of unsteady separation on oscillating control surfaces, wings, and rotating blades to improve aerodynamic stability. J.M.S.

N78-28406# Royal Aircraft Establishment, Farnborough (England). Dept. of Aerodynamics.
INVISCID FLUID MODEL, BASED ON ROLLED-UP VORTEX SHEETS, FOR THREE-DIMENSIONAL SEPARATION AT HIGH REYNOLDS NUMBER
J. H. B. Smith *In* AGARD Three Dimensional and Unsteady Separation at High Reynolds No. Feb. 1978 27 p refs (For primary document see N78-28397 19-34)
Avail: NTIS HC A11/MF A01

The inviscid fluid models which are used to represent flows with three dimensional separation of vortex type are introduced and described. Their strengths and weaknesses are discussed and suggestions are made for improvements. A selection of results for a wide range of problems is presented. The difficulties which arise in trying to extend these models to represent separation from highly swept separation lines on smooth bodies are discussed and a view is given of the present position and developments in the immediate future. J.M.S.

N78-28407# Imperial Coll. of Science and Technology, London (England)
STRUCTURE OF TURBULENCE IN COMPLEX FLOWS
P. Bradshaw *In* AGARD Three Dimensional and Unsteady Separation at High Reynolds No. Feb. 1978 7 p refs (For primary document see N78-28397 19-34)
Avail: NTIS HC A11/MF A01

The effects of unsteadiness or three dimensionality on turbulence and turbulence models are discussed. The response of shear layers to extra rates of strain is outlined and the concept of the 'fairly thin shear layer' presented. The special problems of separated flow are briefly reviewed. J.M.S.

N78-28408# Imperial Coll. of Science and Technology, London (England).
PREDICTION OF SEPARATION USING BOUNDARY LAYER THEORY
P. Bradshaw *In* AGARD Three Dimensional and Unsteady Separation at High Reynolds No. Feb. 1978 8 p refs (For primary document see N78-28397 19-34)
Avail: NTIS HC A11/MF A01

The solution of equations for the shear layer with a pressure distribution at the shear layer edge derived from the inviscid solution is addressed. Presence of a singularity at separation, calculation methods for reversed flow, and cases where the thin shear layer approximation is not accurate enough are among the topics considered. J.M.S.

N78-28409*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
PREDICTION OF UNSTEADY SEPARATED FLOWS ON OSCILLATING AIRFOILS
W. J. McCroskey *In* AGARD Three Dimensional and Unsteady Separation at High Reynolds No. Feb. 1978 8 p refs (For primary document see N78-28397 19-34)
Avail: NTIS HC A11/MF A01 CSCL 20D

Techniques for calculating high Reynolds number flow around an airfoil undergoing dynamic stall are reviewed. Emphasis is placed on predicting the values of lift, drag, and pitching moments. Methods discussed include: the discrete potential vortex method; thin boundary layer method; strong interaction between inviscid and viscous flows; and solutions to the Navier-Stokes equations. Empirical methods for estimating unsteady airloads on oscillating airfoils are also described. These methods correlate force and moment data from wind tunnel tests to indicate the effects of various parameters, such as airfoil shape, Mach number, amplitude and frequency of sinosoidal oscillations, mean angle, and type of motion. J.M.S.

N78-28410*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
STATUS AND FUTURE PROSPECTS OF USING NUMERICAL METHODS TO STUDY COMPLEX FLOWS AT HIGH REYNOLDS NUMBERS
Robert W. MacCormack *In* AGARD Three Dimensional and Unsteady Separation at High Reynolds No. Feb. 1978 2 p (For primary document see N78-28397 19-34)
Avail: NTIS HC A11/MF A01 CSCL 20D

The calculation of flow fields past aircraft configuration at flight Reynolds numbers is considered. Progress in devising accurate and efficient numerical methods, in understanding and modeling the physics of turbulence, and in developing reliable and powerful computer hardware is discussed. Emphasis is placed on efficient solutions to the Navier-Stokes equations. J.M.S.

N78-31401# Advisory Group for Aerospace Research and Development, Paris (France).
INSTABILITY, TRANSITION TO TURBULENCE AND PREDICTABILITY
M. V. Morkovin (Illinois Inst. of Technol., Chicago). Jul. 1978 38 p refs Presented at AGARD Fluid Dyn. Panel Symp. on Laminar-Turbulent Transition, Lyngby, Den., 2-4 May 1977 (AGARD-AG-236; ISBN-92-835-1288-X) Avail: NTIS HC A03/MF A01

A concise state of the art review on the phenomenon of transition which constituted the opening address at the Fluid Dynamics Panel Symposium on Laminar-Turbulent Transition (AGARD-CP-224) held in Lyngby, Denmark, 2-4 May 1977 is presented. Various instability mechanisms leading to transition are proposed and discussed. A variable insight is provided based on existing experimental evidence and postulated flow structures. Critical questions are asked relating to the conceptual foundation on which much of the transition effort is based. To enhance understanding of the basic mechanisms and processes, detailed microscopic experiments are encouraged to increase the data base. G.Y.

37 MECHANICAL ENGINEERING

Includes auxiliary systems (non-power); machine elements and processes; and mechanical equipment.

N78-11391# *Advisory Group for Aerospace Research and Development, Paris (France)*
ADVANCED MANUFACTURING TECHNIQUES IN JOINING OF AEROSPACE MATERIALS
Sep 1977 192 p refs
(AGARD-LS-91, ISBN-92-838-0203-5) Avail: NTIS HC A09/MF A01

A comprehensive survey is presented of joining processes and their application in aerospace industries, thus contributing to an exploitation of welding and similar processes in production technology. For individual titles, see N78-11392 through N78-11397

N78-11392 Grumman Aerospace Corp., Bethpage, N.Y. Advanced Materials and Processes Development.
ADVANCED JOINING TECHNIQUES IN AEROSPACE CELL STRUCTURES
Robert H. Witt *In* AGARD Advanced Manufacturing Tech. in Joining of Aerospace Mater. Sep. 1977 29 p refs (For availability see N78-11391 02-37)
Avail: NTIS HC A09/MF A01

General aspects of advantages and difficulties in welding critical primary aircraft structures are discussed. The all-welded F-14A wing center-section is used as an example to delineate the types of problems inherent in selecting the optimum welding process and procedures to assure structural integrity, minimum cost, distortion control and light weight. The aerospace industry is particularly interested in joining titanium, steel and aluminum alloys in various gages ranging from thin sheet to heavy plate, 2 to 3 in. (50 to 75 mm) thick. Various welding processes and applications are discussed in relation to selection criteria. Developments in electron-beam welding small and large titanium structures are presented with particular attention given to high vacuum welding and directions being taken in non-vacuum and sliding-seal electron-beam welding. Applications of pulsed gas-tungsten-arc, plasma-arc (welding and cutting), laser beam (welding and cutting), weld-bonding, diffusion bonding, and brazing are discussed. The survey continues with a discussion of design for use of modern methods of weld inspection, the effects of defects on weld performance and some experiences in testing large structures. Recommendations for use of design and test data evaluations to minimize cost, increase ease of fabrication, facilitate inspection and increase reliability confidence conclude the paper. Author

N78-11393 Pratt and Whitney Aircraft Group, East Hartford, Conn. Materials Engineering and Research Lab.
PROCESS AND METALLURGICAL FACTORS IN JOINING SUPERALLOYS AND OTHER HIGH SERVICE TEMPERATURE MATERIALS
William A. Owczarski *In* AGARD Advanced Manufacturing Tech. in Joining of Aerospace Mater. Sep. 1977 32p refs (For availability see N78-11391 02-37)
Avail: NTIS HC A08/MF A01

Aircraft gas turbines rely on materials which must operate durably at elevated temperatures. Fabrication methods to make turbine parts are selected for reliability and cost effectiveness. Thus nickel-base superalloys, which are the dominant heat resistant material used in aircraft gas turbines, are frequently metallurgically joined in manufacture or repair of a gas turbine. The nature of the superalloy class of materials makes joining difficult. Several problems exist in welding the superalloys such as heat affected zone hot cracking and post-weld heat treatment cracking. The nature of these difficulties is described, including a metallurgical discussion of their causes. Methods for reducing or eliminating these problems are discussed along with some general guidelines for joining this material class. Some examples of the processes and applications for joining are reviewed along with descriptions of how processes are adapted to provide the quality, properties and reliability required for gas turbine use of welded superalloys. Author

N78-11394 Welding Inst., Cambridge (England)
RECENT DEVELOPMENTS IN WELDING TECHNOLOGY
R. Weck *In* AGARD Advanced Manufacturing Tech. in Joining of Aerospace Mater. Sep. 1977 19 p refs (For availability see N78-11391 02-37)
Avail: NTIS HC A09/MF A01

With the development of pulsed TIG and MIG welding and the universal transistorized power source the ultimate step in the development of fusion welding processes appears to have been taken. Despite the fact that high precision welding is now possible, requirements for quality and reliability have now become so stringent that the available techniques are no longer adequate to achieve them. There is, however, scope for improving the economics in the use of the processes. Solid phase welding processes, such as diffusion bonding and friction welding, are largely free from the problems of the fusion welding processes but the research and development effort in these areas is minimal. International co-operation in welding technology, given the inherent difficulties of communication, is probably at least as good if not better than many other areas, particularly through the work of the International Institute of Welding. Progress in international standardization is slow for commercial and legal reasons and even within the European Community differing standards are a serious obstacle to the free interchange of techniques and equipment. Author

N78-11395 Dortmund Univ. (West Germany)
NON-WELDING JOINING, CUTTING AND THERMAL SPRAYING METHODS
H. D. Steffens *In* AGARD Advanced Manufacturing Tech. in Joining Aerospace Mater. Sep. 1977 25 p refs (For availability see N78-11391 02-37)
Avail: NTIS HC A09/MF A01

No heat at all will necessarily be used in metal or polymer bonding, where no restrictions are given in the selection of material to be joined. The short term low temperature properties of the joints are excellent when thermal resistivity is poor, but long term properties, especially under environmental conditions, are widely unknown. However, many examples are known for applied bonding joints in aerospace industries. Thermal cutting processes are used as preparation methods for metallic components prior to welding or other joining processes. Oxy-acetylene plasma arc and laser beam cutting offer certain advantages for particular materials and sheet thicknesses. There is a strong development in laser techniques by which cutting processes in aircraft industries will be affected. Author

N78-11396 Dortmund Univ. (West Germany)
ASPECTS OF THE MECHANICAL AND ENVIRONMENTAL BEHAVIOR OF JOINTS
H. A. Crostack *In* AGARD Advanced Manufacturing Tech. in Joining of Aerospace Mater. Sep. 1977 29 p refs (For availability see N78-11391 02-37)
Avail: NTIS HC A09/MF A01

The strength of structural components is often limited by the mechanical and environmental behavior of joints. The properties of the inhomogeneous parts are different from the behavior of the base materials. Inside the seam they depend on the heat-treatment and residual stresses. The basic principles of test methods such as fracture mechanics, fatigue tests and tests under environmental conditions are discussed. Applications are presented in some examples of TIG, EB and resistance weldments, high temperature brazements, and bonded structures. The detection of defects in joints in a nondestructive manner, as through application of holography and acoustic emission, is discussed and compared with conventional methods such as ultrasonic or X-Ray testing. Author

N78-11397 Societe Nationale Industrielle Aerospatiale, Paris (France)
WELDED METAL SANDWICH WITH CORRUGATED CORE: IMPROVEMENTS IN MECHANICAL STRENGTH CHARACTERISTICS BY RELAXATION-DIFFUSION HEAT TREATMENT, METHOD OF QUALITY CONTROL OF SPOT WELDS BY INFRA-RED THERMOGRAPHY

S Dzalba-Lyndis *In* AGARD Advanced Manufacturing Tech in Joining of Aerospace Mater Sep 1977 29 p In ENGLISH and FRENCH (For availability see N78-11391 02 37)
Avail NTIS HC A09/MF A01

During the development of a sandwich material with a spot-resistance-welded corrugated core, two particular techniques were tried and evaluated These techniques can be used for all other types of welded structures The first technique, when titanium or titanium alloys are used, consists in subjecting the material, previously spot welded by the resistance method, to a heat treatment in vacuo, which ensures (1) metallurgical homogeneity between the base metal and the zones affected by the welding, (2) relaxation of the welding stresses, and (3) an increase in the bonding areas by solid state diffusion, under the hammered welding forces only This process leads to considerable improvement in the fatigue and static mechanical strength of the material The second technique is a method of quality control of welds during manufacture It consists in observing the surface of the material a brief moment after the formation of a weld point by the use of an infra-red camera, associated with a TV monitor The thermal signature of a weld point is closely related to its quality Author

N78-12428# Advisory Group for Aerospace Research and Development, Paris (France)

A CATALOGUE OF CURRENT IMPACT DEVICES: A WORKING GROUP REPORT

D. H Glaister, ed Sep 1977 60 p refs
(AGARD-R-658; ISBN-92-835-1256-1) Avail: NTIS HC A04/MF A01 CSCL 13I

The standardization of biodynamic impact testing was studied with special reference to seats and harnesses. This report is based on replies to questionnaires sent to research laboratories, and catalogues 52 impact test devices. They are listed according to the operating organizations, and classified by principle of operation (accelerators, decelerators, horizontal, vertical etc). Details of construction, performance and use of each facility are given Also described are some current standards for crash impact testing and the principles of operation of the more common types of test devices. Author

38 QUALITY ASSURANCE AND RELIABILITY

Includes product sampling procedures and techniques; and quality control.

N77-18462# Advisory Group for Aerospace Research and Development, Paris (France)
SOME ENGINEERING PROBLEMS IN THE ROYAL AIR FORCE
H. Durkin (Royal Air Force, London) Feb. 1977 11 p
(AGARD-R-653; ISBN-92-835-1239-2) Avail NTIS HC A02/MF A01

The current problems of the RAF related to the structural and materials areas are described, and the improvements sought in the fields of reliability, maintainability, structural integrity, design, inspection, corrosion and battle damage are indicated Author

N78-26460# Advisory Group for Aerospace Research and Development, Paris (France).
NON-DESTRUCTIVE INSPECTION RELATIONSHIPS TO AIRCRAFT DESIGN AND MATERIALS
Mar 1978 336 p refs In ENGLISH and FRENCH Presented at the 45th Meeting of the AGARD Struct and Mater Panel, Voss, Norway, 27-28 Sep 1977
(AGARD-CP-234; ISBN-92-835-0213-2) Avail NTIS HC A15/MF A01

The state of the art of nondestructive inspection methods for materials of interest to the aerospace industry is considered along with the weak points of some methods and the trends of application. Composite, ceramic, and metallic materials are included. Low angle neutron scattering, digitalized infrared thermography, tomography, and very high frequency ultrasonic beam scattering are among the methods discussed For individual titles, see N78-26461 through N78-26480.

N78-26461# Aeritalia S.p.A., Torino (Italy).
NDI TECHNIQUES IN AEROSPACE
Enrico Bolis *In* AGARD Non-destructive Inspection Relationships to Aircraft Design and Mater Mar 1978 3 p (For availability see N78-26460 17-38)
Avail: NTIS HC A15/MF A01

The application of nondestructive inspection techniques to assure the safety and reliability of aerospace structures and components is discussed. The importance of quality assurance techniques and standards at all levels of development (materials procurement, engineering specifications, structures manufacturing) and in monitoring structures during service life is emphasized J M S

N78-26462# Politecnico di Torino (Italy) Inst Progetto di Aeromobili.
CRITICAL REVIEW OF VARIOUS STRUCTURAL SAFETY CONCEPTS TAKING INTO ACCOUNT NDI METHODS
E. Antona *In* AGARD Non-destructive Inspection Relationships to Aircraft Design and Mater Mar 1978 22 p refs (For availability see N78-26460 17-38)
(Contract CNR-SAS-76-0031)
Avail: NTIS HC A15/MF A01

A critical review is given of the various structural safety concepts adopted during the aeronautical and space technology development, with particular emphasis on fatigue and fracture mechanics A comparison is made between the deterministic and the probabilistic point of view in the analysis of the loading condition and the structural behavior and consequently between the deterministic and the probabilistic formulation of the structural safety concepts As a conclusion to these considerations an analysis is performed relative to the present and the expected impact of fracture mechanics in aerospace structural design philosophy and to the impact of nondestructive inspection methods on fracture mechanics analysis J M S

N78-26463# Air Force Materials Lab., Wright-Patterson AFB, Ohio.
THE ECONOMIC IMPLICATIONS OF NDE: OPPORTUNITIES AND PAYOFF
D. M. Forney and T. D. Cooper *In* AGARD Non-destructive Inspection Relationships to Aircraft Design and Mater Mar 1978 15 p refs (For availability see N78-26460 17-38)
Avail: NTIS HC A15/MF A01

Progress in the development of nondestructive evaluation procedures which may have significant economic benefits is reviewed. Nondestructive evaluation requirements in both initial manufacturing and in-service functions are discussed to exemplify cost effective approaches. Other possible future opportunities are also considered. J M S

N78-26464# Royal Air Force, London (England)
UNFULFILLED NEEDS OF NON-DESTRUCTIVE INSPECTION OF MILITARY AIRCRAFT
H. M. Kent *In* AGARD Non-destructive Inspection Relationships to Aircraft Design and Mater Mar 1978 10 p refs (For availability see N78-26460 17-38)
Avail: NTIS HC A15/MF A01

The research and development needs of nondestructive inspection technology are discussed in terms of maintaining the airworthiness of military aircraft Techniques for in-flight monitoring and detection of defects due to corrosion, residual and thermal stress, and adhesive bond deterioration are included J M S

N78-26465# Fiat Research Center, Orbassano (Italy)
APPLICATION OF SMALL-ANGLE NEUTRON SCATTERING TO NDI OF MATERIALS AND MANUFACTURED COMPONENTS
P. Pizzi *In* AGARD Non-destructive Inspection Relationships to Aircraft Design and Mater Mar 1978 17 p refs (For availability see N78-26460 17-38)
Avail: NTIS HC A15/MF A01

Examples of heat treatment effects, cold work effects, and creep effects measured by small angle neutron scattering are presented. Application of the small angle neutron scattering technique to the study of microstructural degradation phenomena in nickel superalloys and in particular in turbine blades during service is discussed. An example of anisotropic scattering measure in carbon-carbon fiber composites is included J M S

N78-26466# Fiat Research Center, Orbassano (Italy)
SURFACE CORROSION EVALUATION BY RELATIVE MAGNETIC SUSCEPTIBILITY MEASUREMENTS
H. Walther *In* AGARD Non-destructive Inspection Relationships to Aircraft Design and Mater Mar 1978 11 p ref (For availability see N78-26460 17-38)
Avail: NTIS HC A15/MF A01

A method based on the principles of a magnetic balance is proposed for detecting the corrosion effects in the very early stage of the degeneration process. The method is based on the fact that superalloys and stainless steels change their magnetic susceptibility during oxidation and carburization in their subsurface layer Results of measurements performed on IN-100 aircraft turbine blades and INCONEL X-750 power plant gas turbine blades are reported J M S

N78-26467# Lanchester Polytechnic, Coventry (England)
APPLICATION OF X-RAY DIFFRACTION STRESS MEASURING TECHNIQUES
D. Kirk *In* AGARD Non-destructive Inspection Relationships to Aircraft Design and Mater Mar 1978 13 p refs (For availability see N78-26460 17-38)
Avail: NTIS HC A15/MF A01

Examples of residual stress analysis are given to illustrate the wide range of useful applications that are possible for the X-ray stress measuring techniques. The variation of residual stress at the surface for a machined aluminum alloy extrusion and for

the region adjacent to a butt-welded steel plate is discussed along with the variation of residual stress below the original surface for shot-peened components and for a flow-formed maraging steel tube. The advantages of chemical polishing for layer removal are considered. The practical problems associated with unusual geometry and physical size of components are described. J.M.S.

N78-26468# Direzione Laboratori Aeronautica Militaire, Rome (Italy).
X-RAY DIFFRACTION: FROM STRUCTURAL X-RAY DIFFRACTOGRAPHY TO X-RAY OSCILLOGRAPHIC DIFFRACTOSCOPY
Angelo Tronca *In* AGARD Non-destructive Inspection Relationships to Aircraft Design and Mater. Mar. 1978 12 p refs (For availability see N78-26460 17-38)
Avail: NTIS HC A15/MF A01

Fast inspection of jet engine compressor blades is considered. Classical X-ray diffractography which utilizes filtered radiation and plane X-ray films and oscillographic fast inspection are described. Results obtained by each method are presented and correlated. Oscillographic observations of rotating compressor steel blades are reported. J.M.S.

N78-26469# Saab-Scania, Linkoping (Sweden). Aerospace Div.
ON THE DETECTION AND MEASUREMENT OF CRACKS IN CRITICALLY LOADED HOLES
Sven Malmquist *In* AGARD Non-destructive Inspection Relationships to Aircraft Design and Mater. Mar. 1978 3 p (For availability see N78-26460 17-38)
Avail: NTIS HC A15/MF A01

A method developed for the inspection of the surface of a hole with the bolt removed is described. A stereomicroscope and a mirror in the hole, a surface roughness meter, and an eddy current instrument are used in the inspection. Scratches, cracks, corrosion, and fretting corrosion damages are observed with the stereomicroscope and mirror. The depth of scratches is measured with a surface roughness meter, Surtonic 3, which was modified for this purpose. Scratches that have grown into cracks are indicated and measured with an eddy current technique. J.M.S.

N78-26470# Middle East Technical Univ., Ankara (Turkey). Dept. of Metallurgical Engineering.
DYNAMIC NONDESTRUCTIVE TESTING OF MATERIALS
E. M. Uygur *In* AGARD Non-destructive Inspection Relationships to Aircraft Design and Mater. Mar. 1978 43 p refs (For availability see N78-26460 17-38)
Avail: NTIS HC A15/MF A01

It is shown that damping or internal friction and frequency measurements can be used for flaw detection and quality control as well as measurements of physical properties. Application areas and instrumentation used are discussed. J.M.S.

N78-26471# Industrieanlagen-Betriebsgesellschaft m.b.H., Ottobrunn (West Germany).
NDI METHODS ON FULL-SCALE FATIGUE TESTS AND THEIR SERVICE USAGE
Richard Schuetz *In* AGARD Non-destructive Inspection Relationships to Aircraft Design and Mater. Mar. 1978 22 p refs (For availability see N78-26460 17-38)
Avail: NTIS HC A15/MF A01

Procedures used to select the most effective nondestructive inspection methods and intervals are outlined. The problem of fatigue damages undetected by nondestructive inspection during full scale fatigue testing are discussed. J.M.S.

N78-26472# Southwest Research Inst., San Antonio, Tex.
CRITICAL INSPECTION OF BEARINGS FOR LIFE EXTENSION
John R. Barton, Felix N. Kusenberger, and Richard T. Smith *In* AGARD Non-destructive Inspection Relationships to Aircraft Design and Mater. Mar. 1978 29 p refs (For availability see N78-26460 17-38)
Avail: NTIS HC A15/MF A01

Research with the object of developing more definite nondestructive inspection methods for improved reliability and quality of rolling element bearings is reviewed. Inspection of precision mainshaft and transmission bearing assemblies in which the individual components -- outer race, rolling elements, (balls or rollers) and inner race -- can be separated is emphasized. Results obtained with magnetic perturbation for flaw detection, Barkhausen Noise Analysis for residual stress assessment, and laser scattered radiation for surface finish and surface anomaly detection are presented. The critical inspection of bearings for life extension program concept is described; a cardinal element of this program is the examination of new and used bearings, installation of the bearings in gas turbine engines, re-examination of bearings at engine overhaul, and the development of serviceability criteria based on actual service performance of the bearings in engines. J.M.S.

N78-26473# Saab-Scania, Linkoping (Sweden). Aerospace Div.
CRACK DETECTION IN BOLTED JOINTS
Lars Jarfall and Ake Magnusson *In* AGARD Non-destructive Inspection Relationships to Aircraft Design and Mater. Mar. 1978 5 p Prepared in cooperation with Aeronautical Research Inst. of Sweden, Bromma (For availability see N78-26460 17-38)
Avail: NTIS HC A15/MF A01

Fatigue cracks were generated from holes in sheet materials by application of fatigue loading to one hole at a time. From the cracked sheet material, a number of single shear two row lap joints were made. The lap joints were subjected to nondestructive testing (NDT). The ultrasonics method, the X-ray method, and the eddy current method were carried out and results compared. J.M.S.

N78-26474# Royal Aircraft Establishment, Farnborough (England). Structures Dept.
NON-DESTRUCTIVE INSPECTION OF COMPOSITE MATERIALS FOR AIRCRAFT STRUCTURAL APPLICATIONS
D. E. W. Stone *In* AGARD Non-destructive Inspection Relationships to Aircraft Design and Mater. Mar. 1978 18 p refs (For availability see N78-26460 17-38)
Avail: NTIS HC A15/MF A01

The capabilities and limitations of various nondestructive inspection techniques to detect defects in fiber reinforced plastics are reviewed. Emphasis is placed on carbon fiber reinforced plastics. Difficulties in transferring laboratory techniques to prototype and production structural components are discussed along with problem areas. The role of acoustic emission in nondestructive inspection is considered. J.M.S.

N78-26475# Royal Netherlands Aircraft Factories Fokker, Schiphol-Oost. Technological Centre.
THE RESONANCE-IMPEDANCE METHOD AS A MEANS FOR QUALITY CONTROL OF ADVANCED FIBRE REINFORCED PLASTIC STRUCTURES
R. J. Schliekelmann *In* AGARD Non-destructive Inspection Relationships to Aircraft Design and Mater. Mar. 1978 16 p refs (For availability see N78-26460 17-38)
Avail: NTIS HC A15/MF A01

The principles of the resonance frequency/impedance method are discussed. Detection of laminate thickness variations, matrix density variations, and delaminations is considered along with application of the method to inspection of advanced composite structures. J.M.S.

N78-26476# Dornier-Werke G.m.b.H., Friedrichshafen (West Germany).
INSPECTION OF CARBON FIBRE PARTS AFTER FABRICATION AND DURING SERVICE
Michael Kaitatzidis *In* AGARD Non-destructive Inspection

Relationships to Aircraft Design and Mater. Mar. 1978 16 p (For availability see N78-26460 17-38)
Avail: NTIS HC A15/MF A01

The individual parts of the Alpha Jet carbon fiber plastic airbrake were subjected to nondestructive testing by means of ultrasonics and X-rays. Quantity and size of the laminate flaws detected are reported along with adhesive defects in advanced composite structures. The experience gained during the inspection of the prototype airbrakes is described and prospects for proceeding in this field are considered. J.M.S.

N78-26477# *Vereinigte Flugtechnische Werke-Fokker G.m.b.H., Lemwerder (West Germany).* Materials and Processes Development Dept.

DETECTABILITY OF FLAWS IN BORON AND CARBON COMPOSITE PARTS

Gustav Tober and Hilmar Schnell *In* AGARD Non-destructive Inspection Relationships to Aircraft Design and Mater. Mar. 1978 14 p (For availability see N78-26460 17-38)
Avail: NTIS HC A15/MF A01

The experience gained in nondestructive testing in the development of boron fiber reinforced plastics and carbon fiber reinforced plastics is discussed. The soft X-ray technique, ultrasonic, acoustic flaw detector, sonic resonator, holography, and tapping test are among the methods described. Types of faults detected by each method are reported along with the capacity of each method for practical use. J.M.S.

N78-26478# Laboratoire Central Aerospatiale, Suresnes Cedex (France).

THE PRESENT STATUS AND EVOLUTION OF THE INSPECTION OF CARBON COMPOSITE AIRCRAFT STRUCTURES IN FRANCE [ETAT ACTUEL ET EVOLUTION EN FRANCE DU CONTROLE DE STRUCTURES D'AVION EN COMPOSITES CARBONE]

M. Treca *In* AGARD Non-destructive Inspection Relationships to Aircraft Design and Mater. Mar. 1978 7 p refs In FRENCH (For availability see N78-26460 17-38)
Avail: NTIS HC A15/MF A01

A number of nondestructive test methods utilized for the inspection of composite aircraft structures were studied. These methods are now being evaluated and are utilized in industry. The best method suitable for the inspection of monolithic structures is testing by ultrasonic transmission. Holographic interferometry appears to be a global method for the inspection of sandwich structures which can be applied to industrial use. Transl. by B.B.

N78-26479# Societe Nationale Industrielle Aerospatiale, Saint-Medard-en-Jalles (France).

NONDESTRUCTIVE INSPECTION OF COILED STRUCTURES AND THE RECEIPT OF RAW MATERIALS [CONTROLE NON-DESTRUCTIF DES STRUCTURES BOBINEES ET RECEPTION DES MATIERES PREMIERES]

Jean-Pierre Maigret *In* AGARD Non-destructive Inspection Relationships to Aircraft Design and Mater. Mar. 1978 13 p In FRENCH (For availability see N78-26460 17-38)
Avail: NTIS HC A15/MF A01

The reliability of coiled structures, especially those for solid rocket propellants is assured by the acceptance inspection of materials which rely on conventional mechanical tests associated with physical-chemical inspection (infrared microcalorimetry spectroscopy, etc) to verify the peremption level and the aging of organic materials, and by the two-phase nondestructive inspection of subassemblies and completed structures by thermography followed by ultrasonic and X-ray inspection to characterize the defects. Continuing efforts in inspection are directed towards enlarging the field of nondestructive methods by investigating the introduction of holography and acoustic analysis, and by improving physical-chemical techniques for better evaluation of the life of organic materials. Transl. by A.R.H.

N78-26480# Army Missile Research and Development Command, Redstone Arsenal, Ala. Advanced Systems Development and Manufacturing Technology Directorate.

DETECTION OF FLAWS IN METALLIC AND NON-METALLIC COMPOSITE STRUCTURES USING LIQUID CRYSTAL TECHNOLOGY

Shelba Profitt Brown *In* AGARD Non-destructive Inspection Relationships to Aircraft Design and Mater. Mar. 1978 14 p (For availability see N78-26460 17-38)
Avail: NTIS HC A15/MF A01

An experimental nondestructive test technique using brush on liquid crystals and custom liquid crystal films is described. Application of the technique to metallic and nonmetallic composites is discussed along with demonstration of the technique on missile wings and elevons, aircraft and helicopter blades, composite body structures, and numerous types of electronic equipment. J.M.S.

N79-25407# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).

METHODOLOGY FOR CONTROL OF LIFE CYCLE COSTS FOR AVIONICS SYSTEMS

Apr. 1979 150 p refs Lectures presented at Bonn, 7-8 May 1979 and Athens, 10-11 May 1979
(AGARD-LS-100; ISBN-92-835-1321-5) Avail: NTIS HC A07/MF A01

Various aspects of life cycle costs as relating to airborne equipment are presented. Included are: the model of a Canadian microtacan, research on the reliability of the systems, and methods for the control of the costs. For individual titles, see N79-25408 through N79-25411.

N79-25408# General Research Corp., Santa Barbara, Calif.

LIFE CYCLE COST ANALYSIS CONCEPTS AND PROCEDURES

Edward N. Dodson *In* AGARD Methodology for Control of Life Cycle Costs for Avionics Systems Apr. 1979 28 p refs (For primary document see N79-25407 16-38)
Avail: NTIS HC A07/MF A01

The principles and procedures of parametric cost analysis based upon aggregate relationships between cost and the physical/performance characteristics of high technology equipment are presented. M.M.M.

N79-25409# Bell-Northern Research Ltd., Ottawa (Ontario). Contract Reliability Engineering.

THE DEVELOPMENT AND IMPLEMENTATION OF LIFE CYCLE COST METHODOLOGY

T. D. Kiang *In* AGARD Methodology for Control of Life Cycle Costs for Avionics Systems Apr. 1979 25 p refs (For primary document see N79-25407 16-38)
Avail: NTIS HC A07/MF A01

The concepts of the life cycle management and the life cycle costing process suitable for the Canadian Forces environments are presented. The features of the life cycle management cost model and its capability to relate cost and system effectiveness factors are discussed. The results of the model application to the AN/ARN-504 microtacan are presented. M.M.M.

N79-25410# Rome Air Development Center, Griffiss AFB, N.Y.

RECENT EXPERIENCE IN THE DEVELOPMENT AND APPLICATION OF LCC MODELS

Jerome Klion and Anthony Coppola *In* AGARD Methodology for Control of Life Cycle Costs for Avionics Systems Apr. 1979 150 p refs (For primary document see N79-25407 16-38)
Avail: NTIS HC A07/MF A01

A description of various models which incorporate acquisition costs and operation support costs as they apply to avionics procurements are presented. The methods by which the models are developed along with their shortcomings and sensitivities are reported. M.M.M.

N79-25411# Ministry of Defence, London (England).

PROBLEMS IN THE INVESTIGATION OF RELIABILITY-ASSOCIATED LIFE-CYCLE COSTS OF MILITARY AIRBORNE SYSTEMS

P. G. Reich *In* AGARD Methodology for Control of Life Cycle Costs for Avionics Systems Apr 1979 21 p refs (For primary document see N79-25407 16-38)
Avail: NTIS HC A07/MF A01

The problems of deriving improved control of the life cycle costs that are associated with reliability are discussed as well as the relationships between the many possible sorts of investment resulting in better reliability and maintainability and the benefits it achieves. Considered are the difficulty in overcoming data acquisition, and the methodology for handling the complex properties of reliability and maintainability of airborne weapons systems. M.M.M.

N79-25412# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
NON-DESTRUCTIVE INSPECTION METHODS FOR PROPULSION SYSTEMS AND COMPONENTS
Apr 1979 70153 p refs In ENGLISH and partly in FRENCH Lecture series held at London, 23-24 Apr 1979 and Milan, 26-27 Apr 1979
(AGARD-LS-103, ISBN-92-835-0237-X) Avail: NTIS HC A08/MF A01

The state-of-the-art and the foreseeable or hoped progress of the nondestructive inspection methods applied to the turbine and pistons engine are examined and discussed. The following topics are discussed: (1) nondestructive inspection of aircraft engines; (2) high resolution radiography in the aero-engine industry; (3) wear debris analysis; (4) high resolution ultrasonic nondestructive testing of complex geometry components; (5) nondestructive methods for the early detection of fatigue damage in aircraft components; (6) in situ inspection of electron beam weld by acoustic emission; and (7) broadband ultrasonic transducers for nondestructive inspection of aeronautical components. For individual titles, see N79-25413 through N79-25419.

N79-25413# General Electric Co., Cincinnati, Ohio.
STATE-OF-THE-ART OF NONDESTRUCTIVE INSPECTION OF AIRCRAFT ENGINES
D. M. Comassar *In* AGARD Non-destructive Inspection Methods for Propulsion Systems and Components Apr 1979 12 p refs (For primary document see N79-25412 16-38)
Avail: NTIS HC A08/MF A01

There are five basic nondestructive inspection disciplines which are more commonly applied to engine components, namely ultrasonic, eddy current, fluorescent penetration, radiographic and magnetic particle inspection. There are a number of recent advancements in the ultrasonic and eddy current processes as well as improvements in the fluorescent penetration process. These are discussed. These advancements are primarily in the equipment area and in the automation of the inspection process. The discussion focuses on improvements in the ultrasonic, eddy current and fluorescent penetration processes. Several nonconventional techniques used for inspection of development hardware are also discussed. G.Y.

N79-25414# Atomic Energy Research Establishment, Harwell (England). Material Physics Div.
HIGH RESOLUTION RADIOGRAPHY IN THE AERO-ENGINE INDUSTRY
R. W. Parish *In* AGARD Non-Destructive Inspection Methods for Propulsion Systems and Components Apr 1979 38 p refs (For primary document see N79-25412 16-38)
Avail: NTIS HC A08/MF A01

Microfocal X-ray equipment which in certain circumstances can achieve considerably enhanced resolution is discussed and emphasis is placed on the application of these small X-ray sources to aero-engine components. These techniques allow small defects to be resolved which hitherto were undetectable when using conventional X-ray techniques. G.Y.

N79-25415# Royal Aircraft Establishment, Farnborough (England)
WEAR DEBRIS ANALYSIS
N. L. Parr and J. Ritchie *In* AGARD Non-Destructive Inspection Methods for Propulsion Systems and Components Apr 1979 20 p refs (For primary document see N79-25412 16-38)
Avail: NTIS HC A08/MF A01

Factors controlling the cost of ownership of expensive military equipment are outlined with specific reference to the role of wear on scheduled and unscheduled maintenance. The value and limitations of established condition monitoring techniques and procedures are explored for engine, gearbox and hydraulic systems. An account is given of current effort to improve these techniques and of research to evolve meaningful monitoring measures for a more scientific approach to the development and operation of new machinery incorporating advanced engineering designs and materials. An idealized research and development, centered on gear profile failure demonstrator facilities, including a number of supporting scientific, technological and design exercises, is presented. G.Y.

N79-25416# Air Force Materials Lab., Wright-Patterson AFB, Ohio.
HIGH RESOLUTION ULTRASONIC NONDESTRUCTIVE TESTING OF COMPLEX GEOMETRY COMPONENTS
T. J. Moran *In* AGARD Non-Destructive Inspection Methods for Propulsion Systems and Components Apr 1979 6 p refs (For primary document see N79-25412 16-38)
Avail: NTIS HC A08/MF A01

Research in ultrasonic nondestructive inspection methods in the USA has undergone a major change in philosophy in the last four years. Previous emphasis was on the detection of flaws, while present work concentrates on the characterization of the flaw and the material state. The background of events leading to this change are discussed. Along with the change in direction of research, developments efforts concentrated on improving the reliability of the detection of defects. Major programs were directed toward the goal of a completely automated ultrasonic inspection system which would effectively remove the human factor. Several systems which were designed for the inspection of complex shapes are described. G.Y.

N79-25417# Johns Hopkins Univ., Baltimore, Md. Dept. of Mechanics and Materials Science
NON-DESTRUCTIVE METHODS FOR THE EARLY DETECTION OF FATIGUE DAMAGE IN AIRCRAFT COMPONENTS
Robert E. Green, Jr. *In* AGARD Non-Destructive Inspection Methods for Propulsion Systems and Components Apr 1979 31 p refs (For primary document see N79-25412 16-38)
Avail: NTIS HC A08/MF A01

The various nondestructive techniques which are used or which are potentially useful for detection of fatigue damage in aircraft components are described and discussed. Included among the nondestructive techniques which are considered are radiography, penetrant inspection, eddy current, ultrasonics, acoustic emission, magnetic particle and Barkhausen noise analysis, and more exotic techniques such as exoelectron emission, positron annihilation, and other atomic, nuclear, or solid state physics reactions. G.Y.

N79-25418# Centre Technique des Industries Mecaniques, Senlis (France).
IN SITU INSPECTION OF ELECTRON BEAM WELD BY ACOUSTIC EMISSION
P. F. Dumosseau *In* AGARD Non-Destructive Inspection Methods for Propulsion Systems and Components Apr. 1979 14 p refs In FRENCH; ENGLISH summary (For primary document see N79-25412 16-38)
Avail: NTIS HC A08/MF A01

Acoustic emission applicability to nondestructive inspection, particularly to welding control, is discussed. A general presentation of the technique emphasizes instrumentation and signal processing aspects. Advantages and disadvantages are discussed. Experimental work performed to check feasibility of applying this control to welding of gas turbine components is detailed. Emissive behavior of various materials is considered referring to their crack suspectability. It concerns annealed steel, stainless steels, titanium alloys, and Inconel 718. Results of tests conducted on linear and circular welds of specimens and real components are presented and discussed. The practical problems involved in industrial application are considered. G.Y.

N79-25419# Office National d'Etudes et de Recherches Aerospatiales, Paris (France).
BROAD-BAND TRANSDUCERS FOR NONDESTRUCTIVE INSPECTION OF AERONAUTICAL COMPONENTS
Jean-Francois deBelleval *In* AGARD Non-Destructive Inspection Methods for Propulsion Systems and Components Apr 1979 10 p refs In FRENCH, ENGLISH summary (For primary document see N79-25412 16-38)
Avail: NTIS HC A08/MF A01

For ultrasonic nondestructive inspection of aeronautical components, it is mandatory to detect defects both smaller and smaller, and nearer and nearer the surface of these components The quantitative evaluation of these defects, allowing a definition of their mechanical consequences, must also be improved. This requires the use of more sensitive ultrasonic transducers, with a larger bandwidth. The main method used at present to increase the bandwidth of piezoelectric transducers entails an important decrease of their sensitivity: it is based on the damping of the piezoelectric wafer on its rear face. Suggested to use instead damping by a multilayer front face, which allows a simultaneous increase of both sensitivity and bandwidth. In order to study the feasibility of this process, a computing program was developed to calculate the propagation of a wave through several layers of different thicknesses. This program makes it possible to optimize the characteristics (impedance and thickness) of the various layers making up the transducer. Comparisons with actual transducers allowed the validation of this theoretical model. G.Y.

N80-19519# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
AVIONICS RELIABILITY, ITS TECHNIQUES AND RELATED DISCIPLINES
Manfred C. Jacobson (AeG-Telefunken, Ulm, West Germany) Oct. 1979 536 p refs In ENGLISH and FRENCH Conf. held in Ankara, 9-13 Apr. 1979
(AGARD-CP-261; ISBN-92-835-0254-X) Avail: NTIS HC A23/MF A01

A state of the art review of topics related to reliability and logistics in avionics systems is given. General concepts, reliability/availability requirements and demonstration, reliability and maintainability practices and effects in avionics design, development and production, software reliability, and logistics support aspects are among the topics discussed. For individual titles, see N80-19520 through N80-19561.

N80-19520# Naval Postgraduate School, Monterey, Calif.
AN ANALYSIS OF THE EVOLUTION OF THE RELIABILITY AND MAINTAINABILITY DISCIPLINES
M. B. Kline, J. Di Pasquale, T. A. Hamilton, and R. L. Masten *In* AGARD Avionics Reliability, Its Tech. and Related Disciplines Oct. 1979 24 p Prepared in cooperation with Naval Weapons Center (For primary document see N80-19519 10-38)
Avail: NTIS HC A23/MF A01

The results of a study of the development of the reliability and maintainability (R&M) disciplines are presented. The exponential rate of growth shown during this period is an indication of the dynamic nature and importance of these disciplines to system development, design, and operation. Family trees of each discipline developed to indicate the growth and branching of the relevant subject matter are presented. The direction and rate of growth of these disciplines in each of the decades of interest are analyzed along with projections of current and future trends. Applications of R&M in both the private and public sectors, including defense, space, energy, transportation, industrial and consumer items, are examined. J.M.S.

N80-19521# Royal Signals and Radar Establishment, Malvern (England).
DIFFICULTIES IN PREDICTING AVIONICS RELIABILITY
J. E. Green *In* AGARD Avionics Reliability, Its Tech. and Related Disciplines Oct. 1979 7 p refs (For primary document see N80-19519 10-38)
Avail: NTIS HC A23/MF A01

Avionics reliability prediction techniques are considered with particular attention given to factors which significantly influence reliability. These include types of aircraft, the duration and type of sortie, the frequency of use and the incidence of reported but unconfirmed failures which nevertheless result in maintenance actions. It is shown that failures are nonexponentially distributed during a sortie although conventional predictions are based on the exponential distribution. Therefore various proposals for predicting avionics reliability are presented to overcome this discrepancy. The difficulties in making predictions for the latest microelectronic devices are considered with reference to MIL-HDBK-21 B and emphasis on the potential reliability of LSI and microprocessors. The significance of the choice of quality factors is noted. J.M.S.

N80-19522# Naval Postgraduate School Monterey Calif.
RELIABILITY GROWTH MODELS
W. M. Woods *In* AGARD Avionics Reliability, Its Tech. and Related Disciplines Oct. 1979 21 p refs (For primary document see N80-19519 10-38)
Avail: NTIS HC A23/MF A01

The concept of reliability growth models is introduced. Two reliability growth models are presented: one for time data and one for attributes data. Their uses are discussed and the methods for evaluating them are presented in graphical and tabular form. Both models show reasonable accuracy for reasonable amounts of testing under a wide variety of actual reliability growth and nongrowth. J.M.S.

N80-19523# Elektronik-System G.m.b.H., Munich (West Germany)
A SIMULATION PROGRAM FOR THE DETERMINATION OF SYSTEM RELIABILITY OF COMPLEX AVIONIC SYSTEMS
Christian Krause and Hubert Limbrunner *In* AGARD Avionics Reliability, Its Tech. and Related Disciplines Oct. 1979 9 p ref (For primary document see N80-19519 10-38)
Avail: NTIS HC A23/MF A01

The simulation program SIMZUV which computes system reliability according to the Monte Carlo method is described. This program enables the realistic consideration of complex failure logics of meshed systems, couplings of failures of different units and different mission phases, which is possible by the selection of a certain formulation of these marginal conditions. In its capacity as a simulation program, SIMZUV is capable of considering condition and time dependent failure rates and various unit reliability functions. It is shown that it is possible to perform the simulation of a substitute system of higher failure rates with short computer time, after a transformation of the failure rates. It is demonstrated that the reliability curve of the actual system can be computed from the reliability curve of the substitute system via a linear system of equations.

N80-19524# British Aerospace Dynamics Group, Stevenage (England).
MICRO-ELECTRONIC SYSTEMS RELIABILITY PREDICTION
P. D. T. OConnor *In* AGARD Avionics Reliability, Its Tech. and Related Disciplines Oct. 1979 9 p refs (For primary document see N80-19519 10-38)
Avail: NTIS HC A23/MF A01

Existing methods of parts stress analysis failure rate prediction, based upon US-MIL-HBK-217C, as applied to microelectronic logic and memory devices are reviewed. The extent to which the failure rate prediction formulas used in MIL-HBK-217C are compatible with the physics of the various failure modes experienced, and with the failure statistics available, are investigated. The effects of the failure rate distributions of the various failure modes are considered in relation to the objective of deriving a simple constant-failure-rate prediction model. Proposals are made for methods of improving the effectiveness of micro-electronics reliability prediction both as a design aid and for forecasting, and for areas of further study. A proposed alternative model is presented, with an example of its use to predict the failure rate of a typical system. J.M.S.

N80-19525# Air Force Inst. of Tech., Wright-Patterson AFB, Ohio. Dept. of Electrical Engineering.
MARKOVIAN AVAILABILITY MODEL FOR A NETWORK OF

COMMUNICATING COMPUTERS
Thad L Regulinski *In* AGARD Avionics Reliability Its Tech and Related Disciplines Oct 1979 7 p refs (For primary document see N80 19519 10 38)
Avail NTIS HC A23/MF A01

The availability function is modeled from a Markovian state discrete time continuous formulation encompassing those adverse conditions which contribute to the network s total down time The results of three and four state models are derived under assumption of temporally homogeneous first order Markovian process Using sensitivity analysis the effect of variation of state transition probabilities on the steady state availability function is examined and illustrated by an example J M S

N80-19526# Societe Nationale Industrielle Aerospatiale Les Mureaux (France) Div des Systemes Balistiques et Spatiaux
FAST ESTIMATION OF THREE PARAMETERS OF WEIBULL LAW [ESTIMATION RAPIDE DES TROIS PARAMETRES D'UNE LOI DE WEIBULL]
Robert Attuly and Christian Bertin *In* AGARD Avionics Reliability Its Tech and Related Disciplines Oct 1979 27 p refs In FRENCH (For primary document see N80 19519 10 38)
Avail NTIS HC A23/MF A01

Estimating the three parameters of Weibull distribution is a delicate operation particularly in the case of a small size population The maximum likelihood method (M L E) leads to a system of equations requiring considerable calculation moreover the convergence of algorithms is not guaranteed by reason of the particular form of the probability function The saturation method proposed uses the quasi exhaustivity of a small number of statistics related to the population and gives results near those obtained by the M L E method (when it can be used) and also provides the advantages of being easy graphic or analytic The method accounts for the size of the sample Only the statistics associated with the population must be stored in the memory In addition, the method is free (in the sense of E T Jayne) from errors related to the hypothesis of the rule This point leads to the concept of a reduced parametric hypothesis, and in particular, to the four parametric law which generalizes the Weibull distribution, the gamma function and the normal density function at the same time Transl by A R H

N80-19527# Arinc Research Corp Annapolis, Md
RELIABILITY IMPROVEMENT WARRANTY: AN OVERVIEW
Harold S Balaban *In* AGARD Avionics Reliability Its Tech and Related Disciplines Oct 1979 9 p refs (For primary document see N80-19519 10-38)
Avail NTIS HC A23/MF A01

The concept, genesis, and development of reliability improvement warranty (RIW) in the United States is reviewed The application of RIW concepts to military procurements is dicussed The rapidly increasing use of this procurement/logistic concept strongly suggests that RIW is now a viable approach to securing reliable and maintainable equipment at a reasonable cost R E S

N80-19528# Thomson-CSF Orsay (France)
RELIABILITY CLAUSES IN CONTRACTS [LES CLAUSES DE FIABILITE DANS LES CONTRATS]
J P Plantard *In* AGARD Avionics Reliability, Its Tech and Related Disciplines Oct 1979 8 p In FRENCH (For primary document see N80-19519 10-38)
Avail NTIS HC A23/MF A01

The contents of two documents produced by an interministerial Working Group of the Committee for Telecommunication Coordination are examined with respect to the objectives, the most prominent technical points, and the details for their application The documents cited contain recommendations for the introduction of reliability clauses for equipment and systems Guidelines for establishing a reliability plan are included Transl by A R H

N80-19529# Crouzet Aerospace and Systems, Valence (France)
THE INCREASE OF THE RELIABILITY OF ELECTRONIC EQUIPMENT SUBJECT TO RELIABILITY CLAUSES [ETUDE DE LA CROISSANCE DE LA FIABILITE D'UN EQUIPMENT ELECTRONIQUE SOUMIS A DES CLAUSES DE FIABILITE]
J C Chabin *In* AGARD Avionics Reliability, Its Tech and Related Disciplines Oct 1979 9 p refs In FRENCH (For primary document see N80-19519 10-38)
Avail NTIS HC A23/MF A01

The appearance of reliability warranties is one of the preponderant factors in the interest shown by equipment manufacturers in techniques for reliability forecasting The results established at the beginning of work with material are often very far from the forecast but the different tasks associated with the reliability programs applied to equipment allow for improvement in performance Knowledge of the rule of reliability growth as a function of the time of accumulated operation of the equipment that is made the object of permanent efforts of improvement should help the equipment manufacturer to better support his reliability forecast when negotiating a warranty Transl by A R H

N80-19530# Service Technique des Telecommunications de l Air Paris (France)
RELIABILITY IMPROVEMENT DUE TO THE APPLICATION OF CLAUSES OF OPERATIONAL RELIABILITY [AMELIORATIONS DE FIABILITE DUES A L'APPLICATION DES CLAUSES DE FIABILITE OPERATIONELLE]
J Laurensou *In* AGARD Avionics Reliability Its Tech and Related Disciplines Oct 1979 9 p In FRENCH (For primary document see N80 19519 10 38)
Avail NTIS HC A23/MF A01

Good reliability in the diverse constituents is necessary in order to obtain the good operational availability of any weapon system All organized bodies charged with provisioning or maintaining equipment are concerned with obtaining the optimum reliability taking into account the imposed financial constraints Reliability is determined by choices made from the time of equipment design but it can be improved by observing its real operation and by modifying it The system used to recognize and improve the reliability of certain equipment used on different aircraft in the French army is described and results are given for a concrete case To be able to improve the reliability of equipment the following are necessary (1) gather data concerning failures (technical facts) (2) determine the actual reliability during use (3) define the modifications to be made (4) persuade the manufacturer to improve the reliability of the equipment and make modifications and (5) control the incidences of improvements in reliability Transl by A R H

N80-19531# Messerschmitt Boelkow Blohm G m b H Munich (West Germany)
PRODUCTION RELIABILITY ASSURANCE (PRA) TESTING
Artfried Weihe *In* AGARD Avionics Reliability Its Tech and Related Disciplines Oct 1979 10 p (For primary document see N80 19519 10 38)
Avail NTIS HC A23/MF A01

Production reliability assurance (PRA) tests are all equipment reliability tests which are applied for assurance purposes during the production phase of major equipments once the formal qualification status concerning reliability is achieved A fundamental principle of the tests is the liability of the present and/or if the corrective action required (CAR) line is exceeded by the plot of accumulated failures Suitable test conditions for both producer and customer are obtained by selection of an appropriate CAR line and by restart of the plot after a specific test experience is gained A comparison with fixed length tests shows that shorter time to decisions is obtained in the case of PRA testing R E S

N80-19532# Thomson-CSF Malakoff (France)
METHODS USED FOR DISCERNING THE RELIABILITY OF MILITARY AIRCRAFT RADAR [METHODES UTILISEES POUR CONNAITRE LA FIABILITE D'UN RADAR D'AVION D'ARMES]
J C Charlot *In* AGARD Avionics Reliability Its Tech and Related Disciplines Oct 1979 20 p In FRENCH (For primary document see N80 19519 10 38)
Avail NTIS HC A23/MF A01

In an effort to ascertain the reliability of a radar onboard a military aircraft Thomson-CFS formed an organization to collect and process the information necessary to measure the mean time of good operation The methods for data acquisition, the members of the organization in 1979, the data management and prospects for the future (extension to other equipment and information concerning component fabrication) are discussed Transl by A R H

N80-19533# Draper (Charles Stark) Lab Inc Cambridge Mass
A FAULT TOLERANT ARCHITECTURE APPROACH TO AVIONICS RELIABILITY IMPROVEMENT

Donald C Fraser and John J Deyst *In* AGARD Avionics Reliability. Its Tech and Related Disciplines Oct 1979 9 p refs (For primary document see N80-19519 10-38)
Avail NTIS HC A23/MF A01

A difficult technology challenge in the reliability of avionics systems for advanced aircraft is identified. Three architectures are compared on the basis of a number of criteria which together constitute the issues which must be examined when considering the overall reliability, maintenance, and support problem. It is concluded from these comparisons and the limitations identified in contemporary approaches that the only effective and practical solution to the reliability challenge is through architecture. An advanced integrated, distributed fault and damage tolerant digital avionics system architecture is summarized which shows promise of meeting this challenge. Author

N80-19634*# National Aeronautics and Space Administration Langley Research Center, Langley Station, Va
TRENDS IN RELIABILITY MODELING TECHNOLOGY FOR FAULT TOLERANT SYSTEMS
Salvatore J Bavuso *In* AGARD Avionics Reliability, Its Tech and Related Disciplines Oct 1979 12 p refs (For primary document see N80-19519 10-38)
Avail NTIS HC A23/MF A01 CSCL 14D

Developments in reliability modeling for large fault tolerant avionic computing systems are presented. Issues of state size and complexity, fault coverage, and practical computation are addressed. A two-fold developmental effort is described based on the structural and fault coverage modeling approaches. A technique which was successfully applied to an 865 state pure death stationary Markov model is presented. Of particular interest is a short computer program which executes very quickly to produce reliability results of a large state space model. This model also incorporates fault coverage states for processor, memory, and bus line replaceable units. A second structural reliability modeling scheme is aimed at solving nonstationary Markov models. This technique provides the tool required for studying the reliability of systems with nonconstant failure rates and includes intermittent/transient faults, electronic hardware which exhibits decreasing failure rates, and hydromechanical devices which typically have wearout failure mechanisms. Several aspects of fault coverage, including modeling and data measurement of intermittent/transient faults and latent faults, are elucidated and illustrated. The CARE II (computer-aided reliability estimation) coverage is presented and shortcomings to be eliminated are discussed. K L

N80-19635# Dowty Boulton Paul Ltd., Wolverhampton (England)
NONELECTRONIC ASPECTS OF AVIONIC SYSTEM RELIABILITY
C V Kenmir, R G Hilton, and H H Dixon *In* AGARD Avionics Reliability, Its Tech and Related Disciplines Oct 1979 12 p (For primary document see N80-19519 10-38)
Avail NTIS HC A23/MF A01

Methods of obtaining actuation system integrity by means of redundancy are examined. The effects of control surface layout, number of power supplies, and the form of the avionics on the chosen solution are investigated. The effect of redundancy on defect rates is also discussed. Developments which improve reliability and remove constraints are considered. K L

N80-19636# Electronique Marcel Dassault, St. Cloud (France)
IMPACTS OF TECHNOLOGIES SELECTED ON THE RELIABILITY AND OPERATIONAL AVAILABILITY OF EQUIPMENTS. COST CONSIDERATIONS
J M Girard and M Giraud *In* AGARD Avionics Reliability, Its Tech and Related Disciplines Oct 1979 17 p refs (For primary document see N80-19519 10-38)
Avail NTIS HC A23/MF A01

A single criterion, V, is proposed to allow manufacturers to evaluate the merits of technological variants once an equipment baseline version is designed and quoted. The V factor is computed for an airborne digital computer, a Doppler navigational radar, and a search and rescue beacon, each considered in three different versions. K L

N80-19637# Rome Air Development Center, Griffiss AFB, N Y
A NEW APPROACH TO MAINTAINABILITY PREDICTION
Joseph J Naresky *In* AGARD Avionics Reliability, Its Tech. and Related Disciplines Oct 1979 14 p refs (For primary document see N80-19519 10-38)
Avail NTIS HC A23/MF A01

A time synthesis maintainability prediction method was developed which directly relates diagnostic, isolation, and test subsystem characteristics to equipment/system maintainability parameters. A comprehensive set of time standards applicable to physical maintenance actions associated with equipment construction and packaging procedures is also provided. Predicted parameters include mean time to repair, maximum time to repair, mean maintenance man hours per repair, and fault isolation resolution. The method includes techniques for use with both preliminary and final design data. K L

N80-19638# Westinghouse Defense and Electronic Systems Center, Baltimore, Md
RELIABILITY GROWTH THROUGH ENVIRONMENTAL SIMULATION
Lawrence J Phaller *In* AGARD Avionics Reliability, Its Tech and Related Disciplines Oct 1979 8 p refs (For primary document see N80-19519 10-38)
Avail NTIS HC A23/MF A01

Field data were used to identify unreliable line replaceable units and implement design improvements. The rate of reliability growth was found to be dependent on the unit complexity and the state of the art of the unit. Reliability growth occurred in both design and quality control. K L

N80-19639# Marconi-Elliott Avionic Systems Ltd., Rochester (England).
THE A-7 HEAD-UP DISPLAY RELIABILITY PROGRAMME
K. W. Boardman *In* AGARD Avionics Reliability, Its Tech and Related Disciplines Oct 1979 14 p refs (For primary document see N80-19519 10-38)
Avail: NTIS HC A23/MF A01

The evolution of the head-up display from earlier forms of weapon aiming techniques is described. The A-7 head-up display is then introduced in terms of the reliability requirements and the contracting environment. Technical innovations introduced to meet the reliability requirements are described with emphasis on thermal design, ruggedized long life cathode ray tube technology, and durability of low voltage printed circuit connectors. The cost benefit of the reliability program is discussed. K L

N80-19640# Army Avionics Research and Development Activity, Fort Monmouth, N J
MILITARY ADAPTION OF A COMMERCIAL VOR/ILS AIRBORNE RADIO WITH A RELIABILITY IMPROVEMENT WARRANTY
Earl I. Feder and Douglas L. Niemoller (Bendix Corp., Fort Lauderdale, Fla.) *In* AGARD Avionics Reliability, Its Tech. and Related Disciplines Oct 1979 8 p (For primary document see N80-19519 10-38)
Avail NTIS HC A23/MF A01

Low cost, small, lightweight airborne navigation receivers were acquired and reconfigured to meet U.S. Army aircraft specifications. The contract includes a clause requiring the manufacturer to assume responsibility for the field reliability and repair of each receiver for a minimum of four years. If successfully implemented, the reliability improvement warranty should increase reliability, availability, and maintainability and reduce the overall equipment life cycle costs. K L

N80-19641*# National Aeronautics and Space Administration Langley Research Center, Langley Station, Va
EMULATION APPLIED TO RELIABILITY ANALYSIS OF RECONFIGURABLE, HIGHLY RELIABLE, FAULT-TOLERANT COMPUTING SYSTEMS
Gerard E Migneault *In* AGARD Avionics Reliability, Its Tech and Related Disciplines Oct 1979 11 p refs (For primary document see N80-19519 10-38)
Avail NTIS HC A23/MF A01 CSCL 14D

Emulation techniques applied to the analysis of the reliability of highly reliable computer systems for future commercial aircraft are described. The lack of credible precision in reliability estimates obtained by analytical modeling techniques is first established. The difficulty is shown to be an unavoidable consequence of: (1) a high reliability requirement so demanding as to make system evaluation by use testing infeasible; (2) a complex system design technique, fault tolerance; (3) system reliability dominated by errors due to flaws in the system definition; and (4) elaborate analytical modeling techniques whose precision outputs are quite sensitive to errors of approximation in their input data. Next, the technique of emulation is described, indicating how its input is a simple description of the logical structure of a system and its output is the consequent behavior. Use of emulation techniques

is discussed for pseudo-testing systems to evaluate bounds on the parameter values needed for the analytical techniques. Finally an illustrative example is presented to demonstrate from actual use the promise of the proposed application of emulation. M.G.

N80-19542# *Rome Air Development Center, Griffiss AFB, N.Y.* Reliability and Compatibility Div.

RELIABILITY ASSURANCE FOR LARGE SCALE INTEGRATED CIRCUITS

Robert A. McDonald. *In* AGARD Avionics Reliability, Its Tech. and Related Disciplines Oct. 1979 8 p refs (For primary document see N80-19519 10-38)

Avail: NTIS HC A23/MF A01

A procedure for assuring the reliability of large scale integrated circuits is presented. The procedure uses the parts of commercially proven architecture and circuit design while imposing strict procedures on the manufacture and testing of the devices. The program is divided into three broad areas of responsibility. The product evaluation group selects, analyzes, and prepares reports on devices of potential or current interest to the military. The reports are disseminated to government agencies and describe the physical construction, technology, packaging, workmanship, input protection problems, utilization difficulties, and electrical design risks. The electrical characterization group is tasked with characterizing specific devices selected for inclusion in the military specification system. The characterization effort generates the required acceptance tests that each part must pass before use and prepares device detail specifications. Overall effects of circuit loading, technology compatibility, and test vector generation are considered. The reliability assurance group stress tests the devices, assesses the failure modes, and projects a system use failure rate. M.G.

N80-19543# Thomson-CSF, Paris (France). Electron Tube Div.

RELIABILITY OF HIGH-BRIGHTNESS CRTS FOR AIRBORNE DISPLAYS

J. P. Galves and J. Brun. *In* AGARD Avionics Reliability, Its Tech. and Related Disciplines Oct. 1979 14 p (For primary document see N80-19519 10-38)

Avail: NTIS HC A23/MF A01

The reliability of high brightness monochrome or color cathode ray tubes (CRT's) for aircraft head-up display and head-down display systems is examined. The specification, which includes electrooptical performance and environmental conditions, defines the tube quality at zero operating time. Two typical examples of specifications are given. The problems encountered in designing tubes, and the solutions used to obtain the desired level of quality are briefly discussed. Reliability testing concerns random failures that occur during normal operation of the tube. After a short mathematical treatment of the principles involved, three examples of reliability tests carried out on CRT's are given. The electrooptical characteristics of CRT change during operation. This is mainly a cathode and screen wearing-out phenomenon. The life expectancy of a CRT depends on this evolution, and is thus a function of tube operating conditions. M.G.

N80-19544# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (West Germany).

RELIABILITY INVESTIGATIONS ON AN AUTOMATIC TEST SYSTEM

Hans-Herman Molter. *In* AGARD Avionics Reliability, Its Tech. and Related Disciplines Oct. 1979 13 p refs (For primary document see N80-19519 10-38)

Avail: NTIS HC A23/MF A01

Statistical methods, used to determine the reliability of a complex guided missile test system, are presented. When operating such a system, failures occur which are documented in failure reports. The failure-free periods between successive failure events are evaluated in the context of a Weibull distribution, yielding statements as to the mean time between failures, and the type of failure. The results are used to compare various systems; the influences exerted by differing operating conditions likewise become evident. The values determined in this way also contribute to localizing weak points, thus enabling purposive design measures to further increase the reliability of the test system. M.G.

N80-19545# Naval Postgraduate School, Monterey, Calif.

APPLICATION OF THE LOGNORMAL DISTRIBUTION TO CORRECTIVE MAINTENACE DOWNTIMES

Melvin B. Kline and Ronny Almog (Israeli Navy, Tel Aviv) *In* AGARD Avionics Reliability, Its Tech. and Related Disciplines Oct. 1979 14 p refs (For primary document see N80-19519 10-38)

Avail: NTIS HC A23/MF A01

An analysis of corrective maintenance downtimes based on the assumption of the lognormal distribution is presented. Approximately 20 sets of existing maintainability demonstration and field data are analyzed using probability plots and goodness-of-fit tests to determine the appropriate distribution and distribution parameters. From the data analysis it is concluded that the lognormal distribution is a good descriptor of the distribution of corrective maintenance repair time. Fifteen of the nineteen cases from maintainability demonstrations of radically different designs tend to show that, with an acceptable level of significance, this assumption cannot be rejected. Similarly, the data analysis shows that the assumption of an exponential distribution should be rejected in seventeen of the cases. The percentage error in the 'mean time to repair', when assuming an exponential distribution instead of a lognormal distribution, as a matter of convenience, for calculating system availability, is found to be small. M.G.

N80-19546# Elliott-Automation Space and Advanced Military Systems Ltd., Camberley (England).

RELIABILITY MANAGEMENT OF THE AVIONIC SYSTEM OF A MILITARY STRIKE AIRCRAFT

A. P. White and J. D. Pavier. *In* AGARD Avionics Reliability, Its Tech. and Related Disciplines Oct. 1979 13 p refs (For primary document see N80-19519 10-38)

Avail: NTIS HC A23/MF A01

The system management techniques to achieve the reliability requirements for the avionic system of the Panavia Tornado aircraft are described. The method of apportionment of these requirements to each of the constituent parts of the system is explained. The aims, cost effectiveness, and experience to date of reliability demonstrations are outlined. M.G.

N80-19547# AEG-Telefunken, Ulm (West Germany).

INTRODUCTION TO SOFTWARE RELIABILITY: A KEY ISSUE OF COMPUTING SYSTEMS RELIABILITY

Gunter Heiner. *In* AGARD Avionics Reliability, Its Tech. and Related Disciplines Oct. 1979 13 p refs (For primary document see N80-19519 10-38)

Avail: NTIS HC A23/MF A01

An introduction to the problems of computing systems reliability is presented with special emphasis on software reliability. A survey of the fundamental approaches to achieve reliable software is given. Starting from a definition of the basic terms and a classification of various error types the concept of software reliability is examined. The problems involved in treating hardware and software reliability on common terms are discussed. For the purpose of illustrating the concept of software reliability, two simple reliability models are presented. The basic methods of attaining reliable computing are divided into the two complementary approaches of fault-avoidance and fault-tolerance. With regard to software reliability fault-avoidance is still the predominant approach. In this category the two classes of constructive and analytical methods are summarized and discussed. Constructive methods facilitate error-free software construction and provide for a good testability of the software. Analytical methods are used for software validation. The main techniques are proving, static, and dynamic analysis. Especially for systems meeting with very high safety requirements, there is need for software fault-tolerance. Two fundamental approaches to fault-tolerance by program diversity are presented and discussed. M.G.

N80-19548# Marconi Radar Systems Ltd., Chelmsford (England). Software Dept.

SOFTWARE RELIABILITY: UNDERSTANDING AND IMPROVING IT

L. Mackie. *In* AGARD Avionics Reliability, Its Tech. and Related Disciplines Oct. 1979 10 p ref (For primary document see N80-19519 10-38)

Avail: NTIS HC A23/MF A01

Concepts regarding software reliability are examined. Definitions are given of software, its quality, errors and software reliability. A few realities of software development are considered such as: the hardware/software people system; software requirements specifications; software testing; detection and correction of errors, and time necessary for software development. R.C.T.

N80-19549*# SRI International Corp., Menlo Park, Calif. Computer Science Lab.

FORMAL METHODS FOR ACHIEVING RELIABLE SOFTWARE

Jack Goldberg *In* AGARD Avionics Reliability, Its Tech and Related Disciplines Oct 1979 9 p refs (For primary document see N80-19519 10-38)

(Contracts NAS1 13792, N00123-76-C-0195)

Avail NTIS HC A23/MF A01

Requirements for reliable avionic systems are discussed in terms of the effectiveness of programming methodology The need for methods to cope with the complexity of critical real-time systems is emphasized Some general concepts about formal methods are presented and an example is given of the SRI hierarchical development methodology taken from the executive system of the SIFT fault tolerant computer Formal methods with alternatives are compared and the prospects for introducing formal methods into practice are considered R C T

N80-19550# Institut de Recherche d'Informatique et d'Automatisme, Roquencourt (France)

QUANTITATIVE ASSESSMENTS OF SOFTWARE RELIABILITY

J C Rault, G Memmi (ECA Automation, Saint-Cloud, France), and S Dimont *In* AGARD Avionics Reliability, Its Tech and Related Disciplines Oct 1979 11 p refs Prepared in cooperation with Thomson-CSF, Paris (For primary document see N80-19519 10-38)

Avail NTIS HC A23/MF A01

A categorization and a description is given of those quantitative measures of software reliability leading to practical applications The main approaches to quantitatively assessing software reliability are identified models adapted from classical reliability theory wherein reliability is expressed in terms of software error rate, models based on sampling techniques applied to the error domain or to the input data domain, here reliability is related respectively to an estimate of the number of residual errors and to the probability of not using those input data leading to software failures, models based on program complexity measures, their basic principle is attempting to discover correlations between complexity measures and the most likely number of errors made during programming Underlying assumptions and areas of application are indicated It is concluded to the existence of methods of practical interest and of data that might help to understand how often, when, where, and why programmers introduce software errors and how software errors may be detected and corrected R.C.T.

N80-19551# Rome Air Development Center, Griffiss AFB, N.Y.

AN ANALYSIS OF SOFTWARE RELIABILITY PREDICTION MODELS

Alan N Suken *In* AGARD Avionics Reliability, Its Tech and Related Disciplines Oct 1979 11 p refs (For primary document see N80-19519 10-38)

Avail NTIS HC A23/MF A01

Several mathematical models for predicting the reliability and error content of a software package were evaluated against error data extracted from the formalized testing of four software development projects The results of the data collected are described using both Maximum Likelihood and Least Squares methods for estimating model parameters Model predictions are compared on a total project, functional and error severity basis. Model predictions are also compared on an errors/day and errors/week basis for defining model time intervals Conclusions concerning the application of these models are presented R.C.T.

N80-19552# Gesellschaft fuer Wirtschaftliche Bautechnik m b H , Munich (West Germany)

ANALYTICAL SOFTWARE VERIFICATION

W Ehrenberger and P Puhr-Westerheide *In* AGARD Avionics Reliability, Its Tech and Related Disciplines Oct 1979 25 p refs (For primary document see N80-19519 10-38)

Avail NTIS HC A23/MF A01

Various methods for verifying the correctness of software are discussed An example of a manual program analysis is given A FORTRAN subroutine is analyzed, which consists of 166 code lines Some automatic analysis methods are also discussed A short survey is given on the various analysis methods used by automated testing tools In the overall system level, the different kinds of applied testing strategies are mentioned Testing in detail requires a convenient embedding of the modules to be tested It is shown that testing in the module level can be done due to different methods as static analysis and dynamic analysis R C T

N80-19553# Bundesamt fuer Wehrtechnik und Beschaffung, Koblenz (West Germany) Dept of Quality Assurance of Electronic Systems

SOFTWARE QUALITY AND ITS ASSURANCE

P Weigel *In* AGARD Avionics Reliability, Its Tech and Related Disciplines Oct 1979 11 p refs (For primary document see N80-19519 10-38)

Avail NTIS HC A23/MF A01

The causes of failure and the development of software are discussed, and the technical means and measures for eliminating faults and impacting the software quality are described In addition to the technical measures, the organizational means of software quality assurance are summarized R C T

N80-19554# *Elliott-Automation Space and Advanced Military* Systems Ltd., Camberley (England)

SOFTWARE DEVELOPMENT FOR TORNADO: A CASE HISTORY FROM THE RELIABILITY AND MAINTAINABILITY ASPECT

D J Harris *In* AGARD Avionics Reliability, Its Tech and Related Disciplines Oct 1979 23 p (For primary document see N80-19519 10-38)

Avail NTIS HC A23/MF A01

The methods and procedures adopted in the development program for the TORNADO aircraft are presented Software development for TORNADO has been undertaken in four successive, but overlapping phases, namely definition, writing, testing and delivery The key features in these four phases are given that have contributed to software reliability and maintainability R C T

N80-19555# Westinghouse Electric Corp., Hunt Valley, Md Defense and Electronic System Center

INTEGRATED LOGISTICS SUPPORT ADDS ANOTHER DIMENSION TO MATRIX MANAGEMENT

Richard M Drake *In* AGARD Avionics Reliability, Its Tech and Related Disciplines Oct 1979 11 p (For primary document see N80-19519 10-38)

Avail: NTIS HC A23/MF A01

The application of matrix management to integrated logistics support (ILS) is defined as a management and functional process for unified, coordinated acquisition of logistic resources required to support systems and equipments at all echelons of maintenance throughout their planned period of usefulness The concept involves the scientific management of all necessary logistic products and services over the system life cycle with particular emphasis upon coherence, timeliness, execution, and reliability The various elements of logistics services and the integration with matrix management are illustrated The advantages and disadvantages of the integration are delineated and organizational diagrams are presented The program management process is discussed with emphasis given to integrated quantitative planning and ILS products such as communicating and direction, and life cycle costs. A W H

N80-19556# Messerschmitt-Boelkow-Blohm G m b H , Munich (West Germany) Product Support Dept.

MEK: A NEW PROCEDURE FOR DEVELOPMENT OF MAINTENANCES POLICIES

Klaus Lewandowski *In* AGARD Avionics Reliability, Its Tech and Related Disciplines Oct 1979 10 p (For primary document see N80-19519 10-38)

Avail NTIS HC A23/MF A01

A procedure for the development of maintenance policies is presented for the general application in weapon system projects The procedure is based on a detailed collection and evaluation of the maintenance expenditure expected for the weapon system The maintenance expenditure is based upon the system technology, the reliability and maintability attributes including the given lifetime limitations, and the operational requirements and logistic concepts The procedure is illustrated with an analysis of each step in the data collection process The data collection process as defined begins with the task frequencies or specified values of the system specifications, proceeds to scheduled maintenance requirements, maintenance levels, personnel requirements, technical publication requirements, and unscheduled maintenance requirements, and ends with a summary of the results A W H

N80-19557# Westinghouse Electric Corp., Hunt Valley, Md Integrated Logistics Support Div

THE IMPORTANCE OF INTEGRATED LOGISTICS SUPPORT CONSIDERATIONS DURING DESIGN

Robert C Rassa *In* AGARD Avionics Reliability, Its Tech and Related Disciplines Oct 1979 5 p (For primary document see N80-19519 10-38)
Avail NTIS HC A23/MF A01

The relationship and interdependency of the integrated logistics support elements and their relationship to the design of the prime mission equipment is explored The roles of the key personnel involved in the initial considerations are examined Rules for the successful implementation of an integrated logistics support plan are developed and presented A W H

N80-19558# Ministry of Defence, London (England) Procurement Div
THE INTEGRATED MANAGEMENT OF RELIABILITY AND MAINTAINABILITY IN PROCUREMENT
S E Shapcott and K A Brown *In* AGARD Avionics Reliability, Its Tech and Related Disciplines Oct 1979 4 p (For primary document see N80-19519 10-38)
Avail NTIS HC A23/MF A01

An effective procurement strategy for reliability and maintainability is discussed as documented in the DCAD Technical Publication 1/77 Achievement of Avionic Reliability and Maintainability through Integrated Management The evolution of the strategy is reviewed, the requirements of the strategy are discussed and the implementation of the strategy is examined A W H

N80-19559# Royal Air Force, Dereham (England) RAF Maintenance Data Centre
RELIABILITY AND SUPPORT DATA FOR STATISTICAL EVALUATION
A Andrews *In* AGARD Avionics Reliability, Its Tech and Related Disciplines Oct 1979 14 p (For primary document see N80-19519 10-38)
Avail NTIS HC A23/MF A01

The organization and procedures for aircraft data collection, using the maintenance data system, are described together with the methods of data storage, retrieval, and analysis Various applications of the data as part of an integrated reliability management program are outlined The problems in collecting and interpreting field data are discussed and difficulties in relating the data to the reliability measured in the design and development stages of new equipment are described A W H

N80-19560# Ministry of Defence, London (England)
COMPUTER SIMULATION MODEL OF THE LOGISTIC SUPPORT SYSTEM FOR ELECTRICAL ENGINEERING TEST EQUIPMENT
C J P Haynes *In* AGARD Avionics Reliability, Its Tech and Related Disciplines Oct 1979 13 p (For primary document see N80-19519 10-38)
Avail NTIS HC A23/MF A01

A simulation model of the existing logistic support system for electrical engineering test equipment, developed as a research tool for evaluating the adequacy of analytical provisioning models is described Two further simulations developed to model alternative logistic support systems and to compare these with the current maintenance organization, are also described The present logistic support system, the development of the three simulation models and their potential uses are discussed A W H

N80-19561# Arinc Research Corp., Annapolis, Md
THE RELIABILITY IMPROVEMENT WARRANTY AND ITS APPLICATION TO THE F-16 MULTINATIONAL FIGHTER PROGRAM
George Harrison *In* AGARD Avionics Reliability, Its Tech and Related Disciplines Oct 1979 9 p (For primary document see N80-19519 10-38)
Avail NTIS HC A23/MF A01

The F-16 multinational fighter program is described, with particular emphasis on two aspects the development of the F-16 reliability improvement warranty (RIW) program, and the coproduction agreements between the U S and the governments of Belgium, Denmark, Norway, and the Netherlands The fundamentals of an RIW procurement, together with some of the variations that were used to suit particular applications, are described Guidelines for RIW application are presented A W H

39 STRUCTURAL MECHANICS

Includes structural element design and weight analysis; fatigue; and thermal stress.

For applications see *05 Aircraft Design, Testing and Performance* and *18 Spacecraft Design, Testing and Performance*.

N77-22554# Advisory Group for Aerospace Research and Development, Paris (France).
FRACTURE MECHANICS DESIGN METHODOLOGY
Feb. 1977 271 p refs Partly in ENGLISH and FRENCH Presented at the 43d Meeting of the AGARD Struct. and Mater. Panel, London, 28-29 Sep. 1976
(AGARD-CP-221; ISBN-92-835-1090-X) Avail: NTIS HC A12/MF A01

Papers concerning the application of fracture mechanics to the design of aircraft are presented. Several papers deal with analyses for obtaining safe-life fail-safe aircraft structures. Design concepts are highlighted for achieving damage-tolerant structures. For individual titles, see N77-22555 through N77-22567.

N77-22555# Hawker Siddeley Aviation Ltd., London (England).
PRACTICAL APPLICATIONS OF FRACTURE MECHANICS TECHNIQUES TO AIRCRAFT STRUCTURAL PROBLEMS
W. G. Heath, L. F. Nicholls (British Aircraft Corp., London), and W. T. Kirkby (RAE, Farnborough) *In* AGARD Fracture Mech. Design Methodology Feb. 1977 22 p refs (For primary document see N77-22554 13-39)
Avail: NTIS HC A12/MF A01

Experience gained in the UK in the application of fracture mechanics techniques to problems arising in the design, testing and operation of aircraft is outlined. Design examples are taken from studies of crack behavior in stiffened wing panels and also from pressure cabin design, including areas subject to combined mechanical and thermal stresses. Problems of testing are illustrated by reference to the use of COD, and other measurements, in residual strength tests to predict approach to unstable crack growth. Test data are given which illustrate scatter in crack growth in stiffened panels. In addition, the nature of the difficulties that have been encountered in applying fracture mechanics analysis to failures arising in aircraft in service is discussed.
Author

N77-22556# Industrieanlagen-Betriebsgesellschaft m.b.H., Ottobrunn (West Germany).
CRACK PROPAGATION AND RESIDUAL STATIC STRENGTH OF TYPICAL AIRCRAFT FORGINGS
Walter Schuetz *In* AGARD Fracture Mech. Design Methodology Feb. 1977 18 p refs (For primary document see N77-22554 13-39)
Avail: NTIS HC A12/MF A01

A test program was carried out using nose landing gear struts of 7075-T6, manufactured to the same drawings, but forged by several forges in different countries. Cracks were introduced in various sections of the forgings and crack propagation and residual static strength determined by test and compared with calculations. It was not possible to predict residual static strength with any accuracy even if an ASTM-CT specimen was taken out of the same forging near the failure location. Crack propagation under two realistic load sequences was highly irregular and could not be correctly predicted using the Willenborg retardation model. Also, scatter of the above properties was much larger than for the sheet and plate specimens normally used for such tests.
Author

N77-22557# General Dynamics/Fort Worth, Tex.
APPLICATION OF FRACTURE MECHANICS TO THE F-111 AIRPLANE
W. D. Buntin *In* AGARD Fracture Mech. Design Methodology Feb. 1977 12 p refs (For primary document see N77-22554 13-39)
Avail: NTIS HC A12/MF A01

Safe service operations of critical steel components in the F-111 aircraft are assured by analyses and tests developed using principles of fracture mechanics. A unique flaw in a major fitting which forms the inboard section of the wing caused the loss of an airplane in flight. Subsequent analytical and experimental investigations are described which thoroughly investigated the fracture characteristics of all critical steel components in the airframe. Fracture analysis tools were developed and used as essential elements in interpreting experimental data and in describing the damage tolerance of the F-111 fleet. The methodology which was evolved is compared with current airplane damage tolerance requirements.
Author

N77-22558# Northrop Corp., Hawthorne, Calif. F-5 Technology Dept.
NORTHROP/UNITED STATES AIR FORCE DURABILITY AND DAMAGE-TOLERANCE ASSESSMENT OF THE F-5E/F AIRCRAFT
S. R. Murnane, T. D. Stronge, and O. B. Davenport (Aeronautical Systems Div., Wright-Patterson AFB, Ohio) *In* AGARD Fracture Mech. Design Methodology Feb. 1977 33 p refs (For primary document see N77-22554 13-39)
Avail: NTIS HC A12/MF A01

Fatigue test failures experienced during a complete airframe flight-by-flight fatigue test are reviewed, including the application of fracture mechanics employed during resolution of these failures. Damage-tolerance analyses and specimen tests for other primary structure are discussed. State-of-the-art analytical crack growth rate predictions for flight-by-flight spectra are compared with specimen test results. Compliance of the F-5E/F airframe structure with the USAF damage-tolerance requirements is discussed, along with recommendations for the application of fracture mechanics to future aircraft design.
Author

N77-22559# National Aerospace Lab., Amsterdam (Netherlands).
APPLICATION OF FRACTURE MECHANICS IN DESIGNING BUILT-UP SHEET STRUCTURES
H. Vlieger *In* AGARD Fracture Mech. Design Methodology Feb. 1977 18 p refs (For primary document see N77-22554 13-39)
Avail: NTIS HC A12/MF A01

Different analyses that are relevant to the design of a fail-safe aircraft structure are discussed: the static strength, the crack initiation and propagation and the residual strength analyses. The application of fracture mechanics in the crack propagation and residual strength analyses is given particular attention. Theoretical results of an investigation carried out in this field and verification of these results by experiments are shown. Finally, some guidelines for aircraft structural applications are presented.
Author

N77-22560# Aeronautica Macchi S. p. A., Varese (Italy).
COMPARATIVE EXPERIMENTAL OBSERVATIONS AND THEORETICAL ANALYSIS OF THE PROPAGATION OF FATIGUE CRACKS
G. L. DeOtto *In* AGARD Fracture Mech. Design Methodology Feb. 1977 21 p refs (For primary document see N77-22554 13-39)
Avail: NTIS HC A12/MF A01

The fracture sections of two primary structural elements that failed during the fatigue tests on the complete aircraft are examined. The building-up and propagation of the cracks, the interaction effect between the various cracks, the validity of the nondestructive inspection methods and the importance of the test load spectrum are shown by a microfractography examination of the same sections. The assumptions on fatigue striations are verified and crack propagation experimental curves determined for an appropriate selection of the inspection intervals. The experimental propagation curves are compared to the theoretical curves calculated by the equation of Forman.
Author

N77-22561# Pisa Univ. (Italy).
FATIGUE BEHAVIOUR OF CRACKED STIFFENED PANELS
A. Salvetti *In* AGARD Fracture Mech. Design Methodology Feb. 1977 22 p refs Sponsored in part by US Army (For primary document see N77-22554 13-39)
Avail: NTIS HC A12/MF A01

Methods of fail-safe design of aircraft structures were studied. Two main objectives were the development of methodologies to compute the crack growth under fatigue loading in stiffened structures and the determination of minimum weight design methodologies suitable for fail-safe structures. The K-rate relationship in stiffened structures was evaluated, and the methodologies to correlate the stringer fatigue failures with the crack length in the sheet cover were investigated. Results on such topics based on a large set of experimental and theoretical data on cracked stiffened structures are presented. The problem of designing minimum weight panels taking into account the fail-safe requirement was undertaken with reference to the wing lower surface structure. Using mathematical programming, the optimum distribution of resisting material between sheet cover

and stringers was sought, taking into account not only the buckling phenomena connected with negative load factor flight conditions, but also the fail-safe requirement of the fail-safe load for an assigned inspection interval, with given initial damage and load spectrum. Author

N77-22562# National Aerospace Lab., Amsterdam (Netherlands).
CALCULATION OF STRESS INTENSITY FACTORS FOR CORNER CRACKING IN A LUG
R. J. H. Wanhill and C. J. Lof. *In* AGARD Fracture Mech. Design Methodology Feb. 1977 8 p refs (For primary document see N77-22554 13-39)
Avail: NTIS HC A12/MF A01

A three-dimensional finite element analysis of corner flaws in aircraft lugs was conducted. The results were compared with experimental calibration of the effective stress intensity factor and previously suggested analytical solutions. Author

N77-22563# Societe Nationale Industrielle Aerospatiale, Paris (France). Lab. Central.
APPLICATION OF FRACTURE MECHANICS TO THE SELECTION OF ALUMINUM ALLOYS, PART 1 [APPLICATION DE LA MECANIQUE DE LA RUPTURE A LA SELECTION DES ALLIAGES D'ALUMINIUM, 1ERE PARTIE]
Jacques Odorico. *In* AGARD Fracture Mech. Design Methodology Feb. 1977 7 p In FRENCH (For primary document see N77-22554 13-39)
Avail: NTIS HC A12/MF A01

The essential properties to guarantee the safety, availability and longevity of aircraft structures are considered. These properties consist of some of the following: (1) residual static resistance of pre-cracked test material; (2) sensitivity to corrosion under tension; (3) resistance to fatigue; and (4) protection against corrosion for the maintenance of the structures. Results acquired for these different properties are presented. Transl. by B.B.

N77-22564# Societe Nationale Industrielle Aerospatiale, Paris (France). Lab. Central.
APPLICATION OF FRACTURE MECHANICS TO THE SELECTION OF ALUMINUM ALLOYS. PART 2: RESULTS [APPLICATION DE LA MECANIQUE DE LA RUPTURE A LA SELECTION DES ALLIAGES D'ALUMINIUM, 2EME PARTIE: RESULTATS]
Claude Bathias. *In* AGARD Fracture Mech. Design Methodology Feb. 1977 13 p refs In FRENCH (For primary document see N77-22554 13-39)
Avail: NTIS HC A12/MF A01

Three approaches in the application of fracture mechanics to the selection of aluminum alloys are presented, and their behavior is determined. Principal results are shown and discussed along with various means of investigation. Transl. by B.B.

N77-22565# Vereinigte Flugtechnische Werke-Fokker G.m.b.H., Bremen (West Germany).
INFLUENCE OF ENVIRONMENT AND PRODUCTION PROCESSES ON THE CRACK PROPAGATION BEHAVIOR OF UNSTIFFENED SHEET
K. H. Rendigs. *In* AGARD Fracture Mech. Design Methodology Feb. 1977 14 p refs (For primary document see N77-22554 13-39)
Avail: NTIS HC A12/MF A01

The fracture behavior of unstiffened sheet under environmental and production process influences was investigated to give information on how far fracture toughness properties established under normal laboratory conditions can be transferred into practice. Crack propagation properties, K sub c values and residual strength were established on clad 2.0 mm thick sheet of aluminum alloy 2024 in naturally aged condition at a stress level of 88.3 + or - 39.2 N/sq m and under environmental and production process influences. The environmental influences examined were normal laboratory conditions and continual wetting with artificial sea water. The production process influences examined were: (1) stretching with a total amount of stretch forming of 13 and 16 percent respectively; (2) a bonding cycle simulated in the delivered condition; and (3) stretching with a total amount of stretch forming of 13 percent with following bonding cycle. Author

N77-22566# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (West Germany).
PROOF-LOAD TESTING ON 300 M STEEL
Wolfgang Geier and Karl O. Sippel. *In* AGARD Fracture Mech. Design Methodology Feb. 1977 12 p refs (For primary document see N77-22554 13-39)
Avail: NTIS HC A12/MF A01

As a result of the fundamental considerations made on the Proof-Load Procedure, general conditions for its basic applicability were defined. It was established that the procedure is sufficiently safe for use if the maximum operational load is limited or the safe crack growth interval is considered to be a statistical value. The test results proved that the safe crack growth interval can be determined theoretically. The examination of the specific proof-load parameters provided new information on the effects and influence of the test parameters on crack propagation and residual strength. The rate of crack propagation decreases with increasing proof-load in relation to the operational load and with the proof-load interval becoming smaller. The proof-load conditions being constant, the permissible interval for the transport aircraft load spectrum is greater than that for the combat aircraft load spectrum. Author

N77-22567# Air Force Systems Command, Wright-Patterson AFB, Ohio.
DAMAGE TOLERANCE AND DURABILITY ASSESSMENTS OF UNITED STATES AIR FORCE AIRCRAFT
M. D. Coffin, C. F. Tiffany, and R. Bader. *In* AGARD Fracture Mech. Design Methodology Feb. 1977 21 p ref (For primary document see N77-22554 13-39)
Avail: NTIS HC A02/MF A01

A program to conduct damage tolerance and durability assessments of 'in-service' aircraft to assure structural safety and economic life management is discussed. The F-4C/D assessment serves as a classic example to illustrate the objectives, the approach, and the results desired. The general methodology associated with the accomplishment of the technical tasks is presented and discussed. The modification and inspection program resulting from this assessment is described. Author

N77-22568# Advisory Group for Aerospace Research and Development, Paris (France).
SPECIALISTS' MEETING ON ACOUSTIC FATIGUE REVIEW
1976 82 p In ENGLISH; partly in FRENCH. Presented at the 43d meeting of the Struct. and Mater. Panel, London, 30 Sep. 1976
(AGARD-CP-222) Avail: NTIS HC A05/MF A01

Methods and facilities for investigating acoustic fatigue in aircraft construction materials in NATO countries are summarized. For individual titles, see N77-22569 through N77-22573

N77-22569# Industrieanlagen-Betriebsgesellschaft m.b.H., Ottobrunn (West Germany).
REVIEW OF ACOUSTIC FATIGUE ACTIVITIES IN GERMANY
Gerhard Bayerdoerfer. *In* AGARD Specialists' Meeting on Acoustic Fatigue Rev. 1976 10 p refs (For primary document see N77-22568 13-39)
Avail: NTIS HC A05/MF A01

Acoustic fatigue tests were carried out on the German-manufactured parts of the European Airbus A 300 B, the shorthaul transport VFW 614, the vertical takeoff VAK 191, the NRCA, and the Alpha-Jet aircraft. Besides this project-oriented work, studies of a more fundamental nature were concerned with technology. In addition, a number of qualification tests were carried out on spacecraft such as Helios, Cos B, Meteosat OTS, ISEE-B and Marots. Author

N77-22570# Aeritalia, Turin (Italy).
REVIEW OF ACOUSTIC FATIGUE ACTIVITIES IN ITALY
G. Incarbone. *In* AGARD Specialists' Meeting on Acoustic Fatigue Rev. 1976 3 p refs (For primary document see N77-22568 13-39)
Avail: NTIS HC A05/MF A01

Theoretical and experimental research works were cooperatively carried out in Italy on fatigue phenomena and behavior of aeronautical structures under acoustic loads, and research on fracture mechanics of pressurized space structures subjected to acoustic fatigue. In addition, some indications for new work in acoustic fatigue are given. Author

N77-22571# Air Force Flight Dynamics Lab., Wright-Patterson AFB, Ohio.
REVIEW OF ACOUSTIC FATIGUE ACTIVITIES IN THE USA
A. W. Kolb. *In* AGARD Specialists' Meeting on Acoustic Fatigue Rev. 1976 15 p refs (For primary document see N77-22568 13-39)
Avail: NTIS HC A05/MF A01

Recent and current sonic fatigue research and development programs are reviewed. The areas discussed include load criteria, development of long life sonic fatigue design criteria for weldbonded and bonded structures, composites and honeycomb panels for high temperature application. Recent advances and planned programs in testing techniques are also presented. These include the determination of structural mode shapes by computer techniques and development of a programmable high cycle fatigue testing system designed to obtain coupon specimen data to 10 to the ninth power cycles or above. Finally, proposed work is presented. Publications concerning the program discussed are listed for further reference. Author

N77-22572# Societe Nationale Industrielle Aerospatiale, Toulouse (France)

EXPERIMENTAL SOLUTIONS OF ACOUSTIC FATIGUE PROBLEMS [SOLUTION EXPERIMENTALE DE PROBLEMES DE FATIGUE ACOUSTIQUE]

R. Loubet and J. Gay. *In* AGARD Specialists' Meeting on Acoustic Fatigue Rev. 1976 15 p. In FRENCH (For primary document see N77-22568 13-39)

Avail: NTIS HC A05/MF A01

Resonance under sinusoidal excitation and dynamic response and durability under hazardous excitation were measured for carbon and boron reinforced materials. Results were compared with the behavior of light alloy and steel samples under the same conditions. Measurements obtained during a proof test on a carbon fiber rudder are analyzed and used to estimate its behavior at sonic fatigue. Damages to the fairings of an operating aircraft rudder servomechanism are investigated. Replacement of the framework is defined and justified. Transl. by A.R.H.

N77-22573# British Aircraft Corp., Filton (England). Commercial Aircraft Div.

REVIEW OF ACOUSTIC FATIGUE ACTIVITIES IN THE UNITED KINGDOM

D. C. G. Eaton. *In* AGARD Specialists' Meeting on Acoustic Fatigue Rev. 1976 31 p. refs (For primary document see N77-22568 13-39)

Avail: NTIS HC A05/MF A01

Typical airframe acoustic fatigue experience associated with U.K. project activity is presented. Problems associated with mounting of equipment and systems are considered. An account is given of systematic studies of noise induced crack propagation behavior in light alloy machined structure and related sub-structure. Examples are presented of R and D activities and findings in the airframe, space and nuclear engineering sectors. Author

N78-13481# Advisory Group for Aerospace Research and Development, Paris (France).

USE OF GENERAL FATIGUE DATA IN THE INTERPRETATION OF FULL-SCALE FATIGUE TESTS

W. Barrois. Oct. 1977 78 p. refs

(AGARD-AG-228) Avail: NTIS HC A05/MF A01

Stress concentrations due to load transfer through fasteners were investigated for the case of asymmetric single shear of the fasteners. The breakdown of the applied loadings includes the peak-to-peak, ground-air-ground variation. In load transfer by fastener bearing stresses, the low compressive loads may be neglected, the local highest stresses varying from zero to the maximum. Interpretation of full-scale fatigue results, either for a different loading or for a slightly modified local design of the structure, is essentially comparative. In order to locate the computation points within a suitable region of the curves, the stress concentration factor is multiplied by a damage adjustment factor, such that the Miner damage is 1 for the local failure of the structure considered. Author

N79-10477# *Advisory Group for Aerospace Research and Development, Paris (France).*

CHARACTERIZATION OF LOW CYCLE HIGH TEMPERATURE FATIGUE BY THE STRAINRANGE PARTITIONING METHOD

Aug. 1978 350 p. refs In ENGLISH and FRENCH Presented at the 46th Meeting of the AGARD Struct. and Mater. Panel, Aalborg, Denmark, 11-12 Apr. 1978

(AGARD-CP-243, ISBN-92-835-0220-5) Copyright. Avail: NTIS HC A15/MF A01

A number of laboratories in several countries participated, each testing its own materials of interest under its own laboratory conditions to ensure that the results obtained would provide validation for a wide range of aerospace materials and to ensure maximum usefulness to each participating laboratory of the strainrange partitioning method. For individual titles, see N79-10478 through N79-10494.

N79-10478*# Case Western Reserve Univ., Cleveland, Ohio. Dept. of Mechanical and Aerospace Engineering.

THE DEVELOPMENT AND APPLICATION OF STRAINRANGE PARTITIONING AS A TOOL IN THE TREATMENT OF HIGH TEMPERATURE METAL FATIGUE

S. S. Manson. *In* AGARD Characterization of Low Cycle High Temp. Fatigue by the Strainrange Partitioning Method Aug. 1978 11 p. refs (For primary document see N79-10477 01-39)

(Grant NsG-7035)

Avail: NTIS HC A15/MF A01 CSCL 20K

The effects of frequency, stress and strain hold periods, stress and strain ramping, creep-fatigue interspersion, and thermomechanical cycling were studied. Of special interest was the establishment of a set of universalized life relations which were normalized by the ductility of the material. These relations together with a set of rules that were devised for treating multiaxiality by the method, were, for example, useful in predicting torsion behavior, and in particular in establishing a new relationship between torsion and tension that had previously not been considered. They also were useful in the development of a framework for treatment of environmental effects. J.A.M.

N79-10479*# TRW, Inc., Cleveland, Ohio. Materials Technology Lab.

A STRAINRANGE PARTITIONING ANALYSIS OF LOW CYCLE FATIGUE OF COATED AND UNCOATED RENE 80

C. S. Kortovich and A. A. Sheinker. *In* AGARD Characterization of Low Cycle High Temp. Fatigue by the Strainrange Partitioning Method Aug. 1978 23 p. refs Sponsored in part by Army Air Mobility Res. and Develop. Lab. (For primary document see N79-10477 01-39)

(Contract NAS3-17830)

Avail: NTIS HC A15/MF A01 CSCL 20K

A strainrange partitioning analysis was conducted on ultrahigh vacuum, strain-controlled, low-cycle fatigue behavior of uncoated and aluminide coated Rene' 80 nickel-base superalloy at 1000 C (1832 F) and 871 C (1600 F). The results indicated little effect of coating or temperature on the fatigue resistance. There was, however, a significant effect on fatigue life when creep was introduced into the strain cycles. The effect of this creep component was analyzed in terms of the method of strainrange partitioning. Author

N79-10480*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.

STRAINRANGE PARTITIONING BEHAVIOR OF THE NICKEL-BASE SUPERALLOYS, RENE 80 AND IN-100

G. R. Halford and A. J. Nachtigall. *In* AGARD Characterization of Low Cycle High Temp. Fatigue by the Strainrange Partitioning Method Aug. 1978 14 p. refs (For primary document see N79-10477 01-39)

Avail: NTIS HC A15/MF A01 CSCL 20K

A study was made to assess the ability of the method of strainrange partitioning (SRP) to both correlate and predict high temperature, low cycle fatigue lives of nickel-base superalloys for gas turbine applications. Baseline data from strain-controlled, low cycle fatigue tests were expressed in terms of the PP, PC, CP, and CC partitioned inelastic strainrange versus life relationships for coated and uncoated Rene' 80 at 1000 C, Gatorized (creep-formed)IN 100 at 760 C, and cast IN 100 at 925 C. The SRP is shown to correlate the cyclic lives of the baseline tests to within factors of nearly two. The partitioned strainrange versus life relationships for uncoated Rene' 80 and cast IN 100 were also determined from the ductility normalized-strainrange partitioning equations. These were used to predict the cyclic lives of the baseline tests. Predicted and observed cyclic lives agreed to within factors of nearly three. J.A.M.

N79-10481# Pratt and Whitney Aircraft, West Palm Beach, Fla. Mechanics of Materials and Structures Div.

LOW CYCLE FATIGUE BEHAVIOR OF IN-100: STRAINRANGE PARTITIONING METHOD

M. C. VanWanderham, R. M. Wallace, and C. G. Annis, Jr. *In* AGARD Characterization of Low Cycle High Temp. Fatigue by the Strainrange Partitioning Method Aug. 1978 17 p. refs (For primary document see N79-10477 01-39)

Avail: NTIS HC A15/MF A01

The elevated temperature, low cycle fatigue of the gas turbine disk alloy IN-100 was evaluated, using the strainrange partitioning

method. Strainrange partitioning, an advanced life prediction analysis procedure, assumed that any hysteresis loop could be represented by combinations of the four generic cycle definitions PP, CP, PC, and CC. The first letter refers to the material response in tension, either plastic (time independent) or creep (time dependent), and the second letter refers to material response in compression. J.A.M.

N79-10482# Office National d'Etudes et de Recherches Aerospatiales, Paris (France)

APPLICABILITY OF THE SRP METHOD AND CREEP-FATIGUE DAMAGE APPROACH TO THE LCHTF LIFE PREDICTION OF IN-100 ALLOY

J. L. Chaboche, H. Policella, and H. Kaczmarek. *In* AGARD Characterization of Low Cycle High Temp. Fatigue by the Strainrange Partitioning Method Aug. 1978 20 p refs (For primary document see N79-10477 01-39)

Avail: NTIS HC A15/MF A01

The main objective was to compare the actual capabilities of two life prediction methods in the low cycle high temperature regime. (1) The simplest one was the strain range partitioning which needed a number of special tests, involving creep and fatigue interaction, but it was difficult to apply under complex situations where the inelastic strain components were small or when strain and temperature varied simultaneously. (2) The second one was the continuous damage approach, which could be applied to the prediction of the creep-fatigue interaction phenomenon, by means of pure fatigue tests, pure creep tests, and corresponding damage equations. The two methods were evaluated for the IN-100 alloy at 900 and 1000 C. J.A.M.

N79-10483# Cranfield Inst. of Technology, Bedfordshire (England). Dept. of Materials

STRAINRANGE PARTITIONING OF MAR M002 OVER THE TEMPERATURE RANGE 750 DEG C - 1040 DEG C

V. T. A. Antunes and P. Hancock. *In* AGARD Characterization of Low Cycle High Temp. Fatigue by the Strainrange Partitioning Method Aug. 1978 9 p refs Sponsored in cooperation with the Min. of Nacl. de Invest. Cient. e Tecnol. (For primary document see N79-10477 01-39)

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The fatigue behavior of a cast nickel base, superalloy Mar M002 was studied in the temperature range 750 - 1040 C by the method of strainrange partitioning, (SrP). The four basic strainrange vs life relationships Nij - delta epsilon ij (i = P or C, j = P or C) were determined at 850 and 1040 C. A marked temperature sensitivity was observed, and it was not possible to predict 1040 deg lives from 850 data. Satisfactory life prediction could be made by the SrP method over limited temperature ranges. Prediction within the range 750 to 850 C, or within the range 950 - 1040 C proved to be satisfactory, employing a unique set of Nij - delta epsilon ij strainrange vs life relationships for each temperature range. J.A.M.

N79-10484# National Gas Turbine Establishment, Farnborough (England). Materials Science Dept.

THE LOW CYCLE FATIGUE BEHAVIOR OF NIMONIC 90 AT ELEVATED TEMPERATURE

G. F. Harris and M. J. Weaver. *In* AGARD Characterization of Low Cycle High Temp. Fatigue by the Strainrange Partitioning Method Aug. 1978 19 p refs (For primary document see N79-10477 01-39)

Avail: NTIS HC A15/MF A01

High temperature strain controlled fatigue data for the wrought nickel base alloy, Nimonic 90 are presented, together with their interpretation based on the concept of strain range partitioning. When this approach was used to predict data at 650 and 900 C, using those generated at 810 C, the lives at 650 C were accurate to within a factor of two whereas at 900 C, actual test results were much less than the predicted values. The difficulty encountered when using the partitioning approach to predict low frequency test results, is discussed. The data were examined in terms of stress, as opposed to strain and predictions, using a stress/static-creep data approach. J.A.M.

N79-10485# Rolls-Royce Ltd., Derby (England). Material Services Lab

AN APPLICATION OF STRAINRANGE PARTITIONING TO THE LOW CYCLE - HIGH TEMPERATURE FATIGUE LIFE PREDICTION OF WASPALOY

G. Asquith and S. H. Sprinthall. *In* AGARD Characterization of Low Cycle High Temp. Fatigue by the Strainrange Partitioning Method Aug. 1978 13 p refs (For primary document see N79-10477 01-39)

Avail: NTIS HC A15/MF A01

From a limited series of fully reversed strain controlled low cycle fatigue and cyclic creep testing at 700 C, the basic partitioned life relationships were established. It was shown that from these basic relationships reasonable life to failure prediction was possible for more complex combined creep-fatigue interactions. It was observed from the experimental test data that there were marked differences in the mean stress levels generated for each strain range component and level of inelastic strain range. J.A.M.

N79-10486# Laboratorio per la Tecnologia dei Materiali Metallici non Tradizionali, Milan (Italy)

HIGH TEMPERATURE LOW CYCLE FATIGUE BEHAVIOR OF CAST IN738LC ALLOY

L. Massarelli. *In* AGARD Characterization of Low Cycle High Temp. Fatigue by the Strainrange Partitioning Method Aug. 1978 5 p refs (For primary document see N79-10477 01-39)

Avail: NTIS HC A15/MF A01

The high temperature low cycle fatigue behavior of a nickel base alloy in the cast condition was investigated by carrying out tests under diametral strain controlled conditions. The effect of anisotropy at diametral strain, which was especially marked in the cast alloys owing to the large grain size, was offset by mounting the diametral extensometer at a position along the minimum diameter section of the specimen where Poisson's ratio assumed its mean value. Cyclic and fatigue tests under conditions of constant amplitude diametral strain and at two different strain rates were carried out on IN738LC alloy at the temperature of 850 C. The results confirmed the repeatability of the tests carried out. J.A.M.

N79-10487# Centre d'Essai Aeronautique, Toulouse (France). Ingenieur des Etudes et Techniques d'Armement

EVALUATION OF THE STRAINRANGE PARTITIONING APPLIED TO A NICKEL BASE WASPALOY (CONTRIBUTION A L'EVALUATION DE LA METHODE STRAIN RANGE PARTITIONINS APPLICATION A L'ALLIAGE BASE NICKEL WASPALOY)

C. Perruchet. *In* AGARD Characterization of Low Cycle High Temp. Fatigue by the Strainrange Partitioning Method Aug. 1978 19 p refs In FRENCH, ENGLISH summary (For primary document see N79-10477 01-39)

Avail: NTIS HC A15/MF A01

A Waspaloy's basic properties study was completed, including chemical analysis, macrographic and micrographic investigations, linear thermal expansion coefficient measurement, monotonic tensile properties determination at room and elevated temperature (up to 900 c), and cyclic stress-strain properties evaluation. Establishment of the four basic life relationships of SRP was completed at 750 C the SRP method was applied to a complex strain cycle for two values of total diametral strain corresponding to very low cycle fatigue lives (a few hundreds of cycles). In this field, SRP method validity has appeared as excellent, since average difference between predicted and tested values of fatigue life was about 12.5 percent. J.A.M.

N79-10488 National Physical Lab., Teddington (England). Div. of Materials Applications.

CREEP FATIGUE INTERACTION IN ALLOY IN738LC

M. F. Day and G. B. Thomas. *In* AGARD Characterization of Low Cycle High Temp. Faitgue by the Strainrange Partitioning Method Aug. 1978 13 p refs (For primary document see N79-10477 01-39)

Avail: NTIS HC A15/MF A01

Low cycle fatigue test results on a cast Ni-Cr-base alloy IN738LC have shown that cycles containing tensile dwell periods have extended cyclic endurances. The results compared on total inelastic strain (hysteresis strain loop width) fall into two groups, HRSC and CCCR cycles, and BCCR and TCCR cycles. Strain range partitioning could not be successfully applied in its present form to the data produced. Analysis of the data by the method proposed by Ostergren gave cyclic endurance predictions generally within a factor of plus 2 for all the types of test cycles employed at 750 and 850 C. Use of a simple fractional life approach using the pp and pc components to assess the fatigue contribution, and summed dwell times in tension to assess the creep contribution, has given predictions of similar accuracy. Microstructural examination revealed typical fatigue failures in specimens tested with HRSC and CCCR cycles. In specimens tested with BCCR and TCCR cycles there was a tendency to

intergranular creep damage which predominated at the higher strain ranges in TCCR tests J.A.M.

N79-10489# Air Force Materials Lab., Wright-Patterson AFB, Ohio.
AN ANALYSIS OF THE LOW CYCLE FATIGUE BEHAVIOR OF THE SUPERALLOY RENE 95 BY STRAINRANGE PARTITIONING
Jack M. Hyzak and Bernstein (Systems Res. Labs., Dayton, Ohio) *In* AGARD Characterization of Low Cycle High Temp. Fatigue by the Strainrange Partitioning Method Aug. 1978 25 p refs (For primary document see N79-10477 01-39)
(Contracts F33625-76-C-5245, F33615-76-C-5191)
Avail: NTIS HC A15/MF A01

The applicability of strainrange partitioning (SRP) for predicting the low cycle fatigue (LCF) behavior of the superalloy Rene 95 at 922K (1200) was addressed. A three phase test plan in described which consists of baseline strain control testing, cyclic creep tests utilizing load control to strain limits, and validation testing comprised of less conventional waveforms. The data indicated that compressive strain hold cycles were more damaging than tensile strain hold cycles. It was also shown that the LCF behavior of this alloy depends largely on the time in tension per cycle and on the value of the maximum tensile stress which develops large biases during strain hold tests that generated the largest changes in the value of the maximum tensile stress compared to time independent behavior. T.A.M.

N79-10490# Mar-Test, Inc., Cincinnati, Ohio.
AN APPLICATION OF STRAINRANGE PARTITIONING TO COPPER-BASE ALLOYS AT 538 DEG C
R. H. Stentz, J. T. Berling, and J. B. Conway *In* AGARD Characterization of Low Cycle High Temp. Fatigue by the Strainrange Partitioning Method Aug. 1978 20 p refs (For primary document see N79-10477 01-39)
Avail: NTIS HC A15/MF A01

Strain-controlled, low cycle, fatigue tests on two copper alloys, NARloy Z and 1/2 Hard AMZIRC were performed in argon at 538 C. The tests employed symmetrical triangular, strain waveforms at strain rates from .00004 to .01 to sec to the -1 power in addition to asymmetrical strain waveforms of alternating fast and slow strain rates. Partitioned strainrange versus life relationships were established for both alloys with the Delta epsilon sub cp component of strain being identified as the most severely damaging in each case. The relationships for NARloy Z were then used effectively to predict fatigue life values for hold time tests and for other tests involving asymmetrical waveforms. J.A.M.

N79-10491# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Cologne (West Germany).
STRAINRANGE PARTITIONING APPLIED TO Ti-6Al-4V
H. Nowack and J. Vreke *In* AGARD Characterization of Low Cycle High Temp. Fatigue by the Strainrange Partitioning Method Aug. 1978 12 p refs (For primary document see N79-10477 01-39)
Avail: NTIS HC A15/MF A01

The SRP method was applied at Ti-6Al-4V in a temperature range where significant creep occured (450 C). From the tests with HRSC, TCCR and BCCR cycle types, it was determined that the TCCR and CCCR cycles led to alterations in the mean stress level and that the CCCR type reduced the crack initiation life significantly. The predictions of the SRP method for complex cycles coincided well with the corresponding test results, when the test durations for the HRSC, TCCR, CCCR, and for the complex cycles remained of the same order of magnitude. When the testing time with complex cycles significantly increased, a deviation was observed. Some possible explanations for the observed behavior are given. J.A.M.

N79-10492# Bristol Univ. (England). Dept. of Mechanical Engineering.
STRAINRANGE PARTITIONING IN CYCLIC CREEP OF A 1 Cr-Mo-V STEEL
E. G. Ellison *In* AGARD Characterization of Low Cycle High Temp. Fatigue by the Strainrange Partitioning Method Aug. 1978 19 p refs (For primary document see N79-10477 01-39)
Avail: NTIS HC A15/MF A01

A 1-Cr-Mo-V ferritic steel was subjected to fatigue/creep conditions at 565 C. Most of the data obtained were from strain controlled tests with and without hold periods. Some load controlled results were also obtained. The strain range partitioning (SRP) method for predicting lives at long hold periods, and under complex load cycles, was applied. With this material, good correlation of data was obtained using the ductility normalized SRP, although even better correlation resulted when the SRP method was modified to take account of the length of the hold period. J.A.M.

N79-10493# Oak Ridge National Lab., Tenn. Metals and Ceramics Div.
EXPERIENCES IN THE USE OF STRAINRANGE PARTITIONING FOR PREDICTING TIME DEPENDENT STRAIN-CONTROLLED CYCLIC LIFETIMES OF UNIAXIAL SPECIMENS OF 2 1/4 Cr-1 Mo STEEL, TYPE 316 STAINLESS STEEL, AND HASTELLOY 10
C. R. Brinkman, J. P. Strizak, and M. K. Booker *In* AGARD Characterization of Low Cycle High Temp. Fatigue by the Strainrange Partitioning Method Aug. 1978 18 p refs Sponsored in part by DOE (For primary document see N79-10477 01-39)
Avail: NTIS HC A15/MF A01

The concept of strainrange partitioning was used to estimate the cyclic life of uniaxial specimens subjected to strain controlled fully reversed cycling at constant temperatures within the creep range. Strain-time waveforms consisted of ramp loading with tension, or compression, or both tension and compression hold periods at peak strain. Materials included 2 1/4 Cr-1 Mo steel in the annealed condition, solution annealed Hastelloy X, and solution annealed, thermally aged, or irradiated type 316 stainless steel. Inelastic strain life relationships were either developed directly from appropriate experimental data or obtained via the ductility normalization concept and used with the interaction damage rule. Generally good agreement between experimental and predicted cyclic lifetimes was found, although a number of uncertainties were identified and discussed. J.A.M.

N79-10494*# Pennsylvania State Univ., University Park. Dept. of Engineering Science and Mechanics.
THE APPLICATION OF STRAINRANGE PARTITIONING METHOD TO MULTIAXIAL CREEP-FATIGUE INTERACTION
S. Y. Zamrik *In* AGARD Characterization of Low Cycle High Temp. Fatigue by the Strainrange Partitioning Method Aug. 1978 26 p refs (For primary document see N79-10477 01-39)
(Grant NGR-39-009-034)
Avail: NTIS HC A15/MF A01 CSCL 20K

The method of strain range partitioning was applied to a series of torsional fatigue tests conducted on tubular 304 stainless steel specimens at 1200 F (649 C). Creep strain was superimposed on cycling strain, and the resulting strain range was partitioned into four components: (1) completely reversed plastic shear strain, (2) plastic shear strain followed by creep strain, (3) creep strain followed by plastic strain, and (4) completely reversed creep strain. Each strain component was related to the cyclic life of the material. The experimental procedure used to achieve strain partitioning is described, and the torsional test results are compared to those obtained from axial tests. The damaging effects of the individual strain components were expressed by a linear life fraction rule. J.A.M.

N79-20409# Advisory Group for Aerospace Research and Development, Paris (France).
FRACTURE MECHANICS DESIGN METHODOLOGY
Jan. 1979 236 p refs AGARD lecture series presented at Delft, The Netherlands, 5-6 Oct. 1978; Munchen, Germany, 9-10 Oct. 1978; Sacavem, Portugal, 12-13 Oct. 1978
(AGARD-LS-97; ISBN-92-835-1294-4) Copyright. Avail: NTIS HC A11/MF A01

The state of the art of the application of fracture mechanics to the fail safety and damage tolerance assessment of aircraft structures is examined. Basic principles of fracture mechanics are reviewed. It is shown that although damage assessment analysis has passed the stage where tests were the only means to get answers to pertinent questions regarding crack growth and residual strength, tests are still indispensable. For individual titles, see N79-20410 through N79-20420.

N79-20410# Battelle Columbus Labs., Ohio.
INTRODUCTION TO FRACTURE MECHANICS
David Broek *In* AGARD Fracture Mech. Design Methodology Jan. 1979 1 p refs (For primary document see N79-20409 11-39)
Avail: NTIS HC A11/MF A01

The development of the fracture mechanics discipline for computing and predicting the behavior of flaws and cracks during damage tolerance analysis is summarized. Topics discussed include

stress intensity factor, the parameter for crack growth and fracture, plane stress and plane strain, toughness and residual strength, subcritical crack growth, and the energy release rate. A.R.H

N79-20411# Battelle Columbus Labs., Ohio
FRACTURE
David Broek *In* AGARD Fracture Mech. Design Methodology Jan. 1979 15 p refs (For primary document see N79-20409 11-39)
Avail: NTIS HC A11/MF A01

Because the larger part of the primary structure of large civil aircraft consists of reinforced thin plate, plane stress fracture is of vital importance for all major aircraft components. The behavior of thin plates and the analysis of plane stress fracture are discussed. Plane stress behavior is more difficult to analyze than plane strain behavior and has received relatively little attention in the literature. Fracture under plane stress conditions is more complex than plane strain fracture, and no rigorous analysis procedures exist. However, for most practical purposes useful engineering methods can provide approximative answers to plane stress fracture problems. Plane stress and transitional fracture are examined. A.R.H.

N79-20412# Industrieanlagen-Betriebsgesellschaft m.b.H., Ottobrunn (West Germany).
FATIGUE CRACK GROWTH
Walter Schutz *In* AGARD Fracture Mech. Design Methodology Jan. 1979 13 p (For primary document see N79-20409 11-39)
Avail: NTIS HC A11/MF A01

It is now an established fact that structures may go into service containing crack-like manufacturing defects. However, only in very rare cases these cracks are so large that immediate static failure occurs when the first high service loads occur; rather, it is the service loads themselves which produce crack growth starting either from the small manufacturing cracks or from notches which are unavoidable in a structure. In the first case, the whole life of the structure consists of crack growth; it ends when the remaining cross section can no longer sustain the service loads and fails statically. In the second case, at the notch root a crack must first be initiated which then grows to failure and the life consists of the crack initiation and the crack propagation phase. In both cases, crack propagation and its calculation is therefore an important task at least as important as the calculation of residual static strength and much more difficult. This is so because fatigue crack propagation is a cyclic phenomenon and is therefore much more complex and difficult than a static phenomenon. One reason is the very large number of parameters; therefore, experimental verification of calculation methods, hypotheses etc. is very time-consuming and expensive. Author

N79-20413# Northrop Corp., Hawthorne, Calif. Aircraft Group.
STRESS INTENSITY ANALYSIS: ANALYTICAL, FINITE ELEMENT FOR SURFACE FLAWS, HOLES
D. P. Wilhem *In* AGARD Fracture Mech. Design Methodology Jan. 1979 19 p refs (For primary document see N79-20409 11-39)
Avail: NTIS HC A11/MF A01

Several methods are available to obtain stress intensity for developing cracks in structure where uniform loading and symmetric cracks prevail. Unfortunately in all aircraft structure both loading (stress) and crack geometries are far from ideal. These factors combined with localized plasticity require the use of more sophisticated means of obtaining stress intensity factors. Finite element analysis, both with and without special cracked elements, can be used to obtain stress intensity values. Careful attention must be paid in modeling to account for various factors, i.e., fasteners, etc., which affect the stress field. In many cases where elastic-plastic behavior is evident, those finite element programs with nonlinear capability can be effectively used to compute J-integral values for use in both fatigue and fracture studies. One case study presented involves a cutout in the wing in a highly stressed region the root. Other cases deal with part-through-cracks at holes and countersinks and other design details. The use of three dimensional finite element models to obtain stress intensities for cracks at holes provides an opportunity to evaluate the merits of each method of analysis; analytical, finite element and semi-empirical. Comparisons are presented for several cases. A.R.H.

N79-20414# Douglas Aircraft Co., Inc., Long Beach, Calif.
DAMAGE TOLERANCE ANALYSIS OF REDUNDANT STRUCTURES
T. Swift *In* AGARD Fracture Mech. Design Methodology Jan. 1979 34 p refs (For primary document see N79-20409 11-39)
Avail: NTIS HC A11/MF A01

A modern transport aircraft contains wide expanses of basic redundant structure which must be designed with some damage tolerance capability. Reliable and economical analytical procedures are therefore required to ensure the most efficient design which will meet these damage tolerance requirements. Several kinds of analytical approaches are described including finite-element, energy release rate, and displacement compatibility methods. Each of these methods can be used to calculate the crack tip stress intensity and stiffener stress concentration factors necessary for the damage tolerance design of stiffened structure. The role that stiffeners play in reducing the crack tip stress intensity factor to a level which can arrest cracks after rapid propagation is described. The effects of variations in geometry on the crack tip stress intensity factor, stiffener stress, and residual strength are presented, including the results of a parametric study. Finally, analytical procedures are described which account for fastener nonlinear shear displacement and the effects of stiffener plasticity. Author

N79-20415# Battelle Columbus Labs., Ohio.
FATIGUE CRACK GROWTH ANALYSIS
David Broek *In* AGARD Fracture Mech. Design Methodology Jan. 1979 19 p refs (For primary document see N79-20409 11-39)
Avail: NTIS HC A11/MF A01

Basically, damage tolerance means that (real or assumed) cracks do not grow, within a certain defined period, to a size that would cause loss of the aircraft at a specified load. Damage-tolerance assessment involves analysis of fatigue and environmentally assisted growth of an initial flaw under the anticipated service loading, and the residual strength characteristics of the cracked structure. In principle, present day fracture mechanics and modern stress analysis techniques permit the prediction of residual strength characteristics of many structures. Techniques for dealing with random or quasi-random service-load histories were recently proposed. The adequacy of these new techniques for crack growth predictions is examined. Because the load spectrum and the stress history are the most important ingredients of a crack growth analysis, the development of an adequate stress history is discussed. A.R.H.

N79-20416# Industrieanlagen-Betriebsgesellschaft m.b.H., Ottobrunn (West Germany).
DESIGN OF HEAVY SECTIONS
Walter Schutz *In* AGARD Fracture Mech. Design Methodology Jan. 1979 11 p refs (For primary document see N79-20409 11-39)
Avail: NTIS HC A11/MF A01

Because most highly loaded heavy section airframe components are manufactured either from plate or from forging, their crack propagation and residual static strength properties are of interest to the designer, the certification authorities, and the operator. If heavy section components are made from plate their final shape is obtained by machining-interrupting the grain flow. For many forgings the original shape is hardly changed by machining. However, there may be differences in grain flow between individual forgings. The available fracture mechanics data of plate or forged aircraft materials are reviewed, finally, some qualitative suggestions and quantitative results are given for use by the designer of heavy sections. A.R.H.

N79-20417# Industrieanlagen-Betriebsgesellschaft m.b.H., Ottobrunn (West Germany).
TREATMENT OF SCATTER OF FRACTURE TOUGHNESS DATA FOR DESIGN PURPOSES
Walter Schutz *In* AGARD Fracture Mech. Design Methodology Jan. 1979 20 p refs (For primary document see N79-20409 11-39)
Avail: NTIS HC A11/MF A01

The numerical values used in fracture mechanics calculations depend on material properties. Therefore they have an inherent scatter - like all material data. For design puposes, this scatter must be accounted for either by safety factors or by suitable statistical procedures. The mathematical procedures as such are relatively simple and well known; it is, however, a most difficult question which numerical values to use in such a calculation, for example for the coefficient of variation of fracture toughness. this is so because such numerical values are still very scarce, as they are much more difficult and expensive to determine than, for example, fracture toughness values. Also, fracture toughness may be much more sensitive to slight variations in

heat treatment than the mormal mechanical properties; this may result in large differences of fracture toughness between different heats of a nominally identical material. Author

N79-20418# *Douglas Aircraft Co., Inc., Long Beach, Calif.*
DESIGN OF REDUNDANT STRUCTURES
T. Swift *In* AGARD Fracture Mech. Design Methodology Jan. 1979 23 p refs (For primary document see N79-20409 11-39)
Avail: NTIS HC A11/MF A01

The selection of damage sizes to be used in the design of a large commercial transport aircraft is discussed. Development tests are described which assess the capability of different materials and structural configurations to meet the selected criteria. Correlation of various analytical methods is shown for varying degrees of damage for both fuselage and wing structural arrangements. A limited number of tests are described which verify the chosen inspection intervals for externally detectable damage after internal member failure. A.R.H.

N79-20419# Northrop Corp., Hawthorne, Calif. Aircraft Group.
ANALYSIS OF AIRCRAFT STRUCTURE USING APPLIED FRACTURE MECHANICS
D. P. Wilhem *In* AGARD Fracture Mech. Design Methodology Jan. 1979 17 p refs (For primary document see N79-20409 11-39)
Avail: NTIS HC A11/MF A01

An aircraft designed and analyzed for a particular set of usages is often placed in a service environment which is more severe than originally planned. The consequence of this occurrence is that many design details such as cutouts, holes, etc., are placed in a spectrum of loads which result in higher operating stresses. In the original full scale fatigue test, a different (design usage) spectrum is usually employed, and can only indicate fatigue critical areas. Using the finite element approach with stress intensity values and usage spectra, estimates are made of the crack growth life for a part-through-crack at a cutout. These data are then used to establish inspection intervals. Three distinct spectra were developed to represent usage, and analytical/experimental correlation was made for those spectra. In the majority of cases, good agreement was obtained. For these cases where the correlation is not good, refinements need to be made to the stress intensity solutions and/or the crack growth model. The reliance on more than one method of analysis is recommended for stress intensity evaluation of fatigue and fracture-critical areas. A comparison of the methods used in determining crack growth parameters sometimes indicates that the added cost of a more complex technique is not warranted, particularly when parametric design studies are involved. The use of a newer approach to the prediction of both fatigue crack growth and residual strength, employing a wide range resistance curve, is promising. Its usefulness in pinpointing differences in the cutout problem is given. A.R.H.

N79-20420# Battelle Columbus Labs., Ohio.
DAMAGE TOLERANCE IN PRACTICE
David Broek *In* AGARD Fracture Mech. Design Methodology Jan. 1979 13 P refs (For primary document see N79-20409 11-39)
Avail: NTIS HC A11/MF A01

Some practical aspects in the application of damage tolerance criteria in the design and operation of aircraft are discussed, including the complete fracture control plan. Rules issued by various authorities specifying the required damage tolerance of the airplane structure are reviewed. The problem of the application of safety factors is particularly from the point of view of crack-growth prediction. Because substantial testing is still necessary (and also required by the authorities) damage tolerance testing is examined, which offers a possibility for a continuous updating of the predictions of life expectancy and facilitates management decisions. Fleet monitoring is a logical extension of the fracture control plan. A.R.H.

N79-20421# Advisory Group for Aerospace Research and Development, Paris (France).
SELECTION OF STRUCTURAL ANALYSIS COMPUTER PROGRAMS
L. V. Andrew and I. C. Taig Jan. 1979 25 p refs Presented *at the 47th Struct and Mater. Panel Meeting, Florence, Sep. 1978*
(AGARD-R-670; ISBN-92-835-1305-3) Avail: NTIS HC A02/MF A01

The technical and administrative course of action in selecting computer programs are presented. For individual titles, see N79-20422 through N79-20423.

N79-20422# Rockwell International Corp., Downey, Calif.
ROCKWELL INTERNATIONAL'S SUBCOMMITTEE FOR COMPUTERIZED STRUCTURAL ANALYSIS
L. V. Andrew *In* AGARD Selection of Struct. Anal. Computer Programs Jan. 1979 p 1-10 refs (For primary document see N79-20421 11-39)
Avail: NTIS HC A02/MF A01

How the Ad-Hoc SCSA scoped the task of evaluating the computer programs, how it developed the basis for its evaluations and recommendations and how it presents tables that define the grading system that emerged are described. The compilation of the final report which still serves as a guide for the permanent SCSA formed in 1974 was examined. The SCSA formed ASKA and NASTRAN Configuration Control Boards to control the maintenance and development of the programs. The function of these boards in certification of the computer programs and the function of the SCSA in Rockwell Group Services Project reviews are discussed. Some recommendations are made to those who must select computer programs from those that are available. S.E.S.

N79-20423# British Aerospace Aircraft Group, Warton (England).
SELECTION CRITERIA FOR STRUCTURAL ANALYSIS PROGRAM
I. C. Taig *In* AGARD Selection of Struct. Anal. Computer Programs Jan. 1979 p 11-19 (For primary document see N79-20421 11-39)
Avail: NTIS HC A02/MF A01

A procedure to help the user make the best selection of structural analysis programs is presented. A procedure is discussed which includes the following three stages. (1) initial screening; (2) formal assessment; (3) management decision. S.E.S.

N79-21459# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
STRUCTURAL FATIGUE HANDBOOK. VOLUME 2: CAUSES AND PREVENTION OF DAMAGE. CHAPTER 7: SURFACE DAMAGE MECHANICS [MANUEL SUR LA FATIGUE DES STRUCTURES. VOL 2. CAUSES ET PREVENTION DE L'ENDOMMAGEMENT. CHAPITRE 7. ENDOMMAGEMENT MECANIQUE DE LA SURFACE]
W. G. Barrois Dec. 1978 122 p refs In FRENCH
(AGARD-MAN-10; ISBN-92-835-2105-6) Copyright. Avail: NTIS HC A06/MF A01

Practical aspects of various of structural surface fractures are reviewed and compared. These processes can be at the origin of defects or of the final rupture by fatigue or stress corrosion under the influence of loads applied during use. Such damages are provoked by flaws in heat treatment, rectification in grinding, wear, fatigue from rolling, and from contact or sliding friction as well as from abrasion, the erosion by liquid or solid particles or cavitation. Despite apparent differences, the elementary processes of these fracture modes present a real uniformity and involve an initial fatigue phase by repeated plastic deformations. On a microscopic scale, corresponding alternate constraints involve the detachment of particles in each of these processes. It is shown that the essential act of corrosion is limited by the oxidation of residue in laboratory tests, but can have a more complex effect in actual structures in use or over very long periods of time. Transl. by A.R.H.

N79-23449# Advisory Group for Aerospace Research and Development, Paris (France).
BONDED JOINTS AND PREPARATION FOR BONDING
Mar. 1979 317 p refs Lecture series presented at Oslo, 2-3 Apr. 1979, and the Hague, 5-6 Apr. 1979; proposed for presentation at Wright-Patterson AFB, Ohio, 16-17 Oct. 1979
(AGARD-LS-102; ISBN-92-835-13134) Avail: NTIS HC A14/MF A01

The following topics are discussed: (1) operational experience with adhesive bonded structures; (2) interfacial fracture mechanical aspects of adhesive bonded joints; (3) analysis and design of adhesive bonded joints; (4) behavior of adhesive bonded joints under cyclic loading; (5) the nature of adhesion mechanisms and the influence of surface treatments on the behavior of bonded joints; (6) failures in adhesively bonded structures; (7) surface preparation - the key to bondment durability; and (8) nondestructive testing of adhesive bonded joints. For individual titles, see N79-23450 through N79-23457.

N79-23450# Royal Netherlands Aircraft Factories Fokker, Schiphol-Oost. Technological Centre.
OPERATIONAL EXPERIENCE WITH ADHESIVE BONDED STRUCTURES

Rob J. Schliekelmann *In* AGARD Bonded Joints and Preparat ↖ for Bonding Mar. 1979 30 p refs (For primary document se↖ N79-23449 14-39)
Avail: NTIS HC A14/MF A01

A survey is given of the operational experience with adhesive bonded structures in military and civil aircraft. In view of the widely different qualifications of these experiences, from 'highly favourable' through 'very unfavourable', an introduction is given to the various problem areas that caused service troubles. The objective is to develop full understanding of the principle causes of possible failures and to define ways and means to achieve fully reliable bonded joints, that will play in the future an even more important role than today. G.Y.

N79-23451# Propellants, Explosives and Rocket Motor Establishment, Waltham Abbey (England).
INTERFACIAL FRACTURE MECHANICAL ASPECTS OF ADHESIVE BONDED JOINTS
A. J. Kinloch *In* AGARD Bonded Joints and Preparation for Bonding Mar. 1979 15 p refs (For primary document see N79-23449 14-39)
Avail: NTIS HC A14/MF A01

Interfacial locus of failure focuses attention on interfacial fracture mechanical considerations. Mechanisms of environmental failure are reviewed and techniques are considered for estimating and increasing the service-lifetimes of bonded components. Particular emphasis is given to the contribution from the application of continuum fracture mechanics concepts to the study of environmental attack on adhesive joints. G.Y.

N79-23452# Utah Univ., Salt Lake City. Dept. of Mechanical and Industrial Engineering
ANALYSIS AND DESIGN OF ADHESIVE-BONDED JOINTS
K. L. DeVries and G. P. Anderson (Thiokol Corp.) *In* AGARD Bonded Joints and Preparation for Bonding Mar. 1979 25 p refs (For primary document see N79-23449 14-39)
Avail: NTIS HC A14/MF A01

A brief summary outline of the standard test methods that are in common usage is presented. A short development of adhesive fracture mechanics is presented. The use of fracture mechanics for cohesive systems is well established and proved to be a very useful design tool. A number of specific cases are treated. Several recent studies demonstrated how the principles of fracture mechanics may be used to provide insight into specific problems. A variety of test geometries were examined analytically or numerically. These along with several test methods and the type of useful parameters they yield are discussed. Analytical and numerical techniques were developed to use these parameters to predict strength and optimize the design adhesive joints. Specific examples of application in the aerospace, elastomer, medical, dental and other technologies are presented. G.Y.

N79-23453# General Dynamics/Fort Worth, Tex. Materials Research Lab
BEHAVIOR OF ADHESIVELY BONDED JOINTS UNDER CYCLIC LOADING
John Romanko *In* AGARD Bonded Joints and Preparation for Bonding Mar. 1979 42 p refs (For primary document see N79-23449 14-39)
Avail: NTIS HC A14/MF A01

The state of the art in determining the fundamental mechanisms of fatigue degradation in structural adhesive joints and in identifying the dominant fatigue mechanisms with the service environmental regimes, including cyclic mechanical loads, temperature and humidity, is presented. The scope involves an in-depth assessment of fatigue mechanisms and failure modes primarily in adhesively bonded metal/metal joints over the range of loads and environmental conditions experienced by modern high performance aircraft. Analytical and experimental stress analysis methods are described. The joints are analyzed to describe the stress/strain distributions developed within the adhesive interlayer by load/environmental fatigue conditions. Joint fatigue to various stages of joint life are examined for degradation mechanisms. The development of methodology for predicting the necessary service life of adhesively bonded joints is outlined. G.Y.

N79-23454# Douglas Aircraft Co., Inc., Long Beach, Calif.
FAILURES IN ADHESIVELY BONDED STRUCTURES
Edward W. Thrall, Jr. *In* AGARD Bonded Joints and Preparation for Bonding Mar. 1979 89 p refs (For primary document see N79-23449 14-39)
(AF Proj. 486U)
Avail: NTIS HC A14/MF A01

The Primary Adhesively Bonded Structure Technology (PABST) program was undertaken to validate the bonded joint with tests and analyses. The program structural tests conducted to compare the strength of bonded joints to the classical riveted design are presented. The tests were conducted to determine allowables for static, fatigue, and damage tolerance (crack growth). Also presented are the analytical methods for predicting the bond line strength characteristics. The analyses were found to match the test results. G.Y.

N79-23455# Institut fuer Angewandte Materialforschung der Fraunhoffer-Gesellschaft e. V., Bremen (West Germany)
THE NATURE OF ADHESION MECHANISMS AND THE INFLUENCE OF SURFACE TREATMENTS ON THE BEHAVIOUR OF BONDED JOINTS
Walter Brockmann *In* AGARD Bonded Joints and Preparation for Bonding Mar. 1979 23 p refs (For primary document see N79-23449 14-39)
Avail: NTIS HC A14/MF A01

The following topics are discussed: (1) physical, chemical and mechanical bonding mechanisms, (2) surface treatment and bonding durability, and (3) techniques for surface properties. G.Y.

N79-23456# Boeing Commercial Airplane Co., Seattle, Wash.
SURFACE PREPARATION: THE KEY TO BONDMENT DURABILITY
J. Corey McMillan *In* AGARD Bonded Joints and Preparation for Bonding Mar. 1979 30 p refs (For primary document see N79-23449 14-39)
Avail: NTIS HC A14/MF A01

A correlation between the variable service performance of bondments employing the 120 C during modified epoxy adhesives and the varability of production acid etch surface preparation processes is developed using stressed environmental durability test methods. This variability requires special procedures for control in the acid etch processing, but may be precluded by incorporation of phosphoric acid anodizing into the processing sequence. Phosphoric acid anodizing is shown to produce consistent, environmentally durable bondments. A test program comparing the environmental durability of the acid etch with the phosphoric acid and anodized surface preparation process under various exposure and loading conditions is reviewed. G.Y.

N79-23457# Royal Netherlands Aircraft Factories Fokker, Schiphol-Oost.
NON-DESTRUCTIVE TESTING OF ADHESIVE BONDED JOINTS
Rob J. Schliekelmann *In* AGARD Bonded Joints and Preparation for Bonding Mar. 1979 57 p refs (For primary document see N79-23449 14-39)
Avail: NTIS HC A14/MF A01

With the increased interest in the use of adhesive bonded joints in structural applications the importance of a reliable nondestructive evaluation is growing. Requirements for application of nondestructive testing of bonded joints are discussed. Available methods are presented with their capabilities and limitations. G.Y.

N79-23458# Advisory Group for Aerospace Research and Development, Paris (France)
MANUAL ON STRUCTURAL FATIGUE. 2: CAUSES AND PREVENTION OF DAMAGE. 7: MECHANICS OF SURFACE DAMAGE [MANUEL SUR LA FATIGUE DES STRUCTURES. 2: CAUSES ET PREVENTION DE L'ENDOMMAGEMENT. 7: ENDOMMAGEMENT MECANIQUE DE LA SURFACE]
W. G. Barrois Dec. 1978 122 p refs In FRENCH
(AGARD-MAN-10(Fr)) ISBN-92-835-2105-6) Avail: NTIS HC A06/MF A01

The process and practical aspects of various causes of the fracture mechanics of structural surfaces which can be the source of failure, final rupture or stress corrosion cracking during service are reviewed and compared. Corrosion constitutes the most rapid mode of surface deformation, shortens the initiation phase of fatigue cracks, and severely decreases the service life of structural members. The same harmful effects are caused by the surface decarburization of steels during thermal treatment, rectification during grindings, changes in a contact or sliding friction, and wear during service. The fatigue of the surface layer of rollers, wheels, ball bearings, and roller tracks is an important cause of crack initiation. Erosion and cavitation corrosion also initiate the elementary processes of fracture mechanics. Transl. by A.R.H.

N79-33494# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
TECHNICAL EVALUATION REPORT OF THE SPECIALISTS MEETING ON CHARACTERIZATION OF LOW CYCLE HIGH TEMPERATURE FATIGUE BY THE STRAINRANGE PARTITIONING METHOD
J. M. Drapier (Fabrique Nationale Herstal, Belgium) and M. H. Hirschberg (NASA. Lewis Res. Center) Jul 1979 14 p refs (AGARD-AR-130; ISBN-92-835-1328-2) Avail: NTIS HC A02/MF A01

The ability of the Strainrange Partitioning Method SRP was evaluated to correlate the creep-fatigue behavior of gas turbine materials and to predict the creep fatigue life of laboratory specimens subjected to complex cycling conditions. A reference body of high temperature creep fatigue data which can be used in the evaluation of other SRP and low cycle high temperature fatigue predictive techniques was provided. M.M.M.

N80-10532# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
USE OF COMPUTER STRUCTURAL PROGRAMS FOR THE DYNAMIC ANALYSIS OF SATELLITES STRUCTURES
R. Barboni (Rome Univ.) and G. Morelli (Compagnia Nazionale Aerospaziale, Rome) Aug. 1979 17 p refs Presented at the 4th Struct. and Mater. Panel Meeting, Florence, Sep. 1978 (AGARD-R-680; ISBN-92-835-1335-5) Avail: NTIS HC A02/MF A01

The essential aspects of computer programs for structural analysis are analyzed along with the dynamic problems of satellites. Possible future trends are outlined, and the meaningful features in dynamic structural computer programs are presented. F.O.S.

N80-19572# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
DAMPING EFFECTS IN AEROSPACE STRUCTURES
Oct. 1979 193 p refs In ENGLISH and FRENCH Meeting held in Williamsburg, Va., 2-3 Apr. 1979 (AGARD-CP-277; ISBN-92-835-0244-2) Avail: NTIS HC A09/MF A01

Mathematical models, vibration tests, and predictions of structural damping are discussed in terms of aerospace problems where structural damping plays a basic role. Topics addressed include numerical modelling of structures to account for internal damping, spacecraft damping considerations in structural design, damping problems in acoustic fatigue, and damping effects in joints and riveted specimens. For individual titles, see N80-19573 through N80-19584. A.W.H.

N80-19573# National Aerospace Lab., Amsterdam (Netherlands).
MATHEMATICAL FORMULATION OF DAMPING FOR STRUCTURAL RESPONSE ANALYSIS
H. H. Ottens *In* AGARD Damping Effects in Aerospace Struct. Oct. 1979 10 p refs (For primary document see N80-19572 10-39)
Avail: NTIS HC A09/MF A01

A survey of damping models that are commonly used in the structural response analysis of aerospace structures is presented. The various damping models are evaluated with respect to the required knowledge of structural damping, the mathematical complexity and the accuracy of the calculated response. The survey is limited to linear damping models and models which represent lightly damped structures are highlighted. A.W.H.

N80-19574# Southampton Univ. (England). Dept. of Aeronautics and Astronautics.
PREDICTION OF THE STRUCTURAL DAMPING OF A VIBRATING STIFFENED PLATE
Denys J. Mead *In* AGARD Damping Effects in Aerospace Struct. Oct. 1979 15 p refs (For primary document see N80-19572 10-39)
Avail: NTIS HC A09/MF A01

The sources of energy dissipation in a vibrating stiffened plate, typical of a fuselage stringer skin structure are outlined. For a particular specimen, the principal source was identified as the riveted joints attaching the skin to the stringer. These undergo oscillating tension/compression loads (in the direction of the rivet axis) when the plate vibrates. An experiment to measure the basic damping characteristic of a single riveted joint loaded harmonically is described. The non-linearity of the damping was demonstrated, as was the effect of an air pumping mechanism in the joint. The results of the experiment were used to predict the damping of a riveted stringer skin structure containing many such joints. The predicted damping is compared with the value actually measured. The results are of the same order of magnitude, but the numerical difference highlights the difficulties involved in undertaking such damping studies. A.W.H.

N80-19575# Genoa Univ. (Italy). Istituto di Scienza delle Costruzioni.
NUMERICAL MODELLING OF STRUCTURES TO ACCOUNT FOR INTERNAL DAMPING
Riccardo F. Baldacci, Alfred Corsanego, and Andrea DelGrosso *In* AGARD Damping Effects in Aerospace Struct. Oct. 1979 9 p refs (For primary document see N80-19572 10-39)
Avail: NTIS HC A09/MF A01

Various numerical analysis techniques are examined concerning the inclusion of the structural damping effects from the point of view of representing the structural behaviour by means of finite element models. The consequences of assuming some of the more popular damping models are discussed in terms of the solution algorithms. Uncoupling techniques that are only approximate when the structural models possess a nonproportional damping matrix are emphasized and criticized. Various diagonalization schemes are presented for the damping matrix and emphasis is given to the evaluation of the errors involved in the computation. A.W.H.

N80-19576# British Aerospace Aircraft Group, Brough (England).
SOME RECENT MEASUREMENTS OF STRUCTURAL DYNAMIC DAMPING IN AIRCRAFT STRUCTURES
E. J. Phillips *In* AGARD Damping Effects in Aerospace Struct. Oct. 1979 15 p refs (For primary document see N80-19572 10-39)
Avail: NTIS HC A09/MF A01

Values of structural damping obtained during a flutter investigation of a strike aircraft in several wing store configurations, in which the wings were excited by impulses at the wing tips are presented. A vibration test on a large underwing pylon mounted pod during which three suspensions were represented, and a vibration test on a box section shelf mounted on antivibration mounts are described. During the flutter investigation the structural damping was determined from the time decay of filtered accelerometer signals. In the vibration tests, the test items were excited sinusoidally and damping was obtained from accelerometer response curves at resonance. A.W.H.

N80-19577# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Goettingen (West Germany). Inst. fuer Aeroelastik.
EFFECT OF STRUCTURAL DAMPING ON THE DYNAMIC RESPONSE OF SPACECRAFT
M. Degener *In* AGARD Damping Effects in Aerospace Struct. Oct. 1979 19 p refs (For primary document see N80-19572 10-39)
Avail: NTIS HC A09/MF A01

The effect of structural damping on the dynamic response of spacecraft structures, especially satellites, is investigated. Special regard is given to the influence of intermodal damping coupling and of a nonlinear damping behaviour. Results of dynamic tests on satellite structures are studied. A method is presented to determine the dynamic response of a spacecraft structure, taking into account the nonlinear damping behaviour by means of a numerical, iterative procedure based on modal data. A.W.H.

N80-19578*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
SPACECRAFT DAMPING CONSIDERATIONS IN STRUCTURAL DESIGN
B. K. Wada and D. T. DesForges *In* AGARD Damping Effects in Aerospace Struct. Oct. 1979 18 p refs (For primary document see N80-19572 10-39)
(Contract NAS7-100)
Avail: NTIS HC A09/MF A01

The role of damping in the prediction of spacecraft structural responses and loads, and in the structural design of spacecrafts is discussed. The methods used to incorporate damping in the structural analysis are summarized and some experiences and procedures relating to damping in recent spacecraft design are discussed. Methods for modal testing and the experimental determination of damping, the use of discrete dampers, and the estimation of payload response are studied. A collection of damping data for recent spacecraft and related hardware is provided in the appendix. A.W.H.

N80-19579# Rome Univ (Italy) Scuola d'Ingegneria Aerospaziale

VIBRATION DAMPING ON SAN MARCO SATELLITES: RESULTS AND COMMENTS

Carlo Arduini and Alessandro Agneni *In* AGARD Damping Effects in Aerospace Struct Oct 1979 15 p refs (For primary document see N80-19572 10-39)

Avail NTIS HC A09/MF A01

The damping data from dynamic tests of the San Marco structures is surveyed The typical trend of the damping coefficient to decrease with frequency is confirmed However, there is no *clear evidence* of significant variations with the input level This feature is discussed in terms of the limits of the half power method K L

N80-19580# Politecnico di Milano (Italy) Istituto di Ingegneria Aerospaziale

DAMPING PROBLEMS IN ACOUSTIC FATIGUE

Vittorio Giavotto, Marco Borri, and Giorgio Cavallini (Pisa Univ) *In* AGARD Damping Effects in Aerospace Struct Oct 1979 11 p refs (For primary document see N80-19572 10-39)

Avail NTIS HC A09/MF A01

Damping information necessary for the fatigue design of wideband noise excited structures is identified Damping mechanisms are considered and damping test results are presented for stiffened panels typical of aerospace structures The need for models capable of accurately estimating damping effects is emphasized K L

N80-19581# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Stuttgart (West Germany) Inst fuer Bauweisen- und Konstruktionsforschung

DYNAMIC DAMPING INVESTIGATIONS ON COMPOSITES

H Georgi *In* AGARD Damping Effects in Aerospace Struct Oct 1979 20 p refs (For primary document see N80-19572 10-39)

Avail: NTIS HC A09/MF A01

Characteristic regularities and data from a series of damping measurements on fiber reinforced composite materials and structures are presented. Experiments were carried out mainly on natural frequencies of lateral vibrations in free decay and forced excitation. Tests included composite materials with *reinforcement by boron, carbon, glass, and synthetic* fibers, structural components, sandwich and I-beams; and composite structures such as rotor blades. Experimental parameters considered were amplitude, temperature, vibration mode, frequency, air pressure, aspect ratio, and fiber orientation. Dynamic response properties of several composites were compared by means of a simple linear oscillation model with spring, mass, and damping values corresponding to the composite data The structural damping of a wing box and a wind turbine blade was compared with the damping of the respective structural element. Numerical extrapolations of the damping behavior of beams differing from experimental configurations in fiber orientation, air pressure, etc. are discussed. K L

N80-19582# Air Force Materials Lab., Wright-Patterson AFB, Ohio.

VISCOELASTIC DAMPING IN USAF APPLICATIONS

D. I. G. Jones, J. P. Henderson, and L. C. Rogers (AFFDL, Wright-Patterson AFB, Ohio) *In* AGARD Damping Effects in Aerospace Struct. Oct. 1979 24 p refs (For primary document see N80-19572 10-39)

Avail NTIS HC A09/MF A01

The use of viscoelastic damping technology for vibration control in the United States Air Force is reviewed The potential payoff in improved performance and maintainability of vibration critical systems such as large flexible spacecraft structures, digital electronics systems, and rotating jet engine components is very high. K L

N80-19583# Societe METRAVIB, Ecully (France)

REPORT ON THE USE OF ABATEMENT TECHNIQUES FOR PROBLEMS RELATED TO VIBRATIONS AND NOISE [BILAN SUR LA MISE EN OEUVRE DE TECHNIQUES D'AMORTISSEMENT POUR DES PROBLEMES LIES AUX VIBRATIONS ET AU BRUIT]

B. Duperray and L. Gaudriot *In* AGARD Damping Effects in Aerospace Struct Oct. 1979 9 p In FRENCH (For primary document see N80-19572 10-39)

Avail. NTIS HC A09/MF A01

The 10 year history of METRAVIB involvement in using *viscoelastic materials to solve the vibration and noise problems* encountered in the industrial, mechanical, electrical, and naval and aerospace construction sectors is reviewed Particular attention is given to the development of models of structural dynamics, and a viscoelastimeter as well as the transfer of information to industries interested in developing new products using glass fiber reinforced composites and high temperature materials such as glasses and ceramics Specific applications are cited to demonstrate the effectiveness of the techniques used Transl by A R H

N80-19584# Istituto di Tecnologia Aerospaziale, Rome (Italy)

DAMPING EFFECTS IN JOINTS AND EXPERIMENTAL TESTS ON RIVETED SPECIMENS

Luigi Balis Crema, Antonio Castellani, and Alfonso Nappi (SIAI Marchetti) *In* AGARD Damping Effects in Aerospace Struct Oct. 1979 17 p refs (For primary document see N80-19572 10-39)

Avail NTIS HC A09/MF A01

The importance of dynamic damping is highlighted with emphasis on the effect of riveted joints on energy dissipation The state of the art in the field of joint damping is illustrated with reference to several theories on damping mechanisms Results of tests carried out on specimens with riveted joints are discussed K L

42 GEOSCIENCES (GENERAL)

N77-19530# Advisory Group for Aerospace Research and Development, Paris (France).
ARTIFICIAL MODIFICATION OF PROPAGATION MEDIA
H. J. Albrecht, ed. (FGAN, Wachtberg-Werthhoven, Germany) Jan. 1977 189 p refs Conf. Proc. of the Electromagnetic Wave Propagation Panel Specialists' Meeting, Brussels, 26-29 Apr. 1976
(AGARD-CP-192; ISBN-92-835-1234-1) Avail: NTIS HC A09/MF A01

A study concerning the modification of the atmospheric region as a propagation medium is presented. Other areas of discussion were: (1) anthropogeneous changes to non-ionized media, (2) to ionized media by electromagnetic waves, and (3) to ionized media by chemical substances. For individual titles, see N77-19531 through N77-19547.

N77-19531# Schule fuer Wehrgeophysik, Fuerstenfeldbruck (West Germany).
NON-IONISED PROPAGATION MEDIA WITH ARTIFICIALLY MODIFIED PRECIPITATION CHARACTERISTICS
E. Kleinjung *In* AGARD Artificial Modification of Propagation Media Jan. 1977 10 p refs (For primary document see N77-19530 10-42)
Avail: NTIS HC A09/MF A01

Deviations of the meteorological characteristics important for propagation calculations of artificially influenced precipitation and fog are discussed. A comparison is made between the deviations and conditions as they occur in nature. Areas of application are indicated. Author

N77-19532# Hamburg Univ. (West Germany). Meteorologisches Inst.
MAN-MADE MODIFICATION OF CLEAN-AIR PROPAGATION CONDITIONS (VHF TO EHF)
H. Jeske *In* AGARD Artificial Modification of Propagation Media Jan. 1977 5 p refs (For primary document see N77-19530 10-42)
Avail: NTIS HC A09/MF A01

Dispersions of man-made media in the atmosphere (radar chaff, gases, aerosols) or direct modification of the refractive index field, especially characterized by its vertical gradient, ducts and reflecting layers are studied. The use of radar chaff is well defined; other admixtures are less studied under operational conditions. As typical examples for an alteration of the environmental conditions the meteorological situation during large forest fires and the suppression of evaporation by monomolecular films on water surfaces is considered. Above a forest (or other) fire a subnormal refraction layer is formed. The reduction of evaporation diminishes the thickness of the permanent existing evaporation duct over sea and therefore its extensive influence on microwave propagation. The influence of the clear, non-ionized, atmosphere on radio wave propagation some 100 GHz is summarized, and relevant propagation parameters are indentified. Author

N77-19533# Siemens A.G., Munich (West Germany).
REVIEW ON COMMUNICATION ASPECTS OF CHAFF-PRODUCED SCATTER PROPAGATION
E. Lampert *In* AGARD Artificial Modification of Propagation Media Jan. 1977 10 p refs (For primary document see N77-19530 10-42)
Avail: NTIS HC A09/MF A01

With chaff a cloud of many dipoles released into the air communication channels especially for over the horizon links is established. Air communication channels are described, with emphasis placed on the average scatter cross section of the clouds with respect to the length of the dipoles and their distribution in space. The lifetime, fading frequency and coherence bandwidth of the channel are estimated using aerodynamic data from literature. A comparison of the path loss of the chaff channel with that of a troposcatter channel lifetime of the chaff channel is restricted to less than one hour Author

N77-19534# Mainz Univ. (West Germany). Inst. fuer Meteorologie
DISCUSSION OF ARTIFICIAL FOG MODIFICATION
Gottfried Heenel *In* AGARD Artificial Modification of Propagation Media Jan. 1977 3 p refs (For primary document see N77-19530 10-42)
Avail: NTIS HC A09/MF A01

Microphysical effects of artificial fog modification are discussed. Budget considerations are included. Fog particles were divided into classes of particles of almost equal size in dry state as well as equal chemical composition and structure in dry state. The total extinction coefficient or absorption coefficient is given as the sum of the extinction or absorption coefficients of the classes Author

N77-19535# Clermont-Ferrand Univ. (France).
ARTIFICIAL MODIFICATION OF THE AIR MICROSTRUCTURE INSIDE CLOUDY OR SIMPLY MOIST STRATIFIED LAYERS
R. Serpolay, M. Andro (Univ. de Bretagne Occidentale, I.U.T. de Lorient, France), and S. Godard *In* AGARD Artificial Modification of Propagation Media Jan. 1977 13 p refs (For primary document see N77-19530 10-42)
Avail: NTIS HC A09/MF A01

A project in the field of warm fog modification was presented. The method proposed two means; (1) as seeding agent, a polyelectrolyte chemically extracted and prepared from seaweeds; sodium alginate, and (2) for dispersing adequately the chemical finely ground (mean particulate size; 30 micrometers). Results and conclusions are included. Author

N77-19536# Office of Telecommunications, Boulder, Colo.
IONOSPHERIC MODIFICATION INDUCED BY HIGH POWER HF TRANSMITTERS: POTENTIAL FOR COMMUNICATION AND PLASMA PHYSICS RESEARCH
W. F. Utlaut *In* AGARD Artificial Modification of Propagation Media Jan. 1977 4 p refs (For primary document see N77-19530 10-42)
Avail: NTIS HC A09/MF A01

High power, HF, ground based radio transmitters were used to intentionally modify the electron temperature and density in the ionosphere since 1970. Transmitting facilities having power aperture products of the order of 10,000 MW M squared were used, and they provided a power density in the F region of a few tens of microwatts per square meter. Observations were obtained using a facility which used an 18 dB1 gain ring array antenna fed with as much as 2MW average power, to produce the ionospheric modification. It was shown that the modified region acts as a significant radio scatterer to radio frequencies at least as high as UHF. It was possible to demonstrate a potential usefulness of ionospheric modification for telecommunication purposes. It was also shown that ionospheric modification and a significantly large scatterer in the ionosphere was produced with relatively low power and simple antennas -- a few hundred kilowatts and dipole antennas. Author

N77-19537# Rice Univ., Houston, Tex.
THE HEATING EXPERIMENT AT ARECIBO
W. E. Gordon and H. C. Carlson (Texas Univ. at Dallas, Richardson) *In* AGARD Artificial Modification of Propagation Media Jan. 1977 11 p refs (For primary document see N77-19530 10-42)
Avail: NTIS HC A09/MF A01

The ionized atmosphere over the Arecibo Observatory was illuminated by HF waves in the frequency range 5-12 MHz with an incident power density of 11,000 watts per square meter at the bottom of the ionosphere, resulting in (a) normal absorption producing fractional changes in electron temperature of a few 10's percent near and just below reflection height for O and X modes, and (b) anomalous absorption with plasma waves enhanced by a few orders of magnitude when the frequency of the incident wave matches the local plasma frequency. This condition is achieved for ordinary mode polarization, but the extraordinary wave is reflected in the ionosphere before the matching is achieved. Thus, plasma water instabilities are excited by O-mode waves only. Author

N77-19538# White Sands Missile Range, N.Mex.
A REVIEW OF VHF/UHF SCATTERING FROM A HEATED IONOSPHERIC VOLUME
J. Minkoff and I. Weissman *In* AGARD Artificial Modification of Propagation Media Jan. 1977 21 p refs (For primary document see N77-19530 10-42)
Avail: NTIS HC A09/MF A01

It was observed that an ionospheric volume in the F-layer subjected to high power HF illumination becomes an effective scattering medium for radio signals in the VHF/UHF-frequency range. The experimental results are representative of a field-aligned scattering geometry for which the first such observations of VHF/UHF scattering from a heated ionospheric volume are presented. Two distinct and markedly dissimilar scattering modes

are observed: center line and plasma line scattering. Center line scattering is observed at the transmitted radar frequency f; plasma line scattering is observed as a pair of sidebands at f + or - F sub H where F sub H is the heater frequency. Center line scattering is highly aspect sensitive with respect to the direction of the geomagnetic field, B; plasma line scattering is bound to be much less aspect sensitive, if at all. By means of bistatic measurements it is determined that center line scattering takes place from field aligned irregularities. The longitudinal scale size of the irregularities, L, is found to be greater than the maximum antenna diameter, 85' Because of fundamental limitations imposed by the spatial resolution capability of the measurement system no more exact estimate for L is possible. Author

N77-19539# Max-Planck-Institut fuer Aeronomie, Lindau Uber Northeim (West Germany).

ON THE IONOSPHERIC MODIFICATION EXPERIMENT PROJECTED AT MPI LINDAU: SCIENTIFIC OBJECTIVES

P. Stubbe and H. Kopka *In* AGARD Artificial Modification of Propagation Media Jan. 1977 11 p refs (For primary document see N77-19530 10-42)
Avail: NTIS HC A09/MF A01

An ionospheric modification experiment to be carried out near Tromso, Norway is described. The scientific objectives include (a) the study of parametric instabilities using the EISCAT incoherent scatter system (b) nonlinear electromagnetic wave propagation effects, in relation to the polar electrojet, (c) determination of certain parameters of aeronomic interest, (d) modification of natural polar electrojet instabilities, and (e) extension of the diagnostic capabilities of the EISCAT incoherent scatter facility. Author

N77-19540# Max-Planck-Institut fuer Aeronomie, Lindau Uber Northeim (West Germany).

ON THE IONOSPHERIC MODIFICATION EXPERIMENT PROJECTED AT MPI LINDAU: PRACTICAL REALIZATION

H. Kopka, P. Stubbe, and R. Zwick *In* AGARD Artificial Modification of Propagation Media Jan. 1977 7 p refs (For primary document see N77-19530 10-42)
Avail: NTIS HC A09/MF A01

The technical design of the ionospheric modification experiment is outlined. The heating facility consists of 10 100 kW transmitters, feeding into arrays of 5 x 6 crossed dipoles. There are three such arrays to cover the frequency range 2.75 - 8.00 MHz. Author

N77-19541# Stanford Univ., Calif. Radioscience Lab.

MODIFICATION OF THE PROPAGATION CHARACTERISTICS OF THE IONOSPHERE (AND THE MAGNETOSPHERE) BY INJECTION INTO THE MAGNETOSPHERE OF WHISTLER-MODE WAVES

R. A. Helliwell, J. P. Katsufrakis, and P. A. Bernhardt *In* AGARD Artificial Modification of Propagation Media Jan. 1977 8 p refs (For primary document see N77-19530 10-42)
Avail: NTIS HC A09/MF A01

A technique for modifying the electrical properties of the lower ionosphere is described. Electromagnetic waves in the whistler-mode frequency range are used to precipitate energetic electrons into the D and E regions. Advantage is taken of the amplifying properties of the magnetosphere which can increase the power density of a whistler-mode wave by three orders of magnitude. During and after the amplification process, energetic electrons are scattered in pitch angle producing an increase in the particle flux that is absorbed by the ionosphere. Author

N77-19542*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.

LOW FREQUENCY ELECTRIC FIELD VARIATIONS DURING HF TRANSMISSIONS ON A MOTHER-DAUGHTER ROCKET

T. J. Rosenberg (Maryland Univ., College Park), M. C. Maynard, J. A. Holtet, N. O. Karlsen, A. Egeland, T. Moe (Bergen Univ., Norway), and J. Troim (Norwegian Defence Res. Estab., Kjeller) *In* AGARD Artificial Modification of Propagation Media Jan. 1977 11 p refs Sponsored by the Royal Norwegian Council for Scientific and Industrial Res. Prepared in cooperation with Oslo Univ. (For primary document see N77-19530 10-42)
Avail: NTIS HC A09/MF A01

HF wave propagation experiments were conducted on Mother-Daughter rockets in the polar ionosphere. Swept frequency transmissions from the Mother, nominally covering the range from 0.5 to 5 MHz in both CW and pulse modes, are received by the Daughter. In the most recent rocket of the series, the Mother also contained an AC electric field spectrometer covering the frequency range from 10 Hz to 100 kHz in four decade bands. The low frequency response of the ionosphere with respect to waves emitted from the onboard HF transmitter is examined. Author

N77-19543# Max-Planck-Institut fuer Extraterrestrische Physik, Garching (West Germany).

MODIFICATION OF IONIZED MEDIA BY CHEMICAL SUBSTANCES: A REVIEW OF PHYSICAL PROCESSES

G. Haerendel *In* AGARD Artificial Modification of Propagation Media Jan. 1977 15 p refs (For primary document see N77-19530 10-42)
Avail: NTIS HC A09/MF A01

Chemical releases and artificial and natural modification processes are briefly surveyed and summarized. Author

N77-19544# Boston Univ., Mass. Dept. of Astronomy.

SPATIAL-TEMPORAL DEVELOPMENT OF MOLECULAR RELEASES CAPABLE OF CREATING LARGE-SCALE F-REGION HOLES

Michael Mendillo and Jeffrey M. Forbes (Boston College) *In* AGARD Artificial Modification of Propagation Media Jan. 1977 8 p refs (For primary document see N77-19530 10-42)
(Contract F19628-75-C-0044)
Avail: NTIS HC A09/MF A01

Diffusion in an exponetial atmosphere, with and without chemical loss processes for the diffusing substance, and for a variety of possible release heights and solar cycle conditions is under study. Since the amounts of material capable of injection into the F-region are under most projected circumstances, much less than the 1 ton/second of exhaust ejected by the Saturn V second stage engines during the Skylab launch, a thorough analysis of the diffusion process was done for any prediction of the types of smaller holes which can be created. To a first approximation, the rate of decrease of electrons at any particular time and distance from the release point is proportional to the instantaneous concentration of the diffusing substance. The results for diffusion of molecular hydrogen (one of the highly reactive molecules capable of creating F-region holes) shows that chemical loss by atomic oxygen severely affects the expansion of the released gas by creating a chemical sink in the lower thermosphere which competes with diffusion. Author

N77-19545*# Stanford Univ., Calif. Radioscience Lab.

CHEMICAL DEPLETION OF THE IONOSPHERE

P. A. Bernhardt, A. V. DaRosa, and C. G. Park *In* AGARD Artificial Modification of Propagation Media Jan. 1977 16 p refs Sponsored in part by NSF (For primary document see N77-19530 10-42)
(Contract NAS8-31769; Grant NGR-05-020-001)
Avail: NTIS HC A09/MF A01

A theoretical study of the chemical and gas dynamical processes resulting from the release of reactive gases into the daytime ionosphere is discussed. Only point releases, such as from an explosion or a pulsed jet, are considered. Some scientific uses of the artificial reduction of the ionospheric plasma are considered. Author

N77-19546# Leicester Univ. (England).

SOME EFFECTS OF A HIGH ALTITUDE BARIUM RELEASE ON THE PROPAGATION CHARACTERISTICS OF HF RADIOWAVES

T. B. Jones and C. T. Spracklen *In* AGARD Artificial Modification of Propagation Media Jan. 1977 7 p refs Sponsored by the Procurement Executive Ministry of Defence (For primary document see N77-19530 10-42)
Avail: NTIS HC A09/MF A01

The effect that the electron density changes produced by the chemical release have on the propagation of HF radiowaves is studied. Some of the disturbances observed during the release of a Barium cloud at a hight of 175 km over the South Uist range in the UK are reported. Author

N77-19547# Atomic Weapons Research Establishment, Aldermaston (England).

MODIFICATION OF THE IONOSPHERE BY BARIUM ION CLOUDS

A. J. Baxter *In* AGARD Artificial Modification of Propagation Media Jan. 1977 10 p refs (For primary document see N77-19530 10-42)
Avail: NTIS HC A09/MF A01

The types of approximation used to model the development of ion clouds are discussed, and reference is made to the ionospheric parameters that were extracted from the experiments. An ion cloud was viewed directly up the geomagnetic field lines. The characteristics of the ion cloud as it passed through its development phases are quite marked and an interruption to the propagation path of a subsidiary experiment was observed at the time of the onset of structure in the barium cloud. The optical observations are discussed and conclusions made on the form of ionospheric model that was used to describe the phenomena. Perfect coupling to the E layer was explored.
Author

43 EARTH RESOURCES

Includes remote sensing of earth resources by aircraft and spacecraft; photogrammetry; and aerial photography.

For instrumentation see *35 Instrumentation and Photography*

N78-19587# Advisory Group for Aerospace Research and Development, Paris (France)
APPLICATIONS OF REMOTE SENSING TO OCEAN SURVEILLANCE
Sep 1977 277 p refs In ENGLISH and FRENCH AGARD Lecture Series presented at Oslo, 3-4 Oct 1977, Den Helder, Netherlands, 6-7 Oct 1977, Rome 11-12 Oct 1977
(AGARD LS-88, ISBN-92-835-0202-7) Avail NTIS HC A13/MF A01

The mathematical tools and their applications to the problems of resolving, recognizing and identifying targets and sources of activities in the ocean are described described For individual titles, see N78-19588 through N78-19597

N78-19588# Office of Naval Research, Arlington, Va
REMOTE SENSING IN OCEAN SURVEILLANCE: PROMISES, PROBLEMS AND PERSPECTIVES
Robert K Geiger *In* AGARD Appl of Remote Sensing to Ocean Surveillance Sep 1977 13 p (For availability see N78-19587 10-43)
Avail NTIS HC A13/MF A01

The U S Navy's mission and need for global real time information of the environmental factors that affect naval operations are discussed It is said that the potential of remote sensing technology for ocean surveillance needs to be developed through a program of research and engineering and a coordinated exchange of information among the disciplinary scientists, industry, and the military commanders who must interpret remotely sensed data for tactical and strategic decisions Author

N78-19589# Department of the Navy, Washington, D C
OPERATIONAL REQUIREMENTS AND PROBLEMS
R N Keeler *In* AGARD Appl of Remote Sensing to Ocean Surveillance Sep 1977 4 p (For availability see N78-19587 10-43)
Avail NTIS HC A13/MF A01

In general, surveillance functions for naval forces with or without air support are (1) area surveillance for early warning, (2) over-the-horizon detection classification and targeting for launch of offensive weapons, and (3) threat detection Each of these functions levies distinct requirements for upgrading the current surveillance system, but all requirements can be grouped under three general headings The first is improved sensors These would be active and passive, and organic or remote The second general heading in location or identification technique, and the third is data transfer analysis or dissemination or that aspect of command, control and communications Along with the surveillance functions and requirement, the problem areas related to some of the more critical elements of the threat spectrum are considered. Author

N78-19590# Cologne Univ (West Germany) Inst of Geophysics and Meteorology
RADIATION AND ENVIRONMENTAL PHYSICS REFRESHER
Erhard Raschke *In* AGARD Appl of Remote Sensing to Ocean Surveillance Sep 1977 13 p refs (For availability see N78-19587 10-43)
Avail NTIS HC A13/MF A01

Basic facts of radiative transfer theory and of physical and radiative transfer properties of the atmosphere and oceans are briefly outlined Author

N78-19591# Naval Research Lab Washington, D C Space Science Div
MICROWAVE SCANNING RADIOMETRY
James P Hollinger *In* AGARD Appl of Remote Sensing to Ocean Surveillance Sep 1977 11 p refs (For availability see N78-19587 10-43)
Avail NTIS HC A13/MF A01

The basic principles of microwave radiometry including a description of antenna properties a definition of antenna temperature, brightness temperature, and system temperature and a discussion of measurement techniques and accuracies are briefly presented Then the microwave signals to be expected from calm and rough seas, sea ice, ships and ship wakes, oil slicks, and terrain as well as the attenuation and radiation from the atmosphere are described Detailed description and the specifications and performance of existing aircraft-borne scanners are given Selected measurements from these imaging systems are presented to demonstrate their application. Author

N78-19592# British Aircraft Corp (Operating) Ltd., Bristol (England)
MICROWAVE SCANNING RADIOMETRY (APPLICATIONS)
E P L Windsor and H McD Mooney *In* AGARD Appl of Remote Sensing to Ocean Surveillance Sep 1977 25 p (For availability see N78-19587 10-43)
Avail NTIS HC A13/MF A01

The characteristics of satellite borne passive microwave radiometer described in terms of their potential sensitivity in measurement of physical parameters together with the spatial resolution and global coverage achievable The application of similar techniques to aircraft borne systems is also discussed Author

N78-19593# Tetra Tech, Inc., Pasadena, Calif
INFRARED RADIOMETRY AND VISIBLE SPECTROMETRY
Henric Hodara and Willard H Wells *In* AGARD Appl of Remote Sensing to Ocean Surveillance Sep 1977 47 p (For availability see N78-19587 10-43)
Avail NTIS HC A13/MF A01

An equation is derived that describes radiometric temperature fluctuations and identifies two major sources of error that mask the true sea temperature changes humidity fluctuation in the air column between the sea surface and the radiometer, and reflected sky radiance from the rough sea surface These masking effects are minimized by suitable design of the radiometer Typical power spectra calculated from radiometric measurements are presented Author

N78-19594*# National Aeronautics and Space Administration Goddard Space Flight Center, Greenbelt, Md
VISIBLE AND INFRARED IMAGING RADIOMETERS FOR OCEAN OBSERVATIONS
W L Barnes *In* AGARD Appl of Remote Sensing to Ocean Surveillance Sep 1977 20 p refs (For availability see N78-19587 10-43)
Avail NTIS HC A13/MF A01 CSCL 20F

The technology of visible and infrared imaging sensors designed for the remote monitoring of the oceans is assessed Emphasis is placed on multichannel scanning radiometers that are either operational or under development Present design practices and parameter constraints are discussed Airborne sensor systems examined include the Ocean Color Scanner (OCS) and the Ocean Temperature Scanner (OTS) The Coastal Zone Color Scanner (CZCS) and Advanced Very High Resolution Radiometer (AVHRR), are reviewed with emphasis on design specifications, expected completion, and anticipated performance Finally, recent technology advances and their probable impact on sensor design are examined Author

N78-19595# Thomson-CSF, Malakoff (France)
SIDEWAYS-LOOKING RADAR (SLR) USING A SYNTHETIC AERIAL
J Genuist *In* AGARD Appl of Remote Sensing to Ocean Surveillance Sep 1977 22 p In ENGLISH and FRENCH (For availability see N78-19587 10-43)
Avail NTIS HC A13/MF A01

The sideways-looking radar with synthetic aerial enables a very high resolution image to be obtained of the terrain overflown by an aircraft The radar range resolution along the direction perpendicular to the path of the aircraft is obtained with a very fine pulse transmission-reception, using pulse compression technique The longitudinal resolution, along the path of the aircraft is obtained by processing the Doppler signal Two categories processing were tried processing by simple filtering and processing by correlation Different experimental results are presented for each of the processes, analysing the advantages and disadvantages Author

N78-19596# Genoa Univ (Italy)
FUNDAMENTALS OF ELF COMMUNICATION AND DETECTION
Giorgio Tacconi *In* AGARD Appl of Remote Sensing to Ocean Surveillance Sep 1977 50 p refs Prepared in cooperation

with CNR, Genoa (For availability see N78-19587 10-43)
Avail: NTIS HC A13/MF A01

The propagation of waves in layered media and the inherent possibilities of transferring information from one layer to another or within a layer, can be used for communications, detection, or evaluation of structural anomalies of the geological zones in which the propagation phenomenon takes place. A conceptual physical-mathematical introduction is given taking into account the environmental structure of the natural man-made noise and the boundaries conditions. Some practical applications in communications, detection and environmental studies are shown. Features and properties for different scenarious of propagation are considered, together with limitations and the dependence on technology of the achievement of certain operational performances. Author

N78-19587# Naval Ocean Systems Center, San Diego, Calif.
ELECTRIC AND MAGNETIC SENSING SYSTEMS: APPLICATIONS
Frank Chilton (Science Applications, Inc., Palo Alto, Calif.), Lowell Wood (Lawrence Livermore Lab., Livermore, Calif.), and Rod Buntzen *In* AGARD Appl. of Remote Sensing to Ocean Surveillance, Sep. 1977 26 p refs (For availability see N78-19587 10-43)
Avail: NTIS HC A13/MF A01

The underlying principles of electric and magnetic sensing are reviewed and some of the more recent advances in the associated technologies are discussed. Some insight into the use of such systems in ocean surveillance are provided. Author

N80-10536# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France)
HUMAN FACTORS IN THE DESIGN AND EVALUATION OF AVIATION MAPS
V. David Hopkin (Royal Air Force Inst. of Aviation Medicine, Farnborough, England) and Robert M. Taylor (Royal Air Force Inst. of Aviation Medicine, Farnborough, England) Jun 1979 259 p refs
(AGARD-AG-225, ISBN-92-835-1318-5) Avail NTIS HC A12/MF A01

Information processing is appraised for map design. Methods and measures for the evaluation of maps are discussed. The skills and abilities of the successful map designer and the effective map user are considered. The communication of cartographic information in aviation is discussed in the area of separating human factors data from other sources and how to apply this to man design and map reading. A.W.H.

44 ENERGY PRODUCTION AND CONVERSION

Includes specific energy conversion systems, e g , fuel cells and batteries, global sources of energy, fossil fuels, geophysical conversion, hydroelectric power, and wind power

For related information see also *07 Aircraft Propulsion and Power, 20 Spacecraft Propulsion and Power, 28 Propellants and Fuels,* and *85 Urban Technology and Transportation*

N80-10683# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France)

FLUID DYNAMIC ASPECTS OF WIND ENERGY CONVERSION

O. DeVries (Natl Aerospace Lab., Amsterdam) Jul 1979 145 p refs

(AGARD-AG-243, ISBN-92-835-1326-6) Avail NTIS HC A07/MF A01

The theory of horizontal axis and vertical axis wind driven turbines is discussed Inhomogeneous flow, turbulence effects, turbine control, wake interference effects, and wind concentrator concepts are surveyed K L

46 GEOPHYSICS

Includes aeronomy; upper and lower atmosphere studies, ionospheric and magnetospheric physics, and geomagnetism.

For space radiation see *93 Space Radiation*.

N78-31681# Advisory Group for Aerospace Research and Development, Paris (France).

AN INTRODUCTION TO TURBULENCE IN GEOPHYSICS AND AIR-SEA INTERACTIONS

Michel F. Coantic (CNRS, Marseille) Jul. 1978 252 p refs Presented as lecture series at California Univ., San Diego, spring quarter 1975

(AGARD-AG-232; ISBN-92-835-1284-7) Avail: NTIS HC A12/MF A01

The effects of turbulence and air-sea interactions upon the atmosphere and oceanographic environment are discussed along with the planetary boundary layer. Instantaneous equations, averaged equations, and the Boussinesq approximation are presented. The interaction between turbulence and radiation is also discussed. S.B.S.

51 LIFE SCIENCES (GENERAL)

Includes genetics

N77-19731# Advisory Group for Aerospace Research and Development, Paris (France)
RECENT ADVANCES IN SPACE MEDICINE
J Colin, ed Jan 1977 113 p refs In ENGLISH, partly in FRENCH Conf Proc of the Aerospace Medical Panel Specialists' Meeting, Athens, 20-24 Sep 1976
(AGARD CP-203, ISBN-92-835-0186-1) Avail NTIS HC A06/MF A01

Some of the topics discussed are the effect of free fall on the vestibular organ and of its post flight readaptation as part of the shuttle program, successful transfer of adaptation aquired in a slow rotation room to motion environments in Navy flight training, environmental investigations on motion sickness susceptibility, and space mission simulation The significance of physical fitness in selection and training of spacelab crews, and the psychometric characteristics of astronauts are also reviewed

N77-19732# Milan Univ (Italy)
INVESTIGATION OF THE EFFECT OF FREE FALL ON THE VESTIBULAR ORGAN AND OF ITS POST-FLIGHT READAPTATION AS PART OF THE SHUTTLE PROGRAM: A CONTRIBUTION TO BASIC VESTIBULAR PHYSIOLOGY AND TO THE PROBLEM OF SPACE SICKNESS
Torquato Gualtierotti *In* AGARD Recent Advances in Space Medicine Jan 1977 7 p refs (For primary document see N77-19731 10-51)
Avail NTIS HC A06/MF A01

Basic vestibular physiology and the problem of space sickness was reviewed A space experiment monitoring the single vestibular statoreceptors output indicated important reversible and unreversible changes The significance of such changes is discussed Author

N77-19733*# Naval Aerospace Medical Research Lab, Pensacola, Fla
SUCCESSFUL TRANSFER OF ADAPTATION ENVIRONMENTS IN NAVY FLIGHT TRAINING
D B Cramer, A Graybiel, and W J Oosterveld *In* AGARD Recent Advances in Space Medicine Jan 1977 5 p refs Sponsored by NASA (For primary document see N77-19731 10-51)
Avail NTIS HC A06/MF A01

Two flight students, grounded for the reason they were highly susceptible to motion sickness, completed their training after gradually adapting 10 rpm, achieved by executing head movements during small stepwise increases in angular velocity Subject 1 executed a total of about 77,000 head movements within a period of five months and Subject 2 executed about 108,000 head movements within a period of 42 days The transfer of the adaptation acquired in the laboratory to most motion environments aloft was good; the notable exception involved weightless maneuvers in the case of Subject 1. Both were on flight status when contacted recently The current motion sickness susceptibility of Subject 1 in the fall of 1975 was assessed He reached a (mild) motion sickness endpoint, in the rotating room, at 17 rpm, the average endpoint is 7 to 8 rpm Some practical and theoretical implications are discussed. Author

N77-19734# Air Force Inst of Aviation Medicine, Fuerstenfeldbruck (West Germany)
EXPERIMENTAL INVESTIGATIONS ON MOTION SICKNESS SUSCEPTIBILITY
W Hoffelt *In* AGARD Recent Advances in Space Medicine Jan 1977 5 p refs (For primary document see N77-19731 10-51)
Avail NTIS HC A06/MF A01

The sensory conflict theory formulated by REASON was experimentally examined with psychological and sensory-physiological methods in two groups differing in their resistence towards coriolis accelerations In all tests applied both groups showed consistent behavioral differences which may be interpreted in the sense of the conflict theory Author

N77-19735# Air Force Inst of Aviation Medicine, Fuerstenfeldbruck (West Germany)
SPACE MISSION TRAINING: A NECESSARY ELEMENT IN PLANNING AND TRAINING FOR SHUTTLE SPACELAB MISSIONS
Eduard C Burchard *In* AGARD Recent Advances in Space Medicine Jan 1977 13 p (For primary document see N77-19731 10-51)
Avail NTIS HC A06/MF A01

In an attempt during the last 2 years to evaluate space mission simulations, two shuttle spacelab simulations were performed at the NASA Lyndon B Johnson Space Center The first spacelab mission simulation provided valuable insights into the many Shuttle Spacelab Operations which were not necessarily payload dependent Two crewmen, free of Orbiter duties, acted as mission specialist and payload specialists to operate 12 typical life sciences experiments on one shift schedule The second spacelab mission simultion involved one mission specialist and two payload specialists in a 7-day multidiscipline simulation which included 20 life sciences experiments and one cosmic ray laboratory experiment The use of space mission simulations in preparation for Shuttle Spacelab Missions is discussed Author

N77-19736# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Bad Godesberg (West Germany) Inst fuer Flugmedizin
NEUTRAL BUOYANCY: ONE POSSIBLE TOOL FOR MAN'S TRAINING IN A SIMULATED ZERO-G ENVIRONMENT
Heinz Oser *In* AGARD Recent Advances in Space Medicine Jan 1977 5 p refs (For primary document see N77-19731 10-51)
Avail: NTIS HC A06/MF A01

In order to get the payload specialists well prepared for performing their tasks under space conditions in a resonable time, the water immersion technique for simulating certain aspects of zero and partial gravity condition is amongst others one possible tool The water immersion technique was used mainly for three purposes (1) studying physiological responses to weightlessness, (2) evaluating human performance under quasi weightless conditions, and (3) testing equipment, facilities and simulation techniques Author

N77-19737# Erno Raumfahrttechnik G m b H, Bremen (West Germany)
HUMAN ENGINEERING: CREW SYSTEMS TOOL FOR SPACELAB DESIGN
Udo G Munkelt (McDonnell-Douglas Corp, St Louis) and Harold S Jencks (McDonnell-Douglas Corp, St Louis) *In* AGARD Recent Advances in Space Medicine Jan 1977 9 p refs (For primary document see N77-19731 10-51)
Avail NTIS HC A06

The space shuttle spacelab system is described with emphasis on crew accommodation/utilization The artificially supplied internal environment is discussed which provides for the well being of the crew in the hostile surroundings of space including atmosphere, temperature, lighting and noise The interior arrangement of spacelab showing architectural considerations which essentially provide a one - G oriented concept in respect to work stations, display control consoles, floor, ceiling, etc, minimizing disorientation and facilitng ground operations is explained The restraint systems are cited which enable the crewman not only to overcome the negative aspects of working in zero - G, but also to take advantage of the positive aspects Several photos and sketches are provided showing full scale Mockups and neutral buoyancy test fixtures which support the human engineering considerations in Spacelab design/development Author

N77-19738*# Royal Air Force Inst of Aviation Medicine, Farnborough (England)
THE EFFECTS OF PROLONGED SPACEFLIGHT ON THE REGIONAL DISTRIBUTION OF FLUID, MUSCLE AND FAT: BIOSTEREOMETRIC RESULTS FROM SKYLAB
M W Whittle, R E Herron (Texas Inst for Rehabilitation and Res, Houston), J R Cuzzi (Texas Inst for Rehabilitation and Res, Houston), and C W Keys (Technology Inc, Houston) *In* AGARD Recent Advances in Space Medicine Jan 1977 5 p refs (For primary document see N77-19731 10-51)
(Contract NAS9-11604)
Avail NTIS HC A06/MF A01

Biostereometric analysis of body form was performed several times preflight and postflight on the astronauts of all three skylab flights The analysis was made by deriving the three dimensional coordinates of numerous points on the body surface from stereoscopic pairs of photographs of the subject using a

stereoplotter. The volume of segments of the body, and of the body as a whole, was calculated by integration of cross sectional areas derived from the coordinate data. All nine astronauts demonstrated regional changes in volume distribution which could be related to changes in total body water, muscle mass, and fat deposits. The change in water resulted from a redistribution of fluid in response to zero gravity. Changes in muscle mass resulted from an alternation in patterns of muscle activity in the absence of gravity, and changes in fat resulted from discrepancies between the individual's caloric needs and his food consumption. Author

N77-19739# Air Force Inst. of Aviation Medicine, Fuerstenfeldbruck (West Germany)

OPHTHALMOLOGICAL REQUIREMENTS FOR SPACELAB ASTRONAUT-SCIENTISTS

F. J. Dauman. *In* AGARD Recent Advances in Space Medicine Jan. 1977 6 p refs (For primary document see N77-19731 10-51)

Avail: NTIS HC A06/MF A01

Ophthalmological requirements for visual acuity, field of vision, binocular vision, accommodation, color vision, and equilibrium of eye muscles are presented from an occupational medical point of view. Correction of visual deficiencies by means of glasses and contact lenses is discussed. The necessity of full visual field, binocular vision, dark adaptation and color vision is stressed. Next, anomalies and diseases compatible with the stresses of a payload-specialist and those causing rejection are covered. Author

N77-19740# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Bad Godesberg (West Germany). Inst. fuer Flugmedizin.

ATHLETIC ENDURANCE TRAINING: ADVANTAGE FOR SPACE FLIGHTS? THE SIGNIFICANCE OF PHYSICAL FITNESS FOR SELECTION AND TRAINING OF SPACELAB CREWS

K. E. Klein, H. M. Wegmann, and P. Kuklinski. *In* AGARD Recent Advances in Space Medicine Jan. 1977 13 p refs (For primary document see N77-19731 10-51)

Avail: NTIS HC A06/MF A01

The morphological and functional changes obtained with an athletic endurance training are rather specific, and not at all of general advanatage for the tolerance to space stresses. In particular during gravitational loads they allow a higher shift of fluid into the lower extremities with the possible consequence of a reduced tolerance. This response obviously, is accentuated through immersion and weightlessness; also, the aerobic work capacity is more impaired. Author

N77-19741# School of Aerospace Medicine, Brooks AFB, Tex.

PSYCHOMETRIC CHARACTERISTICS OF ASTRONAUTS

Bryce O. Hartman and Richard C. McNee. *In* AGARD Recent Advances in Space Medicine Jan. 1977 9 p refs (For primary document see N77-19731 10-51)

Avail: NTIS HC A06/MF A01

Detailed information on the role of psychological testing in the selection process for NASA astronauts is reported. Because of the current activity in the European space agency, where there is a requirement for astronaut selection, psychometric procedures and data are of renewed scientific interest. An overview of the psychometric process and extensive statistical analyses are reported. Author

N77-19742# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Hamburg (West Germany). Inst. fuer Flugmedizin

PSYCHOLOGICAL SELECTION OF ASTRONAUT-SCIENTISTS (PAYLOAD SPECIALISTS)

Klaus-Martin Goeters. *In* AGARD Recent Advances in Space Medicine Jan. 1977 5 p refs (For primary document see N77-19731 10-51)

Avail: NTIS HC A06/MF A01

Psychological testing of spacelab-payload specialists is mandatory. Astronaut-scientists characteristics were discussed. (1) High basic technical comprehension and practical skills, (2) high motivation, (3) adequate group behavior, and (4) emotional maturity and stress resistence. The significance of these psychological factors for working in confinement are demonstrated by experimental results. Author

N77-19743# Royal Air Force Inst. of Aviation Medicine, Farnborough (England)

EXPERIMENTAL BASIS FOR THE USE OF HYPNOTICS BY AEROSPACE CREWS

A. N. Nicholson, R. G. Borland, Coral H. Clarke, and Barbara M. Stone. *In* AGARD Recent Advances in Space Medicine Jan. 1977 11 p refs (For primary document see N77-19731 10-51)

Avail: NTIS HC A06/MF A01

The work which was carried out at the Royal Air Force Institute of Aviation Medicine on the immediate and residual effects of hypnotics on performance, the effectiveness of hypnotics, and the problems associated with the use of hypnotics at unusual times of the day is reviewed. Author

N77-19744*# National Aeronautics and Space Administration, Washington, D.C.

SPACE AGE HEATLH CARE DELIVERY

Walter L. Jones. *In* AGARD Recent Advances in Space Medicine Jan. 1977 9 p refs (For primary document see N77-19731 10-51)

Avail: NTIS HC A06/MF A01 CSCL 06E

Space age health care delivery is being delivered to both NASA astronauts and employees with primary emphasis on preventive medicine. The program relies heavily on comprehensive health physical exams, health education, screening programs and physical fitness programs. Medical data from the program is stored in a computer bank so epidemiological significance can be established and better procedures can be obtained. Besides health care delivery to the NASA population, NASA is working with HEW on a telemedicine project STARPAHC, applying space technology to provide health care delivery to remotely located populations. Author

N77-20735# Advisory Group for Aerospace Research and Development, Paris (France).

SPECIAL ASPECTS OF AVIATION OCCUPATIONAL AND ENVIRONMENTAL MEDICINE

M. S. Hughes, ed. (RAF Inst. of Aviation Medicine, Farnborough England) Feb. 1977 88 p refs In ENGLISH; partly in FRENCH Conf. Proc. of the Aerospace Medical Panel Specialists' Meeting, Athens, 20-24 Sep. 1976

(AGARD-CP-202; ISBN-92-835-0188-8) Avail: NTIS HC A05/MF A01

The medical, psychiatric, and psychological problems of air traffic controllers and radar operators are discussed. The monitoring, measurement, and assessment of potential hazards associated with aircraft operations are explored. Methods for controlling industrial hazards connected with aircraft and missile operations are given. For individual titles, see N77-20736 through N77-20747

N77-20736# Royal Air Force Inst. of Aviation Medicine, Farnborough (England).

PSYCHOLOGICAL PROBLEMS OF AIR TRAFFIC CONTROLLERS AND RADAR OPERATORS

V. David Hopkin. *In* AGARD Special Aspects of Aviation Occupational and Environmental Medicine Feb. 1977 7 p refs (For primary document see N77-20735 11-51)

Avail: NTIS HC A05/MF A01

Secondary radar, advances in display technology and flexibility in workspace design provide solutions to some of the psychological problems associated with air traffic controllers and radar operators. The effects of stress on efficiency and well being are discussed, as well as the problem of boredom. When automation in the form of computer assistance is applied to decision making and problem solving, its implications extend beyond system performance and efficiency to influence job satisfaction, professional pride, opportunities to acquire and use skills, and the integration of the roles of man and machine. These less manifest effects of automation are the source of numerous psychological problems for air traffic controller and radar operators. Author

N77-20737# Eurocontrol Agency, Brussels (Belgium).

STATISTICAL ANALYSIS OF THE PATHOLOGY OF AIR TRAFFIC CONTROL-RADAR OPERATORS: THEIR RELATIONSHIP TO WORK RELATED STRESS

E. Evrard. *In* AGARD Special Aspects of Aviation Occupational and Environmental Medicine Feb. 1977 12 p refs In FRENCH (For primary document see N77-20735 11-51)

Avail: NTIS HC A05/MF A01

Causes of death in 693 radar/controllers from the Belgian air force using nonautomated equipment, and 149 civil operators using only automated systems were studied to determine if the

psychological and physiological responses associated with their work result in a particular pathology, with significant frequency. The study shows an almost total absence of visual or auditory pathology in those using automated equipment. Pathology associated with nervous tension is more difficult to interpret. A comparison of the pathologies in controllers, assistance controllers, students, technicians, and administrative personnel reveal no evidence of a pathology peculiar to controller/radar operators. Author

N77-20738# Italian Air Force Medical Appeal Board, Rome.
PSYCHOPATHOLOGY OF AIR TRAFFIC CONTROLLERS AND RADAR OPERATORS
Luigi Longo *In* AGARD Special Aspects of Aviation Occupational and Environmental Medicine Feb. 1977 5 p refs (For primary document see N77-20735 11-51)
Avail: NTIS HC A05/MF A01

The activities of air traffic controllers and radar operators have, within the aeronautical sphere, particular connotations because of the environment in which they are carried out and because of their technical and operational content. These connotations are such that they may give rise to a stress effect with consequent psychic pathology of variable intensity. On the basis of observations and personal experience, a general nosgraphic description of the syndromes and of the psychopathologic states most frequently noted, is submitted and considerations and proposals are formulated with the aim of preventing and containing them. Author

N77-20739# School of Aerospace Medicine, Brooks AFB, Tex. Radiobiology Div.
USAF EXPOSURE STANDARDS FOR RADIOFREQUENCY/MICROWAVE HAZARDS CONTROL
John C. Mitchell *In* AGARD Special Aspects of Aviation Occupational and Environmental Medicine Feb. 1977 7 p refs (For primary document see N77-20735 11-51)
Avail: NTIS HC A05/MF A01

The effects of radiofrequency radiation on the nervous system, behavior, and the eye, and such indirect biological effects as cardiac pacemaker interference are discussed in terms of their impact on setting appropriate personnel exposure criteria for operational RF emitters. Of primary importance is the recognition that radiofrequency (10 kHz - 300 GHz) radiation insult to man is strongly frequency dependent. Thus, all bioeffects data generated in the laboratory using smaller animals must be carefully scaled/extrapolated to equivalent effects on man before meaningful exposure standards can be established. This frequency dependent concept is reflected in United States Air Force Regulation 161-42, which establishes a 50 mW/sq cm permissible exposure limit (PEL) for radiofrequencies from 10 kHz to 10 MHz and retains the previously established 10 mW/sq cm PEL for radiofrequencies from 10 MHz to 300 GHz. Author

N77-20740# Letterman Army Inst. of Research, San Francisco, Calif. Non-Ionizing Radiation Div.
BIOEFFECTS RESEARCH IN THE DETERMINATION OF LASER HAZARDS
Edwin S. Beatrice, Harry Zwick, and David J. Lund *In* AGARD Special Aspects of Aviation Occupational and Environmental Medicine Feb. 1977 5 p refs (For primary document see N77-20735 11-51)
Avail: NTIS HC A05/MF A01

A summary of the endpoints used in the establishment of ocular damage threshold levels from laser exposure includes the evaluation of grossly visible retinal opacity photoreceptor alteration at the level of the light and electron microscope and functional alteration in the task oriented animal subject. The threshold determination at the light and ultrastructural levels extends the sensitivity and educes the threshold level for all laser wavelengths. The behavioral evaluation of laser exposures are one thousand times below the visible lesion endpoint and demonstrates changes which must be taken into account in the evaluation of permissible human levels. A review of the research in the area of retinal effects from laser radiation will provide, at low levels, a comprehensive review of the function of the retina and central nervous system interconnections as applied to normal ambient light level exposures. Author

N77-20741# Army Aeromedical Research Lab., Fort Rucker, Ala. Bioacoustics Div.
THE ATTENUATION EFFICIENCY SCORE: A MEASURE OF OVERALL HEARING PROTECTIVE EFFICIENCY OF HEARING PROTECTORS
Robert T. Camp, Jr. *In* AGARD Special Aspects of Aviation Occupational and Environmental Medicine Feb. 1977 7 p refs (For primary document see N77-20735 11-51)
Avail: NTIS HC A05/MF A01

A method is given for obtaining an overall description of sound attenuation characteristics of hearing protectors with a single value. The derivation of the attenuation efficiency score (AES) is presented with emphasis on the reasons why it is an unbiased estimate and is compared with other methods that express overall attenuation in a single decibel value. The normalization of low and high frequency attenuation values into percentiles eliminates high frequency biasing of overall evaluations that occur with averaged decibel values. Author

N77-20742# Ministry of Defence, London (England). Directorate of Civilian Medical Services.
NOISE LEVELS AND THEIR MEASUREMENTS AND INTERPRETATION IN THE VICINITY OF MILITARY AIRFIELDS
S. Kanagasabay *In* AGARD Special Aspects of Aviation Occupational and Environmental Medicine Feb. 1977 6 p refs (For primary document see N77-20735 11-51)
Avail: NTIS HC A05/MF A01

Indexes for nuisance noise from road traffic, aircraft and industrial premises were formulated and related to the civilian environment. The noise source from aircraft and in particular, the noise in the vicinity of airfields was studied. In view of already existing legislation providing recompense for the population affected by noise levels in excess of criteria laid down for civil airfields. The Royal Air Force was required to develop criteria for noise in the vicinity of military airfields. Author

N77-20743# Office of the Surgeon General (Air Force), Washington, D.C.
US AIR FORCE ENVIRONMENTAL AND OCCUPATIONAL HEALTH PROGRAM
Johan E. Bayer *In* AGARD Special Aspects of Aviation Occupational and Environmental Medicine Feb. 1977 5 p (For primary document see N77-20735 11-51)
Avail: NTIS HC A05/MF A01

The greater awareness of the inter-relationship between man and his environs caused the Air Force and its surrounding communities to integrate efforts to cope with the problems of air and water pollution, noise control, national environmental policy act, and occupational safety and health. Also of concern are specific industrial and environmental health problems associated with aircraft servicing and maintenance: fuel spillage, wash rack effluent, industrial wastes, drinking water, and electromagnetic energy. The numerous laws and the impact on the daily activities of the Air Force are discussed. The manpower and organizational structures the Air Force created and proposes to create in response to new legislation and policies are described. Author

N77-20744# Aerospace Medical Div. Aerospace Medical Research Labs. (6570th), Wright-Patterson AFB, Ohio. Toxic Hazards Div.
OCCUPATIONAL HAZARDS OF MISSILE OPERATIONS WITH SPECIAL REGARD TO THE HYDRAZINE PROPELLANTS
Kenneth C. Back, Vernon L. Carter, Jr., and Anthony A. Thomas *In* AGARD Special Aspects of Aviation Occupational and Environmental Medicine Feb. 1977 10 p refs (For primary document see N77-20735 11-51)
Avail: NTIS HC A05/MF A01

Hydrazine (HZ), monomethylhydrazine (MMH), and 1,1-dimethylhydrazine (UDMH) are quite toxic and present a potential hazard for personnel who handle or are in contact with them under any and all conditions. In addition, they pose a hazard to the general population if accidentally released into the environment as a result of missile malfunction or transportation mishap. Experimental studies indicate that the convulsive action of MMH and UDMH can be aborted by the use of vitamin B6, though the agent is ineffective against hydrazine. Evidence from animal experiments indicates that HZ, MMH, and UDMH may possess oncogenic potential as well as chronic systemic effects. Threshold limit value, emergency tolerance criteria for short-term exposure to the public, and oncogenic potential of these hydrazines are explored. Author

N77-20745# British Airways Medical Service, Middlesex (England).

THE USE AND CONTROL OF HAZARDOUS MATERIALS IN AIRCRAFT MAINTENANCE

D M Bruton *In* AGARD Special Aspects of Aviation Occupational and Environmental Medicine Feb 1977 3 p (For primary document see N77-20735 11-51)

Avail NTIS HC A05/MF A01

The principles of toxic materials control involve the use of the least hazardous material compatible with technical requirements, containment, local exhaust ventilation and the avoidance of direct handling In addition, there is need for good general standards of ventilation and housekeeping, safe methods of work, and the use, where necessary, of protective clothing and equipment Materials control procedures require a system of communication enabling materials to be identified, their hazards evaluated and brought to the attention of management and employees, and the necessary safeguards established, communicated, and implemented Two measures developed in British Airways as part of the control and communication process are described Author

N77-20746# Ministry of Defence, London (England)

OCCUPATIONAL HEALTH HAZARDS ASSOCIATED WITH AIRCRAFT SHELTER OPERATIONS

S Kanagasabay *In* AGARD Special Aspects of Aviation Occupational and Environmental Medicine Feb 1977 8 p refs (For primary document see N77-20735 11-51)

Avail NTIS HC A05/MF A01,

The design features of shelters, which are intended to give a reasonable probability of survival of the aircraft and maintain an operational capability, are those which also fulfil the criteria for a confined space The occupational health hazards to personnel employed in shelter operations therefore are essentially those associated with aircraft operations qualified by the restrictions applicable to a limited work-space Potential hazards are identified as those arising from the turbine and petrol engines of ground support equipment necessary for front line maintenance. These are noise, fuel vapor and exhaust pollutants. Environmental levels of the pollutants under typical operations are compared with current threshold limit values Recommendations are made for: (1) reduction of exposure, (2) permissible excursions above current threshold limit values for specific pollutants; and (3) biological monitoring of exposed personnel. Author

N77-20747# Institutes fuer Wehrmedizin und Hygiene, Koblenz (West Germany) Defense Physiology Div.

CO DOSE METER FOR WORKING PLACES EXPOSED TO EXTREME PEAKS OF CO-CONTAMINATION

G Kleinhanss and C Piekarski *In* AGARD Special Aspects of Aviation Occupational and Environmental Medicine Feb. 1977 5 p refs (For primary document see N77-20735 11-51)

Avail NTIS HC A05/MF A01

For certain marginal conditions the product of carbon monoxide concentration (c) times the time of exposure (t) determines the amount of CO load which affects subjects working in several industries and military facilities. The determination of c times t is easy whenever c remains constant. If c varies, the following methods can be used: continuous integration of c over the elapsed time (Im), or collection of aliquot quantities of gas samples during exposition and following multiplication of the mean concentration of c with the time lapsed t (SM). Advantages and disadvantages of both methods are discussed. As a consequence, a modified sampling method is introduced (MSM) which combines essential advantages of LM and SM especially accuracy, reliability in field tests, and validity. Author

N79-19605# Advisory Group for Aerospace Research and Development, Paris (France).

OPERATIONAL HELICOPTER AVIATION MEDICINE

S. C. Knapp, ed. (Army Aeromed. Res. Lab.) Dec. 1978 614 p refs In ENGLISH and FRENCH Meeting held at Fort Rucker, Ala., 1-5 May 1978

(AGARD-CP-255; ISBN-92-835-0226-4) Avail: NTIS HC A99/MF A01

Aviation medicine topics unique to helicopters, helicopter operations, and the aircrew who fly helicopters are discussed. Specific topics covered include: medical aspects of evacuation and search and rescue operations; environmental aspects of helicopter operations; helicopter operations crew fatigue; human factors of helicopter design and operations; visual and acoustic aspects of helicopter design and operations; and helicopter safety and crashworthiness. For individual titles, see N79-19606 through N79-19666.

N79-19606# German Army Hospital, Munich (West Germany). Rescue Center.

RESCUE HELICOPTERS IN PRIMARY AND SECONDARY MISSIONS

B. Gorgass, G. Frey, W. Stotz, G. Kugler, and I. Karger *In* AGARD Operational Helicopter Aviation Med. Dec. 1978 5 p refs Prepared in cooperation with Allgemeiner Deutscher Automobil-Club-e. V, Munich, West Ger. (For primary document see N79-19605 10-51)

Avail NTIS HC A99/MF A01

The experience of the Federal Republic of Germany in the use of rescue helicopters in the civilian rescue service on a trial basis in 1967 and 1968 is summarized. The area of operations of rescue helicopter bases is considered in terms of geographical distribution of hospitals and special clinics as well as the population density and airspeed of the helicopter. The composition of the technical and medical crew, the range of functions and operation tactics, the range of patients transported, and the medical equipment onboard the rescue helicopter are among the topics covered. J.M.S

N79-19607# Wood (William C.), Memphis, Tenn

AEROMEDICAL EVACUATION ON THE PREDICTED EUROPEAN BATTLEFIELD: A SCENARIO IN URGENT NEED OF ATTENTION

William C. Wood *In* AGARD Operational Helicopter Aviation Med. Dec. 1978 4 p refs (For primary document see N79-19605 10-51)

Avail NTIS HC A99/MF A01

A program of medical evacuation using primarily ground vehicle evacuation forward of the brigade trains area is presented. It is suggested that MedEvac helicopters be used on a shuttle basis, operating between the brigade trains area and the supporting combat support hospital. It is believed that this plan will accomplish the mutually supporting goals of increasing the number of lives saved and improving helicopter ambulance survivability on the predicted European battlefield. J.M.S

N79-19608# Maryland Inst. for Emergency Medical Services, Baltimore.

MARYLAND'S MED-EVAC HELICOPTER PROGRAM

R. Adams Cowley *In* AGARD Operational Helicopter Aviation Med. Dec. 1978 8 p refs (For primary document see N79-19605 10-51)

Avail. NTIS HC A99/MF A01

A Med-Evac helicopter program, developed by the Maryland Institute for Emergency Medical Services in 1968 with the Maryland State Police Aviation Division, to transport patients to the Maryland Institute for Emergency Medical Services' Shock Trauma Center is described. The system was developed to reduce the high rural fatality rate. Helicopters pick up victims from the scene of accidents and speed them to special care centers which can manage severe multiple trauma and other medical problems. The helicopters are also used for interhospital transfer of critically ill and injured patients, physician emergencies, transport of premature or ill neonates, transport of medical personnel and supplies. By using the helicopters 90 percent of flight time for police work, the cost of Med-Evac transports has been kept down. The survival rate has improved since the beginning of the program to 82 percent of all transports. J.M.S.

N79-19609# German Air Force, Porz-Wahn (West Germany). Helicopter Transportation Wing.

NIGHT RESCUE OPERATION PROCEDURE OVER SEA WITH BELL UH-1D HELICOPTERS

Heinz Knoche *In* AGARD Operational Helicopter Aviation Med. Dec. 1978 8 p refs (For primary document see N79-19605 10-51)

Avail. NTIS HC A99/MF A01

Flight physiological aspects and disorientation problems of night rescue missions with Bell UH- 1 D helicopters are shown. Countermeasures which have proved to be successful in fighting disorientation are mentioned. J.M.S

N79-19610# Federal Armed Forces Medical Coll., Munich (West Germany).

COORDINATION OF MEDICAL ASPECTS OF THE AIR RESCUE SERVICE IN THE FEDERAL REPUBLIC OF GERMANY

H. J. Linde *In* AGARD Operational Helicopter Aviation Med. Dec. 1978 9 p (For primary document see N79-19605 10-51)

Avail: NTIS HC A99/MF A01

The use of specially equipped rescue helicopters in the Federal Republic of Germany to provide emergency internal and surgical treatment to patients quickly at the scene of the accident and to evacuate them by helicopter to a special clinic, if required, is discussed. The establishment of 24 air rescue stations ensuring almost complete coverage of the territory of the Federal Republic of Germany, coordination of the regulations governing the employment and equipment of all helicopters so that every patient would receive the best possible treatment under identical criteria, and the increasing number of cases requiring aeromedical evacuation by fixed-wing aircraft of tourists and employees of German firms involved in accidents in foreign countries, are among the factors considered. Guidelines specifying minimum requirements for aeromedical evacuation of sick and injured persons and the standardization of the onboard equipment for these cases are included. J.M.S.

N79-19611# Army Agency for Aviation Safety, Fort Rucker, Ala. Medical Div

MEDICAL ASPECTS OF HELICOPTER EVALUATION AND RESCUE OPERATIONS

Daniel S. Berliner *In* AGARD Operational Helicopter Aviation Med. Dec. 1978 3 p (For primary document see N79-19605 10-51)

Avail: NTIS HC A99/MF A01

Four areas of concern in helicopter patient movement are examined. These include: (1) knowledge of the health care provider as to the suitability of helicopter evacuation for a particular patient, (2) preparation and stabilization of patients prior to helicopter flight by the sending facility or field site; (3) inflight protection of the patient from the vibratory and noise stresses of helicopter flight and the continuation of medical monitoring and treatment while flying; and (4) knowledge by the receiving facility as to the stresses and capabilities of helicopter patient movement. Education of referring health care providers and onboard patient care attendants and standardization of inflight equipment are suggested as means to solving problems existing in these areas. J.M.S.

N79-19612# Army Aeromedical Research Lab., Fort Rucker, Ala.

AN EVALUATION OF THE EFFECTS OF A STABILITY AUGMENTATION SYSTEM UPON AVIATOR PERFORMANCE/WORKLOAD DURING A MEDEVAC HIGH HOVER OPERATION

M. G. Sanders, R. I. Burden, Jr., R. R. Simmons, M. A. Lees, and K. A. Kimball *In* AGARD Operational Helicopter Aviation Med. Dec. 1978 9 p refs (For primary document see N79-19605 10-51)

Avail: NTIS HC A99/MF A01

A method of aiding the MedEvac pilot in performing a hover maneuver while perhaps reducing workloads was investigated. A modular, four-axes stability augmentation system (Ministab) with integrated rate attitude and heading retention was installed on the USAARL JUH-1H helicopter. Participating personnel for the project were nine US Army aviators with a total average of 1172 flight hours. The aviators hovered at 30 feet above ground level for five minutes under each of the three following flight control conditions: (1) unaided--normal hover with visual flight rules conditions; (2) using Force Trim; and (3) using the Ministab. Continuous information from twenty pilot and aircraft monitoring points was recorded on an incremental digital recorder for all flights. Multivariate analyses were performed on both aircraft status variables and control input workload/activity measures. Under the conditions tested, the stability augmentation system evaluated did not provide a clearcut improvement in flight performance and workload across all flight parameters. J.M.S.

N79-19613# Naval Air Development Center, Warminster, Pa. Aircraft and Crew Systems Technology Directorate.

THE BOAT THAT IS A RAFT

George P. Gillespie *In* AGARD Operational Helicopter Aviation Med. Dec. 1978 6 p refs (For primary document see N79-19605 10-51)

Avail: NTIS HC A99/MF A01

A one man life raft that demonstrates superior water survivability characteristics, improved logistics, and improved operational interfaces is described. Characteristics of the Mini Boat include center of mass located below the center of buoyancy, comfortable support for the body, and a thermal barrier between the sea and the body. Introduction of the Mini Boat into the Naval Air fleet is discussed. J.M.S.

N79-19614# Sikorsky Aircraft, Stratford, Conn. Dept. of Engineering.

UH-60A MEDEVAC KIT

Horace T. Hone *In* AGARD Operational Helicopter Aviation Med. Dec. 1978 9 p (For primary document see N79-19605 10-51)

Avail: NTIS HC A99/MF A01

A kit designed for converting the standard BLACK HAWK aircraft to medical evacuation configuration, after removal of eight troop seats is described. Four crash-attenuated litters are carried, plus a 60 Hz, 115 volt power pack that permits the use of regular hospital equipment by casualities in transit. Litters can be loaded transversely from either side of the aircraft. A lifting facility is provided for the upper litters. J.M.S.

N79-19615# Societe Nationale Industrielle Aerospatiale, Marignane (France.) Helicopter Div.

CASUALTY EVACUATION BY HELICOPTER

Louis Vachon and Wilfrid Messens *In* AGARD Operational Helicopter Aviation Med. Dec. 1978 18 p ref *In* ENGLISH and FRENCH (For primary document see N79-19605 10-51)

Avail: NTIS HC A99/MF A01

Casualty evacuation procedures which allow in-flight performance of all medical actions required for reanimation and small surgery together with transmission of medical data to the hospital are described. An in-flight test of DAUPHIN, a modern ambulance installation for helicopters, on the occasion of a traffic accident simulation and, at the same time, an actual evacuation mission, is documented. A full success demonstrated the validity of the concept. J.M.S.

N79-19616# Canadian Armed Forces Base Hospital, Bushell Park (Saskatchewan).

DEVELOPMENT OF A CASUALTY EVACUATION KIT FOR THE LIGHT OBSERVATION HELICOPTER (KIWA)

R. M. Goede *In* AGARD Operational Helicopter Aviation Med. Dec. 1978 5 p refs (For primary document see N79-19605 10-51)

Avail: NTIS HC A99/MF A01

The design and testing of a casualty evacuation kit utilizing the Kiowa helicopter is described. This kit consisted of a stretcher support frame, aluminum stretcher, and two rear doors with bubble extensions to ensure the necessary width to transport one patient across the rear passenger compartment. Flight testing was carried out to determine the aerodynamic characteristics of the Kiowa aircraft with the kit installed. This kit was designed to fit any Kiowa helicopter in the Canadian Forces fleet. In the event of an aircraft crash, this kit could be installed in the first available aircraft in approximately fifteen minutes. J.M.S.

N79-19617# Max-Planck-Institut, Bad Kreuznach (West Germany). Anthropotechnics Working Group.

HUMAN EXPOSURE TO MECHANICAL VIBRATION AT LYING POSTURE IN THE AMBULANCE HELICOPTER UH-1D

Heinrich Dupuis *In* AGARD Operational Helicopter Aviation Med. Dec. 1978 11 p refs (For primary document see N79-19605 10-51)

Avail: NTIS HC A99/MF A01

The vibration exposure of wounded or sick people during transportation by the UH-1D helicopter was investigated. Accelerations were measured at the mounting parts of the stretcher, at four points of transferring from the stretcher to the human body, and at two places upon the body. This was done under 11 flight situations: racing the engine, ground running, lifting up, suspense-flight, ascending-flight, horizontal-flight 60, 80, 100 and 116 kn, landing-flight and running out the engine. Effective values (rms) of acceleration and frequency analysis were used as a basis for evaluation. The vibration stress was found to be about 90% smaller when transported by helicopter than by wheeled vehicles. The middle of the three positions of the stretcher showed the relative lowest vibration comparing upper and ground position. From the mounting parts of the stretcher to the points of entrance into the body vibration decreases at about 90%. Besides low frequencies (5 to 10 Hz) high frequency vibration (30 to 50 Hz) was found. J.M.S.

N79-19618# Naval Air Development Center, Warminster, Pa. Aircraft and Crew Systems Technology Directorate.

PROTECTIVE APPROACHES IN THE MODERATION OF THE PHYSIOLOGICAL EFFECTS OF EXTREME AMBIENT CONDITIONS IN HELICOPTER OPERATIONS

Louis J. SantaMaria *In* AGARD Operational Helicopter Aviation Med. Dec. 1978 7 p refs (For primary document see N79-19605 10-51)
Avail: NTIS HC A99/MF A01

To study the effectiveness of a head cooling system, three subjects were individually exposed to ambient temperature levels of 32.2 C and 40.6 C. Tests were conducted with and without head cooling under resting conditions. Under conditions of light activity simulating an increase in metabolic heat production of 150-200 KCAL/hr, only the cooling mode was used at each ambient temperature. The assessment was based on temperature and comfort sensation, skin and body temperature, heart rate and total weight loss. The moderating effects of head cooling were indicated in the setting-resting conditions; with exercise the advantages were less apparent, possibly as a result of system limitations. In the cold water phase, the encapsulating life raft (ELR) and the USN LR-1 raft were tested at three levels of air-water temperature conditions, i.e., 15.6 C/10 C, 7.2 C/1.6 C, and 2.8 C/-6/7 C, and a constant wind velocity of 25 km/hr. Two volunteer subjects were similarly equipped with minimal personal protective equipment. The advantages gained by the use of the ELR were indicated in terms of body temperatures and subjective reports even under the most stressful conditions of the program. J.M.S.

N79-19619# Army Aeromedical Research Lab., Fort Rucker, Ala.
IN-FLIGHT TOXICOLOGY OF FIXED AND ROTARY WING AIRCRAFT CREW STATIONS
Gary D. Pollard and Doris W. Hirsch *In* AGARD Operational Helicopter Aviation Med. Dec. 1978 7 p refs (For primary document see N79-19605 10-51)
Avail: NTIS HC A99/MF A01

A system was designed and developed for the measurement of toxic gases while in flight. The system is based on the use of several instruments including a multichannel infrared spectrometer, a mass spectrometer as well as several other instruments and techniques. The techniques were applied to the evaluation of weapons gases and contamination from engine exhaust in the Utility Tactical Transport Aircraft System (UTTAS) as well as other aircraft systems. Results are presented. J.M.S.

N79-19620# German Air Force, Porz-Wahn (West Germany). Helicopter Transportation Wing.
BACKACHE IN UH-1D HELICOPTER CREWS
H. C. Schulte-Wintrop (LTK, Munster, W. Ger.) and H. Knoche *In* AGARD Operational Helicopter Aviation Med. Dec. 1978 12 p refs (For primary document see N79-19605 10-51)
Avail: NTIS HC A99/MF A01

A questionnaire was prepared and handed to the crews (6). Out of a total of 145 pilots, flight engineers and air rescue medics questioned 40% complained of backache during flight and 51% of backache after flight. The steady RPM setting during normal flight was marked to cause discomfort in 37% of the cases as opposed to only 4% when increasing RPM. In 39% of the cases the pain was described as a lasting one. 29% reported one of short duration. In 34% it was felt in the middle of the back over the dorsal process, in 54% in the lumbar region, and in only 17% in the neck. It is concluded that the following factors are causative to backache in helicopter crews: vibration; seating posture; draft; lack of specific exercises; and vertebral abnormalities. J.M.S.

N79-19621# Army Aeromedical Research Lab., Fort Rucker, Ala.
US ARMY AVIATION FATIGUE-RELATED ACCIDENTS, 1971 - 1977
Gerald P. Krueger and Yvonna F. Jones *In* AGARD Operational Helicopter Aviation Med. Dec. 1978 11 p refs (For primary document see N79-19605 10-51)
Avail: NTIS HC A99/MF A01

An accident data survey was made to determine how frequently aviator crew fatigue may have contributed to US Army aviation accidents from 1971 to 1977. All accident reports in the US Army Agency for Aviation Safety (USAAAVS) data base were reviewed. Aviator fatigue was deemed to be a contributing factor in 42 rotary wing accidents which resulted in a total of 51 fatalities and 63 personnel injuries. Fatigue contributed to 10 fixed wing accidents, resulting in three fatalities and five injuries. These fatigue related accidents are categorized by aircraft and mission type and by time of day and day of week of the accident. Pilots activities prior to the accidents which promote the likelihood of pilot fatigue contributions are described. The personnel and equipment costs of these accidents to the Army are estimated, and the relative importance of such accidents to the total US Army aviation accident picture is assessed. J.M.S.

N79-19622# Advisory Group for Aerospace Research and Development, Paris (France). Aerospace Medical Panel
EVALUATION OF AIRCREW FATIGUE DURING OPERATIONAL HELICOPTER FLIGHT MISSION
C. Koch (Italian Air Force, Rome) and F. Monesi *In its* Operational Helicopter Aviation Med. Dec. 1978 2 p refs (For primary document see N79-19605 10-51)
Avail: NTIS HC A99/MF A01

Monitoring of physiological parameters for the assessment of workload in laboratory and also field studies is described. In-flight recordings of ECG, breathing rate and amplitude, EMG, EEG, EOG and Gz were transmitted telemetrically from the helicopter crew station to the ground receiving station. The investigators were provided with some objective data on the increase in biological cost for an Agusta/Bell 204 helicopter pilot trying to maintain a given level of performance. In fact, the same task was performed by the pilot in two successive phases of an operational flight mission, the latter being more demanding. The crucial question is which physiological parameters prove of practical value in revealing the onset of a state of acute fatigue. Undoubtedly, breathing rate and amplitude show relatively early changes with the increase in workload during helicopter flying (Pettyjohn) as well as EMG and EOG. However, adequate computerized analysis of other physiological and behavioral parameters is necessary to provide the investigator with more subtle tools for the identification of fatigue. J.M.S.

N79-19623# Army Aeromedical Research Lab., Fort Rucker, Ala.
CHANGES IN THE ROTARY WING AVIATOR'S ABILITY TO PERFORM AN UNCOMMON LOW ALTITUDE REARWARD HOVER MANEUVER AS A FUNCTION OF EXTENDED FLIGHT REQUIREMENTS AND AVIATOR FATIGUE
M. A. Lees, R. R. Simmons, L. W. Stone, and K. A. Kimball *In* AGARD Operational Helicopter Aviation Med. Dec. 1978 14 p refs (For primary document see N79-19605 10-51)
Avail: NTIS HC A99/MF A01

Changes in man-helicopter system performance for a variety of flight maneuvers were examined. The system performance changes in the rearward hover maneuver across five days of an extended flight schedule are described. System performance is categorized into measures of the pilot's control performance, measures of the aircraft's stability, and combined measures of total system performance for each primary aircraft control channel. System performance changes across the five flight days and within the flight days were examined using multivariate analysis. Significant changes in each aircraft control channel are presented and the overall changes in system performance are discussed. J.M.S.

N79-19624# Wood (William C.), Memphis, Tenn.
IMPLEMENTATION OF A DIVISIONAL AVIATION PROGRAM TO DECREASE FLIGHT CREW FATIGUE
William C. Wood *In* AGARD Operational Helicopter Aviation Med. Dec. 1978 7 p refs (For primary document see N79-19605 10-51)
Avail: NTIS HC A99/MF A01

A vigorous and continuing program to recognize aviator fatigue implemented in the U.S. First Armored Division in Europe is described. Aviators are given lectures which review the various stresses inherent in aviation. The two types of aviator fatigue, acute skill fatigue and chronic skill fatigue, are discussed in detail. The emphasis is on recognition by the aviators themselves of symptoms and signs of fatigue. Flight hour limitation is an important part of a crew rest program, but does not replace the other elements as presented. Prevention of fatigue and recognition of fatigue which has developed is an essential component of an aviation safety program. J.M.S.

N79-19625# Sikorsky Aircraft, Stratford, Conn.
ADVANCEMENTS IN HELICOPTER COCKPIT TECHNOLOGY
Howard P. Harper *In* AGARD Operational Helicopter Aviation Med. Dec. 1978 7 p refs (For primary document see N79-19605 10-51)
Avail: NTIS HC A99/MF A01

The requirements of future missions are discussed in terms of the need for advanced controls and displays and improvements in cockpit vision, workload, and comfort. A number of technological areas are reviewed as candidates for inclusion in an advanced cockpit. A cockpit design incorporating this technology is presented. J.M.S.

N79-19626# British Aerospace Dynamics Group, Bristol (England).
VISUAL EFFECTS OF HELICOPTER MANEUVRE ON WEAPON AIMING PERFORMANCE
P. R. Michael, T. E. Jardine, and M. K. Goom. *In* AGARD Operational Helicopter Aviation Med. Dec. 1978 15 p refs (For primary document see N79-19605 10-51)
Avail: NTIS HC A99/MF A01

The problem areas associated with the guidance of command-to-line-of-sight missiles from helicopters were examined and assessed experimentally. The weapon system considered employed a sight which was stabilized in pitch and yaw and which incorporated a manually operated servocontrol for moving the sight in azimuth and elevation. Four interactions likely to degrade performance were studied. These were: (1) the simultaneous use of sight and missile controls; (2) helicopter vibration; (3) helicopter forward motion; and (4) helicopter maneuver (roll, pitch and yaw). Results of a first series of simulation experiments established that, in general, helicopter vibration and forward motion did not degrade the operators' performance and that an operator could use the sight and missile guidance controls simultaneously without loss of accuracy. However, any helicopter maneuver which caused the field-of-view through the sight to roll was found to cause considerable degradation of performance, regardless of any previous flying experience of the subjects. This effect of roll phasing (cross coupling) was investigated in a second series of simulations which contained some experiments where a system of roll compensation was used. This compensation caused the missile axes to appear and remain parallel to a graticule in the sight, and the field-of-view retained its attitude at launch throughout the engagement. Provided the compensation was able to reduce roll phasing to less than 20 deg there was no degradation in performance. J.M.S.

N79-19627# Royal Aircraft Establishment, Farnborough (England). Flight Systems Dept.
HUMAN FACTORS EVALUATIONS OF TODAY'S HELICOPTERS AS AN AID TO FUTURE SYSTEMS DESIGN
E. J. Lovesey. *In* AGARD Operational Helicopter Aviation Med. Dec. 1978 7 p refs (For primary document see N79-19605 10-51)
Avail: NTIS HC A99/MF A01

Methods of identifying the shortcomings of helicopter weapon systems and avionics design are discussed in terms of the interface with the operator. Cine filming, eyemark, and voice recording are considered along with structured interviews and questionnaires. Emphasis is placed on discovery of good human features and shortcomings in order to eradicate the bad in future designs. J.M.S.

N79-19628# Hughes Helicopters, Culver City, Calif. Human Factors Engineering
TADRAP: A COMPUTER-AIDED TECHNIQUE FOR REDUCING AIRCREW TASK ANALYSIS DATA
David E. Gobuty. *In* AGARD Operational Helicopter Aviation Med. Dec. 1978 9 p ref (For primary document see N79-19605 10-51)
Avail: NTIS HC A99/MF A01

As part of the human factors engineering activity during design of the YAH-64 advanced attack helicopter, a technique was developed for the computer aided reduction of aircrew task analysis data. The Task Analysis Data Reduction and Analysis Program (TADRAP) begins with the processing of raw data from a classical task analysis which was structured around a five-tiered pyramidal scheme for mission description. Once coded and keypunched, TADRAP converts the task analysis data into estimates of operator workload based upon expected task completion time, plus weighted values representing the complexity factors of action cycle, sensory modality, and task position. The TADRAP facilitates task analysis validation and presents workload data in tabular form. Future plans include expanding TADRAP routines to provide computer graphics illustrations of analyzed mission profiles. J.M.S.

N79-19629# Paris V Univ. (France). Laboratoire d'Anthropologie et d'Ecologie Humaine
THE USE OF BIOSTEREOMETRY IN HELICOPTER COCKPIT DESIGN [UTILISATION D'UNE METHODE DE BIOSTEREOMETRIE DANS LA CONCEPTION D'UN POSTE DE PILOTAGE D'HELICOPTERE]
A. Coblentz, Y. Deloison, G. Ignazi, and J. Prudent. *In* AGARD Operational Helicopter Aviation Med. Dec. 1978 19 p. In FRENCH (For primary document see N79-19605 10-51)
Avail: NTIS HC A99/MF A01

The functional anthropometric characteristics of French land force helicopter pilots were analyzed to define new norms for equipping pilot stations and making them adaptable to the needs of the operators. An apparatus was developed which can be raised by each anatomic point and by each point chosen on the equipment. A simulator of the pilot station was constructed so that the X, Y, Z coordinates could be obtained in a fixed reference geometry. The precise results obtained were used in the simulator and the ergonometric and data and dimensions were integrated. With the use of this three dimensional measurement system, the adjustments necessary to provide comfort to different subjects were measured and pilot positions were analyzed so the variations in pilot attitude could be considered in the simulated pilot performance. Transl. by A.R.H.

N79-19630# National Aerospace Lab., Amsterdam (Netherlands).
AN ANALYSIS OF HELICOPTER PILOT CONTROL BEHAVIOR AND WORKLOAD DURING INSTRUMENT FLYING TASKS
J. Smit and Wewerinke. *In* AGARD Operational Helicopter Aviation Med. Dec. 1978 11 p refs (For primary document see N79-19605 10-51)
Avail: NTIS HC A99/MF A01

During helicopter instrument hover and navigation (tracking) tasks a number of flight data, physiological measures and subjective ratings were collected. Mathematical models were used to describe and analyze the pilot's control behavior and attention workload. The optimal control model seems to offer a suitable framework for the description of control tasks as complex as helicopter instrument flying. A control effort model, which was formulated in terms of the optimal control model, describes the relationship between performance and attention paid to the task. The physiological variables and subjective ratings in general reflected the variations in control effort connected with the various tasks. J.M.S.

N79-19631# Naval Air Development Center, Warminster, Pa. Aircraft and Crew Systems Technology Directorate.
DESIGN PROCEDURE FOR AN INFORMATION TRANSFER METHOD CUBITS FOR ALLOCATING PANEL AREA FOR AIRCREW STATION CONTROLS AND DISPLAYS
Patrick M. Curran. *In* AGARD Operational Helicopter Aviation Med. Dec. 1978 10 p refs (For primary document see N79-19605 10-51)
Avail: NTIS HC A99/MF A01

A systematic and objective method for the allocation of panel areas in aircrew workspaces was developed. The developed procedure is based on: (1) the criticality of the control or display on crew safety and mission effectiveness; (2) the frequency of utilization; and (3) the amount of information which is conveyed by the operator to the system through control actuation or which is conveyed to the operator by the display presentation. This procedure utilizes a computational method called CUBITS to establish a single figure of merit for the allocation of panel space. This method also deals with the number of control settings and accuracy required in the computation of the amount of information being transferred. J.M.S.

N79-19632# Naval Air Development Center, Warminster, Pa. Aircraft and Crew Systems Technology Directorate.
HUMAN FACTOR ENGINEERING TEST AND EVALUATION OF THE US NAVY LAMPS HELICOPTER SYSTEM
Patrick M. Curran, George J. Laurent, and Paul M. Linton. *In* AGARD Operational Helicopter Aviation Med. Dec. 1978 8 p refs (For primary document see N79-19605 10-51)
Avail: NTIS HC A99/MF A01

The human factors engineering (HFE) planning, implementation, and contributions in the evaluation of the U.S. Navy Light Airborne Multi-purpose System (LAMPS) during calibrated range and open-sea operations are presented. Human factor engineering participation in this overall program was directed to the critical evaluation of the interfaces among the various system operators and their equipments in the two LAMPS system versions. The adequacy of the air and ship crews and their station designs in the two LAMPS system versions was assessed. The major sources

of HFE data were subjective, operator questionnaire, structured observations, and tape-recorded interviews. Objective data included mission key-event printouts, internal communication system (ICS) voice tapes, and aircraft and shipboard display photographs. Conclusions are presented and discussed. J.M.S.

N79-19633# Centre d'Etudes et de Recherches, Toulon (France).
A DESCRIPTION OF THE RECENT NEUROPSYCHOLOGICAL SELECTION OF PILOTS FOR LAND FORCES LIGHT AIRCRAFT [DESCRITION DE LA NOUVELLE SELECTION NEUROPSYCHOLOGIQUES DES PILOTES DE L'AVIATION LEGERE DE L'ARMEEE DE TERRE]
E. J. Caille, D. Ziane (Aviation Legere de l'Armee de Terre, Villacoublay Air, France), A. Goavec (Antenne-Aviation Legere de L'Armee de Terre, Vincennes, France), and A. Elzear (Antenne-Aviation Legere de l'Armee de Terre, Vincennes, France) *In* AGARD Operational Helicopter Aviation Med. Dec. 1978 6 p. (For primary document see N79-19605 10-51)
Avail: NTIS HC A99/MF A01

Modern methods of automatic recording and analysis are used in an experimental battery of tests developed between 1974 and 1977 and validated on 200 operational helicopter pilots. The principal originality of the new selection process rests in the objective study of vulnerability manifested in the course of controlled situations (voluntary hypernea, intermittent luminous simulation, mental calculation, and muscular exercise) as manifested on EEG and EEC. The tracings are subjected to harmonic analysis and treated in real time on microprocessors. Classic cognitive tests, six psychometric questionnaires, and proof of piloting capability as demonstrated in a simulator are included in the pilot selection process. Transl. by A.R.H.

N79-19634# Hopital Begin, St. Mande (France).
RADIOLOGICAL EXAMINATION OF THE RACHIS AND FITNESS FOR EMPLOYMENT AS A HELICOPTER PILOT [EXAMEN RADIOLOGIQUE DU RACHIS ET APTITUDE AL'EMPLOI DE PILOTE D'HELICOPTERE]
R. P. Delahaye, Auffret, and P. J. Metges *In* AGARD Operational Helicopter Aviation Med. Dec. 1978 3 p. refs. In FRENCH (For primary document see N79-19605 10-51)
Avail: NTIS HC A99/MF A01

Spinal pain in helicopter pilots is due partly to the pilot's position and partly to vibrations generated by the aircraft. Clinical medicine shows that spinal pain has a variable intensity ranging from a simple annoyance to a painful ache. The chronic discomfort that evolves with or without pain during or after flight is caused by the pilot's position and is not experienced by airplane pilots. Both clinical and physiopathological evidence supports the arguments that a specific standard of aptitude should be applied in the selection of helicopter pilots. A common standard of aptitude cannot be developed for both combat aircraft and helicopter pilots because the lumbar rachis and the lumbo-sacral joint constitute the critical segment for the helicopter pilot, while the dorsal rachis and dorso-lumbar joint are the most critical in combat aircraft pilots following ejection. Transl. by A.R.H.

N79-19635# Royal Naval Air Medical School, Seafield Park (England).
A SYSTEM OF TRAINING IN AVIATION PHYSIOLOGY AND HUMAN FACTORS FOR ARMY AND NAVY HELICOPTER AIRCREW
P. S. Ormerod *In* AGARD Operational Helicopter Aviation Med. Dec. 1978 9 p. refs (For primary document see N79-19605 10-51)
Avail: NTIS HC A99/MF A01

Aeromedical training courses designed specifically for helicopter aircrews are described. Methods used to devise the present courses and the factors considered to be important in determining the usefulness of aeromedical training to aircrews are emphasized. J.M.S.

N79-19636# Textron Bell Helicopter, Ft. Worth, Tex. Human Factors and Cockpit Arrangement Group.
VISUAL REQUIREMENTS FOR THE HELICOPTER PILOT
William F. Lowe *In* AGARD Operational Helicopter Aviation Med. Dec. 1978 6 p. ref (For primary document see N79-19605 10-51)
Avail: NTIS HC A99/MF A01

Flight test results of pilots flying obstacle avoidance maneuvers are discussed. Prediction that pilots would maneuver closer to obstacles on their side of the aircraft as opposed to obstacles on the copilot/observer side and that as speed of fly by maneuvers increased the distance required for safe clearance would increase were not completely supported by the data. Explanation of these contradictory results are offered. A survey of commercial operators to determine the unique requirements of their operations is included along with a vision plot of a new commercial twin turbine helicopter. J.M.S.

N79-19637# Coast Guard, Alameda, Calif.
OBSERVATION OF NIGHT SHIPBOARD HELICOPTER OPERATIONS FROM A 210 FOOT US COAST GUARD CUTTER
W. W. Harvey, Jr. *In* AGARD Operational Helicopter Aviation Med. Dec. 1978 6 p. refs (For primary document see N79-19605 10-51)
Avail: NTIS HC A99/MF A01

Night helicopter operations were conducted to observe the effectiveness of flight deck lighting. These observations are outlined, and a simple review of visual perception is given. Emphasis is placed on improving safety aspects of night flight. J.M.S.

N79-19638# Army Aeromedical Research Unit, Fort Rucker, Ala.
OCULOMOTOR PERFORMANCE OF AVIATORS DURING AN AUTOROTATION MANEUVER IN A HELICOPTER SIMULATOR
Richard N. Armstrong, Gerald P. Krueger, John H. Sapp, and Yvonna F. Jones *In* AGARD Operational Helicopter Aviation Med. Dec. 1978 14 p. refs (For primary document see N79-19605 10-51)
Avail: NTIS HC A99/MF A01

The oculomotor performance of ten US Army pilots, a group of five experienced and a group of five newly graduated aviators, was filmed during helicopter simulator flights conducted under precision instrument flight conditions. Each pilot flew a one hour precision instrument flight in a simulator on each of four days. On the fourth day, the flight scenario included a simulated engine failure that required the pilot to execute an autorotation maneuver. Oculomotor performance, pilot control, and aircraft flight dynamic measures were recorded during the fourth flight. The allocation of pilot visual activity to various instruments was observed to differ as a function of two phases of the autorotation maneuver. Pilots controlled rotor speed and airspeed closer to desired limits in the second phase than they did in the initial phase of the autorotation. Few differences of pilot visual activity were exhibited as a function of the experience level of the pilots. J.M.S.

N79-19639# Centre de Recherches de Medecine Aeronautique, Paris (France).
PROVIDING AN EYE SEPARATOR ON A COLOR CATHODE TUBE [POUVOIR SEPARATEUR DE L'OELL SUR TUBE CATHODIQUE COULEUR]
G. F. Santucci *In* AGARD Operational Helicopter Aviation Med. Dec. 1978 10 p. refs. In FRENCH (For primary document see N79-19605 10-51)
Avail: NTIS HC A99/MF A01

The visual acuity of simultaneously colored contrast on a radar video buffer television screen was studied using originally designed apparatus. Equal luminance was used during tests of the follo... ng colors: red, green, blue, purple, greenish-blue, yellow, and white. Tests conducted on 60 pilots between the ages of 20 and 50 resulted in the definition of the optimum proportion of character needed to assure recognition of form with good probability, as well as the precise contrast of color needed for rapid perception. The data thus obtained permits optimal reading of informtion on a cathode tube. Transl. by A.R.H.

N79-19640# Army Aeromedical Research Lab., Fort Rucker, Ala.
VISUAL PERFORMANCE/WORKLOAD OF HELICOPTER PILOTS DURING INSTRUMENT FLIGHT
R. R. Simmons, M. A. Lees, and K. A. Kimball *In* AGARD Operational Helicopter Aviation Med. Dec. 1978 17 p. refs (For primary document see N79-19605 10-51)
Avail: NTIS HC A99/MF A01

Visual and psychomotor performance data was collected in an attempt to investigate and study the general visual performance of aviators during IFR conditions. Two groups of aviators, with varied experience levels, were the subjects. A NAC Eye Mark Recorder and the Helicopter In-Flight Monitoring System were utilized to collect the required data. The results indicated, among other findings, that pilot subjective opinion does not agree with

objective data. Additionally, the attitude indicator and radio compass comprised over 60 percent of the pilot's total visual workload, while the aircraft's status gauges were monitored less than 10 percent of the total time. These data should provide invaluable information concerning the visual requirements of pilots for safe helicopter operations. J.M.S.

N79-19641# Army Aeromedical Research Lab., Fort Rucker, Ala.

VISUAL POCKETS: A DESIGN PARAMETER FOR HELICOPTER INSTRUMENT PANELS

R. W. Bailey and David D. Glick *In* AGARD Operational Helicopter Aviation Med. Dec. 1978 4 p refs (For primary document see N79-19605 10-51)

Avail: NTIS HC A99/MF A01

The concept of fixation points between instruments ('Visual Pockets') for instrument flight of helicopters was proposed as a new concept to reduce pilot workload and improve performance. It was also proposed that this concept be applied to cockpit instrument panel design. In view of the significance attached to this revolutionary concept of 'Visual Pockets', a review and perspective of helicopter pilot visual information requirements are presented with special emphasis on the impact of 'Visual Pocket' concepts. J.M.S.

N79-19642# Federal Aviation Agency, Oklahoma City, Okla. Aviation Physiology Lab.

VISUAL AND OPTICAL ASSESSMENT OF GAS PROTECTIVE FACE MASKS

K. W. Welsh and J. A. Vaughan *In* AGARD Operational Helicopter Aviation Med. Dec. 1978 7 p refs (For primary document see N79-19605 10-51)

Avail: NTIS HC A99/MF A01

The visual characteristics of ophthalmic design requirements for smoke/gas protective face masks for pilots and aircrew members were studied. Visual tests with the mask in place include (1) peripheral field of vision, (2) visual acuity, (3) stereoscopic depth perception, (4) color vision, and (5) spectacle frame displacement. Measurements were made on five adult males (age range 35 to 54 years) while wearing each of the 26 devices and again without the masks. Reduction in the temporal and inferior field was found with some of the goggle-mask (two-piece) combinations. These data indicate that 30.8 percent of the test items degraded visual acuity below 20/20 at the 0.4 m distance, 15.4 percent at 0.76 m, and 7.6 percent at 6.0 m. Mean values of depth perception ranged from 2.4 percent to 404.4 percent over control (no mask) values. The three goggles with tinted facepieces created no alterations in color perception. Spectacles worn with the two-piece protective masks were displaced upward on the face. Full-face (one-piece) masks displaced the spectacles downward. Suggested criteria for an acceptable protective mask are discussed. J.M.S.

N79-19643# Human Engineering Labs., Aberdeen Proving Ground, Md.

INTERNAL COCKPIT REFLECTIONS OF EXTERNAL POINT LIGHT SOURCES FOR THE MODEL YAH-64 ADVANCED ATTACK HELICOPTER

Christopher C. Smyth *In* AGARD Operational Helicopter Aviation Med. Dec. 1978 16 p refs (For primary document see N79-19605 10-51)

Avail: NTIS HC A99/MF A01

The US Army Human Engineering Laboratory (HEL) developed a computer program for computing the internal cockpit reflections on the transparent canopy surfaces of external point light sources. Computations were completed for the YAH-64 advanced attack helicopter (low glare canopy design). The results show that primary reflections as seen from the pilot's position are possible on: (1) the upper rear corners of the forward side canopy surfaces, (2) the upper edges of the rear sides, and (3) the sides of the top surface. Computations were also completed for the copilot's position and show possible reflections on the front and side surfaces. A computer graphics output is used to show reflection points on canopy layouts and perspectives of the cockpit. J.M.S.

N79-19644# Italian Air Force Medical Service H. Q., Rome.

SENSORIAL ASPECTS OF HELICOPTER OPERATIONS

Gaetano Rotondo In AGARD Operational Helicopter Aviation Med. Dec. 1978 5 p refs (For primary document see N79-19605 10-51)

Avail: NTIS HC A99/MF A01

The effects of sensorial phenomena related to the use of rotor-powered aircraft are examined, as components of physical and psychic workload in the piloting of helicopters, and therefore, as possible pathogenetic concurrent factors of operational fatigue in helicopter aircrews. Particularly, acoustic and nonacoustic vibrations are discussed with special reference to the effects exerted by vibratory motions on visual function. Another problem taken into consideration is the disorientation that the pilot may experience whenever there is a conflict between his own sensorial evaluations and the information supplied by the instruments. The means that might be employed for the purpose of ascertaining functional changes and possibly preventing negative effects produced by sensorial phenomena, are examined in order to attain a high degree of flight safety in helicopter operations as a result of the prevention of flight accidents due to the human factor. J.M.S.

N79-19645# Army Aeromedical Research Lab., Fort Rucker, Ala. Bioacoustics Div.

THE EFFECTIVE ACOUSTIC ENVIRONMENT OF HELICOPTER CREWMEN

Robert T. Camp, Jr. and Ben T. Mozo *In* AGARD Operational Helicopter Aviation Med. Dec. 1978 2 p (For primary document see N79-19605 10-51)

Avail: NTIS HC A99/MF A01

Measurements taken to determine the acoustic environment of helicopter crewmen are discussed. It is indicated that the attenuation characteristics of helmets and hearing protectors and the variables of the physiology of the human ear as well as the acoustic hazards of voice communications systems, influence the overall acoustic environment of the flight personnel. J.M.S.

N79-19646# Army Avionics Research and Development Activity, Fort Monmouth, N. J.

A SURVEY OF COMMUNICATIONS IN THE HIGH NOISE ENVIRONMENT OF ARMY AIRCRAFT

Mitchell S. Mayer and Arthur W. Lindberg *In* AGARD Operational Helicopter Aviation Med. Dec. 1978 18 p refs (For primary document see N79-19605 10-51)

Avail: NTIS HC A99/MF A01

In Army aircraft, the noise environment consists of a continuous noise level comprised of a mixture of random (broadband) and periodic frequencies (the aircraft noise signature or whine) and in the case of gunships, transient high-level noise bursts generated by the weapons systems. The noise environment reaching the aviator's ear is comprised of direct ambient noise penetration and communications systems processed noise (during periods of communications use, or open mike operations). The most insidious impact of the high noise levels is the long-term permanent hearing threshold shift, or hearing loss, that the aviator may incur from his prolonged exposure to the aircraft's interior sound pressure levels. Improvement of speech intelligibility under all flight conditions will improve the aviator's effectiveness by reducing the number of transmission repetitions necessary to assure that a message is correctly conveyed, thus reducing the distraction level during critical mission phases. Reducing the ambient aircraft noise processed by the communications system will further improve speech intelligibility and reduce this particular increased noise contribution to pilot stress. Author

N79-19647# Royal Aircraft Establishment, Farnborough (England). Human Engineering Div.

SOME ASPECTS OF HELICOPTER COMMUNICATIONS

G. M. Rood and E. J. Lovesey *In* AGARD Operational Helicopter Aviation Med. Dec. 1978 7 p refs (For primary document see N79-19605 10-51)

Avail: NTIS HC A99/MF A01

Factors that influence helicopter radio communications are examined. These include: the characteristics of the signal transmitter and receivers and their siting; the effects of noise and distortion of the signals; and the ability of the operator to perceive the signals while performing other tasks. The interface of the man with the equipment and the helicopter environment and the effect of the helicopter environment upon his ability to receive and process audio signals is emphasized. Helicopter noise levels, helmet attenuation, signal masking, total operator noise dose, and crew task difficulty are considered in terms of improving the overall helicopter/crew efficiency. J.M.S.

N79-19648# Royal Air Force Inst. of Aviation Medicine, Farnborough (England).

DISORIENTATION IN ROYAL NAVAL HELICOPTER PILOTS

A. P. Steel-Perkins and D. A. Evans (Royal Naval Air Medical School, Hillhead, England) *In* AGARD Operational Helicopter Aviation Med. Dec. 1978 5 p refs (For primary document see N79-19605 10-51)
Avail: NTIS HC A99/MF A01

The incidence of pilot disorientation in fixed and rotary wing aircraft was investigated. Information regarding special orientation problems of naval helicopter pilots engaged in operations at sea and landing on moving platforms was obtained when a survey of 104 active USN pilots was reported. This questionnaire was adapted and distributed to Royal Navy helicopter pilots. The aims of the surveys were that useful information would be obtained on aircraft manning, cockpit and instrument design for future helicopter pilots regarding disorientation and thus a possible improvement in flight safety. J.M.S.

N79-19649# Army Aeromedical Research Lab., Fort Rucker, Ala.

OPERATIONAL CONSIDERATION OF AN/PVS-5 NIGHT VISION GOGGLES FOR HELICOPTER NIGHT FLIGHT

Wun C. Chiou *In* AGARD Operational Helicopter Aviation Med. Dec. 1978 9 p refs (For primary document see N79-19605 10-51)
Avail: NTIS HC A99/MF A01

Experimental results and operational problems are discussed in which artificial illumination is being utilized to increase helicopter night vision goggle (NVG) training duration when ambient illumination is insufficient. Two types of artificial illumination were evaluated. The first type utilizes the existing helicopter landing light as an illumination source. The second type uses auxiliary external illumination sources such as a searchlight. A modified one kilowatt AN/VSS-4 (XG-4) armored illuminator and the fire-fly lighting system were flight tested. Results reveal that the former provides a far better illumination pattern than the latter. Spectral transmission characteristics and optical quality of these artificial illumination sources are given in detail. Various advantages and disadvantages of using one kind versus the other will also be discussed in detail. It is shown that an artificial illumination source or a combination of various sources can be utilized to increase the helicopter NVG training time at night. J.M.S.

N79-19650# Army Aeromedical Research Lab., Fort Rucker, Ala.

TRAINING REQUIREMENTS FOR HELICOPTER OPERATION WITH NIGHT VISION GOGGLES

Isaac Behar, Dana M. Young, and James E. Johnson *In* AGARD Operational Helicopter Aviation Med. Dec. 1978 4 p refs (For primary document see N79-19605 10-51)
Avail: NTIS HC A99/MF A01

The Army Aviation Center experience in night vision goggle (NVG) stagefield training at night which identified numerous problem areas and their remediation are described. An evaluation of an approach to circumventing many of these problems as well as providing an added margin of safety by providing the initial part of the NVG training during the daytime using appropriate filters for the goggles is included. J.M.S.

N79-19651# Army Aeromedical Research Lab., Fort Rucker, Ala.

HEAD AIMING/TRACKING ACCURACY IN A HELICOPTER ENVIRONMENT

Robert W. Verona *In* AGARD Operational Helicopter Aviation Med. Dec. 1978 18 p refs (For primary document see N79-19605 10-51)
Avail: NTIS HC A99/MF A01

This experiment was conducted to measure man's head aiming/tracking capability using a helmet mounted sighting device. The influences of target speed, helmet suspension types, sighting eye dominance, and helmet weighting parameters on head aiming/tracking were investigated. If the aiming/tracking accuracy was sensitive to manipulation of the man machine interface parameters, then it would seem to indicate that improved aiming/tracking accuracy could be obtained by improving the interface. The factors analyzed were: eye dominance, helmet weighting, target speed, and helmet suspension. The eye dominance and target speed factors were statistically significant. However, the only factor of practical significance was target speed. A subject aiming at a static target with his head has an RMS error of about 3.5 milliradians. If the target begins to move 4 deg/sec the error increases to about 10.5 milli-radians. When the subject begins to vibrate too, the error increases to 13 milliradians. If the target speed doubles as he is vibrating, the error increases to 16.8 milliradians. J.M.S.

N79-19652# Army Aeromedical Research Lab., Fort Rucker, Ala.

AVIATOR VISUAL PERFORMANCE: A COMPARATIVE STUDY OF A HELICOPTER SIMULATOR AND THE UH-1 HELICOPTER

R. R. Simmons, M. A. Lees, and K. A. Kimball *In* AGARD Operational Helicopter Aviation Med. Dec. 1978 13 p refs (For primary document see N79-19605 10-51)
Avail: NTIS HC A99/MF A01

The visual performance/workload of pilots during helicopter and simulated helicopter instrument flights was compared. The corneal reflection technique was utilized to obtain the visual data. Although pilot performance in the Army's UH-1FS simulator and the UH-1H helicopter were similar, several differences were noted. Additionally, the zone/cost factor theory was expanded. Pilots visual requirements for safe mission accomplishment was emphasized. J.M.S.

N79-19653# Michigan Univ., Ann Arbor. Inst. of Highway Safety Research.

OCCUPANT INJURY MECHANISMS IN CIVIL HELICOPTER ACCIDENTS

Richard G. Snyder *In* AGARD Operational Helicopter Aviation Med. Dec. 1978 14 p refs Sponsored in part by FAA and NTSB (For primary document see N79-19605 10-51)
Avail: NTIS HC A99/MF A01

Mechanisms incurred in several selected accidents involving roll-over, rotor blade strike, and seat and restraint system failures are discussed. The present injury and fatality rate could be reduced in civil accidents by improved restraints, including use of upper-torso belts, energy-absorbing seats, crashworthy fuel systems, and increased use of protective helmets. J.M.S.

N79-19654# Army Agency for Aviation Safety, Fort Rucker, Ala.

COMPARATIVE INJURY PATTERNS IN US ARMY HELICOPTERS

Laurel D. Sand *In* AGARD Operational Helicopter Aviation Med. Dec. 1978 7 p refs (For primary document see N79-19605 10-51)
Avail: NTIS HC A99/MF A01

The type of injuries, body area injured, and cause of injuries to 740 U.S. Army aviators involved in 388 rotary wing accidents from 1 January 1972 through 30 September 1977 are examined. Considerations are given to two main areas: (1) relationship to injury regarding the aviator's height, weight, and location aboard the aircraft, cockpit condition, and aircraft altitude; and (2) comparison of present injury experience with previous injury studies. The results, through statistical analyses, show that not one, or even combinations, of those factors listed were significant in injury causation. Further, comparisons of injuries show that the overall injury pattern has not changed significantly in the past 20 years. For example, injuries to the extremities, the head, and the spine continue to be among the leading body areas to be injured. Also, 94 percent of all accidents from 1957 to the present were classified as survivable but produced 33 percent of all fatalities. J.M.S.

N79-19655# Army Agency for Aviation Safety, Fort Rucker, Ala.

ENGINEERING ANALYSIS OF CRASH INJURY IN ARMY AIRCRAFT

James E. Hicks *In* AGARD Operational Helicopter Aviation Med. Dec. 1978 11 p refs (For primary document see N79-19605 10-51)
Avail: NTIS HC A99/MF A01

A methodology for identification of crashworthiness deficiencies in Army aircraft is discussed. The methodology provides for injury and impact data to be extracted from accident reports using a specially developed injury coding system. Personnel injuries are costed through a technique which provides for consideration of each injury based on its relative severity as determined by medical examination. Crash injury causes are identified and ranked according to the magnitude of their effect and probability of occurrence. The technique is designed to provide recommendations as to the most urgent crashworthiness research/development/procurement efforts for consideration by aircraft systems managers and aviation research laboratories. An application of the methodology to an operated Army aircraft is shown. Preliminary results as to the more significant crash hazards in this aircraft are discussed. Recommendations are made as to the use of the methodology and to additional investigation aids which would improve the future identifications of crash hazards. J.M.S.

N79-19656# Laboratoire de Medecine Aerospatiale, Bretigny-sur-Orge (France)

VERTEBRAL PAINS IN HELICOPTER PILOTS [LES ALGIES VERTEBRALES DES PILOTES D'HELICOPTERES]

R Auffret, R P Delahaye, P J Metges, and Vicens *In* AGARD Operational Helicopter Aviation Med Dec 1978 7 p In FRENCH (For primary document see N79-19605 10-51)

Avail NTIS HC A99/MF A01

Despite progress in aeronautical technology, pathological conditions of the rachis caused by piloting helicopters still persists On the functional level, lumbar pain is the main constituents of the chronic condition and is often compounded by shooting pains, sometimes associated with sciatica, whose delayed appearance is, without doubt, caused by flight rhythms Radiology reveals the presence of arthrosis signs and, on occasion, a congenital anomaly In 30 percent of the cases studied, radiology is normal Dorsal pain exists in about 50 percent of the cases with discrete signs of arthrosis in the 8th, 9th, and 10th vertebrae Clinical evidence of this is practically nonexistent in the population studied In all of the pilots examined a type of arthrosis is revealed in the 5th, 6th, and 7th cervical vertebrae, often associated with cervical rectitude in the sagital plane These dorsal and cervical radiological anomalies appear with great frequency in relatively young subjects Transl by A R H

N79-19657# Army Agency for Aviation Safety, Fort Rucker, Ala.

ASSESSMENT OF THE BENEFITS OF AIRCRAFT CRASHWORTHINESS

Andrew E Gilewicz *In* AGARD Operational Helicopter Aviation Med Dec 1978 8 p refs (For primary document see N79-19605 10-51)

Avail NTIS HC A99/MF A01

An assessment is made of the economic benefits of providing crashworthiness improvements within future Army helicopters Crashworthiness features which would be most worthwhile in preventing or reducing injury and hardware damage are discussed from a cost effectiveness standpoint Predictions of future accident losses for a number of candidate utility helicopter replacements are given Projections were derived based on each helicopter's crashworthiness design features and the effectiveness in injury and hardware damage prevention The technical adequacy of the design requirements is verified based on typical Army helicopter crash impacts J M S

N79-19658# Army Aviation Research and Development Command, Fort Eustis, Va. Applied Technology Lab.

CRASHWORTHY HELICOPTER SEATS AND OCCUPANT RESTRAINT SYSTEMS

George T Singley, III and Stanley P DesJardins (Simula, Inc., Tempe, Ariz.) *In* AGARD Operational Helicopter Aviation Med Dec 1978 32 p refs (For primary document see N79-19605 10-51)

Avail NTIS HC A99/MF A01

Seats and restraint systems offering substantial improvements in comparison to existing helicopters with respect to strength, body restraint, and crash force attenuation are described These seat and restraint systems are capable of retaining the seated occupant in the same relative position within the aircraft throughout the 95th percentile potentially survivable accident without the occupant being subjected to conditions in excess of human tolerance Cockpit and cabin seat and restraint systems retention strengths are shown to withstand drop and sled tests with velocity changes of 50 ft/sec and peak accelerations of 48G for drop tests and 30G for sled tests This increased strength is achieved with lightweight designs and is made possible by the application of load limiting principles This crash force attenuation characteristic limits the impact loading not only of the seat structure but also of the seat occupant J.M.S.

N79-19659# Royal Air Force Inst. of Aviation Medicine, Farnborough (England).

SOME IMPROVEMENTS TO THE UK HELICOPTER COCKPIT

D C Reader *In* AGARD Operational Helicopter Aviation Med. Dec 1978 3 p refs (For primary document see N79-19605 10-51)

Avail NTIS HC A99/MF A01

The human-factor aspects of helicopters are discussed. These include: improvements to the restraint harnesses; the location and methods of stowage of the survival aids; and the strength, adjustment and anti vibration properties of the crew seats Experiments conducted to investigate the feasibility of different configurations of flight control are described J M S

N79-19660# Army Aeromedical Research Lab Fort Rucker Ala

HELICOPTER CRASHWORTHY FUEL SYSTEMS AND THEIR EFFECTIVENESS IN PREVENTING THERMAL INJURY

Stanley C Knapp, Pierre Allemond (Army Agency for Aviation Safety, Ft Rucker, Ala.), and David H Karney *In* AGARD Operational Helicopter Aviation Med Dec 1978 7 p refs (For primary document see N79-19605 10-51)

Avail NTIS HC A99/MF A01

All Army helicopter accidents during the period 1968-1976 are reviewed and classified by survivability and whether or not the aircraft was equipped with a crashworthy fuel system Accident associated fatalities and injuries are reclassified as to the primary injury involved and its relationship to the existence of any postcrash fire The direct costs involved in the care of thermal fatalities and thermal injuries are calculated using the most conservative estimates It is shown that the helicopter crashworthy fuel system essentially eliminated postcrash fatalities and injuries in accidents involving helicopters equipped with the new system J M S

N79-19661# Arizona State Univ., Tempe Engineering Safety Center

A METHOD FOR SELECTING A CRASHWORTHY FUEL SYSTEM DESIGN

S Harry Robertson and James W Thurbow *In* AGARD Operational Helicopter Aviation Med Dec 1978 6 p (For primary document see N79-19605 10-51)

Avail NTIS HC A99/MF A01

A rating method that a crashworthy fuel system designer can use to help determine the amount of hardware and special design considerations needed to obtain a desired reduction in the fuel system fire hazard level is discussed Man's tolerance to the thermal environment, and the escape time available to the aircraft occupants are among the factors considered J M S

N79-19662# Louisiana State Univ., Shreveport School of Medicine

BIOMEDICAL CONSTRAINTS ON THERMAL PROTECTIVE FLIGHT CLOTHING DESIGN: A BIOENGINEERING ANALYSIS

Francis S Knox, III, Thomas L Wachtel (California Univ., San Diego), and Stanley C Knapp (Army Aeromedical Research Lab., Ft Rucker, Ala.) *In* AGARD Operational Helicopter Aviation Med Dec 1978 11 p refs (For primary document see N79-19605 10-51)

Avail NTIS HC A99/MF A01

From studies of the dynamics of large JP-4 fuel fires and of instrumented helicopter hulks immersed in such fires, the worst credible postcrash fire environment was defined Data from these fires allowed the the construction and calibration of a JP-4 fueled postcrash fire simulator This simulator was used to expose 95 domestic white pigs (animal for human skin) to simulated postcrash fires of various intensities and various durations In some instances fabrics (e.g., Nomex) were placed between the fire and the pig The resultant burns were graded on surface appearance and on depth of damage The relationship between thermal energy and burn depth is complex and depends on, among other things, initial skin temperature, skin color, length of hair stubble, exposure time, and amount and rate of tissue water boiling Fabrics tend to lower the amount of energy transmitted to the skin provided they remain intact and maintain an insulating air layer The experimental burn data presented and survival data from the Natural Burn Information Exchange form the basis of a rational consideration of the biomedical constraints on thermal protective flight clothing design when compared with textile engineering and cost factors. J.M.S.

N79-19663# Sikorsky Aircraft, Stratford, Conn. Systems Engineering Branch.

CRASH SURVIVABILITY OF THE UH-60A HELICOPTER

Brian L Carnell *In* AGARD Operational Helicopter Aviation Med Dec 1978 10 p (For primary document see N79-19605 10-51)

Avail NTIS HC A99/MF A01

The Sikorsky UH-60A or BLACK HAWK is designed to

minimize the hazards found in the many accidents that occurred in the combat environment of Southeast Asia. Its crash survivability design features are discussed. These include (1) a protective shell is maintained around the occupants, the energy absorbing landing gear cushions the crash impact and the structure is designed to minimize penetration by rotor blades, transmissions and engines, (2) the loads on the occupants are limited to noninjurious levels, all seats are energy attenuating, (3) major postcrash fires are prevented, a complete crash survivable fuel system is installed, (4) the interior is noninjurious, no hard structure is in the head strike zones. Padding and shielding in the cockpit protect the aircrew from injury and entrapment, and (5) adequate emergency escape capability is provided, jettisonable cockpit doors and cabin windows allow rapid emergency egress. J.M.S.

N79-19664# Hughes Helicopters, Culver City, Calif. Structural Analysis Section

THE APPROACH TO CREW PROTECTION IN THE CRASH ENVIRONMENT FOR THE YAH-64

John M. McDermott *In* AGARD Operational Helicopter Aviation Med. Dec. 1978 7 p refs (For primary document see N79-19605 10-51)

Avail: NTIS HC A99/MF A01

The approach to crashworthiness in protecting the crew of the advanced attack helicopter is described. Basic requirements of crash criteria specified by the Army are presented. Impact modes and impact velocities are discussed. The means used to meet these requirements using a total systems approach (i.e., landing gear, plus fuselage crushing and energy absorbing seats all in series) are presented. Crash pulses felt by the occupants during the various crash impacts are presented. Design of energy absorbing seats is discussed. Protection of the crew by use of turnover structure and by means of high load factors on heavy mass items which could penetrate the cockpit is illustrated. Maintaining living space during crash barrier impacts, and protection against blade strikes using the roll over structure are discussed. J.M.S.

N79-19665# Naval Training Equipment Center, Orlando, Fla.

HELICOPTER UNDERWATER ESCAPE TRAINER (9D5)

William F. Cunningham *In* AGARD Operational Helicopter Aviation Med. Dec. 1978 3 p refs (For primary document see N79-19605 10-51)

Avail: NTIS HC A99/MF A01

A helicopter equivalent of the Navy Dilbert Dunker long used as an underwater escape procedures trainer is described. The same principles of of the Dilbert Dunker apply to the helicopter escape trainer. Aircrews ride the trainer from different seat positions, thoroughly gaining confidence in their ability to successfully escape from anywhere in the helicopter. This training reflects the belief that successful escape from a ditched/sinking helicopter depends largely on spontaneous action achieved through repetitive drills. The results tend to prove this true. J.M.S.

N79-19666# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick (West Germany).

BAILOUT FROM AUTOROTATING HELICOPTERS

H. D. Melzig, U. Schmidt, and E. A. Bockemuller *In* AGARD Operational Helicopter Aviation Med. Dec. 1978 9 p refs (For primary document see N79-19605 10-51)

Avail: NTIS HC A99/MF A01

Parachute jumps were conducted from an autorotating helicopter to prove the possibility of bailout with a parachute as a means of rescue in emergency cases. The tests were conducted at glide angles of 17 deg proving by their good agreement with the computed results the general applicability of the computational method to glide angles up to 90 deg. The results show that bailout from autorotating helicopters is possible for all glide angles. It is recommended, however, that crew members are taught to perform the ball attitude and give a delay of 3 sec before releasing their parachute. J.M.S.

N80-14678# Advisory Group for Aerospace Research and Development, Paris (France).

RECENT ADVANCES IN AERONAUTICAL AND SPACE MEDICINE

Raymond H. Murray, ed. (Mich. State Univ., East Lansing) Sep. 1979 80 p refs In ENGLISH and FRENCH Presented at the Aerospace Med. Panel's Spec. Meeting, Brussels, 22-26 Jan. 1979

(AGARD-CP-265; ISBN-92-835-0250-7) Avail: NTIS HC A05/MF A01

The selection and life support of aircrews and spacecrews, including the European payload specialists for shuttle/Spacelab missions are discussed. Physiological factors in space operations are examined, as well as the medical and physiological problems addressed during the development and operation of commercial supersonic vehicles. For individual titles, see N80-14679 through N80-14683.

N80-14679# Advisory Group for Aerospace Research and Development, Paris (France).

PROBLEMS RELATED TO MEDICAL CRITERIA FOR THE SELECTION OF MILITARY NAVIGATION PERSONNEL [PROBLEMES RELATIFS AUX CRITERES MEDICAUX DE SELECTION DU PERSONNEL NAVIGANT MILITAIRE]

E. Evrard *In its* Recent Advan. in Aeron. and Space Med. Sep. 1979 22 p refs In FRENCH (For primary document see N80-14678 05-51)

Avail: NTIS HC A05/MF A01

Visual, auditory and vestibular, and psychological or psychiatric criteria for personnel selection are considered. Specific problems discussed relate to (1) special possible criteria for determining precociousness and the immediate problem of the specialization of operational personnel; (2) a possible raising of the standards for aviators destined to pilot new generation fighter aircraft; and (3) female navigational personnel. The standardization of visual and auditory criteria is recommended as well as additional research on the problems considered in order to reduce the rate of elimination during the pilot training course. Transl. by A.R.H.

N80-14680# Royal Air Force Inst. of Aviation Medicine, Farnborough (England).

AN ADVANCED OXYGEN SYSTEM FOR FUTURE COMBAT AIRCRAFT

J. Ernsting *In* AGARD Recent Advan. in Aeron. and Space Med. Sep. 1979 17 p refs (For primary document see N80-14678 05-51)

Avail: NTIS HC A05/MF A01

The operational and physiological requirements for an advanced oxygen system for future high performance combat aircraft are considered and reviewed. It is concluded that such an oxygen system should employ a molecular sieve on board oxygen generation system, pressure premix for dilution of the oxygen by air and a twin demand regulator package. The principles of operation of such a system are considered and a design is proposed. Author

N80-14681# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Bonn (West Germany). Inst. fuer Flugmedizin

THE EUROPEAN APPROACH TO THE SELECTION AND TRAINING OF SL PAYLOAD SPECIALISTS

K. E. Klein and J. R. Hordinsky *In* AGARD Recent Advan. in Aeron. and Space Med. Sep. 1979 12 p refs (For primary document see N80-14678 05-51)

Avail: NTIS HC A05/MF A01

The completed selection of European payload specialists (PS) for the first Spacelab mission (SL-1) is described. Future developments in European selection programs are projected. The immediate training requirements for the SL-1 PS are described. The integration of such varied training categories as biomedical and physical with the more general SL experiment training is reviewed. The usefulness of mission simulations is also discussed. Author

N80-14682*# National Aeronautics and Space Administration Lyndon B. Johnson Space Center, Houston, Tex.

PHYSIOLOGICAL FACTORS IN SPACE OPERATIONS. EMPHASIS ON SPACE SHUTTLE

Sam L. Pool, Paul C. Rambaut, and Jerry L. Homick *In* AGARD Recent Advan. in Aeron. and Space Med. Sep. 1979 12 p refs (For primary document see N80-14678 05-51)

Avail: NTIS HC A05/MF A01 CSCL 06P

Problems such as space motion sickness, redistribution of body fluids, and cardiovascular deconditioning are of concern in short-duration space shuttle flights. The expanded participation of nonastronaut crewmembers or payload specialists in these flights increases the life scientists' interest in the space shuttle flights. Problems such as loss of skeletal mass, decreased red blood cell production, and numerous endocrine changes are of more concern on long-duration flights. The Life Sciences Program is therefore concerned with a wide variety of problems that

range from the applied to the basic. The common thread is biology, the context is space. Several physiological factors associated with space shuttle operations are summarized including space motion sickness, cardiovascular deconditioning, bone and muscle loss, hematology, fluid and electrolyte changes, reentry g-forces, radiation safety, noise, atmosphere, extravehicular activity, toxicology, nutrition, biowaste, and health maintenance.
Author

N80-14683# Medical de l'Aeronautique Civile, Paris (France).
SUPERSONIC AERIAL TRANSPORT: MEDICAL AND PHYSIOLOGICAL ASPECTS [LE TRANSPORT AERIEN SUPERSONIQUE ASPECTS MEDICO-PHYSIOLOGIQUES]
Jean Raboutet *In* AGARD Recent Advan. in Aeron. and Space Med. Sep. 1979 7 p In FRENCH (For primary document see N80-14678 05-51)
Avail: NTIS HC A05/MF A01

From 1964 to 1974, two medical subgroups, one French and one British, researched the medical and physiological problems presented by supersonic air transportation. All the problems were addressed by committees of specialists that included physicians, physicists, chemists, and engineers. Thus, the loss of pressurization, ozone, ionizing radiation, noise, visual problems, and air conditioning were the objects of profound study. Very satisfying solutions were found. In certain cases, notably ozone and cosmic radiation, it could be proved that it was a matter of false problems, and that supersonic flight at 17,000 meters offered no danger. As the consequence of all the favorable results obtained, the Concorde could easily obtain the authorization necessary for flight.
Transl. by A.R.H.

52 AEROSPACE MEDICINE

Includes physiological factors, biological effects of radiation, and weightlessness

N78-15688# Advisory Group for Aerospace Research and Development, Paris (France)
COMPARATIVE STUDY OF REGULATIONS ON STANDARDS OF MEDICAL FITNESS FOR FLYING DUTIES IN NINE AIR FORCES COVERING SEVEN NATO COUNTRIES
E Evrard Nov 1977 124 p *refs*
(AGARD-AG-213(Eng), AGARDograph-213(Eng),
ISRN-92-835-1265-0) Avail NTIS HC A06/MF A01

Comparisons were made of *current* standards for assessing fitness for flying duties in the Armed Forces of seven NATO nations. Regulations used were provided by Belgium, France, Canada, Britain, Norway, the Federal Republic of Germany, and the United States. The study was done to provide medical officers in each of the allied countries with the main texts, recommendations and provisions applicable to military aircrews of the others, and to initiate a review of ideas and doctrines used in assessing medical fitness. Author

N78-17658# Advisory Group for Aerospace Research and Development, Paris (France)
THE USE AND ABUSE OF SOCIAL DRUGS
Harry C Holloway, ed Jan 1978 53 p *refs* Conf held at Koln, West Germany, 18-22 Apr 1977
(AGARD-CP-218) Avail NTIS HC A04/MF A01

The conference proceedings on the use and abuse of social drugs are reported. Topics discussed include (1) the need for drugs and alcohol programs that are unique to military organizations; (2) the influence of tobacco from a medical standpoint on French pilots; (3) the United Kingdom approach to alcoholism in air crews; (4) diagnosis of alcoholism: The Munich alcoholism test; and (5) influence of socially used drugs on vision and vision performance. For individual titles, see N78-17659 through N78-17663

N78-17659# Walter Reed Army Inst. of Research, Washington, D.C. Dept. of Military Psychiatry.
THE NEED FOR DRUG AND ALCOHOL PROGRAMS THAT ARE UNIQUE TO MILITARY ORGANIZATIONS
Larry H Ingraham *In* AGARD The Use and Abuse of Social Drugs Jan 1978 6 p refs (For availability see N78-17658 08-52)
Avail NTIS HC A04/MF A01

An epidemiological field study of illicit drug use is the basis for this study. The study used multidisciplinary methods including biochemical measures, mass questionnaire surveys, depth interviews, archival record searches, and participant observation. The details were reported elsewhere, but the themes and major findings are reviewed to understand succeeding arguments and propositions. Author

N78-17660# Ministere de l'Air, Paris (France)
THE INFLUENCE OF TOBACCO FROM A MEDICAL STANDPOINT ON FRENCH PILOTS [INFLUENCE DU TABAC DANS L'EXPERTISE MEDICALE DES FORCES AERIENNES FRANCAISES]
R Carre, J L Charmeau, A Thabaut, J L Durosoir, J Hainaut, A M Clauzel, G Trinquet, and A Meyer *In* AGARD The Use and Abuse of Social Drugs Jan 1978 10 p refs In FRENCH (For availability see N78-17658 08-52)
Avail NTIS HC A04/MF A01

Some of the following items were discussed and analyzed in detail in reference to the influence of tobacco on the performance expertise of navigation personnel such as mechanics, pilots, and radio navigators. (1) the influence of tobacco on ventilation and pulmonary diffusion, (2) spirometric scanning, and (3) measurement of carbon monoxide transfer. Tobacco influence on the dosage of alpha 2 macroglobulin and a protamine test were examined. Results of these tests showed better evidence of vascular risks factors between smokers and nonsmokers. A statistical comparison of various protein series of pilots, smokers and nonsmokers showed significant decrease of immunoglobin G and a significant rise in the rate of alpha 1 antitrypsine and haptoglobin with smokers in comparison to nonsmokers.
Transl by B B

N78-17661# Royal Air Force, Wroughton (England)
THE UK APPROACH TO ALCOHOLISM IN AIR CREW
D N Johnstone *In* AGARD The Use and Abuse of Social Drugs Jan 1978 3 p (For availability see N78-17658 08-52)
Avail NTIS HC A04/MF A01

It was determined that it is appropriate to deal with an individual as an alcoholic by reference to the World Health Organization definition. It is argued that to return to moderate use of ethanol is a desirable, and even an attainable goal for an alcoholic, however, evidence is not convincing. The risk of returning to the former level of abuse cannot be tolerated in military aviation. It is therefore demanded that total and permanent abstention be the goal of treatment. There appears to be two statistical peaks of alcoholic drinkers in UK service population, one composed of single airmen, of average age 21, and the second of married men, average 38 years. (The aircrew fall into the second group.) G Y.

N78-17662# Deutsche Forschungsanstalt fuer Psychiatrie (Max-Planck-Institut), Munich (West Germany)
DIAGNOSIS OF ALCOHOLISM: THE MUNICH ALCOHOLISM TEST (MAT)
C Ringer, W. Feuerlein, H. Kufner, and K. Antons *In* AGARD The Use and Abuse of Social Drugs Jan. 1978 8 p (For availability see N78-17658 08-52)
Avail: NTIS HC A04/MF A01

A diagnostic instrument which would permit sufficiently reliable differentiation between alcoholics and healthy as well as sick persons was developed, and empirically tested. For this purpose roughly 250 diagnostically relevant items were selected from the extensive literature on alcoholism and in three separate phases with a total of 1335 patients evaluated for their ability to differentiate. The best items were selected on the basis of various statistical criteria and then cross validated. The result is the Munich Alcoholism Test, which consists of two complementary parts, a seven item physician's assessment part, and a 24 item self assessment part. Author

N78-17663# California Univ., Berkeley.
INFLUENCE OF SOCIALLY USED DRUGS ON VISION AND VISION PERFORMANCE
A J Adams, B Brown, M C Flom, A Jampolsky, and R T Jones *In* AGARD The Use and Abuse of Social Drugs Jan 1978 8 p refs (For availability see N78-17658 08-52)
Avail NTIS HC A04/MF A01

In a four-year study on vision and vision performance the drug and placebo treatments were administered double blind using replicated, balanced Latin Square design. The major oculomotor findings are (1) an increase in tonic convergence, (2) the maximum velocity of smooth eye tracking is decreased by alcohol and not by marijuana, (3) optokinetic nystagmus and peripheral gaze nystagmus are affected by both drugs but more by alcohol, (4) pupil size is reduced by marijuana and unaffected by alcohol. The major visual sensory findings are (1) no change in visual acuity with either drug, (2) a marked reduction in the acuity of moving objects by alcohol and to a lesser extent by marijuana, (3) a prolonged glare recovery associated with either drug, (4) small reduction in color discrimination similar to those seen in mild protonomaly, and (5) a decrease in visual search time for alcohol but not for marijuana. In general combined doses of alcohol and marijuana failed to support a simple additive model for drug activity. All observed changes reached a maximum within 2 hours, and lasted for up to 6 hours after drug ingestion, and most of the changes are dose related. Author

N78-28793# Advisory Group for Aerospace Research and Development, Paris (France)
FIFTH ADVANCED OPERATIONAL AVIATION MEDICINE COURSE

G F. Perdriel, ed Jun 1978 83 p Course held at L'Ecole d'Application du Service de Sante pour l'Armee de l'Air, Paris, 12-23 Sep 1977
(AGARD-R-666, ISBN-92-335-1287-1) Avail NTIS HC A05/MF A01

Procedures in opthalmology and oto-rhino-laryngology for selecting flying personnel are discussed For individual titles, see N78-28794 through N78-28805

N78-28794# Advisory Group for Aerospace Research and Development, Paris (France)
COLOR VISION IN AVIATION
J P Chevaleraud (Service Ophtalmologie C P E M P N, Paris) *In its* 5th Advanced Operational Aviation Med Course Jun 1978 p 1-6 (For primary document see N78-28793 19-52)
Avail NTIS HC A05/MF A01

The role of color perception in all phases of aeronautics is outlined with emphasis on the safe operation of the flight vehicle Systematic detection of color vision abnormalities in flight personnel candidates is recommended Various methods used to detect dyschromatopsias are briefly described J M S

N78-28795# Advisory Group for Aerospace Research and Development, Paris (France)
VISION AT LOW LUMINANCE LEVELS IN AVIATION
J P Chevaleraud (Service Ophtalmologie C P E M P N, Paris) *In its* 5th Advanced Operational Aviation Med Course Jun 1978 p 7-11 (For primary document see N78-28793 19-52)
Avail NTIS HC A05/MF A01

Low luminous vision in aeronautics, on the ground as well as in flight, is discussed in terms of pilot selection Preadaptation and administration of medicines to improve performance are briefly assessed. J M S

N78-28796# Advisory Group for Aerospace Research and Development, Paris (France).
GLARE AND ITS ADVERSE CONSEQUENCES IN AVIATION
J. P Chevaleraud (Service Ophtalmologie C P E M P N, Paris) *In its* 5th Advanced Operational Aviation Med Course Jun 1978 p 13-16 (For primary document see N78-28793 19-52)
Avail NTIS HC A05/MF A01

The effects of glare in the aeronautical environment are discussed. Sensory disturbances, deterioration of the optical image, and psychological disturbances are considered along with individual variations in the resistance to glare and in recovery of visual acuity after exposure. Selection of flight personnel as a function of sensitivity to glare and systematic checking at each follow-up medical examination is recommended. Methods to improve recovery and protective devices are described. J.M.S.

N78-28797# Advisory Group for Aerospace Research and Development, Paris (France).
DEPTH VISION IN AVIATION
P J Manent (Service Ophtalmologie, Hospital d'Instruction des Armees D Larrey, Versailles, France) *In its* 5th Advanced Operational Aviation Med. Course Jun. 1978 p 17-22 (For primary document see N78-28793 19-52)
Avail NTIS HC A05/MF A01

The significance of depth perception in aviation is discussed for the following operations: landing, in flight, ground maneuvers--taxiing, weapon firing, and parachute jumping. Monocular and binocular factors involved in depth perception are described along with methods of measurement in flight personnel to predict visual performance. Extrinsic and intrinsic factors affecting depth vision are considered including ground configurations at low altitude, speed, light environment, sensorimotor, fatigue, and air sickness. J.M.S.

N78-28798# Advisory Group for Aerospace Research and Development, Paris (France).
VISUAL PROBLEMS RAISED BY LOW ALTITUDE HIGH SPEED FLIGHT
P J Manent (Service Ophtalmologie, Hospital d'Instruction des Armees D. Larrey, Versailles, France) *In its* 5th Advanced Operational Aviation Med. Course Jun. 1978 p 23-28 (For primary document see N78-28793 19-52)
Avail NTIS HC A05/MF A01

Visual problems associated with visual flight rule (VFR) reconnaissance or photographic missions or bombing missions are discussed Physical, physiological, and psychological stresses of low altitude high speed flight which affect vision by modifying the visual information and the visual performance and by disturbing the visual function are considered. Means designed to ensure an optimal man machine interaction, filling the mission requirements and following safety rules, are outlined Pilot selection, periodic check ups, pilot training, protective devices, and human factors engineering are among the factors included J M S

N78-28799# Advisory Group for Aerospace Research and Development, Paris (France)
THE CONTRIBUTION OF ELECTROPHYSIOLOGY
J P Chevaleraud (Service Ophtalmologie C P E M P N, Paris) *In its* 5th Advanced Operational Aviation Med Course Jun 1978 p 29-34 (For primary document see N78-28793 19-52)
Avail NTIS HC A05/MF A01

Visual electrophysiological examinations are discussed in relation to the selection and medical surveillance of flight personnel. The diagnostic and prognostic value of examinations is cited It is stated that electrophysiological examinations are objective and provide information that is easily documented. J M S

N78-28800# Advisory Group for Aerospace Research and Development, Paris (France).
AUDITORY INFORMATION OF FLYING PERSONNEL: ANATOMICAL AND PHYSIOLOGICAL BASIS
L R Bondes(Service Oto-rhino-laryngologie, Hospital d'Instruction des Armees D Larrey, Versailles, France) *In its* 5th Advanced Operational Aviation Med Course Jun 1978 p 35-44 (For primary document see N78-28793 19-52)
Avail NTIS HC A05/MF A01

An anatomical review of the auditory system is presented along with a study of physiological acoustics. An analysis of the physiology of hearing is included. F.O.S.

N78-28801# Advisory Group for Aerospace Research and Development, Paris (France).
AVIATOR HEARING LOSS
P Blanc (Service O.R.L., C.P.E.M.P.N., Paris) *In its* 5th Advanced Operational Aviation Med. Course Jun. 1978 p 45-46 (For primary document see N78-28793 19-52)
Avail NTIS HC A05/MF A01

Hearing loss in flying personnel is discussed in terms of frequencies. F.O.S.

N78-28802# Advisory Group for Aerospace Research and Development, Paris (France).
PSYCHOPATHOLOGY IN EQUILIBRATION IN AEROSPACE MEDICINE
L. R. Bondes (Service Oto-rhino-laryngologie, Hospital d'Instruction des Armees D. Larrey, Versailles, France) *In its* 5th Advanced Operational Aviation Med. Course Jun. 1978 p 47-58 (For primary document see N78-28793 19-52)
Avail: NTIS HC A05/MF A01

Physiological aspects of equilibrium are discussed in terms of induced reflex responses. The physiopathology of equilibrium in flight is described. F.O.S.

N78-28803# Advisory Group for Aerospace Research and Development, Paris (France).
NEW ASPECTS OF BAROTRAUMA IN O.R.L.
L. R. Bondes(Service Oto-rhino-laryngologie, Hospital d'Instruction des Armees D. Larrey, Versailles, France) *In its* 5th Advanced Operational Aviation Med. Course Jun. 1978 p 59-66 (For primary document see N78-28793 19-52)
Avail: NTIS HC A05/MF A01

The conditions for atmospheric variations in man are reviewed along with the physiology of pressure changes in the ear. The sinus ventilation mechanism is described. F.O.S.

N78-28804# Advisory Group for Aerospace Research and Development, Paris (France).
NOSE PATHOLOGY OF FLYING PERSONNEL
P. Blanc (Service Oto-rhino-laryngologie, C.P.E.M.P.N., Paris) *In its* 5th Advanced Operational Aviation Med. Course Jun. 1978 p 67-70 (For primary document see N78-28793 19-52)
Avail: NTIS HC A05/MF A01

Techniques for the practical examination of the nasal cavity, sinuses and Eustachian tubes are discussed along with chronic nasal affections due to infections, or allergies. F.O.S.

N78-28805# Advisory Group for Aerospace Research and Development, Paris (France).
PRACTICAL PROBLEMS RAISED BY OTO-RHINO-LARYNGOLOGY STANDARDS

P Blanc (Service Oto-rhino-laryngologie, C.P.E.M.P.N., Paris) *In its* 5th Advanced Operational Aviation Med. Course Jun. 1978 p 71-74 (For primary document see N78-28793 19-52)
Avail: NTIS HC A05/MF A01

Otoscopic and cochlear problems are studied in terms of clinical and functional examinations. F.O.S.

N79-11692# Advisory Group for Aerospace Research and Development, Paris (France)
PROSPECTIVE MEDICINE OPPORTUNITIES IN AEROSPACE MEDICINE
J. H. Triebwasser, ed. (School of Aerospace Med.) Sep. 1978 100 p refs Presented at Aerospace Medical Panel's 34th Panel Meeting/Specialists' Meeting, London, 24-28 Oct. 1977
(AGARD-CP-231 ISBN-92-835-1293-6) Avail: NTIS HC A05/MF A01

Various applications of prospective medicine techniques are discussed with relation to the practice of aerospace medicine. Studies were conducted on special population of military aircrew in the prevalence, incidence of findings. Multiple risk assessments, correlation of with disease risks, and results of efforts to modify the risk for disease and their clinical manifestations were examined. For individual titles, see N79-11693 through N79-11704.

N79-11693# National Defence Headquarters, Ottawa (Ontario). Directorate of Preventive Medicine
THE CANADIAN FORCES LIFE QUALITY IMPROVEMENT PROGRAMME
John E. Bardsley. *In* AGARD Prospective Med. Opportunities in Aerospace Med. Sep. 1978 6 p (For primary document see N79-11692 02-52)
Avail: NTIS HC A05/MF A01

The Canadian Gorces introduced a life quality improvement program to counteract the ravages of diseases which arise from risks prevalent in most lifestyles in Western society. These so-called diseases of choice are discussed in terms of their self-imposed risks. A summary of the program concept is given centering around 15 factors and six philosophies deemed essential for success. Central in the program is the individual assessment which is composed of various biomeasurements, a health hazard appraisal, a health questionnaire and an interview. In support of this assessment will be an educational/promotional campaign and a variety of supportive clinics. B.B.

N79-11694*# National Aeronautics and Space Administration, Washington, D. C.
THE ROLE OF PHYSICAL EXAMINATIONS AND EDUCATION IN PROSPECTIVE MEDICINE
Walton L. Jones, Jean Mockbee, Carolyn K. Snow, and J. Richard Compton (Natl. Health Services, Inc.). *In* AGARD Prospective Med. Opportunities in Aerospace Med. Sep. 1978 9 p refs (For primary document see N79-11692 02-52)
Avail: NTIS HC A05/MF A01

NASA's prospective medicine program, with the principal elements of physical examinations and an educational program for health awareness is described. Participation in the voluntary physical examination program is increasing. In 1976 13,621 employees were given partial or complete examination in NASA Health Units. From the 941 examinations performed at NASA Headquarters in 1976, 522 principal findings were detected. Equipment and techniques in exercise EKG, tonometry, and colonoscopy were partially responsible for this high rate. The health awareness program includes consultations with physicians, training devices and courses, health bulletins, and special screening programs. Epidemiological studies, now underway, will be used to evaluate the health awareness programs. B.B.

N79-11695# Naval Aerospace Medical Research Lab., New Orleans, La.
MEDICAL QUALIFICATION PROCEDURES FOR HAZARDOUS-DUTY AEROMEDICAL RESEARCH
D. J. Thomas, P. L. Majewski, C. L. Ewing, and N. S. Gilbert. *In* AGARD Prospective Med. Opportunities in Aerospace Med. Sep. 1978 13 p refs (For primary document see N79-11692 02-52)
Avail: NTIS HC A05/MF A01

Volunteer subjects were recruited for hazardous duty impact and vibration acceleration stress experiments during the past 10 years. Dental and lumbosacral spinal abnormalities are the major cause of disqualification. From a group of 1,277 prospective volunteers, only 63 (4.9 percent) were qualified and only 44 (3.4 percent) successfully completed the experimental program. The procedures and findings of the selection program are presented. Volunteers were recruited, evaluated, and used in strict accordance with specified procedures. B.B.

N79-11696# Federal Aviation Administration, Washington, D. C.
EXPERIENCE WITH PERIODIC AVIATION MEDICAL EXAMINATIONS
Edwin E. Westura. *In* AGARD Prospective Med. Opportunities in Aerospace Med. Sep. 1978 15 p refs (For primary document see N79-11692 02-52)
Avail: NTIS HC A05/MF A01

Personal observations and experience with civilian aviation medical examinations and the Federal Aviation Administration (FAA) certification system from June 1964 through June 1977 are presented. Special attention was devoted to methods used in the assessment of the cardiovascular system. Emphasis was placed upon a systematic approach to those cardiovascular conditions especially coronary heart disease which might adversely affect pilot performance and which present a hazard to public safety. Coronary heart disease and its clinical manifestations are the major cardiovascular problem in United States civilian aviation medicine today. Evaluation techniques were used in detecting potentially dangerous conditions. B.B.

N79-11697# School of Aerospace Medicine, Brooks AFB, Tex. Clinical Sciences Div.
A PROSPECTIVE MEDICINE APPROACH TO THE PROBLEM OF ISCHEMIC VASCULAR DISEASE IN THE USAF
Malcolm C. Lancaster. *In* AGARD Prospective Med. Opportunities in Aerospace Med. Sep. 1978 5 p refs (For primary document see N79-11692 02-52)
Avail: NTIS HC A05/MF A01

A program of ischemic vascular disease risk factor identification and intervention is described. An individual risk calculation was performed which identifies the current risk for the individual and also projects the effect of modification of individual risk upon the combined risk figure. B.B.

N79-11698# Medizinische Poliklinik der Univ. Wuerzburg (West Germany)
THE SIGNIFICANCE OF RHYTHM DISTURBANCES IN ASYMPTOMATIC PERSONS
Armin Dietz and Josef Walter. *In* AGARD Prospective Med. Opportunities in Aerospace Med. Sep. 1978 6 p refs (For primary document see N79-11692 02-52)
Avail: NTIS HC A05/MF A01

Nearly all rhythm disturbances can be found in persons without clinically significant heart disease. Various ECG methods and epidemiologic studies help to clarify their prognosis. The results of such investigations are of special importance to aviation medicine, because arrhythmias can cause sudden incapacitation. Those arrhythmias occurring in a well controlled asymptomatic population such as flying personnel are described. The immediate hemodynamic consequences of these ECG alterations and possible prognostic implications for the incidence of sudden dangerous arrhythmias are discussed. B.B.

N79-11699# School of Aerospace Medicine, Brooks AFB, Tex. Internal Medicine Branch
DISTINGUISHING BORDERLINE HYPERTENSIVES FROM NORMOTENSIVES: A CLINICAL STUDY OF 300 AIRCREWMEN
David H. Hull, Roger A. Wolthuis, Joseph R. Fischer, John H. Triebwasser, Jacki T. Curtis, and Donald A. McApoose. *In* AGARD Prospective Med. Opportunities in Aerospace Med. Sep. 1978 8 p refs (For primary document see N79-11692 02-52)
Avail: NTIS HC A05/MF A01

Ambulant aircrewmen (299) referred to a clinical consultation service were evaluated with a brief orthostatic test: blood pressure (BP) and heart rate were recorded alternately during both supine rest and 5 minutes of quiet standing. The patients were divided into four groups depending on BP history (normotension vs. borderline hypertension) and BP from the current clinical examination (normal vs. elevated). During supine rest, most patients with a normotensive history and a majority of those with a borderline hypertensive history and BPs in the normal range. During stand, BP remained normal in most normotensives but was elevated in a majority (62 percent) of borderline hypertensives. These results were used to compute the probability of borderline hypertension in an individual patient, given either the BP from his current clinical examination or the average BP from the stand part of his orthostatic test, or both. Curves were

constructed showing this probability in populations with various prevalences of borderline hypertension The value of an orthostatic test combined with a standard clinical BP in distinguishing between borderline hypertension and normotension was apparent B B

N79-11700# Naval Air Development Center Warminster, Pa Biochemistry Lab

MOLECULAR DETERMINANTS FOR THE PREDICTION AND SURVIVAL OF ISCHEMIC ANOXIC STRESS PATHOLOGY

B David Polis *In* AGARD Prospective Med Opportunities in Aerospace Med Sep 1978 5 p refs (For primary document see N79-11692 02-52)

Avail NTIS HC A05/MF A01

Quantitation of membrane phospholipids in mitochondria and microsomes from acceleration stressed as well as radiation stressed animals revealed significant variations in individual species of phospholipids which were reiterated in the blood plasma Application of the methodology to humans showed the feasibility of achieving a molecular index to stress via blood plasma phospholipids These results were complimented with studies for noninvasive procedures using the techniques of high pressure liquid chromatography and electron spin resonance spectroscopy to detect excited state metabolites in urine which could be correlated with stress intolerance With this procedure a significant increase in free radical forming species was found in the urine of volunteers centrifuged to grayout as well as in a civilian population of patients scheduled for heart surgery Correlation of the free radical concentrations with values for lipid peroxides and phenolic compounds have a three dimensional readout which separated stress tolerant individuals from those with debilitating intolerance to stress Author

N79-11701# School of Aerospace Medicine Brooks AFB, Tex Neuropsychiatry Branch

PSYCHOSOCIAL ASPECTS OF SYNCOPE AND VERTIGO IN AIRCREW

James A Boydstun and William H Sledge *In* AGARD Prospective Med Opportunities in Aerospace Med Sep 1978 7 p refs (For primary document see N79-11692 02-52)

Avail NTIS HC A05/MF A01

For an 8 5 month period, all cases (N 47) referred to the USAF School of Aerospace Medicine for evaluation of syncope, vertigo, or dizziness were seen for a standardized psychiatric interview, mental status examination, hyperventilation experience, and psychometrics Twenty one patients reported that their symptoms of hyperventilation were the same as or very similar to their reference symptoms The findings from the subgroup were analyzed and compared to a group of 31 control subjects The study group reported a great deal more symptoms after hyperventilating (a checklist was used) They were much more apt to report job maladjustment, parental conflict, and separation from their families Common mental status findings were low self-esteem worry, helplessness, fearfulness, suspiciousness, evasive guardedness, meticulousness, and perfectionism Their prominent mental defense mechanisms included projection, intellectualization, and repression The Cornell Index and Cattell's 16 PF showed significant group differences Author

N79-11702# Royal Air Force Hospital, Halton (England)

BETA-ADRENOCEPTOR ANTAGONISTS: CENTRAL EFFECTS

J N C Cooke and A N Nicholson (Royal Air Force Inst of Aviation Med) *In* AGARD Prospective Med Opportunities in Aerospace Med Sep 1978 3 p refs (For primary document see N79-11692 02-52)

Avail NTIS HC A05/MF A01

Beta adrenoceptor antagonists used widely in therapeutics, and intended for the treatment of angina pectoris and cardiac arrythmias were reviewed Their ability to lower blood pressure in hypertension proved to be the major clinical application These drugs aroused interest in aviation medicine because of their possible use in the management of mild hypertension, but the question arises whether their use in aircrew may be accompanied by unacceptable changes in the function of the central nervous system There is evidence that their hypotensive effect may involve cerebral mechanisms, and that their use may lead to behavioral disturbances such as dreams and visual hallucinations They may be used in the management of neurological disorders such as essential tremor thyrotoxicosis, anxiety, migraine and possibly schizophrenia, and it is these observations which suggest that a cautious approach may be appropriate when impaired central nervous activity is to be avoided B B

N79-11703# School of Aerospace Medicine Brooks AFB Tex

THE PREDICTION OF THE EXISTENCE OR NONEXISTENCE OF CORONARY ARTERY DISEASE USING ROUTINE CLINICAL LABORATORY MEASUREMENT

Raymond G Troxler, Robert J Fuchs Eugene A Sprague Martin T Bailey, John H Triebwasser, and Emmanuel L Mosser *In* AGARD Prospective Med Opportunities in Aerospace Med Sep 1978 4 p (For primary document see N79 11692 02 52)

Avail NTIS HC A05/MF A01

Multivariate analysis shows that plasma cortisol contributes significantly over the above cholesterol and age as a discriminator between those patients with positive coronary arteriograms and patients with negative studies Data from 57 patients were used to develop a multiple logistic risk function for cholesterol age and plasma cortisol The resulting predictive model demonstrated a predictive value of 86% for a positive test and predictive value of 89% for a negative test The model was then tested on 78 additional patients who had coronary angiography The predictive value of a positive test was 91% and the predictive value of a negative test was 78% on the validation group If further testing continues to validate these findings, it appears that plasma cortisol may be a risk factor for the prediction of coronary artery disease B B

N79-11704# Montefiore Hospital, New York Inst for Steroid Research

COMPARISON OF PLASMA AND URINARY STEROIDS IN MEN WITH TYPE A AND TYPE B BEHAVIOR PATTERNS

Barnett Zumoff, Robert S Rosenfeld, Meyer Friedman Sanford O Byers, Ray H Rosenman, and Leon Hellman *In* AGARD Prospective Med Opportunities in Aerospace Med Sep 1978 8 p refs Prepared in cooperation with Mount Zion Hospital and Medical Center, San Francisco, Calif (For primary document see N79-11692 02-52)

Avail NTIS HC A05/MF A01

A large number of urinary and plasma steroidal parameters were compared in men with Type A and Type B behavior patterns Two differences were found between these groups (1)Type A men showed higher daytime (0900-1800)uriary excretion of testosterone glucuronide than Type B men, (2) Type B men showed higher average plasma concentrations of dihydrotestosterone The results suggest that it may be possible to decrease the risk of coronary heart disease in Type A men by intervening to change the levels or antagonize the effects of certain steroid hormones B B

N79-11705# Advisory Group for Aerospace Research and Development, Paris (France)

SPECIFIC FINDINGS IN CARDIOLOGY AND PULMONARY FUNCTION WITH SPECIAL EMPHASIS ON ASSESSMENT CRITERIA FOR FLYING

M C Lancaster, ed (School of Aerospace Med Brooks AFB, Tex) Sep 1978 170 p refs Presented at Aerospace Med Panel's 34th Panel Meeting/Specialists Meeting, London, 24-28 Oct 1977

(AGARD-CP-232 ISBN-92 835-0221-3) Avail NTIS HC A08/MF A01

Cardiopulmonary disease among military and flight personnel is discussed in terms of premature disability Data on normal values, natural history, performance of testing methods, assessment of newer techniques for disease detection and definition as well as philosophies of determination of fitness to fly are presented For individual titles, see N79-11706 through N79-11726

N79-11706# Centre de Medecine Aeronautique, Brussels (Belgium)

FOLLOW-UP AND TRANSVERSAL STUDY OF VITAL CAPACITY AND FEV SUB VALUES AMONG PERSONNEL OF THE BELGIAN ARMY FORCES

J Bande, J Clement and K P Yandewgesti *In* AGARD Specific Findings in Cardiology and Pulmonary Function with Spec Emphasis on Assessment Criteria for Flying Sep 1978 10 p refs Prepared in cooperation with Academisch Ziekenhuis St Raphael, Leuven, Belgium (For primary document see N79-11705 02-52)

Avail NTIS HC A08/MF A01

Vital capacity (VC) and one second forced expiratory volume (FEV sub 1) measured in 7123 subjects during annual or biennial medical examinations were analyzed as a function of age (A) weight (W) and standing height (H) The subjects were grouped according to their smoking habits, nonsmokers, light and heavy smokers Two different studies were performed a transversal

(comparison between subjects) and longitudinal study (comparison within subjects at successive times). The VC and FEV sub 1 were found to increase with age up to 22 23 years, thereafter a steady decline was observed, more pronounced in smokers than in nonsmokers. The decrease with age was more marked in the longitudinal study. In both longitudinal and transversal surveys, body weight influences the values of VC and FEV sub 1 especially via the cross products HW, AW, indicating that the effect of weight on the spirometric values varies with age and height. An increase of weight tends to be accompanied with an increase of VC and FEV sub 1 in the younger, taller, and lighter subjects. This effect weakens or even reverses with increasing age and weight, decreasing height, and with heavier smoking (in the longitudinal study). The influence of height on VC and FEV sub 1 appeared to depend more on the cross product HW, than on H or a power of H, indicating that the effect of height depends markedly on the weight of the subjects, as well in the longitudinal as in the transversal study. Author

N79-11707# Centre d Essais en Vol, Bretigny-sur Orge (France)
DETECTION AND SUPERVISION OF OBSTRUCTED RESPIRATORY FLOW IN FLIERS. ADVANTAGES OF DEBIT-VOLUME GRAPHS [DETECTION ET SURVEILLANCE DES TROURCES VENTILATOIRES OBSTRUCTIFS CHEZ LE PERSONNEL NAVIGANT. INTERET DES COURBES DEBIT-VOLUME]
J. Droniou (Hop. d Instruction des Armees, Clamart, France), H. Vieillefond, and G. Leguay (Hop. d Instruction des Armees, Versailles). *In* AGARD Specific Findings in Cardiology and Pulmonary Function with Spec. Emphasis on Assessment Criteria for Flying Sep. 1978 9 p refs In FRENCH (For primary document see N79-11705 02-52)
Avail: NTIS HC A08/MF A01

Because of the multiplication of factors affecting the bronchi, the diagnosis and evaluation of obstructive respiratory flow has importance in the pneumatologic management of flying personnel. Until now, obstructive syndromes were detected by current spirographic practice according to classic parameters measured during forced expiration tests, such as the second maximum expiration volume and the volume expired between 75% and 25% of the vital capacity. The recording of debit volume curves renews interest in forced expiration tests. Maximum expiratory debits measured at low volume are, under certain conditions, independent of effort and reflect the state of the distal bronchi which are rapidly obstructed in chronic obstructive bronch-pneumapathologies. These properties, together with their reproductibility in a given subject, assure to the method an undeniable superiority over classic spirography. The recording of the debit-volume curve is a simple test, well tolerated, then repeated, which requires no complicated equipment.
Trans. by A R H

N79-11708# Naval Aerospace Medical Research Lab., Pensacola, Fla.
LONG TERM PULMONARY FUNCTION PATTERNS IN THE AVIATOR: THE THOUSAND AVIATOR STUDY
Neil R. MacIntyre, Robert E. Mitchell, Albert Oberman, and Ashton Graybiel. *In* AGARD Specific Findings in Cardiology and Pulmonary Function with Spec. Emphasis on Assessment Criteria for Flying Sep. 1978 7 p refs (For primary document see N79-11705 02-52)
Avail: NTIS HC A08/MF A01

Lung function from a 30 year longitudinal study of 622 Naval aviators, all age 52, was analyzed. Age related deterioration in volume spirometry and the prevalence of obstructive lung disease in these subjects compares favorably with other large civilian studies. Military aviation, including the first generation of tactical jet aviation, had no effect on any measured parameters. Cigarette smoking, however, had a marked effect on the prevalence of obstructive lung disease. Even in clinically healthy subjects, cigarette smoking significantly augmented age related deterioration in vital capacity. Smokers who quit early and consumed less than 9100 total packs of cigarettes seemed to be similar to nonsmokers in their risk of disease development and the aging of their lung function. Author

N79-11709# Technische Hochschule, Aachen (West Germany).
MECHANICS OF BREATHING DURING GRADED EXERCISE MEASURED WITH THE BODYPLETHYSMOGRAPH
F. Detering, J. D. Meyer-Erkelenz, H. Sieverts, and S. Effert. *In* AGARD Specific Findings in Cardiology and Pulmonary Function with Spec. Emphasis on Assessment Criteria for Flying Sep. 1978 7 p refs (For primary document see N79-11705 02-52)
Avail: NTIS HC A08/MF A01

Airway resistance, thoracic gas volume, and gas dynamics of breathing of 20 healthy subjects with an average age of 22.6 years were measured during graded exercise with a ventilation system. It was observed, that up to a load of 50 watt the breathing rest position rises in spite of an increase of 66% in the tidal volume and even at 75 watt is still above the initial value. The expiratory reserve volume is called up at a load of 100 watt through an intensified use of the expiratory muscles. The airway resistance increases nearly linear from 2.0 cm H20/1/s at rest to 6/95 cm H20/1/s at 100 watt. J.M.S.

N79-11710# Bundeswehrsanitaetszentrum, Hamburg (West Germany).
STANDARDIZED EXAMINATION METHODS IN ERGOMETRY
J. Prohl. *In* AGARD Specific Findings in Cardiology and Pulmonary Function with Spec. Emphasis on Assessment Criteria for Flying Sep. 1978 8 p (For primary document see N79-11705 02-52)
Avail: NTIS HC A08/MF A01

Standard procedures for ergometry examinations are given along with standard ranges used to compare the measured values with a normal collective. Emphasis is placed on optimum utilization of ergometer stations with an average frequency of 300 examinations per month, while meeting the criteria of (1) simplicity of performance, (2) saving of time, (3) reliability of measurement data, (4) strength of evidence, (5) reproducibility, and (6) comparability of results. J.M.S.

N79-11711# National Defence Medical Centre, Ottawa (Ontario). Cardio-Pulmonary Unit.
CORONARY ATHEROSCLEROSIS AND FITNESS FOR FLYING
Gerald M. Fitzgibbon. *In* AGARD Specific Findings in Cardiology and Pulmonary Function with Spec. Emphasis on Assessment Criteria for Flying Sep. 1978 10 p refs (For primary document see N79-11705 02-52)
Avail: NTIS HC A08/MF A01

Coronary artery disease in flying personnel is considered in terms of the policy of the Canadian Armed Forces that any degree of coronary atherosclerosis is cause for grounding a member of the aircrew. Emphasis is placed on the reliability of various physiological tests: electrocardiogram, Master's two step test, the treadmill exercise test, and selective coronary angiography in detecting coronary artery disease. J.M.S.

N79-11712# School of Aerospace Medicine, Brooks AFB, Tex.
DETECTION OF CORONARY ARTERY DISEASE IN APPARENTLY HEALTHY, ASYMPTOMATIC AIRCREW MEMBERS USING THALLIUM-201 MYOCARDIAL PERFUSION SCINTIGRAPHY
John H. Triebwasser, Thomas Kay, Thomas H. Loecker, Robert Carretta, Gary D. Harris, Roger A. Wolthuis, and Malcolm F. Lancaster. *In* AGARD Specific Findings in Cardiology and Pulmonary Function with Spec. Emphasis on Assessment Criteria for Flying Sep. 1978 6 p refs (For primary document see N79-11705 02-52)
Avail: NTIS HC A08/MF A01

Thallium-201 exercise myocardial perfusion scintigraphy was accomplished in 25 aircrewmembers prior to their undergoing coronary arteriography. Ten patients had arteriographic evidence of obstructive coronary disease. Three had abnormal myocardial scintigrams. One had a borderline abnormal scintigram. Of six patients having normal scintigrams, five had greater than 50% obstruction of one or more vessels. Three of these five had multiple vessel disease. Thirteen of the 15 patients having no arteriographic coronary disease had normal scintigrams. The remaining two had borderline abnormal scans. An abnormal myocradial scintigram was associated with significant obstructive disease. However, a normal scan did not rule out the presence of high grade obstruction. This procedure is of limited value, and cannot replace coronary arteriography as a definitive method for ruling out coronary artery disease in aircrewmembers. J.M.S.

N79-11713# Royal Air Force Central Medical Establishment, London (England).
THE SIGNIFICANCE OF T WAVE ABNORMALITIES
H. B. Kelly. *In* AGARD Specific Findings in Cardiology and Pulmonary Function with Spec. Emphasis on Assessment Criteria for Flying Sep. 1978 4 p refs (For primary document see N79-11705 02-52)
Avail: NTIS HC A08/MF A01

The commonest abnormalities of routine aircrew ECG's to cause concern are those of repolarisation. These men are

usually asymptomatic and the evaluation of the ECG abnormality is one of the major problems in the assessment of fitness to fly. Twenty such cases with radiologically normal coronary arteries, and the manner in which the repolarisation abnormalities may be affected by adrenaline beta adrenergic blockade, and other factors are considered. Author

N79-11714# Centre Principal d'Expertises Medicales du Personnel Navigant, Paris (France)

DIFFICULTIES POSED BY LEFT AXIS DEVIATION IN THE EVALUATION OF FLIERS, AND THEIR RELATIONS TO THE CONCEPT OF LEFT ANTERIOR HEMIBLOCK [LES DIFFICULTES POSEES DANS L'EXPERITSE DU PERSONNEL NAVIGANT PAR LA DEVIATION A GAUCHE DE L'AXE DE QRS ET SES RAPPORTS AVECLE CONCEPT D'HEMIBLOC]

A. Didier and R. Carre. *In* AGARD Specific Findings in Cardiology and Pulmonary Function with Spec. Emphasis on Assessment Criteria for Flying Sep. 1978 12 p refs (For primary document see N79-11705 02-52)

Avail: NTIS HC A08/MF A01

Possible and probable causes of left QRS axis deviation in 60 subjects are discussed. In 34 individuals, previous documentation affirmed the existence of this condition before the age of 25 years as well as its stability over a number of years. This aspect is found at the extreme left of the normal electrocardiogram and the activation of the entire left ventricle is able to depend exclusively on posterior fibers as in left anterior hemiblock. Thus, everything occurs as if the left anterior bundles were barely functioning or not funtioning at all. It is a matter of anonpathological variety of ventricula activation mode. Trans. by A.R.H.

N79-11715# Army Aeromedical Research Lab., Fort Rucker, Ala.

LEFT ANTERIOR HEMIBLOCK (LAH): DIAGNOSIS AND AEROMEDICAL RISK

Frank S. Pettyjohn, Heber D. Jones, Joseph C. Denniston, John C. Kelliher, Lloyd A. Akers, George P. Rice, and James M. Faber. *In* AGARD Specific Findings in Cardiology and Pulmonary Function with Spec. Emphasis on Assessment Criteria for Flying Sep. 1978 6 p refs (For primary document see N79-11705 02-52)

Avail: NTIS HC A08/MF A01

Eighteen US Army initial flight applicants and trained aircrew were evaluated for the electrocardiographic diagnosis of left anterior hemiblock (LAH). This diagnosis was sustained in 50% by the addition of vectorcardiographic criteria. With computer processing and calculation of delay of the intrinsicoid deflection (ID) of the high lateral left ventricular activation time, the diagnosis was sustained in 50% of those records available. Review of the etiology, histopathology, and prognosis indicates definitive abnormalities of the trifascicular left bundle branch conduction system. Its is essential a complete electrocardiogram (ECG) and vectorcardiogram (VCG) study of military aircrew be obtained to establish the diagnosis of true LAH. The incidence of true LAH is not available but the rarity of this finding with an unknown risk should preclude entry into military flight training. Complete cardiovascular evaluation of the trained airman with acquired LAH should include electrophysiologic studies and selective coronary arteriography and ventriculography prior to consideration for return to full flying duties. Author

N79-11716# Hopital d'Instruction des Armees, Versailles (France)

CARDIAC CONDUCTION AND APTITUDE PROBLEM OF FLIERS. THE BENEFITS OF ENDOCAVITAL RECORDING OF THE His BUNDLES [TROUBLES DE LA CONDUCTION ET APTITUDE AUPERSONNEL NAVIGANT. INNTERET DE L'ENGREGISTREMENT ENDOCAVITAIRE DU FAISCENAU DE His]

G. Leguay, J. C. Duret (Hopital d'Instruction des Armees Percy, Clamart, France), J. Droniou (Service de Cardiologie de l'Armee, France), B. Yettes (Lab. de Med. Aerospatiale), and J. Pernod (Service de Cardiologie de l'Armee, France). *In* AGARD Specific Findings in Cardiology and Pulmonary Function with Spec. Emphasis on Assessment Criteria for Flying Sep. 1978 9 p refs In FRENCH (For primary document see N79-11705 02-52)

Avail: NTIS HC A08/MF A01

Problems of cardiac conduction can be observed in young subjects with otherwise healthy hearts. The suprahistine localization of the trouble, its vague nature and its functional and reversible character are shown in the endocavital recording of the bundles of His as well as in the oculo-cardiac reflex in both stimulation and pharmaco-dynamic tests. Some of these subjects can recover their physical fitness. However, in addition to data from endocavital recording of the activity of the bundles of His, clinical data and good tolerance in constraint tests must be considered. Trans. by A.R.H.

N79-11717# Centre Principal d'Expertises Medicales du Personnel Navigant, Paris (France)

MEASURING SYSTOLIC TIME INTERVALS AT REST AND UNDER STRESS BY EXTERNAL METHODS. ADVANTAGES IN THE EVALUATION OF FLIERS [MESURES DES INTERVALLES DE TEMPS SYSTOLIQUES PAR METHODES EXTERNES AU REPOS ET A L'EFFORT. INTERET DANS L'EXPERTISE DU PERSONNEL NAVIGANT]

M. Pijoun, F. Plas, and R. Carre. *In* AGARD Specific Findings in Cardiology and Pulmonary Function with Spec. Emphasis on Assessment Criteria for Flying Sep. 1978 13 p refs In FRENCH (For primary document see N79-11705 02-52)

Avail: NTIS HC A08/MF A01

The electromechanical interval and preisometric contraction, the projection interval, the isovolumetric contraction, and the ejection time were measured in 46 subjects at rest and while pedalling a bicycle against a constant force for five minutes. The systolic time at the end of the exercise and during recouperation was measured for 10 minutes. A sensible decrease in the time of isolvumetric contraction and a significant decrease in the ratio of isovolumetric contraction time over ejection time were observed. The value of this ratio as an index of myocardial contraction is discussed as well as the advantages of mechanographic methods in the examination of flying personnel. The replacement of a carotidogram by a rheographic tracing for a space experiment is described. Trans. by A.R.H.

N79-11718# Hopital d'Instruction des Armees, Versailles (France)

THE ADVANTAGES OF ULTRASONIC ECHOCARDIOGRAPHY IN THE CARDIOLOGICAL EVALUATION OF FLIERS [INTERET DE L'ECHOCARDIOGRAPHIE PAR ULTRASONS DANS L'EXPERTISE CARDIOLOGIQUE DU PERSONNEL NAVIGANT]

J. Droniou (Hopital d'Instruction des Armes Percy, Clamart, France), G. Leguay, J. C. Duret (Service de Cardiologie de l'Armee, France), and J. Pernod (Service de Cardiologie de l'Armee, France). *In* AGARD Specific Findings in Cardiology and Pulmonary Function with Spec. Emphasis on Assessment Criteria for Flying Sep. 1978 8 p refs In FRENCH (For primary document see N79-11705 02-52)

Avail: NTIS HC A08/MF A01

The principles and techniques of echocardiography are review and the value of this technique in diagnosing obstructive cardiomyopathy, in affirming mitral valve prolapsus in the case of mesosystolic click, and in evaluating myocardial function is assessed. Because of its nontraumatic nature, it is recommended for the cardiological evaluation of flying personnel.

Trans. by A.R.H.

N79-11719# School of Aerospace Medicine, Brooks AFB, Tex. Internal Medicine Branch

EFFECT OF AGE ON RELAXED -G SUB z TOLERANCE OF AIRCREWMEN

David H. Hull, Roger A. Wolthuis, Kent K. Gillingham, John W. McCracken, and John H. Triebwasser. *In* AGARD Specific Findings in Cardiology and Pulmonary Function with Spec. Emphasis on Assessment Criteria for Flying Sep. 1978 4 p refs (For primary document see N79-11705 02-52)

Avail: NTIS HC A08/MF A01

Healthly aircrewmen from 30 to 55 years old volunteered for a centrifuge study to determine the effect of age on acceleration responses. A visual end point was used to measure their relaxed tolerance to -Gz forces applied gradually (GORs) and rapidly (RORs). Variability between individual subjects was much more marked with GORs than RORs. Tolerance was higher to the initial GOR than to the second GOR in most subjects. There was a tendency for relaxed G-tolerance to increase with age, but this was statistically significant ($p < .05$) only for initial GORs. These results suggest that healthy middle aged aircrewmen suffer no age related impairment of G-tolerance which would prejudice their fitness to pilot high-performance military aircraft. These results also provide a standard against which to measure the relaxed -Gz tolerance of aircrew with medical disorders, treated and untreated. J.M.S.

N79-11720# School of Aerospace Medicine, Brooks AFB, Tex. Internal Medicine Branch

REPRODUCIBILITY OF HUMAN CARDIOVASCULAR RESPONSES TO ORTHOSTATIC STRESS

Roger A Wolthius, David H Hull, Joseph R Fisher, and John H Triebwasser *In* AGARD Specific Findings in Cardiology and Pulmonary Function with Spec Emphasis on Assessment Criteria for Flying Sep 1978 5 p refs (For primary document see N79-11705 02-52)

Avail NTIS HC A08/MF A01

Orthostatic stress testing was accomplished biweekly on 19 healthy men, each man completed at least eight tests over a period of 16-21 weeks The test involved 10 minutes of supine rest, followed by 5 minutes of quiet standing against a wall heart rates and auscultatory blood pressures were recorded on *alternate minutes Variability between tests was similar for all* meaurement/protocol condition combinations indicating that the individual's response to quiet stand and orthostatic change is as variable as his response to supine rest Further the range (i e 1 SD 1-9 mmHg or bpm) and magnitude (i e 1 SD approximately 5 mmHg or bpm) of this variability *illustrates the* need for repeated orthostatic testing when attempting to characterize the typical orthostatic response of a given individual J M S

N79-11721# Freiburg Univ (West Germany) Cardiological Centre

CARDIOLOGICAL FINDINGS IN 115 PILOTS: DIAGNOSES AND ASSESSMENT OF THEIR FLYING FITNESS

Horst H Renemann, Sabine Koehler, and Herbert Reindell *In* AGARD Specific Findings in Cardiology and Pulmonary Function with Spec Emphasis on Assessment Criteria for Flying Sep 1978 3 p refs (For primary document see N79-11705 02-52)

Avail NTIS HC A08/MF A01

Results of cardiological examinations of 115 out of 1438 professional and nonprofessional airmen with abnormal or marginal findings in preliminary cardiological examinations are presented Diagnoses include (1)24 out of the 115 airmen were found to have isolated ECG alterations without any evidence of organic disease 22 were relicensed (2)21 airmen were found to have coronary heart disease 19 were declared permanently *unfit for flight duty and 2 were given a waiver and were required* to be re examined (3)17 airmen were found to have myocarditis 2 were declared permanently unfit for flight duty and 15 were relicensed after successful treatment (4)15 were shown to have pseudoangina pectoris 1 was declared permanently unfit for flight duty due to chronic psychic liability, and (5) 11 were shown to have hypotensive disturbances of blood pressure and *were advised to undergo intensive sports therapy. 1 was declared* permanently unfit for flight duty J M S

N79-11722# Centro di Studi e Ricerche di Medicina Aeronautica e Spaziale Rome (Italy)

NORMAL AND PATHOLOGICAL CARDIOVASCULAR FINDINGS IN APPLICANTS TO THE AIR FORCE SERVICE

C A Ramacci and P Rota *In* AGARD Specific Findings in Cardiology and Pulmonary Function with Spec Emphasis on Assessment Criteria for Flying Sep 1978 6 p refs (For primary document see N79-11705 02-52)

Avail NTIS HC A08/MF A01

Data resulting from the medical and instrumental examinations *of 1000 subjects are considered Tests conducted include humeral* arterial blood pressure control, electrocardiographic registration, and X-ray screening of the thorax *Data are discussed in terms* of risk indicators J M S

N79-11723# Aerospace Medical Div Aerospace Medical *Research Labs (6570th), Wright-Patterson AFB, Ohio*

EVALUATION OF CARDIAC RISK AND SUBJECT RESPONSE TO AMELIORATIVE EFFORTS

Roy L DeHart *In* AGARD Specific Findings in Cardiology and Pulmonary Function with Spec Emphasis on Assessment Criteria for Flying Sep 1978 8 p refs (For primary document see N79-11705 02-52)

Avail NTIS HC A08/MF A01

A group of mid-level military and civilian personnel attending a senior service school was provided the opportunity to participate in a cardiac risk evaluation program Following the evaluation, each participant was provided an individual prescription for health sugggesting methods for reducing factors with excesssive risk *through life style alterations The risk factors assessed included* family cardiac history, obesity, smoking, pulmonary function, blood pressure, blood lipids, and physical fitness The assessment was conducted in three stages historical review of medical records and by questionnaire, blood chemistry and enzyme screen physical *examination and indirect determination of aerobic power* A follow-on survey was distributed to the student body and faculty three years following the initial cardiac risk assessment Both program participants and nonparticipants were requested to complete and return the survey form The survey evaluated the individual's perception of his current health, life style changes which may alter cardiac risk and factors influencing the individual's decision to reduce or ignore risk The results of this survey are presented and their implications for military prospective medicine programs discussed J M S

N79-11724# Civil Aviation Authority London (England)

THE IMPACT OF CORONARY VASCULAR RISK FACTORS ON PROFESSIONAL AIRCREW LICENSE LOSS IN THE UNITED KINGDOM

Michael Joy *In* AGARD Specific Findings in Cardiology and Pulmonary Function with Spec Emphasis on Assessment Criteria for Flying Sep 1978 6 p refs (For primary document see N79-11705 02-52)

Avail NTIS HC A08/MF A01

The causes of license loss in UK professional aircrew were studied Results indicate that nearly 60% are lost due to cardiovascular causes It is suggested that preventative medicine and not more rigorous screening is the sensible approach to a reduction of flight deck incapacitation from cardiovascular causes J M S

N79-11725# Italian Air Force Medical Service H Q Rome

CARDIOVASCULAR DISEASES AS A CAUSE OF UNFITNESS FOR FLYING SERVICE IN AIRCREWS OF ITALIAN AIR FORCE: ETIOPATHOGENESIS, INFLUENCE OF PERFORMANCE IN FLIGHT, AND PREVENTION

Gaetano Rotondo *In* AGARD Specific Findings in Cardiology and Pulmonary Function with Spec Emphasis on Assessment Criteria for Flying Sep 1978 7 p refs (For primary document see N79-11705 02-52)

Avail NTIS HC A08/MF A01

Cardiac arteriosclerotic and degenerative diseases arterial hypertension the diseases including functional cardiac disorders, acute and chronic rheumatic *cardiopathies are cited as causes* of unfitness for flight duty An evaluation and interpretation is made of possible causes of the high inhabilitating incidence of cardiovascular diseases, and in particular of arteriosclerosis, in provoking unfitness to flying duty among aircrews, and in influencing the military performance in flight Preventive and predictive measures are also taken into consideration Conclusive deductions emphasize the advisability of attempting to improve and refine methods adoped in diagnosing early signs of atherosclerotic disease in flying personnel, particularly after the age of 40 as well as the opportunity of researching major risk factors This task could be achieved mainly by means of a periodical executiona nd correct evaluation of the tests which are recognized *as useful for the early diagnosis of atherosclerosis and of the* most important cardiovascular diseases J M S

N79-11726# Civil Aviation Authority, London (England) Medical Dept

CARDIOVASCULAR FITNESS OF PILOTS OF TRANSPORT AIRCRAFT

G. Bennett *In* AGARD Specific Findings in Cardiology and Pulmonary Function with Spec Emphasis on Assessment Criteria for Flying Sept. 1978 4 p (For primary doucment see N79-11705 02-52)

Avail NTIS HC A08/MF A01

Cardiovascular disease is discussed in terms of threatening *safety in civil two-pilot transport operations* Improvements in medical screening to reduce the already low risk of in-flight incidents and better operational training and control measures to prevent the cardiovascular incidents from becoming accidents are among the topics covered J M S

N79-20729# Advisory Group for Aerospace Research and Development, Paris (France).

TECHNICAL EVALUATION REPORT ON THE AEROSPACE MEDICAL PANEL LONDON SPECIALISTS' MEETING, FALL 1977

Jan. 1979 12 p ref Meeting held at London, 24-28 Oct. 1977

(AGARD-AR-131; ISBN-92-835-1307-X) Avail: NTIS HC A02/MF A01

Methods for early disease detection are required to assure optimum air crew selection criteria and to maintain air crew

effectiveness in an increasingly stressful environment. A universal approach to a basic framework for developing prospective medicine programs is far from being defined. Yet, prospective medicine proves of value in risk identification and intervention. Examination techniques for the assessment of cardiopulmonary diseases of flying personnel still shows deficiencies, problems, and the need for further research and development to help solve this important health problem. For individual titles, see N79-20730 through N79-20731.

N79-20730# Air Force Medical Center, Wright-Patterson AFB, Ohio

PROSPECTIVE MEDICINE OPPORTUNITIES IN AEROSPACE MEDICINE

J. Triebwasser, ed. *In* AGARD Tech. Evaluation Rept. on the Aerospace Med. Panel London Specialists' Meeting Jan. 1979 p 1-3 (For primary document see N79-20729 11-52)
Avail: NTIS HC A02/MF A01

Various applications of prospective medicine techniques to the practice of aerospace medicine are discussed. Studies were conducted in the special population of military aircrew on the prevalence/incidence of findings, including multiple risk assessments, correlation of these with disease risks, and the results of efforts to modify the risk for disease and its clinical manifestations. Major problem areas addressed include: (1) the design and potential value of screening physical examinations and other health appraisal methods for the identification of aircrew members at risk for manifestations of disease having aeromedical significance; (2) methods for modifying risk with emphasis on disease prevention; and (3) definition of the significance of abnormal findings resulting from health appraisals conducted within an apparently healthy aircrew population. A.R.H.

N79-20731# School of Aerospace Medicine, Brooks AFB, Tex. Clinical Sciences Div.

SPECIFIC FINDINGS IN CARDIOLOGY AND PULMONARY FUNCTION WITH SPECIAL EMPHASIS ON ASSESSMENT CRITERIA FOR FLYING

M. C. Lancaster, ed. *In* AGARD Tech. Evaluation Rept. on the Aerospace Med. Panel London Specialists' Meeting Jan. 1979 p 5-7 (For primary document see N79-20729 11-52)
Avail: NTIS HC A02/MF A01

Normal values, natural history, performance of testing methods, assessments of newer techniques for disease detection and definition and, philosophies of determination of flight fitness are discussed in relation to cardiopulmonary problems in flying personnel. Research and development needs within the NATO countries are identified. A.R.H.

N79-23661# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France)

SURVIVAL AND PROTECTION OF AIRCREW IN THE EVENT OF ACCIDENTAL IMMERSION IN COLD WATER

C. Boutelier (Aerospace Med. Lab., Bretigny-sur-Orge, France) Feb. 1979 125 p refs
(AGARD-AG-211(Eng); ISBN-92-835-1301-0) Avail: NTIS HC A06/MF A01

The survival of aircrews in the case of accidental cold water immersion is limited by the extent of thermal losses. In this AGARDograph, the physical laws governing thermal exchanges in both air and water are described. The state-of-the-art in the fields of physiological reactions, tolerance, acclimatization, cold induced accidents and their treatment is reviewed. Finally, the major items of protective equipment used in aeronautics and the methods applied to test their effectiveness are described. L.S.

N79-31901# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France)

MODELS AND ANALOGUES FOR THE EVALUATION OF HUMAN BIODYNAMIC RESPONSE, PERFORMANCE AND PROTECTION

H. E. Vongierke, ed. (AMRL) Jun. 1979 404 p refs In ENGLISH, partly in FRENCH Presented at the Aerospace Med. Panel's Specialists' Meeting, Paris, 6-10 Nov. 1978
(AGARD-CP-253; ISBN-92-835-0240-X) Avail: NTIS HC A18/MF A01

Whole body kinematic models for the prediction of body motion are considered as well as spinal models, head-neck models, and heat injury models for the prediction of internal stress and strain and injury probability under escape, crash, and windblast conditions. Cardiovascular models are included to describe and explain human response to sustained acceleration and air combat maneuvers. Biodynamic models interpreting physiological and performance response as well as human operator control capability in vibration and roll motion environments are also presented. Operational injury analyses as well as laboratory human and animal data are discussed as a basis for further model development and validation. Applications of the models include the prediction of body motions, physiological response and injury probability under biodynamic stress and the assistance in protective system crashworthiness, and cockpit design. For individual titles, see N79-31902 through N79-31931.

N79-31902# Aerospace Medical Research Labs., Wright Patterson AFB, Ohio

PREDICTION OF WHOLE-BODY RESPONSE TO IMPACT FORCES IN FLIGHT ENVIRONMENTS

Ints Kaleps *In* AGARD Models and Analogues for the Evaluation of Human Biodyn. Response, Performance and Protect. Jun. 1979 14 p refs (For primary document see N79-31901 22-52)
Avail: NTIS HC A18/MF A01

The general predictive and structural properties of human body gross motion simulation models and their applicability to flight associated problems are discussed. A specific application of such a model is demonstrated by the simulation of human response to whole body -G sub x impact and the comparison of the results with experimentally observed human responses to the same dynamic exposures. The simulations were performed using the articulated total body (atb) computer model based on rigid body mechanics and possessing a number of internal and external force and constraint options to reflect resistive forces within human joints and to allow the interaction of external configurational elements. The predicted data of limb motions, their accelerations and forces generated in the harness restraint system are compared with those obtained experimentally from acceleration transducers on the head and chest of human test subjects. The model structure and its dynamic modeling capability, the general data input requirements, the specific set of data used for the -G sub x impact simulations, and some of the shortcomings and required improvements indicated by the simulation are discussed. J.M.S.

N79-31903# Dayton Univ. Research Inst., Ohio

PROCEDURES USED TO GENERATE INPUT DATA SETS FOR THE ARTICULATED TOTAL BODY MODEL FROM ANTHROPOMETRIC DATA

Duane G. Leet *In* AGARD Models and Analogues for the Evaluation of Human Biodyn. Response, Performance and Protect. Jun. 1979 15 p refs (For primary document see N79-31901 22-52)
Avail: NTIS HC A18/MF A01

Computer software simulation techniques used to evaluate safety aspects of aircraft ejection are discussed with emphasis on generation of input data sets from anthropometric data to define body segments and motion. Body segment inertial data, joint locations, segment contact ellipsoids, and body and joint axes orientation are among the input data required on each segment. The techniques developed to generate these data sets are described. J.M.S.

N79-31904# Aerospace Medical Research Labs., Wright-Patterson AFB, Ohio

CORRELATION OF MECHANISM OF EXTREMITY INJURY AND AERODYNAMIC FACTORS IN EJECTIONS FROM F-4 AIRCRAFT

Steven P. Combs *In* AGARD Models and Analogues for the Evaluation of Human Biodyn. Response, Performance and Protect. Jun. 1979 4 p refs (For primary document see N79-31901 22-52)
Avail: NTIS HC A18/MF A01

Extremity injuries incurred during the ejection sequence in 43 of 399 F-4 ejections were analyzed. Of the 43 ejections there were 95 extremity injuries. The injuries were divided into two groups: severe and minimal. Severe injuries consisted of fractures, dislocations, ligamentous tears and nerve palseys. There were 61 severe injuries. Minimal injuries consisted of contusions, lacerations, minor sprains. There were 34 minimal injuries. The 61 severe injuries were divided into 39 upper extremity injuries and 22 lower extremity injuries. The majority of the severe upper extremity injuries involved the proximal joints and the majority of the severe lower extremity injuries involved the distal joints. When the windblast/windflail injuries were compared to the various variables correlation was seen with the knots indicated airspeed, aircraft attitude, and aircraft type. The incident of extremity injury increases with increased airspeed, a nose down attitude, and decreases in the RF-4C aircraft configuration. J.M.S.

N79-31905# Technische Hochschule Darmstadt (West Germany) Inst fuer Mechanik

REFERENCE PARAMETERS FOR SHOCK INPUTS AND SHOCK TOLERANCE LIMITS

K E Meier-Doernberg *In* AGARD Models and Analogues for the Evaluation of Human Biodyn Response, Performance and Protect Jun 1979 18 p refs (For primary document see N79-31901 22-52)

Avail NTIS HC A18/MF A01

A data reduction technique based on control techniques and system analysis but adapted and extended for the purpose of single shock events in nonlinear systems is described The major features of the method include evaluation and definition of system relevant input quantities and of input relevant system properties as reference parameters and uniform plotting of the various deduced shock data input values, exposure limits, safety requirements, test and design parameters, standard Fourier and response spectra in terms of the defined reference parameters As examples, severity criteria, models, and methods which are used to describe head or whole body tolerance are compared with data by means of the established reference parameters in order to discuss their mechanical meaning and suitable range of application J M S

N79-31906# Naval Aerospace Medical Research Lab., New Orleans, La.

MULTIAXIS DYNAMIC RESPONSE OF THE HUMAN HEAD AND NECK TO IMPACT ACCELERATION

C L Ewing, D J Thomas, and L Lustick *In* AGARD Models and Analogues for the Evaluation of Human Biodyn Response, Performance and Protect Jun 1979 27 p refs (For primary document see N79-31901 22-52)

Avail NTIS HC A18/MF A01

The complete kinematic response of the head and the first thoracic vertebral body was measured over the range of variables required for human analog development during impact acceleration experiments The relationships of the kinematic variables are graphically presented and statistically analyzed A head and neck model for two dimensional response is evaluated The approaches and constraints for a three dimensional model are evaluated Anthropometric effects on the dynamic response are presented The data base serves as a basis for the validation of human surrogate head and neck response to -X and +Y acceleration. J M S

N79-31907# Naval Aerospace Medical Research Lab., New Orleans, La

TRANSIENT INTRAVENTRICULAR CONDUCTION DEFECTS OBSERVED DURING EXPERIMENTAL IMPACT IN HUMAN SUBJECTS

P L Majewski, T J Borgman, Jr., D J Thomas, and C L Ewing *In* AGARD Models and Analogues for the Evaluation of Human Biodyn Response, Performance and Protect Jun 1979 11 p refs (For primary document see N79-31901 22-52)

Avail NTIS HC A18/MF A01

Impact acceleration research utilizing normal human volunteer subjects and electrocardiographic monitoring is discussed Four episodes of transient intraventricular conduction disturbances are presented and discussed relative to previous clinical and experimental investigations. J M S

N79-31908# Wayne State Univ., Detroit, Mich Bioengineering Center

SIMULATION OF HEAD AND NECK RESPONSE TO -G SUB x AND +G SUB z IMPACTS

A I King, S S Nakhla, and N K Mital *In* AGARD Models and Analogues for the Evaluation of Human Biodyn Response, Performance and Protect Jun 1979 13 p refs (For primary document see N79-31901 22-52)

(Contract N00014-75-C-1015)

Avail NTIS HC A18/MF A01

A two dimensional mathematical model of the spine was exercised to identify mechanisms of neck injury due to hyperflexion. Loss of pilots due to ditching at sea was one of the motivations for this study It was found that helmets have the potential of increasing injury severity particularly during a combined +G sub z and -G sub x impact, with the pulses coincident in time. The four parameters that are potentially injurious are neck shear, chin-chest contact force, odontoid process excursion into the spinal canal and spinal cord stretch. R E S

N79-31909# Yale Univ., New Haven, Conn Engineering Lab. for Musculoskeletal Diseases

A THREE-DIMENSIONAL MATHEMATICAL ANALOGUE OF THE SPINE STRUCTURE: A COMPREHENSIVE APPROACH

Manohar M Panjabi *In* AGARD Models and Analogues for the Evaluation of Human Biodyn Response, Performance and Protect Jun 1979 10 p refs Sponsored in part by NIH (For primary document see N79-31901 22-52)

Avail NTIS HC A18/MF A01

The human spine was viewed as a collection of functional spinal units, each unit consisting of two adjacent vertebrae and the interconnecting soft tissue Mathematically this unit of the spine was modelled as two rigid bodies connected by a single deformable link The latter was a three dimensional three element viscoelastic solid Experimental techniques were developed which provide the physical properties of the human functional spinal units in three dimensional space These properties incorporated into a three dimensional mathematical model provided, for the first time, a mathematical analog of the spine which was entirely based upon experimentally derived spine data R E S

N79-31910# Northwestern Univ., Evanston, Ill Dept of Civil Engineering

A THREE DIMENSIONAL DISCRETE ELEMENT DYNAMIC MODEL OF THE SPINE, HEAD AND TORSO

Ted Belytschko and Eberhart Privitzer *In* AGARD Models and Analogues for the Evaluation of Human Biodyn Response, Performance and Protect Jun 1979 15 p refs Prepared in cooperation with Stanford Res Inst., Menlo Park, Calif (For primary document see N79-31901 22-52)

(Contracts F33615-76-C-0506, F33615-78-C-0523)

Avail NTIS HC A18/MF A01

A three dimensional, discrete model of the human spine, head and torso is described This model is an evolution of earlier discrete models which are reviewed and discussed The anatomy was modeled by a collection of rigid bodies, which represent skeletal segments such as the vertebrae, pelvis, and ribs, interconnected by deformable elements, which represent ligaments, cartilagenous joints, viscera and connective tissues The model was validated by comparing its impedance to measurements on human volunteers The principal feature of this model is the generality of its formulation which enables it to be applied to a wide variety of impact situations. Simulations are reported for a vertical ejection, a pre-ejection alignment and bird impact on a canopy A postprocessor was developed which interprets the complex time history output in terms of injury potential R E S

N79-31911# Aerospace Medical Research Labs., Wright-Patterson AFB, Ohio.

APPLICATION OF BIODYNAMIC MODELS TO THE ANALYSIS OF F-16 CANOPY BIRDSTRIKE

Lawrence J Specker, Norman S Phillips (Dayton Univ. Res. Inst.), and James W Brinkley *In* AGARD Models and Analogues for the Evaluation of Human Biodyn Response, Performance and Protect Jun 1979 12 p refs (For primary document see N79-31901 22-52)

Avail NTIS HC A18/MF A01

High speed film data were analyzed from F-16 birdstrike tests to quantitatively define the deflection motion as a function of the initial test conditions Crewmember position studies indicated probable head contact with the canopy surface during birdstrike at comfortable seating positions Helmet size and crewmember size were shown to have a negligible effect on increasing clearance between helmet and canopy A specially instrumented head-neck apparatus was designed and used in the tests to measure the accelerations of the head and the impact forces and moments at the head and neck The acceleration data from the head-neck test apparatus were used as input to a head injury severity prediction model to determine the level of injury sustained by the pilot. The force data were compared to known injury force levels. A second approach involved the use of the photometric data to describe the response shape and velocity of the canopy and inertial properties associated with the impact as a driving input to a computer model of the helmeted crewman to further evaluate the crewman response to birdstrike Author

N79-31912# Strathclyde Univ., Glasgow (Scotland) Bioengineering Unit

A FAILURE CRITERION FOR HUMAN, VERTEBRAL CANCELLOUS BONE

M J Pearcy and J H Evans *In* AGARD Models and Analogues for the Evaluation of Human Biodyn Response. Performance and Protect Jun 1979 7 p refs (For primary document see N79-31901 22-52)
Avail NTIS HC A18/MF A01

In order to define a realistic criterion of failure, the compression and shear characteristics of human, vertebral, cancellous bone were investigated To produce shear, torsion tests were used and the atmospheric environment during the tests was controlled to simulate physiological conditions A rational mathematical characterization of the bone was developed to enable a realistic failure criterion to be established, encompassing the large biological variation of the results The mechanical characteristics of the bone are complex but an elementary consideration of anisotropy led to a characterization that would appear to be sufficient R E S

N79-31913# Royal Air Force, Halton (England) Inst of Pathology and Tropical Medicine.
INJURY MECHANISMS ANALYSIS IN AIRCRAFT ACCIDENTS
I R Hill *In* AGARD Models and Analogues for the Evaluation of Human Biodyn Response. Performance and Protect Jun 1979 10 p refs (For primary document see N79-31901 22-52)
Avail NTIS HC A18/MF A01

An analysis of 30 fatal aircraft accidents, some of which were survivable shows that the basic mechanisms of injury are common to many different accidents From the investigation the following conclusions can be made (1) serious or fatal head injury is the single most serious problem in aircraft accidents, particularly in light aircraft, (2) there is a wide margin in injury severity between survivors and fatalities, (3) restraint systems are still inadequate, especially for passengers, (4) the severity of injury is increased by (a) 'ejection' from the aircraft, (b) severe damage to the airframe, (c) poor design features such as badly sited fuel tanks, (5) the principle method of serious injury is forward flexion over a lap belt, and (6) mathematical scoring of injuries makes more accurate analysis of accidents a feasible proposition R E S

N79-31914# *Aerospace Medical* Research Labs., Wright-Patterson AFB, Ohio Biodynamics and Bioengineering Div
THE VALIDATION OF BIODYNAMIC MODELS
Leon E Kazarian and Henning E vonGierke *In* AGARD Models and Analogues for the Evaluation of Human Biodyn Response. Performance and Protect Jun 1979 14 p refs (For primary document see N79-31901 22-52)
Avail NTIS HC A18/MF A01

The biological data required for developing and validating an axial musculoskeletal computer model of subhuman primates that in turn can be used to support the validation of a human response model and assist in predicting human tolerance is presented Comparisons are made between the various validation approaches The shortcomings and advantages of the various types of biodynamic data presently collected and available are delineated Comparative whole body primate spinal impact tolerance curves are presented Some physical constants for subhuman primate tissue are given, and areas where additional data are required to validate a subhuman primate model are identified M M M

N79-31915# Kentucky Univ., Lexington
FREQUENCY RESPONSE OF CARDIOVASCULAR REGULATION IN CANINES TO SINUSOIDAL ACCELERATION AT FREQUENCIES BELOW 1 Hz (BASIS FOR BIODYNAMIC MODELING)
C F Knapp, J A Marquis, J M Evans, and D R Randall *In* AGARD Models and Analogues for the Evaluation of Human Biodyn Response. Performance and Protect. Jun 1979 17 p refs (For primary document see N79-31901 22-52)
(Contract F44620-74-C-0012)
Avail NTIS HC A18/MF A01

Sinusiodal, whole body acceleration was used as a noninvasive forcing function to the cardiovascular system of unanesthetized, chronically instrumented canines to determine the low frequency (less than 1 Hz) dynamics of integrated barostatic cardiovascular regulation Aortic pressure and flow, right and left ventricular pressure, heart rate and spinal axis acceleration were digitally sampled and filtered The filtered data were then Fourier analyzed The participation of neurally mediated cardiac and vascular baroreflex mechanisms in the overall response was evaluated by comparing the subjects' response in a reflexive and nonreflexive condition Transfer functions were then derived to describe the passive acceleration-induced intravascular pressure distrubances and the control action of the major baroreflex mechanisms The dynamic (oscillatory) frequency response of the major cardiac and vascular baroreflex mechanisms was found to be limited primarily to the frequency range below 0 10 Hz A comparison of the participation of cardiac and vascular mechanisms in the overall responses indicated that barostatic control is achieved principally via the systemic vascular mechanisms below 0 02 Hz, via the cardiac mechanisms from 0 04 to 0 10 Hz, and by the combined action of the two between 0 02 and 0 04 Hz M M M

N79-31916# School of Aerospace Medicine, Brooks AFB, Tex Biodynamics Branch
MATHEMATICAL MODELING OF ARTERIAL OXYGEN SATURATION AND EYE-LEVEL BLOOD PRESSURE DURING -G SUB Z STRESS
Kent K Gillingham and Richard C McNee *In* AGARD Models and Analogues for the Evaluation of Human Biodyn Response. Performance and Protect Jun 1979 7 p refs (For primary document see N79-31901 22-52)
Avail NTIS HC A18/MF A01

Mathematical descriptions of the dynamics of human arterial oxygen saturation (SaO2) and eye-level arterial blood pressure (ELBP) under conditions of varying -G sub Z stress were obtained by Fourier analysis Simulated aerial combat maneuvering (SACM) G-stress profiles and the resulting physiologic responses to the G stress provided input-output data from which transfer functions were derived Ensemble averaging of single-run transfer functions generated enhanced empirical G-to-SaO2 and G-to-ELBP transfer functions, which were approximated by various synthetic functions Examination of predictive abilities of the empirical and synthetic transfer functions was accomplished by comparison of predicted and mean actual responses to SACM and nonSACM G-stress profiles Author

N79-31917# Missouri Univ.-Rolla
UNSTEADY-STATE RESPONSE OF THE VASCULAR SYSTEM TO TRANSIENT AND SUSTAINED AEROSPACE ACCELERATION PROFILES
Xavier J R Avula and Hans L Oestreicher *In* AGARD Models and Analogues for the Evaluation of Human Biodyn Response. Performance and Protect Jun 1979 9 p refs Prepared in cooperation with AMRL (For primary document see N79-31901 22-52)
Avail NTIS HC A18/MF A01

A mathematical method to determine the response of the blood vessels to transient and sustained acceleration forces is presented The method is based on coupling of the Navier-Stokes equations for blood flow and the large elastic deformation theory for the deformation of the blood vessels, and solving them numerically under the appropriate initial and boundary conditions A mathematical reasoning to neglect the effect of acceleration on microcirculation per se is given However microcirculation is indirectly affected by acceleration forces which tend to pool blood and bring about pressure changes in large vessels. Aortic pressures are calculated for examples of monotonically increasing and transient -G sub Z acceleration profiles, and one of the solutions is compared with an available, experimentally measured pressure from an animal experiment In the absence of proper physiological scaling laws, the qualitative agreement between the theory and experiment is satisfactory M M M

N79-31918# *Naval Civil Engineering Lab.*, Port Hueneme, Calif
A HEAD INJURY MODEL
Carley Ward *In* AGARD Models and Analogues for the Evaluation of Human Biodyn Response. Performance and Protect Jun 1979 12 p refs (For primary document see N79-31901 22-52)
(Contract DOT-HS-5-01132)
Avail NTIS HC A18/MF A01

The history of analytical head injury modeling is briefly reviewed, and the design restrictions that limit their usefulness are discussed One of the most recent models, a linear finite element idealization of the human brain, is presented Intracranial pressures computed by this model are compared to pressures measured in human cadaver head impact tests The computed pressures and observed injuries are correlated for a series of ten tests Injury prediction based on maximum intracranial pressure is compared to prediction based on the Gadd Severity Index and the Head Injury Criterion Index It was concluded that adequate padding of possible head impact surfaces and helmets could be very effective in preventing the type of injury observed in these tests Such padding would eliminate the high-magnitude, impulsive-type head accelerations that produce high-magnitude pressure pulses in the brain M M M

N79-31919# Rehabilitationsklinik Loipl, Bischofswiesen Berchtesgaden (West Germany)

POTENTIAL RELATIONSHIP BETWEEN HUMAN CENTRAL NERVOUS SYSTEM INJURY AND IMPACT FORCES BASED ON PRIMATE STUDIES

F Unterharnscheidt and C L Ewing *In* AGARD Models and Analogues for the Evaluation of Human Biodyn Response Performance and Protect Jun 1979 8 p refs Prepared in cooperation with Naval Aerospace Med Res Lab New Orleans (For primary document see N79-31901 22-52)
Avail NTIS HC A18/MF A01

Different species of monkeys underwent impact acceleration forces delivered to the head and neck by three different mechanisms The first applied linear impact forces directly to the calvarium of the animal approximately through the center of gravity of the head resulting primarily in translational motion and deformation of the calvarium The second mechanism applied angular impact forces directly to the calvarium by a device molded to the calvarium which forces the head through 45 degrees of forward flexion The third mechanism applied impact forces indirectly to the head and neck by acceleration of the entire animal using a pelvic-torso restraint in which the head and neck were unrestrained Low level, no injury experiments to high level, fatal injury experiments were accomplished by each mechanism G Y

N79-31920# Army Aeromedical Research Lab, Fort Rucker, Ala Bioengineering and Life Support Equipment Div

CORRELATION OF HEAD INJURY WITH MECHANICAL FORCES BASED ON HELMET DAMAGE DUPLICATION

Bruce Slobodnik *In* AGARD Models and Analogues for the Evaluation of Human Biodyn Response, Performance and Protect Jun 1979 12 p refs (For primary document see N79-31901 22-52)
Avail NTIS HC A18/MF A01

Human tolerance to head impact was assessed by correlating the force levels required to duplicate damage seen in 14 SPH-4 aviator helmets retrieved from US Army helicopter crashes with resulting head injury The data obtained were used to validate the following (1) the Wayne State University Concussive Tolerance Curve (2) the Severity Index value of 1500 currently used in the US by the National Operating Committee on Standards for Athletic Equipment as the concussive threshold for helmeted head impacts (3) the Head Injury Criterion value of 1000 currently used in the US by the Department of Transportation in occupant crash protection tests as the concussive threshold for impacts to the unprotected head, (4) the peak acceleration value of 400 G currently used by the US Army in evaluating aircrew protective headgear as the survivable limit, and (5) the peak transmitted force value of 5000 lb currently specified in British Standard 2495 as the survivable limit for helmeted head impacts G Y

N79-31921# Naval Aerospace Medical Research Lab, New Orleans, La

THE EFFECT OF IMPACT ACCELERATION ON THE ELECTRICAL ACTIVITY OF THE BRAIN

Marc S Weiss and Michel D Berger *In* AGARD Models and Analogues for the Evaluation of Human Biodyn Response, Performance and Protect Jun 1979 9 p (For primary document see N79-31901 22-52)
Avail NTIS HC A18/MF A01

In a series of pilot experiments, eight Macaca Mulatta with chronically implanted cortical recording electrodes were tested using a range of -X impact accelerations Both EEG and somatosensory evoked potential (SEP) data were collected and analyzed The results suggest that for the peak acceleration levels used (281 m/sq s to 1550 m/sq s) the SEP is a more sensitive index of the inertial load on the brain than is the EEG In particular, the duration of changes in shape of the early part (less than 100 ms latency) of the SEP is monotonically related to the peak sled acceleration This has important implications for the physiological monitoring of human subjects in impact acceleration experiments G Y

N79-31922# Naval Air Development Center, Warminster, Pa Aircraft and Crew Systems Technology Directorate

A HUMAN BODY AND CREW STATION MODELLING SYSTEM FOR MOTION STUDIES

George D Frisch (Naval Aerospace Medical Research Lab, New Orleans) *In* AGARD Models and Analogues for the Evaluation of Human Biodyn Response Performance and Protect Jun 1979 13 p refs (For primary document see N79-31901 22-52)
Avail NTIS HC A18/MF A01

The need to visualize and interpret human body movement data from experiments and simulations led to the development of a computerized three dimensional representation of the human body and crew station Particular emphasis was placed on head and neck motion within the confines of the A7E LAMPS H2 and F18 crew stations, although the program is general enough to accomodate any geometrical configuration There are numerous computer programs for the analysis or simulation of human movement in various environments, but perhaps the only common feature of all these systems is that they produce motion data to manipulate some skeletal model of the human body Dissatisfaction with existing body models and stick figure displays led to the development of a human and crew station model for the computer with distinct advantages in display realism, movement definition, collision or interaction detection and cost effectiveness in a real-time animation play-back environment G Y

N79-31923# Army Aviation Research and Development Command, Fort Eustis, Va

THE USE OF MATHEMATICAL MODELING IN CRASH-WORTHY HELICOPTER SEATING SYSTEMS

George T Singley III and Joseph L Haley *In* AGARD Models and Analogues for the Evaluation of Human Biodyn Response, Performance and Protect Jun 1979 21 p refs Prepared in cooperation with Army Aeromed Res Lab, Fort Rucker, Ala (For primary document see N79-31901 22-52)
Avail NTIS HC A18/MF A01

Crashworthy helicopter accident data revealing injury types related to seat design seat occupant injury criteria, recent crashworthy seat test data, and crashworthy seat/occupant modeling technology are discussed The designer's dilemma in finding the minimum injury solution by designing to the many conflicting variables is presented The relationship between the spinal vertebra stress-strain characteristics and irreversible injury is discussed G Y

N79-31924# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick (West Germany)

MAN, DUMMY, TEST VEHICLE: A COMPARISON OF TEST RESULTS FOR ESCAPE SYSTEMS WITH THE 3 DIFFERENT TEST METHODS

H-D Melzig, E A Bockemueller, and U Schmidt *In* AGARD Models and Analogues for the Evaluation of Human Biodyn Response, Performance and Protect Jun 1979 8 p ref (For primary document see N79-31901 22-52)
Avail NTIS HC A18/MF A01

To prove the validity of experimental results gained with dummies or test vehicles for the qualification of man carrying parachutes, series of tests were conducted with parachute jumpers and their 2 analogues rubber torso dummies and bomb shaped test vehicles The results for the maximum filling force (opening shock) show significant differences, with highest values for the test vehicle, 75% less for the rubber dummy and an additional 75% less for the man G Y

N79-31925# Centre d'Essais en Vol, Bretigny-sur-Orge (France)

TENTATIVE ESTIMATION OF THE INJURIES LIKELY TO OCCUR DURING THE CRASH OF A SA 341 GAZELLE HELICOPTER, FROM A STUDY ON MANNEQUINS [TENTATIVE D'ESTIMATION DES LESIONS POUVANT SURVENIR AU COURS D'UN CRASH D'HELICOPTERE GAZELLE SA 341 A PARTIR D'UNE ETUDE SUR MANNEQUINS]

B Vettes and R Eckert *In* AGARD Models and Analogues for the Evaluation of Human Biodyn Response, Performance and Protect Jun 1979 19 p refs In FRENCH (For primary document see N79-31901 22-52)
Avail NTIS HC A18/MF A01

An SA 341 Gazelle helicopter was released to the ground with equal horizontal and vertical speeds in order to estimate the chances of survival of the occupants, to improve the resistance of the structure, and to construct a mathematical model of an anticrash structure Besides the different instruments fixed on the structures, three anthropometric dummies, clothed to represent the pilot, the copilot, and a passenger, were installed and equipped with accelerometers in the head, thorax, and pelvis A constraint gauge was placed in the dorsal-lumbar region of the pilot Structural damage was appraised at impact The acceleration undergone by the occupants was given in intensity curves as a function of time The most important accelerations are on the Z axis and are between 25 g and 30 g for durations on the order

of 20 ms with a mean jolt of 1000 g/s and a vertebral compression of almost 400 daV. Accelerations along the X axis do not exceed 15 g. Injuries to the occupants are localized in the dorsal-lumbar region. Because of lack of data, the injuries eventually inflicted on the low cervical column (C5 to C7) by the rabbit punch are not completely known. Transl. by A.R.H.

N79-31926# Royal Aircraft Establishment, Farnborough (England). Human Engineering Div.

THE USE OF SPINAL ANALOGUE TO COMPARE HUMAN TOLERANCE OF REPEATED SHOCKS WITH TOLERANCE OF VIBRATION, PART 1

Geof Allen. *In* AGARD. Models and Analogues for the Evaluation of Human Biodyn. Response, Performance and Protect. Jun. 1979. 15 p. refs. (For primary document see N79-31901 22-52)
Avail: NTIS. HC A18/MF A01.

A method is evolved for comparing theoretically the compatibility between ISO 2631 limits for human tolerance of vertical vibration and recent proposals for limits of tolerance of repeated shocks based on a spinal analogue. The method is applied both limits over a wide range of conditions, including a proposal for the maximum acceptable vibration crest factor to be increased from the present value of 3. to 6. Previous work on biodynamic modelling is briefly reviewed in relation to its application to standards for human tolerance of vibration and shock. G.Y.

N79-31927# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Bonn (West Germany). Inst. of Aviation Medicine.

THE RESPONSE OF A REALISTIC COMPUTER MODEL FOR SITTING HUMANS TO DIFFERENT TYPES OF SHOCKS

H. Mertens and L. Vogt. *In* AGARD. Models and Analogues for the Evaluation of Human Biodyn. Response, Performance and Protect. Jun. 1979. 17 p. refs. (For primary document see N79-31901 22-52)
Avail: NTIS. HC A18/MF A01.

A mechanical model of the human body in the sitting posture is described. The model parameters were derived from the results of steady state vibration experiments conducted under various levels of static acceleration up to +4 Gz. The resulting nonlinear behavior of the human body was modeled by calculating the characteristics of the model elements. To investigate the model's response under impact loads, the characteristics of the elements were extrapolated beyond 4 G. The model was exercised with different input pulse shapes and the resulting forces and mass displacements were calculated. G.Y.

N79-31928# Naval Air Development Center, Warminster, Pa. Life Sciences Div.

SOME HUMAN RESPONSES TO REPEATED +G SUB z PULSES

Edwin Hendler and David C. Johanson. *In* AGARD. Models and Analogues for the Evaluation of Human Biodyn. Response, Performance and Protect. Jun. 1979. 17 p. refs. (For primary document see N79-31901 22-52)
Avail: NTIS. HC A18/MF A01.

Six unprotected and relaxed subjects were exposed to haversine-shaped acceleration pulses while seated upright in a centrifuge and simultaneously performing a continuous tracking task and a discrete visual-motor response-time task. Twenty-five different acceleration pulses were used. Each subject made 5 successive runs a day, with each run containing a different acceleration pulse; each week of 5 test days therefore included all 25 pulses. From the data collected, relationships were explored between the dependent variables (mean heart rate (MHR), mean respiration rate (MRR), mean tracking error (MTE), and mean response time (MRT)) with pulse level (G sub z) and plateau duration (t) for the entire runs and for the individual phases of runs. Multiple regression equations were derived relating MHR and MTE to both G sub z and t. Correlations between dependent variables were calculated, as were measures of relative variability. G.Y.

N79-31929# Southampton Univ. (England). Inst. of Sound and Vibration Research.

THE BIODYNAMIC RESPONSE OF THE HUMAN BODY AND ITS APPLICATION TO STANDARDS

Michael J. Griffin, Christopher H. Lewis, Kenneth C. Parsons, and Elen M. Whitham. *In* AGARD. Models and Analogues for the Evaluation of Human Biodyn. Response, Performance and Protect. Jun. 1979. 18 p. refs. (For primary document see N79-31901 22-52)
Avail: NTIS. HC A18/MF A01.

The results of five experiments with groups of up to one hundred and twelve subjects and ten experiments with a single subject. The experiments were designed to investigate factors that affect the transmission of vertical (z-axis) vibration to the head over the frequency range 1 to 100 Hz. The distributions of response within subject groups were determined as a function of vibration frequency and it was found that subject weight affected seat-to-head transmissibility. There were differences in transmissibility between men and women and between men and boys. Changes in subject posture had a large effect on transmissibility. The effects of changes in muscle tension, head and foot position were also studied and methods of determining transmissibility with discrete sine, swept sine and random vibration inputs were compared. It was found that seat configuration greatly affected the transmission of vibration to the head. The experimental results are considered in the context of the possible development of standards on the biodynamic response of the body. G.Y.

N79-31930# Systems Technology, Inc., Hawthorne, Calif.

PROGRESS IN MEASURING AND MODELING THE EFFECTS OF LOW FREQUENCY VIBRATION ON PERFORMANCE

Henry R. Jex and Raymond E. Magdaleno. *In* AGARD. Models and Analogues for the Evaluation of Human Biodyn. Response, Performance and Protect. Jun. 1979. 11 p. refs. Sponsored in part by the Air Force and Navy (For primary document see N79-31901 22-52)
Avail: NTIS. HC A18/MF A01.

Several facets of the comprehensive biodynamic modeling program presented at the AGARD Aerospace Medical Panel Meeting at Oslo, 1974, were successfully completed and are reported. The development of a variety of lumped parameter models to explain and codify the known data on low-frequency vibration effects and to predict likely effects in new situations was brought to a useful level. The relationship and applications of these and other related models are discussed with respect to their development status and potential applications. Specific recommendations are made for more refined experimental data (e.g., simultaneous accelerations on various body locations and better postural and dynamic mode shapes via cinematography, etc.) and interface compatibility among various models. G.Y.

N79-31931# Aerospace Medical Research Labs., Wright-Patterson AFB, Ohio.

THE APPLICATION OF CONTROL THEORY TO THE INVESTIGATION OF ROLL MOTION EFFECTS ON HUMAN OPERATOR PERFORMANCE

A. M. Junker and W. H. Levison. *In* AGARD. Models and Analogues for the Evaluation of Human Biodyn. Response, Performance and Protect. Jun. 1979. 9 p. refs. Prepared in cooperation with Bolt, Beranek, and Newman, Inc., Cambridge, Mass. (For primary document see N79-31901 22-52)
Avail: NTIS. HC A18/MF A01.

The application of manual control theory to the investigation of the effects of motion cues on pilot control behavior is presented. Experiments and modeling approaches which have led to the development of a predictive motion sensitive optimal-control pilot-vehicle model for roll axis motion cues are described. The way in which human operators make use of disturbance and commanded motion cues are also delineated. Author

N80-15806# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).

SLEEP, WAKEFULNESS AND CIRCADIAN RHYTHM

Sep. 1979. 283 p. refs. Lectures held in London, 1-2 Oct. 1979, in Paris, 4-5 Oct. 1979, and in Toronto, 9-10 Oct. 1979. (AGARD-LS-105. ISBN-92-835-0249-3) Avail: NTIS. HC A13/MF A01.

Papers concerning the physiological and psychological aspects of sleep, and the adaptation of man to disturbed sleep are presented. The management of irregular rest and activity is also discussed. For individual titles, see N80-15807 through N80-15819.

N80-15807# Centre National de la Recherche Scientifique, Paris (France). Lab. de Physiologie.

CIRCADIAN AND CIRCANNUAL RHYTHMS IN HEALTHY ADULTS

Alain Reinberg. *In* AGARD. Sleep, Wakefulness and Circadian Rhythm. Sep. 1979. 13 p. refs. (For primary document see N80-15806 06-52)
Avail: NTIS. HC A13/MF A01.

Physiological processes in any living organism including man are not constant as a function of time regular and predictable variations with period, tau of about 24 hours (circadian), about 1 year (circannual) etc can be detected Each rhythm can be characterized by estimating such parameters as acrophase theta (crest time) amplitude A and mesor M (rhythm adjusted mean) The estimation of tau, theta, A and M of a set of variables under specified experimental conditions enable the visualization of an aspect of the temporal organization (or biologic time structure) Aims of chronobiology are to quantify and investigate mechanisms of biological time structures Biological rhythms and the related temporal organization are genetic in origin However, one or several rhythm parameters may be influenced by cyclical variations of environmental factors (synchronizers or Zeitgeber) The latter has practical implications since phase shifts of synchronizers may occur with transmeridian flights, night-working and shift-working Chronobiology also involves the study of rhythmic changes in endocrine activities (chronoendocrinology) and in drugs effects (chronopharmacology) F O S

N80-15808# *Deutsche Forschungs- und Versuchsanstalt fuer* Luft- und Raumfahrt, Bonn (West Germany) Inst fuer Flugmedizin

CIRCADIAN RHYTHMS OF HUMAN PERFORMANCE AND RESISTANCE: OPERATIONAL ASPECTS

Karl E Klein and Hans-M Wegmann *In* AGARD Sleep, Wakefulness and Circadian Rhythm Sep 1979 17 p refs Also presented at the 4th Ann Sci Meeting of the Aerospace Med Assoc, Bal Harbour, Fla, 13 May 1976 (For primary document see N80-15806 06-52)

Avail NTIS HC A13/MF A01

Circadian rhythmicity of mental and physical efficiency, and resistance to noxious hazards are reviewed The interaction with internal and operational factors and implications are given for the management of human operations The significance of the biorhythm concept for the prediction of human behavior, and the occurrence of man-related accidents are discussed F O S

N80-15809# Montefiore Hospital, New York Dept of Neurology

SLEEP STAGE ORGANIZATION: NEURO ENDOCRINE RELATIONS

Elliot D Weitzman *In* AGARD Sleep, Wakefulness and Circadian Rhythm Sep 1979 9 p refs (For primary document see N80-15806 06-52)

Avail NTIS HC A13/MF A01

The circadian and shorter term episodic patterns of hormone systems are discussed These include ACTH-cortisol, growth hormone (GH), prolactin, and the gonadotrophins, luteinizing hormone (LH), and follicle stimulation hormone (FSH) F O S

N80-15810# Naval Health Research Center, San Diego, Calif

SLEEP DISTURBANCES IN HUMANS

Laverne C Johnson *In* AGARD Sleep, Wakefulness and Circadian Rhythm Sep 1979 16 p refs (For primary document see N80-15806 06-52)

Avail NTIS HC A13/MF A01

Disturbed sleep results in feelings of fatigue and, usually, in impaired performance regardless of whether the disturbed sleep is due to excessive noise or a chronic sleep disorder In addition to noise, some other environmental factors that disturb sleep are temperature, unscheduled operational demands that fragment sleep time, rotating shift-work schedules, and operational requirements that result in air travel across several time zones. While appropriate attention to sleep logistics may minimize the environmental causes of disturbed sleep, resolution of the disturbed sleep of those with sleep disorders is more difficult. The focus in sleep disorders must be on the individual. The major sleep complaint is insomnia, not enough sleep, usually due to prolonged sleep latency A more serious medical problem, however, may be the complaint of excessive daytime sleep or hypersomnia Most patients with complaints of hypersomnia are usually diagnosed as having narcolepsy or sleep apnea Relative to narcolepsy, sleep apnea (episodes of respiratory arrest during sleep) has only recently received attention In addition to a sleep problem, sleep apneic patients may have hypertension and/or cardiac arrhythmia F O S

N80-15811# Centre de Recherches du Service de Sante des Armees, Lyons (France)

VIGILANCE AND ATTENTION

M Defayolle *In* AGARD Sleep, Wakefulness, and Circadian Rhythm Sep 1979 13 p refs (For primary document see N80-15806 06-52)

Avail NTIS HC A13/MF A01

The relations between vigilance and attention are considered using computer, psychological and physiological techniques After considering the different types of available measures, the factors influencing attention are reviewed The characteristics of signals, the environmental conditions, the individual features and the possible interactions between these factors are then studied The various theories are reviewed and a mathematical model is proposed which integrates activation, the use of processing ability and filtering, taking into consideration the data relative to the environment and to motivation In conclusion, different methods are proposed from ergonomical, psychological and pharmacological viewpoints F O S

N80-15812# School of Aerospace Medicine, Brooks AFB, Tex Crew Technology Div

BIOCHEMICAL INDICES OF STRESS: BIOCHEMICAL ASPECTS OF THE STRESS RESPONSE

Bryce O Hartman and James P Ellis *In* AGARD Sleep, Wakefulness and Circadian Rhythm Sep 1979 32 p refs (For primary document see N80-15806 06-52)

Avail NTIS HC A13/MF A01

The release of hormones in response to acute flight stresses was investigated in fighter pilots The biochemical indices discussed include hormones, hormone precursors, hormone metabolites, nonhormone metabolites, and enzymes of hormone formation/production Abstracts and operational applications of previously published reports are presented F O S

N80-15813# Montefiore Hospital, New York Human Chronophysiology Lab

BIOLOGICAL RHYTHMS OF MAN LIVING IN ISOLATION FROM TIME CUES

Elliot D Weitzman, Charles A Czeisler, and Martin C MooreEde *In* AGARD Sleep, Wakefulness and Circadian Rhythm Sep 1979 9 p refs Prepared in cooperation with Harvard Med School (For primary document see N80-15806 06-52)

Avail NTIS HC A13/MF A01

The results are presented of prolonged measurements of sleep-waking functions in human subjects for periods of 25 to 105 calendar days in an environment free of all time cues It was found that the biological rhythms of human beings free-run at periods greater than 24 hours, typically at approximately 25 hours During free-running, the sleep to total time ratio remains constant, approximately .30 F O S

N80-15814# Naval Health Research Center, San Diego, Calif

SLEEP DISTURBANCE AND PERFORMANCE

Laverne C Johnson *In* AGARD Sleep, Wakefulness and Circadian Rhythm Sep 1979 15 p refs (For primary document see N80-15806 06-52)

Avail NTIS HC A13/MF A01

While the type of sleep obtained does not appear to be an important factor in performance, the time of day the sleep is obtained and when the performance occurs are very important Time-of-day effects are a more crucial factor in performance than the preceding sleep patterns The effect of total sleep loss becomes pronounced after 48 to 60 hours, consistent performance decrement following reduced sleep or fragmented sleep was not found Feelings of fatigue, however, are a consistent finding in all sleep-loss studies A significant relation between sleep quality (good vs poor sleep) and performance is not easily found The deleterious effect of hypersomnia, especially that due to narcolepsy is discussed F O S

N80-15815# Centre National de la Recherche Scientifique, Paris (France) Lab. de Physiologie

TOLERANCE TO SHIFT WORK: A CHRONOLOGIC APPROACH

Alain Reinberg *In* AGARD Sleep, Wakefulness and Circadian Rhythm Sep 1979 11 p refs (For primary document see N80-15806 06-52)

Avail NTIS HC A13/MF A01

The hypotheses was tested of possible relationships between the amplitude A of the circadian rhythm of oral temperature on the speed of adjustment during shift work, and tolerance to shift work. Study 1 involved 25 oil refinery operators A negative correlation ($r = -0.63$; P less than 0.01) was found between the mean A and the acrophase shift delta O resulting from the first night-shift the larger the A, the smaller the delta O Study

2 involved 23 steel industry workers and 25 chemical industry workers with either good or poor tolerance to shift work. Tolerance was evaluated conventionally according to 3 types of complaints: digestive troubles, persistant fatigue, sleep alterations. Circadian A of oral temperature is larger in subjects who tolerate to shift work than in intolerant subjects. The study 3 involved 29 oil refinery operators and was designed to retest both hypothesis, their complementarity and to take different age groups into account. Good tolerance to shift work, over many years, appears to be associated with a large circadian amplitude and a slow adjustment during night-shifts (small delta 0). F.O.S.

N80-15815# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Bonn (West Germany). Inst. fuer Flugmedizin.

CIRCADIAN RHYTHMS IN AIR OPERATIONS

Karl E. Klein and Hans-M. Wegmann. *In* AGARD Sleep, Wakefulness and Circadian Rhythm. Sep. 1979. 25 p. refs. (For primary document see N80-15806 06-52)

Avail: NTIS HC A13/MF A01

After a brief introduction into the principles of environmental and biological timing systems, the phenomenology of post-transmeridian de- and re-synchronization of circadian rhythms is presented, its control and modification through external and internal factors described, and the consequences for human efficiency and health discussed. There are conclusions drawn as to possible relief measures, formulas and models which define the physiological processes, and predict work loads occurring in transmeridian flight operations. Finally, the incorporation of circadian rhythm aspects into Rest/Duty Regulations is described. Author

N80-15817# Centre de Recherches du Service de Sante des Armees, Lyons (France).

PSYCHOSTIMULANTS

M. Defayolle. *In* AGARD Sleep, Wakefulness and Circadian Rhythm. Sep. 1979. 12 p. refs. (For primary document see N80-15806 06-52)

Avail: NTIS HC A13/MF A01

The state-of-the-art of psychostimulants is reviewed, and a brief historical and geographical survey are presented. The basic neurochemical data on vigilance are considered and the various systems of mediators involved in synaptic conduction are differentiated. The methodology of therapeutic tests on psychotropes is then discussed. The effects induced by the use of the various types of drugs: noo-analeptics, nootropes, thymo-analeptics and metabolic adjuvants are considered. These data are incorporated into a general model of vigilance including the data handling capacity and filtering concepts. The indications and contraindications in the use of psychostimulants are presented. F.O.S.

N80-15818# Royal Air Force Inst. of Aviation Medicine, Farnborough (England).

HYPNOTICS AND THE MANAGEMENT OF DISTURBED SLEEP

A. N. Nicholson, R. G. Borland, and Barbara M. Stone. *In* AGARD Sleep, Wakefulness and Circadian Rhythm. Sep. 1979. 11 p. refs. (For primary document see N80-15806 06-52)

Avail: NTIS HC A13/MF A01

The effects of hypnotics on visuo-motor performance are discussed. The hypnotics studied include barbiturates, benzodiazepines, diazepam and its hyroxylated metabolites, and nordiazem. The effects of hypnotics on sleep are also discussed. F.O.S.

N80-15819# School of Aerospace Medicine, Brooks AFB, Tex. Crew Technology Div.

MANAGEMENT OF IRREGULAR REST AND ACTIVITY

Bryce O. Hartman. *In* AGARD Sleep, Wakefulness and Circadian Rhythm. Sep. 1979. 13 p. refs. (For primary document see N80-15806 06-52)

Avail: NTIS HC A13/MF A01

Biomedical aspects of the irregularity of air operations are discussed in terms of the requirements of aircrews to work without regards for the clock. In practice, operational managers consider the crew limitations and develop workable compromises between these limitations and mission requirements. That variables that must be considered are listed. Data collected from airlift missions are analyzed along with tactical operations. Sleep and the work-rest cycle during missions are discussed. F.O.S.

N80-17702# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).

THE SURVIVAL AND PROTECTION OF EQUIPMENT IN THE EVENT OF ACCIDENTAL IMMERSION IN COLD WATER

C. Boutelier. Jan. 1979. 125 p. refs. In FRENCH (AGARD-AG-211-FR) Avail: NTIS HC A06/MF A01

The physiological reactions of the human body to thermal aggression and eventual pathological incidences and their treatment are described for airmen and designers of equipment designed for protecting pilots against cold water following accidental immersion. Topics covered include: (1) heat transfer from the human body in ambient cold by conduction, convection, evaporation, and radiation, (2) the physiological response to immersion - tolerance and acclimatization, (3) diagnosis and treatment of local and general effects of cold, including hypothermia, (4) the theoretical basis for protective clothing, (5) methods for evaluating protective clothing, and (6) the design and construction of anti-immersion equipment: wet suits, dry suits, life vests, and lifeboats. Transl. by A.R.H.

53 BEHAVIORAL SCIENCES

Includes psychological factors, individual and group behavior, crew training and evaluation, and psychiatric research

N77-31783# Advisory Group for Aerospace Research and Development, Paris (France)

THE PSYCHO-PATHOLOGY OF THE STUDENT PILOT AND MEDICO-PSYCHOLOGICAL MONITORING IN THE FLYING SCHOOL

J R Galle-Tessoneau (Centre Medical de Psychologie Clinique de l'Armee de l'Air, Paris) Aug 1977 45 p refs (AGARD-AG-227, ISBN-92-835-0201-9) Avail NTIS HC A03/MF A01

The practice of medicine among the population of young student pilots is discussed in terms of interest for the young doctor. It is suggested that the going beyond the affected organ, the symptom presented', tries to understand the whole of the personality he is examining. The medical manifestations most often encountered with student pilots are reviewed. Author

54 MAN/SYSTEM TECHNOLOGY AND LIFE SUPPORT

Includes human engineering, biotechnology, and space suits and protective clothing

N77-30757 Advisory Group for Aerospace Research and Development, Paris (France)

HUMAN FACTORS TOPICS IN FLIGHT SIMULATION: AN ANNOTATED BIBLIOGRAPHY

S. Hunter (RAF Inst. of Aviation Med.), A. J. Gundry (RAF Inst. of Aviation Med.), and J. M. Rolfe (RAF Inst. of Aviation Med.), Jun. 1977, 142 p, refs

(AGARD-R-656, ISBN 92-835-1246-4) Avail: NTIS, HC A07

This bibliography contains 504 references with summaries, to reports concerned with human factors topics in flight simulation. Reports dealing solely with the engineering aspects of flight simulation have been excluded, unless they contain items of human interest. The bibliography, covering the years 1940 to 1976, is mainly comprised of English language reports and contains no reference to classified material. Author

N78-16621# Advisory Group for Aerospace Research and Development, Paris (France)

STUDIES ON PILOT WORKLOAD

Robert Auffret, ed. (Centre d'Essais en Vol, Bretigny-sur-Orge, France), Nov. 1977, 125 p, refs, Partly in ENGLISH and FRENCH, Presented at the Aerospace Med. Panel Specialists' Meeting, Cologne, 18-22 Apr. 1977

(AGARD-CP-217, ISBN 92-835-0205-1) Avail: NTIS, HC A06/MF A01

The different variables which can influence human performance during the operational use of helicopters or other aircraft having high acceleration loads are assessed to quantify the sum of work which can be provided at each moment during flight. For individual titles, see N78-16622 through N78-16632.

N78-16622# Italian Air Force Medical Service, H. Q., Rome.

WORKLOAD AND OPERATIONAL FATIGUE IN HELICOPTER PILOTS

Gaetano Rotondo. *In* AGARD, Studies on Pilot Workload, Nov. 1977, 11 p, refs (For availability, see N78-16621 07-54)

Avail: NTIS, HC A06/MF A01

The possible causes of the operational fatigue to which flight crews are subject during the performance of their duties are reviewed. The influence of the physical, psychic, and emotive components of the stress factor associated with the professional activities of helicopter pilots are analyzed, and their effects in the genesis of flight fatigue is assessed. On the basis of this analytical survey, it is possible to conclude that the piloting of helicopters involves a psycho-physical workload that is not inferior to the one experienced by the pilots of faster and more powerful aircraft. Author

N78-16623# Army Aeromedical Research Lab., Fort Rucker, Ala., Aviation Psychology Div.

VISUAL WORKLOAD OF THE COPILOT-NAVIGATOR DURING TERRAIN FLIGHT

Michael G. Sanders, Mark A. Hofmann, Ronald R. Simmons, and J. Nicholas DeBonis. *In* AGARD, Studies on Pilot Workload, Nov. 1977, 9 p, refs (For availability, see N78-16621 07-54)

Avail: NTIS, HC A06/MF A01

A high speed camera and a modified eye mark recorder were used to examine the oculomotor performance of the navigator/copilot during various tasks involved in nap-of-the-earth, contour, and low level flight of a UH-1H helicopter. The visual performance was examined during (1) visual time inside the cockpit on flight and engine instruments, (2) time inside the cockpit on the map and other navigational aids, and (3) time outside the cockpit in various windscreen sectors. A visual free time task was utilized to determine the amount of visual time the navigator had available during flight over the prescribed course for a nonflight related task. The data indicate that the navigator's normal workload was demanding, the visual free time task was utilized only 3% of the total time. The data also indicate that the duty of navigating required 92.2% of the copilots total visual time while the engine and flight instruments were utilized only 4% of the time. These data are discussed in relation to the copilot's specified duties. Author

N78-16624# Royal Aircraft Establishment, Farnborough (England), Flight Systems Dept.

IN-FLIGHT RECORDING OF HELICOPTER PILOT ACTIVITY

E. J. Lovesey. *In* AGARD, Studies on Pilot Workload, Nov. 1977, 11 p, refs (For availability, see N78-16621 07-54)

Avail: NTIS, HC A06/MF A01

A fully portable cine camera fitted with a wide angle lens was used to record pilots' head and hand movements in 6 different helicopters and 2 fixed wing aircraft types during nap of the earth, low level and other flight phases. Apart from highlighting problem areas in the cockpit, the film records show that activity patterns depend more upon the flight profile than upon the helicopter type or the individual pilot. Subsequent film analysis has shown that the pilot time tends to increase with decreasing height above the ground. During nap-of-the-earth tactical flying, a pilot may spend over a third of the time looking inside the cockpit at maps, instruments and radios. This is precisely the time when he needs to spend the maximum time looking outside to detect and evade potential hazards such as wires, trees, enemy positions, etc. Reasons for the apparently paradoxical behaviour and the effect upon pilot work load are discussed. Typical pilot activity patterns are presented, together with an example of how poor cockpit design can obviously increase work-load and reduce efficiency. Author

N78-16625# Army Aeromedical Research Lab., Fort Rucker, Ala., Aviation Psychology Div.

THE ASSESSMENT OF ROTARY WING AVIATOR PRECISION PERFORMANCE DURING EXTENDED HELICOPTER FLIGHTS

Michael A. Lees, Kent A. Kimball, and Lewis W. Stone. *In* AGARD, Studies on Pilot Workload, Nov. 1977, 13 p, refs (For availability, see N78-16621 07-54)

Avail: NTIS, HC A06/MF A01

Man-machine system performance during a five day extended flight was evaluated with emphasis on the changes in pilot performance and aircraft stability during the stabilized 3 ft. precision hover maneuver. Changes in subjective ratings of fatigue and flight performance and in the measurement of auditory reaction time are also discussed. Data obtained suggest the occurrence of a learning effect across the first day of extended flight. The most stable hover performance was observed during the second flight day. By the third flight day, pilots attempted to maintain high quality precision hovers through an increase in the number of control inputs. On the fourth day of flight the pilots have shifted their control technique from active control of the helicopter to a more passive strategy of responding to observed error. The subjective rating scales demonstrate a progressive increase in the rated levels of fatigue between and within flight days. This increase in the level of fatigue corresponds to a general decrease in the ratings of flight performance. Author

N78-16626# Centre d'Essais en Vol, Bretigny-sur-Orge (France)

EVALUATING THE WORK LOAD OF HELICOPTER PILOTS. IN-FLIGHT RECORDINGS OF HEART RATE AND CARDIAC ARRHYTHMIA [EVALUATION DE LA CHARGE DE TRAVAIL DES PILOTES D'HELICOPTERES: ENREGISTREMENTS EN VOL DE LA FREQUENCE ET DE LA VARIABILITE DUE RYTHME CARDIAQUE]

Bernard Vettes. In AGARD, Studies on Pilot Workload, Nov. 1977, 13 p, refs, Partly in FRENCH and ENGLISH (For availability, see N78-16621 07-54)

Avail: NTIS, HC A06/MF A01

In-flight recordings were made of the heart rate and cardiac arrhythmia in four helicopter test pilots during increasingly difficult ILS approaches. Five types of tasks were identified, each task being repeated five times during the same flight. An analyses of the data obtained indicates an increase of heart rate with low concommitant rhythm variations, especially if the subject had a greater number of variations when at rest. This increase of cardiac rhythm is exacerbated by the addition of external function factors (turbulence). The influence of apprehension is evidenced by a sensible decrease in heart rate during successive repetitions of the same task. The inclusion of subjective criteria can provide some useful information. A study of arrhythmia appears to be a better measure than the instantaneous heart rate, however, an exact relationship between these parameters and the aviator's workload can not yet be affirmed. Transl. by A.R.H.

N78-16627# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick (West Germany). Inst. fuer Flugfuehrung

A STUDY ON PILOT'S WORKLOAD IN HELICOPTER OPERATION UNDER SIMULATED IMC EMPLOYING A FORWARD LOOKING SENSOR

R Beyer *In* AGARD Studies on Pilot Workload Nov 1977 11 p refs (*For availability see N78-16621 07-54*)
Avail NTIS HC A06/MF A01

Various measures of pilot workload are known which are presently applied to human engineering investigations. It is difficult, however, to find a measure which has proved to be universally applicable and adequately validated. Measures tailored to a specific application may be less flexible but can provide relevant and sufficient information on pilot workload. Some aspects of workload measurement are discussed, and some workload measurements and the results are presented by referring to flight tests with advanced displays for the helicopter. Author

N78-16628# School of Aerospace Medicine, Brooks AFB, Tex. Crew Technology Div.

AIRCREW FATIGUE IN NONSTOP, TRANSOCEANIC TACTICAL DEPLOYMENTS

William F. Storm, Bryce O. Hartman, and Donald L. Makalous *In* AGARD Studies on Pilot Workload Nov 1977 7 p refs (For availability see N78-16621 07-54)
Avail NTIS HC A06/MF A01

Stress and fatigue were evaluated in F-4D crews before and after flying nonstop, transoceanic deployments from New Mexico to Germany and return. The measurement battery consisted of subjective fatigue ratings, self ratings of fitness to fly, sleep logs, and biochemical analyses of urine samples for norepinephrine, epinephrine, 17-hydroxycorticosteroids, urea, sodium, and postassium. The magnitude and the consistency of behavioral and physiological changes indicated the occurrence of mild fatigue immediately after both flights. The fatigue was acute and was ameliorated by one uninterrupted sleep period. Author

N78-16629# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Bad Godesberg (West Germany). Inst. fuer Flugmedizin.

ENDOCRINE-METABOLIC COST OF PILOTING F-104 G AIRCRAFT

Hans M. Wegmann, Reinhold Hermann, and Paul Tuklinski *In* AGARD Studies on Pilot Workload Nov 1977 4 p refs (For availability see N78-16621 07-54)
Avail NTIS HC A06/MF A01

Metabolic endocrinological aspects of flight stress were studied in student pilots during a training course for the F-104 G. All of these were already experienced jet pilots. Responses to flying were evaluated by comparing pre- and postflight levels of blood constituents, including 11-hydroxycorticosteroids, glucose, adenosinetriphosphate, cholesterol, and the activity of three cell enzymes (MDH, GOT, GPT). From the results the following conclusions were obtained: 1. Flying the F-104 G caused significant changes of most parameters. 2. The blood constituents differed in their work-load sensitivity. 11-OHCS, GPT, and MDH proved to be the most sensitive, GOT, cholesterol, and ATP the most insensitive parameters for the load. Blood glucose does not seem to be an unequivocal variable to measure workload. Reviewing the pertinent literature and comparing the figures with those obtained from studies with standardized stressors, the operational significance of the results are discussed. Author

N78-16630# Dunlap and Associates, Inc., La Jolla, Calif.

METHODS TO ASSESS PILOT WORKLOAD AND OTHER TEMPORAL INDICATORS OF PILOT PERFORMANCE EFFECTIVENESS

Clyde A. Brittson *In* AGARD Studies on Pilot Workload Nov 1977 7 p refs (For availability see N78-16621 07-54)
Avail NTIS HC A06/MF A01

A systematic approach to define, measure and describe how certain pilot-related variables influence carrier landing performance during sustained operations is outlined. Previous exploratory research on the interrelations between psychophysiological variables, pilot experience and performance is described. Pilot work activity, mood and sleep are identified as indicators of a pilot's temporal state of readiness. A field study design and techniques to measure and describe temporal readiness during prolonged flight operations are provided to demonstrate the methodology in an operational environment. Potential applications of the research are discussed along with the future role of temporal, psychological and other moderator variables in estimating pilot flight status. Author

N78-16631# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Hamburg (West Germany). Inst. fuer Flugmedizin.

SUBJECTIVE RATINGS OF FLYING QUALITIES AND PILOT WORKLOAD IN THE OPERATION OF A SHORT HAUL JET TRANSPORT AIRCRAFT

K. Steininger *In* AGARD Studies on Pilot Workload Nov 1977 12 p refs (For availability see N78-16621 07-54)
Avail NTIS HC A06/MF A01

A representative sample of pilots employed by an airline operating a short haul jet transport aircraft assessed the acceptability of the cockpit layout and instrumentation, the handling quality, and the feasibility of the system operation in regard to the pilots workload. The assessment consisted of two parts: (1) a questionnaire of 82 fixed items being answered on a 7 step rating scale, (2) a semi-structured interview concerning 19 items, being answered on tape recorder. The justification to apply subjective ratings as a scientific method, instead of measuring objectively the physiological, and psychological reactions of the pilot is to be seen in the output. Critical points and favourable capabilities of the man machine system can be evaluated economically and objectively, provided there is a carefully chosen questionnaire and interview strategy, a well established rating scale, and a sufficient sample of persons for statistical evidence of the data. Author

N78-16632# Institute of Aviation Medicine, Fuerstenfeldbruck (West Germany).

SUBJECTIVE STRESS ASSESSMENT AS A CRITERION FOR MEASURING THE PSYCHOPHYSICAL WORKLOAD ON PILOTS

Hans-Peter Goerres *In* AGARD Studies on Pilot Workload Nov 1977 8 p refs (For availability see N78-16621 07-54)
Avail NTIS HC A06/MF A01

The psychophysiological workload induced by an activity depends not only on the duration and intensity of stressing stimuli, but also upon intra-individual factors in the stressed subject itself (physical features functioning of sensory organs, vegetative status, and present state of health as a prerequisite to physical performance; job-related knowledge, abilities, skills; need for achievement, experience, emotional stress resistance as psychic and mental determinants of strain). The results obtained by using standardized interviews and questionnaires to assess these psychophysiological strain parameters in 217 pilots of various type aircraft used by the German Federal armed forces are presented. Author

N78-18770# Advisory Group for Aerospace Research and Development, Paris (France).

ASSESSING PILOT WORKLOAD

Feb. 1978 83 p refs
(AGARD-AG-233; ISBN-92-835-74-X) Avail: NTIS HC A05/MF A01

Pilot workload was defined and classified according to physical and mental stresses. The need for workload assessment was summarized while principles and methods of subjective assessment were discussed. Physiological tests used in the assessment of workload were presented. Tests recorded the functions of the respiratory, nervous, and cardiovascular systems. B.L.P.

N78-31745# Advisory Group for Aerospace Research and Development, Paris (France).

METHODS TO ASSESS WORK LOAD

Jun 1978 136 p refs Presented at the Aerospace Med. Panel Specialists Meeting, Cologne, 18-22 Apr. 1977
(AGARD-CP-216; ISBN-92-835-1285-5) Avail: NTIS HC A07/MF A01

Physiological and mathematical methods are examined for determining pilot and air traffic controller workloads. For individual titles, see N78-31746 through N78-31758.

N78-31746# Naval Aerospace Medical Research Lab., Pensacola, Fla.

IS MAN THE WEAKEST LINK?

Harvey G. Gregoire *In* AGARD Methods to Assess Workloads Jun 1978 3 p (*For primary document see N78-31745 22-54*)
Avail: NTIS HC A07/MF A01

A portable video tape recorder and camera were installed on the aft bulkhead of the crew compartment to obtain inflight video records of aircrew activity during test flights of a new antisubmarine (ASW) aircraft. The technique proved successful in providing graphic records of real time crew utilization of systems.

controls and displays. In combination with crew briefing and debriefing interviews, the annotated tapes provided a basis for activity sampling, scoring task times and error rates, evaluating display utilization, counting control inputs and display mode changes, and for other observations pertinent to crew task loading. Data was obtained during passive acoustic submarine search and track operation during actual ASW test flights. This data indicated that during passive acoustic search and tracking, individual control tasks requiring one or more pushbutton operations were performed from 6 to 10 times per minute. Display mode changes occurred at intervals of approximately two minutes. The operators in this limited sample made integrated control system inputs exclusively with the right hand. G.G.

N78-31747# Army Aeromedical Research Lab., Fort Rucker, Ala. Aviation Psychology Div.

METHODOLOGICAL CONSIDERATIONS OF VISUAL WORKLOADS OF HELICOPTER PILOTS

Ronald R. Simmons and Kent A. Kimball. *In* AGARD Methods to Assess Workloads Jun. 1978 9 p refs (For primary document see N78-31745 22-54)

Avail: NTIS HC A07/MF A01

The techniques and modifications for assessing visual performance/workload of pilots during helicopter operations are reviewed. Although the corneal reflection technique for gathering eye movement data is not new, innovative modifications had to be developed to permit accurate data collection in this flight environment. G.G.

N78-31748# *Human Engineering Labs., Aberdeen Proving Ground, Md.*

USE OF EYE-MOVEMENT MEASURES TO ESTABLISH DESIGN PARAMETERS FOR HELICOPTER INSTRUMENT PANELS

John A. Barnes. *In* AGARD Methods to Assess Workloads Jun. 1978 9 p refs (For primary document see N78-31745 22-54)

Avail: NTIS HC A07/MF A01

The pilot's eye-scan path and fixation point recordings during actual helicopter flight provided an accurate measure of the visual workload imposed by a particular panel design. Initial work was done in the UH-1 helicopter using experienced instrument-rated pilots flying actual maneuvers on instruments. The knowledge gained from these data was used to design a helicopter instrument panel in which the most referred to instruments were placed so that the eye-scan paths were minimized. This design considerably lessens the pilot's visual workload, cuts fatigue and allows him more time for other tasks. G.G.

N78-31749# Royal Air Force Inst. of Aviation Medicine, Farnborough (England).

AUDITORY COMMUNICATION AND WORKLOAD

Roger Green and Ray Flux. *In* AGARD Methods to Assess Workloads Jun. 1978 8 p refs (For primary document see N78-31745 22-54)

Avail: NTIS HC A07/MF A01

Psychomotor workload interference with the performance of an auditory communications task was studied. Two experiments are described: The first illustrates that an auditory task from which a cumulative response time measure is taken is effected by changes in signal quality, and the second experiment shows that the same auditory task is also affected by a realistic form of workload (flying an aircraft simulator). The implications of those findings are discussed both in terms of assessing the quality required of a communications system and in terms of the use of secondary tasks in the assessment of workload. G.G.

N78-31750# Royal Air Force Inst. of Aviation Medicine, Farnborough (England).

PITCH AND FORMANT ANALYSIS OF THE VOICE IN THE INVESTIGATION OF PILOT WORKSHOP

R. Cannings, R. G. Borland, L. E. Hill, and A. N. Nicholson. *In* AGARD Methods to Assess Workloads Jun. 1978 11 p refs (For primary document see N78-31745 22-54)

Avail: NTIS HC A07/MF A01

Typical log spectral, cepstral and smoothed spectral estimates, obtained from in-flight recordings, are reported. The pitch peak in the cepstrum corresponded to a constant frequency of 94 Hz. The first formant peak was clearly visible and the peak picking algorithm showed it to be increasing from 520 to 575 Hz through the time course of the phonem. In this particular example the second formant peak is well defined (1400 Hz) and the third and fourth formants may also be seen at 2250 Hz and 3100 Hz, respectively. Preliminary examination of in-flight recordings indicates that this technique is useful for classifying specific phonems and is effective despite the noise corruption of the raw data. The nature of cockpit communications determines the choice of phonems. G.G.

N78-31751# Technische Hochschule, Darmstadt (West Germany).

DETERMINATION OF STRESS AND STRAIN OF AIR TRAFFIC CONTROL OFFICERS

Walter Rohmert. *In* AGARD Methods to Assess Workloads Jun. 1978 8 p refs (For primary document see N78-31745 22-54)

Avail: NTIS HC A07/MF A01

Air traffic controlling means a work system with manual performance. All three partial functions, efficiency/controlling/monitoring, necessary to be fulfilled in each work system are operated by man himself. Based on the concept of the man-at-work-system and the description of strain-related work contents, a new ergonomic job description questionaire was developed. The results allow a deeper inlook into methods and techniques needed for evaluation purposes as well as for designing future air traffic control systems. G.G.

N78-31752# Defence and Civil Inst. of Environmental Medicine, Downsview (Ontario).

INSTRUMENTS AND METHODOLOGY FOR THE ASSESSMENT OF PHYSIOLOGICAL COST OF PERFORMANCE OF STRESSFUL CONTINUOUS OPERATIONS: THE AIR TRAFFIC SERVICES TOWER ENVIRONMENT

Jacques Soutendam. *In* AGARD Methods to Assess Workloads Jun. 1978 32 p refs (For primary document see N78-31745 22-54)

Avail: NTIS HC A07/MF A01

A total of 39 females and males were used as subjects in a study designed to test the general validity and utility of methods and instruments of potential use in the determination of the physiological cost of work performance in stressful environments. A second goal of the study was to attempt a preliminary test of the hypothesis that a form of employment (air traffic service) traditionally considered stressful, was significantly different from general forms of employment traditionally considered less stressful. A consistent statistical significance was established when the entire sample was recategorized on the basis of subjective sleep adequacy assessment rather than by job description. G.G.

N78-31753# Technische Universitaet, Munich (West Germany). Inst. fuer Arbeitsphysiologie.

PHYSIOLOGICAL MEASURES OF WORKLOADS: CORRELATIONS BETWEEN PHYSIOLOGICAL PARAMETERS AND OPERATIONAL PERFORMANCE

Helmut Strasser. *In* AGARD Methods to Assess Workloads Jun. 1978 8 p refs (For primary document see N78-31745 22-54)

Avail: NTIS HC A07/MF A01

The influence of different hypoxic gas mixtures on pursuit tracking and on some physiological parameters was studied. The following conclusions are made: Already, in relatively mild hypoxia, physiological changes are present, but normally were concealed by reactions due to prolonged test time. In spite of statistically significant physiological effects, no noticeable deterioration of performance in tracking was measured in hypoxia down to a hypoxic gas mixture of only 13% 02 in inspired air. Not until before 11% 02 significant and mentionable impairments of tracking performance were found. The same, shown for hypoxia, is true of noise. Decreased performance in noise was not found, but an increased level of heart rate indicated the stress. Physiological indicators definitely react already in a low workload in order to bring in action reserves of energy. Operational measures alone fail to indicate the strain of the human operator. Only in high workload, correlations performance and physiological measures are expected. G.G.

N78-31754# Army Aeromedical Research Lab., Fort Rucker, Ala.

USE OF INSPIRATORY MINUTE VOLUMES IN EVALUATION OF ROTARY AND FIXED WING PILOT WORKLOAD

Frank S. Pettyjohn, Roderick J. McNeil, Lloyd A. Akers, and James M. Faber. *In* AGARD Methods to Assess Workloads Jun. 1978 3 p refs (For primary document see N78-31745 22-54)

Avail: NTIS HC A07/MF A01

Inspiratory minute volume (IMV) measurements were utilized in the evaluation of US Army aircrew workload and

stress in helicopter and fixed wing aircraft. The IMV data demonstrated a significant stress and/or workload level of the aviator in performance of helicopter day nap-of-the-earth NOE), night nap-of-the-earth flight (NNOE) and with the use of night vision devices (NVD). IMV 20.05 to 38.11 liters per minute NTPD were obtained during the performance of these combat operational techniques. IMV determination in-flight is considered a valuable clinical tool in the assessment of aircrew stress and/or workload. G.G.

N78-31755# Johann-Wolfgang-Goethe-Universitat, Frankfurt am Main (West Germany).
NEUROPHYSIOLOGICAL ASSESSMENT OF FUNCTIONAL STATES OF THE BRAIN
Kurt Offenloch *In* AGARD Methods to Assess Workloads Jun. 1978 4 p refs (For primary document see N78-31745 22-54)
Avail: NTIS HC A07/MF A01

Neurophysiological methods are used to assess functional states of the brain with precision that surpasses that of classical psychological methods. Not only neurological syndromes but also slight changes on the vigilance scale as well as functional changes associated with cognitive and intellectual functions can be correlated with the electrical activity of the brain and hereby be objectively determined. G.G.

N78-31756# Naval Air Development Center, Warminster, Pa.
THE HUMAN OPERATOR SIMULATOR: WORKLOAD ESTIMATION USING A SIMULATED SECONDARY TASK
Norman E. Lane, Melvin I. Strieb (Analytics, Inc., Willow Grove, Pa.), and Robert J. Wherry, Jr. (Analytics, Inc., Willow Grove, Pa.) *In* AGARD Methods to Assess Workloads Jun. 1978 12 p refs (For primary document see N78-31745 22-54)
Avail: NTIS HC A07/MF A01

The use of the human operator simulator (HOS) for identifying potential workload problems is described. HOS is applicable during the midrange of system development, between early analytical prediction methods and later simulator evaluations. The HOS creates a software simulation of a trained human operator, his system hardware/software, and required interfaces. The results demonstrate the applicability of HOS for workload evaluation and explore HOS operator behavior under varying conditions of task demand. Problems of definition and methodology for current workload measures are discussed and alternatives identified using HOS to control task difficulty and task demand parameters. The implications of HOS application for cost and flexibility improvements are examined, and further developments of the model for workload evaluation are prepared. G.G.

N78-31757# Naval Air Development Center, Warminster, Pa. Dept. of Crew Systems.
OPERATOR WORKLOAD ASSESSMENT MODEL: AN EVALUATION OF A VF/VA-V/STOL SYSTEM
Paul M. Linton, Dieter W. Jahns (Boeing Co., Seattle, Wash.), and Paul R. Chatelier (NASC, Washington, D. C.) *In* AGARD Methods to Assess Workloads Jun. 1978 12 p refs (For primary document see N78-31745 22-54)
Avail: NTIS HC A07/MF A01

The term operator workload generally refers to a concept used in evaluating the extent to which a human operator is occupied with meeting system demands. By systematically describing the steps undertaken to estimate the workload in a conceptual fighter/attack V/STOL aircraft, meeting Navy mission requirements, it is shown that while a single crewmember can probably manage the V/STOL in its primary mission phases, additional and refined workload assessment evaluations are required to conclusively settle the issue for all aspects of deployment. G.G.

N78-31758# School of Aerospace Medicine, Brooks AFB, Tex.
MATHEMATICAL ANALYSIS AND COMPUTER SIMULATION IN MILITARY MISSION WORKLOAD ASSESSMENT
Richard A. Albanese *In* AGARD Methods to Assess Workloads Jun. 1978 7 p refs (For primary document see N78-31745 22-54)
Avail: NTIS HC A07/MF A01

Mathematical and computer approaches to the assessment of crew workload during military missions are discussed. Three analysis tools are reported: (1)estimation algorithms, (2) linear models; and (3) nonlinear/hybrid models. These separate but interacting methods provide increasing levels of detail with the focus on methods which attempt to determine whether a typical aircrew can accomplish the workload presented to it by an aircraft weapon system and mission requirements. G.G.

N79-16560# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France)
OPTIMISATION OF PILOT CAPABILITY AND AVIONIC SYSTEM DESIGN
F. S. Stringer, ed. Nov. 1978 95 p refs (AGARD-AR-118, ISBN-92-835-1292-8) Avail: NTIS HC A05/MF A01

The objective of the Group was to prepare a joint report which would guide future combat aircraft and system designers to achieve a better blend of aircrew and machine. For individual titles, see N79-16561 through N79-16568.

N79-16561# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France)
OPTIMISATION OF PILOT CAPABILITY AND AVIONIC SYSTEM DESIGN, INTRODUCTION
In its Optimisation of Pilot Capability and Avionic System Design Nov. 1978 4 p (For primary document see N79-16560 07-54)
Avail: NTIS HC A05/MF A01

The main objectives are to curb the continued development of more sophisticated equipment which disregards the human factors, to examine the aircrew potential, and to suggest how the latter could be better exploited to satisfy the operational requirements. The crew capabilities and limitations are examined, and then methods are devised to match the system to these capabilities. Training methods that will best exploit aircrew capabilities are discussed. L.S.

N79-16562# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France)
HUMAN CAPABILITIES
In its Optimisation of Pilot Capability and Avionic System Design Nov. 1978 6 p refs (For primary document see N79-16560 07-54)
Avail: NTIS HC A05/MF A01

A brief description is given of man's capabilities. A bibliography is provided to allow more detailed study of specific aspects.
Author

N79-16563# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France)
SYSTEMS DESIGN
In its Optimisation of Pilot Capability and Avionic System Design Nov. 1978 18 p refs (For primary document see N79-16560 07-54)
Avail: NTIS HC A05/MF A01

It is pointed out that in designing man machine subsystems, technology offers many similar solutions in answer to each partial problem and as a result design decisions are liable to be taken on a limited number of possible alternatives open to analysis, thus sometimes giving rise to vague criteria. It is stressed that systematic analysis techniques are needed to combat this problem. L.S.

N79-16564# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France)
PILOT WORKLOAD QUALIFICATION FOR AVIONICS DESIGN
In its Optimisation of Pilot Capability and Avionic System Design Nov. 1978 8 p refs (For primary document see N79-16560 07-54)
Avail: NTIS HC A05/MF A01

Recent avionics development has been in the direction of increasing complexity, cost, and separation of aircraft control from the human pilot. One current underlying philosophy in avionics design seems to be to remove aircraft control from the human pilot whenever the required profile requires him to handle flight information at a rate beyond his inherent capability. This philosophy has probably resulted in avionics over-automation. A properly posed avionics system design problem should include human capability constraints cast in systems engineering terms. It is this modelling of human capability which is treated here.
Author

N79-16565# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
TRAINING IMPLICATIONS
In its Optimisation of Pilot Capability and Avionic System Design Nov. 1978 12 p refs (For primary document see N79-16560 07-54)
Avail: NTIS HC A05/MF A01

The fascination with technology resulted in a tendency to optimize the equipment portion of a system, sometimes almost

to exclusion of considerations for the human who must operate the system. This trend toward automation and sophisticated equipment has apparently contributed to the ever-increasing cost of aircraft. The purpose here is to review the concept of reducing the level of automation and increasing the responsibility for task completion to the man in the man-machine loop and possible implications for training. Author

N79-16566# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
THE DESIGN OF AIR COMBAT AIRCRAFT
In its Optimisation of Pilot Capability and Avionic System Design Nov. 1978 16 p refs (For primary document see N79-16560 07-54)
Avail: NTIS HC A05/MF A01

Various ways are suggested in which the crew station designer could reduce avionics complexity and costs, depending upon the aircraft mission. The air combat aircraft is taken as an example. Firstly, the combat aircraft missions are described. Then some of the associated problems are considered, followed by suggested methods to reduce complexity and cost of the avionics of this type of aircraft. Methods used in the design of the total aircraft system, are discussed subsequently together with the system tradeoffs the designer must face. Conclusions and recommendations for future research are then offered. Author

N79-16567# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
GROUND ATTACK
In its Optimisation of Pilot Capability and Avionic System Design Nov. 1978 7 p (For primary document see N79-16560 07-54)
Avail: NTIS HC A05/MF A01

The ground attack aircraft missions are described. Some of the associated problems are considered, followed by suggested methods to reduce complexity and cost of the avionics of this type of aircraft. Methods used in the design of the total aircraft system, are discussed together with the system tradeoffs the designer must face. L.S.

N79-16568# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
THE HELICOPTER
In its Optimisation of Pilot Capability and Avionic System Design Nov. 1978 9 p refs (For primary document see N79-16560 07-54)
Avail: NTIS HC A05/MF A01

The main theme of this discussion on helicopters is the optimisation of the balance between human capability and system automation with the object of providing the most effective operational system and the most cost effective designs of both helicopter and equipment. Author

N79-31941# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France)
CONTRIBUTIONS OF PSYCHOPHYSIOLOGICAL TECHNIQUES TO AIRCRAFT DESIGN AND OTHER OPERATIONAL PROBLEMS
Robert D. ODonnell (Aerospace Med. Res. Lab., Wright-Patterson AFB, Ohio) Jul. 1979 88 p refs
(AGARD-AG-244; ISBN-92-835-1325-8) Avail: NTIS HC A05/MF A01

Various techniques of proven or potential value to applied areas of human engineering in general, and noting the instances of their application to the human factors of aircraft design in particular are presented. Emphasis was given to the techniques revealing the processes of intervining between stimulus and response. Techniques and problems of psychophysiological measurements are considered along with the current status and future possibilities of research in the areas of sensation and cognition. M.M.M.

N79-31942# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France)
HUMAN FACTORS ASPECTS OF AIRCRAFT ACCIDENTS AND INCIDENTS
B. O. Hartman, ed. (School of Aerospace Medicine) Jun. 1979 95 p refs In ENGLISH and FRENCH. Presented at the Aerospace Med. Panel Specialists' Meeting, Paris, 6-10 Nov. 1978
(AGARD-CP-254; ISBN-92-835-0241-8) Avail: NTIS HC A05/MF A01

A broad spectrum of aircraft accident areas and a number of different approaches to the problem are presented with emphasis on stress and its effects on the body, cognition, and the emotions. For individual titles, see N79-31943 through N79-31953.

N79-31943# Air Force Inspection and Safety Center, Norton AFB, Calif. Life Sciences Div.
THREE DECADES OF USAF EFFORTS TO REDUCE HUMAN ERROR ACCIDENTS, 1947-1977
Andrew F. Zeller *In* AGARD Human Factors Aspects of Aircraft Accidents and Incidents Jun. 1979 9 p (For primary document see N79-31942 22-54)
Avail: NTIS HC A05/MF A01

Thirty years after the formal inception of the USAF, major accidents had been reduced from 1,555 to 90. Human error associated with these accidents was reduced as much as material and other involvements. Analysis of the preventive efforts shows three distinct, although overlapping, approaches which have been employed. The administrative approach is the best known. This investigate-evaluate-fix cycle is the common dimension of almost all accident prevention effort. The scientific approach supplements the information by centering upon a systematic and intensive evaluation of human limitations in a defined man/machine setting. The third concept, total system management, emphasizes improvement in the management of the entire system, though the details of what will be instrumental in the prevention of a specific accident are often not defined. In practice, a viable accident prevention program incorporates all three approaches with emphasis defined in relation to need. A.R.H.

N79-31944# Tactical Air Command, Langley AFB, Va. Aerospace Medicine Div.
MEDICAL AND OPERATIONAL FACTORS OF ACCIDENTS IN ADVANCED FIGHTER AIRCRAFT
Leonard W. Johnson, Jr. *In* AGARD Human Factors Aspects of Aircraft Accidents and Incidents Jun. 1979 4 p (For primary document see N79-31942 22-54)
Avail: NTIS HC A05/MF A01

The proper mix and interface between improving aircraft capabilities and man's capabilities and limitations produce success in aerial and aerospace operations. A dysequilibrium between the medical and operational aspects of man and aircraft combine to produce accidents. Some of man's physiological systems and advanced fighter aircraft characteristics are described as well as multiple operational requirements imposed on men who fly high performance fighter aircraft. The interface between the operational requirements and the medical aspects of some of the accidents therein are related. The establishment, in NATO, of a viable aircraft accident information gathering and dissemination program which would prevent accidents in advanced fighter aircraft is proposed. A.R.H.

N79-31945# Belgian Air Force, Brussels
ANALYSIS OF THE INTERVENTION OF THE HUMAN FACTOR AS A PRINCIPAL CAUSE OR INFLUENCE IN ACCIDENTS OF MIRAGE AIRCRAFT IN THE BELGIAN AIR FORCE [ANALYSE DE L'INTERVENTION DU FACTEUR HUMAIN EN TANT QUE CAUSE PRINCIPALE OU D'INFLUENCE DANS LES ACCIDENTS D'AVIONS MIRAGE A LA FORCE AERIENNE BELGE]
A. Flion *In* AGARD Human Factors Aspects of Aircraft Accidents and Incidents Jun. 1979 6 p In FRENCH (For primary document see N79-31942 22-54)
Avail: NTIS HC A05/MF A01

Statistics are presented showing that, between 1971 and 1977, human factors were responsible for 56 of 91 accidents involving Mirage aircraft used by the Belgian Air Force. Certain parameters likely to be considered eventually in the notion of human factors are analyzed. These include the age of the pilot, his flight experience, the circumstances of the accident in the design of the mission accomplished, the pilot's previous medical history (both physical and psychical), the intervention of leadership, and the interferential factors happening unexpectantly in the triangle formed by man-medium-machine. The effects of the accidents on the pilots are analyzed showing the injuries received, the duration of limited aptitude, and their post-accident careers. Transl. by A.R.H.

N79-31946# Institute of Aviation Medicine, Farnborough (England)
THE PSYCHOLOGIST IN AIRCRAFT ACCIDENT INVESTIGATION
R. G. Green and R. M. Taylor *In* AGARD Human Factors Aspects of Aircraft Accidents and Incidents Jun. 1979 5 p refs (For primary document see N79-31942 22-54)
Avail: NTIS HC A05/MF A01

It is well established that in both military and civil flying operations, a large proportion of all accidents occur in serviceable

aircraft where the only failure in the system was in the human element. There is therefore an obvious case for the psychologist to attempt to understand the nature of the errors which are made in the hope that such an understanding may lead to the avoidance of such errors. The way in which RAF psychologists are involved in the accident investigation process is described. The way in which this work has enabled accidents to be categorized is also speculatively discussed and compared with the findings of more academic work. Author

N79-31947# Centro di Studi e Ricerche di Medicina Aeronautica e Spaziale, Rome (Italy)

THE INFORMATION IN AIRCRAFT ACCIDENTS INVESTIGATION

G. Paolucci. *In* AGARD. Human Factors Aspects of Aircraft Accidents and Incidents. Jun. 1979. 5 p. (For primary document see N79-31942 22-54)

Avail: NTIS. HC A05/MF A01

In aircraft accidents, the data achieved by the survey on the spot are completed by information, contributing to reach in such a way the cause of the accident. The fields to investigate are the event, and the man, the machine, and the medium - before, *during, and after the accident.* Particular attention has to be paid to the witnesses, not only for their declaration, but even and mostly, for the trustworthiness of their evaluation. Ways and techniques for collecting information in this type of investigation are outlined. A.R.H.

N79-31948# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Oberpfaffenhofen (West Germany). Inst. *fuer Physik der Atmosphaere*

THE LIMITED RANGE OF THE HUMAN EYE FOR OPTICAL AIRCRAFT ACQUISITION

H.-E. Hoffmann. *In* AGARD. Human Factors Aspects of Aircraft *Accidents and Incidents.* Jun. 1979. 11 p. refs. (For primary document see N79-31942 22-54)

Avail: NTIS. HC A05/MF A01

A pilot flying according to visual flight rules receives the *first information* from an approaching aircraft when he can just see this aircraft. The distance in which the approaching aircraft can just be seen i.e. detected, is among other things dependent on the contrast threshold of the human eye. The contrast threshold value indicates what extent must have the difference of luminance between object and its background so that this luminance difference can be just perceived. The DFVLR made experiments determining the influence of different contrast threshold values on the maximum detection range, that range in which an approaching aircraft just can be seen. The results of these experiments were also influenced by environmental parameters (e.g. degree of atmospheric turbidity, background, adaptation luminance) and by characteristics of the approaching aircraft (e.g. inherent contrast, size). The conduct of the experiments is described. Author

N79-31949# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick (West Germany).

ANALYSES OF MIDAIR COLLISIONS IN GERMAN AIRSPACE: METHODOLOGY AND RESULTS

O. Weber. *In* AGARD. Human Factors Aspects of Aircraft Accidents and Incidents. Jun. 1979. 14 p. refs. (For primary document see N79-31942 22-54)

Avail: NTIS. HC A05/MF A01

Theoretical studies concerning conflict detection and resolution in visual meteorological conditions by means of the see and avoid concept, and lessons learned from analyses of midair accidents in German airspace are addressed. The methodology is concerned with some supplementary aspects of the visual detection of an aircraft, *the observation and extrapolation of its* flight path, and the distance limits where an efficient maneuver can be initiated taking observation errors into account. Restrictions of a pilot's ability to detect an approaching aircraft caused by a *small apparent size or unfavorable silhouette of that aircraft,* and by opaque structures in his cockpit are discussed. Also treated is the apparent track of an aircraft on the windshield in front of the observing pilot. The features of five real midair *conflicts in German airspace are demonstrated.* G.Y.

N79-31950# Institute of Aviation Medicine, Farnborough (England)

PILOT INCAPACITY IN FLIGHT

D. C. Reader. *In* AGARD. Human Factors Aspects of Aircraft Accidents and Incidents. Jun. 1979. 5 p. refs. (For primary document see N79-31942 22-54)

Avail: NTIS. HC A05/MF A01

Incapacity of any crew member of an airplane can have serious implications for *the aircraft and occupants. However, in* the case of the pilot, the outcome can be disastrous. The hazards of pilot incapacity can be reduced by carrying more than one pilot (such as in transport aircraft). The pilot can be removed *from the controls in time to retain control of the aircraft.* However, under certain conditions (for instance at low altitudes) this may not be possible; moreover, the pilot may slump forward and restrict the controls. Various restraint systems were devised and *these were considered* in turn to determine whether their use could avoid the hazards. The incidence of pilot incapacitation was reviewed in both military and civil aircraft and the risk compared with other flight hazards. G.Y.

N79-31951# Institute of Aviation Medicine, Farnborough (England). General Psychology Section

GEOGRAPHICAL DISORIENTATION AND FLIGHT SAFETY

R. M. Taylor. *In* AGARD. Human Factors Aspects of Aircraft Accidents and Incidents. Jun. 1979. 11 p. refs. (For primary document see N79-31942 22-54)

Avail: NTIS. HC A05/MF A01

Geographical orientation is the psychological process whereby the aircraft pilot maintains an awareness of his position in relation to geographical points. The antithesis, geographical disorientation is a common occurrence in flight, the consequences of which vary in seriousness. Case studies of individual accidents and incidents indicated that in many respects geographical disorientation in flight can be as insidious, compelling and as stressful as spatial disorientation. Geographical disorientation may precipitate spatial disorientation and vice versa. In severe cases, where the realization of the error is sudden, there is evidence of panic and disorganization of behavior leading to loss of control of the aircraft. Preventative actions that may reduce the incidence of geographical disorientation include better training and preflight planning, improved awareness of the problem, elimination of system induced errors, and improved navigation aids, including maps and charts. G.Y.

N79-31952# Italian Air Force Medical Service H.Q., Rome

HUMAN FACTORS IN PRODUCTION AND PREVENTION OF AIRCRAFT ACCIDENTS DUE TO DISORIENTATION IN FLIGHT

Gaetano Rotondo. *In* AGARD. Human Factors Aspects of Aircraft Accidents and Incidents. Jun. 1979. 6 p. refs. (For primary document see N79-31942 22-54)

Avail: NTIS. HC A05/MF A01

To prevent and reduce those flight accidents occasionally due to spatial disorientation, which are tied to the human factor *and whose causes can, therefore, be influenced and corrected,* it is very important that the pilot has exact knowledge of the possible illusory phenomena which can occur in flight, the awareness that they can be anticipated, and finally that timely actuation of adequate preventive measures allows one to avoid loss of orientation during the various conditions of flight. For that reason the most frequent circumstances and conditions should be examined which can facilitate spatial disorientation in the pilot favoring the mental conflict which originates when there is sensorial incongruity between erroneous sensations coming from the vestibular apparatus and/or the proprioceptors and inadequate visual information. The possible measures necessary to prevent those various conditions contributing to or facilitating disorientation in flight, or neutralizing them whenever they are already in effect, are discussed. G.Y.

N79-31953# *National Defence Headquarters, Ottawa (Ontario)*

BETWEEN INCIDENT AND ACCIDENT

M. L. Tepper and N. H. Haakonson. *In* AGARD. Human Factors Aspects of Aircraft Accidents and Incidents. 1979. 6 p. refs. *(For primary document see N79-31942 22-54)*

Avail: NTIS. HC A05/MF A01

In the evolution of an aircraft occurrence combined stress often plays a significant role. Conceptual models of how a combination of stress inducing factors can lead to the no man's land between normal operation and incident, between incident and accident are presented. The models are primarily for presentation to aircrew when discussing stress. G.Y.

N80-14728# Advisory Group for Aerospace Research and Development, Paris (France)

MAINTENANCE OF AIR OPERATIONS WHILE UNDER ATTACK WITH CHEMICAL AGENTS

J Ernsting, ed (RAF Inst of Aviation Med., Farnborough, U.K.) Sep 1979 51 p Presented at the Aerospace Med Panel's Specialists' Meeting, Brussels, 22-26 Jan 1979
(AGARD-CP-264-Suppl; ISBN-92-835-0251-5) Avail: NTIS HC A04/MF A01

The capability of NATO Forces to maintain air operations while under attack with chemical agents depends on effective personal and collective protection for the aircrew and ground personnel while allowing them to perform adequately their operational duties. Topics cover the effects and detection of chemical warfare agents as well as protection against them. For individual titles, see N80-14729 through N80-14738.

N80-14729# Aberdeen Proving Ground, Md. Biomedical Lab
THE EFFECTS OF ACUTE AND CHRONIC LOW DOSE EXPOSURE TO ANTICHOLINESTERASES
F. C. Cadigan and M. Chipman *In* AGARD Maintenance of Air Operations While Under Attack with Chem. Agents Sep. 1979 3 p refs (For primary document see N80-14728 05-54)
Avail: NTIS HC A04/MF A01

Acute sublethal and chronic subclinical exposures to toxic anticholinesterases may result in long term neurobehavioral deficits. The deficits most likely to occur include: slowed reaction times, erratic mood swings, sleep disturbances, and impaired visual memory. Individuals who operate high performance equipment and are acutely exposed should be kept off the job until examinations of brain function are normal. Author

N80-14730# School of Aerospace Medicine, Brooks AFB, Tex.
CONSIDERATION OF PYRIDOSTIGMINE AS A PROPHYLACTIC AGENT FOR AIRCREW
B. Richardson *In* AGARD Maintenance of Air Operations While Under Attack with Chem. Agents Sep. 1979 2 p refs (For primary document see N80-14728 05-54)
Avail: NTIS HC A04/MF A01

The carbamate pyridostigmine shows considerable promise as a first-generation prophylatic for nerve agent poisoning. Although it is unlikely to yield all the benefits desirable, the potential utility of pyridostigmine in conjunction with appropriate therapy warrants detailed study. Author

N80-14731# Norwegian Defence Research Establishment, Kjeller. Toxicology Div.
THE EFFECT OF LOCALLY APPLIED ORGANOPHOSPHATES ON MIOSIS AND ACETYLCHOLINESTERASE ADAPTATION TO CHRONIC TREATMENT
Didrik Malthe-Sorenssen, Nils E. Soli, and Frode Fonnum *In* AGARD Maintenance of Air Operations While Under Attack with Chem. Agents Sep. 1979 5 p refs (For primary document see N80-14728 05-54)
Avail: NTIS HC A04/MF A01

Topical administration of organophosphates to the eye of guinea pigs inhibited acetylcholinesterase of different parts of the eye to a different degree. The differences reflected most likely dilution of the agent caused by diffusion into the eye. The effect of locally applied organophosphates was ascribed to an effect on the iris and ciliary muscle and not on the retina. The degree of miosis and recovery of pupillary function after soman treatment correlated better to inhibition of external acetylcholinesterase than total acetylcholinesterase. Chronic treatment with soman reduced the miotic potency of soman and reduced the recovery time of the miosis. This adaptation was dependent on other factors than cholinergic. Local treatment of miosis with topical application of oximes to the eye reduced the miosis and reactivated acetylcholinesterase in the cornea and iris. The reactivation was enhanced in the presence of benzalkonium.
Author

N80-14732# Federal Armed Forces Medical Coll., Munich (West Germany). Dept. of Toxicology and Pharmacology.
THERAPY ON NERVE AGENT POISONING
Nikolaus P. Weger *In* AGARD Maintenance of Air Operations While Under Attack with Chem. Agents Sep. 1979 4 p refs (For primary document see N80-14728 05-54)
Avail: NTIS HC A04/MF A01

The therapeutic properties of various combinations of the bispyridinium salts HS-3 and HS-6 and the cholinolytics atropine and benactyzine against soman poisoning were investigated in unanesthetized male beagles. Present data demonstrate that from all antidotes tested HGG-12-Cl and HGG-42-J in doses effective for treatment of men show good therapeutic effects in beagles poisoned with soman, sarin, and Vx. Best effect has HGG-42-J in a dose of 30 micron Mol/kg (= 18.27 mg/kg). In soman poisoning no reactivation of serum cholinesterase and cholinesterase in erythrocytes was observed. Other mechanisms of therapeutic activity must be explored. A.R.H.

N80-14733# Air Force Systems Command, Wright-Patterson AFB, Ohio. Life Support System Program Office
APPROACHES TO CW AGENT AREA DETECTION SYSTEMS FOR AIRFIELDS
Francis T. Crimmins and John J. McCambridge *In* AGARD Maintenance of Air Operations While Under Attack with Chem. Agents Sep. 1979 10 p (For primary document see N80-14728 05-54)
Avail: NTIS HC A04/MF A01

United States Air Force (USAF) efforts to develop a chemical agent area detection system for the protection of air bases are examined. Point detection techniques which might provide a limited and interim area detection capability are discussed and the A/E23D-3 Chemical Agent Automatic Alarm and its characteristics are described. The USAF requirement for an instrument which will detect toxic chemical agents before they reach the intended target along with the capabilities such a detector must possess are presented. The Air Force's present views on how such a system might operate are explored. A.R.H.

N80-14734# Air Force Systems Command, Wright-Patterson AFB, Ohio. Life Support System Program Office
PHILOSOPHY OF PROTECTION OF US AIRCREWS AGAINST CHEMICAL WARFARE AGENTS
John J. McCambridge and D. E. Root *In* AGARD Maintenance of Air Operations While Under Attack with Chem. Agents Sep. 1979 2 p (For primary document see N80-14728 05-54)
Avail: NTIS HC A04/MF A01

In 1975, the USAF recognized the need to provide protective equipment to aircrews that would allow them to accomplish their operational missions after having been attacked by an enemy using chemical warfare agents. This requirement was deemed to be an urgent one; thus, a two phase program was initiated. Phase one was the development and production of near term equipment which would provide the required operational capability with delivery of equipment to the field to begin within two years. Phase two consists of a longer term program to provide more complete protection with a reduced operational burden.
Author

N80-14735# Service Technique de l'Aeronautique, Paris (France)
CONCERNING INDIVIDUAL EQUIPMENT FOR FIGHTER PILOTS IN THE AIR FORCE [A PROPOS DES EQUIPEMENTS INDIVIDUELS DES PILOTES DE CHASSE DE L'ARMEE DE L'AIR]
P. H. V. Gaspa *In* AGARD Maintenance of Air Operations While Under Attack with Chem. Agents Sep. 1979 3 p In FRENCH (For primary document see N80-14728 05-54)
Avail: NTIS HC A04/MF A01

In addition to the protection provided for all the armed services by way of protective suits, gloves, foot coverings, and masks for filtering particles, aircraft pilots require equipment that must be integrated with the aircraft, with parachutes, with the oxygen supply, and with survival equipment. It must meet the particular specification to provide minimal comfort needed to maintain the potential psychophysiology of the pilots, so they can accomplish their mission (which is always delicate in three dimensional space) in the midst of toxic flight factors and enemy intervention. There must be no thermal nor respiratory constraints. The design of equipment cannot impede pilot movements, the observation of parameters useful for flight, the carrying out of certain commands, nor the tactile agility of the fingers. Transl. by A.R.H.

N80-14736# Air Force Systems Command, Wright-Patterson AFB, Ohio. Life Support System Program Office
US AIRCREW CHEMICAL DEFENSE ASSEMBLIES
Charles H. Leone and Paul F. Fallon *In* AGARD Maintenance of Air Operations While Under Attack with Chem. Agents Sep. 1979 7 p (For primary document see N80-14728 05-54)
Avail: NTIS HC A04/MF A01

The current aircrew chemical defense ensemble which is divided into four subsets: eye/respiratory/head, body, hand and foot protection is described. The associated chemical agent and flight qualification testing is discussed for each piece of equipment. The status of follow on development efforts which concentrate on the aircrew chemical defense eye/respiratory/head protection is reviewed. A.R.H.

N80-14737# Bluecher G.m.b.H. Duesseldorf (West Germany).
FRG AIRCREW CHEMICAL DEFENCE ASSEMBLIES

Hubert vonBluecher *In* AGARD Maintenance of Air Operations While Under Attack with Chem. Agents Sep. 1979 4 p (For primary document see N80-14728 05-54)
Avail: NTIS HC A04/MF A01

Topics covered include: (1) nonbattle casualty (NBC)-protection gloves for high performance aircraft pilots; (2) SAr spherical adsorber systems; (3) the NBC-protective suit (or garment) for German propeller-aircraft pilots with emphasis on construction of the materials, life-time, and influence of water and sweat; and (4) flame-proofing for NBC-protective clothing. A.R.H.

N80-14738# Air Force Systems Command, Wright-Patterson AFB, Ohio. Life Support System Program Office.
INTEGRATION OF PROTECTION AGAINST CHEMICAL WARFARE AGENTS WITH AIRCREW PERSONAL EQUIPMENT
John J. McCambridge and Charles H. Leone *In* AGARD Maintenance of Air Operations While Under Attack with Chem. Agents Sep. 1979 3 p (For primary document see N80-14728 05-54)
Avail: NTIS HC A04/MF A01

Protection of the aircrew member through personal equipment is a concept which assumes that such protection can not be provided in any other way. Current efforts to incorporate chemical defensive capabilities into protective equipment for the eyes, respiratory system, body, hands, and feet are described. Integration of chemical agent protection into life support systems on a superior plane would eliminate the need for providing protection through personal equipment - a shirt sleeve environment, so to speak. Such a concept would require protection of the cockpit interior at all times from the introduction of chemical agents and would require the effective filtration of influent air by the environmental control systems. A.R.H.

N80-14739# Advisory Group for Aerospace Research and Development, Paris (France).
SURVEY OF METHODS TO ASSESS WORKLOAD
Bryce O. Hartman, ed. (School of Aerospace Med.) and Richard E. McKenzie, ed. (School of Aerospace Med.) Aug. 1979 160 p *refs*
(AGARD-AG-246; ISBN-92-835-1332-0) Avail: NTIS HC A08/MF A01

Methods of measuring aircrew workload are reviewed. The methods reviewed include areas of systems design engineering, operations research, the behavioral sciences, aerospace medicine, physiology, biochemistry, and biotechnology in general. The measurement domains include measures of sensory threshold, measures of sensory integration, cognitive function tests, measures of motor function, vigilance, reaction time, psychophysiologic responses, and physiologic and biochemical changes. For individual titles, see N80-14740 through N80-14758.

N80-14740# Gartner (Walter B.) and Murphy (Miles R.), Menlo Park, Calif.
CONCEPTS OF WORKLOAD
Walter B. Gartner and Miles R. Murphy *In* AGARD Surv. of Methods to Assess Workload Aug. 1979 p 1-2 refs (For primary document see N80-14739 05-54)
Avail: NTIS HC A08/MF A01

A summary of the attempts made to quantify the workload imposed on a pilot by a particular aircraft design or operational procedure, or to access the effects of fatigue upon system performance are discussed in regard to the more precise specification of workload and fatigue concepts and to the adequacy of assessment criteria and techniques. The principle unresolved issues in conceptualizing and measuring pilot workload and fatigue are addressed. The conception of workload is divided into three functionally related components: (1) input load, (2) operator effort, and (3) work result. A.W.H.

N80-14741# Gartner (Walter B.) and Murphy (Miles R.), Menlo Park, Calif.
CONCEPTS OF FATIGUE
Walter B. Gartner and Miles R. Murphy *In* AGARD Surv. of Methods to Assess Workload Aug. 1979 p 3-5 refs (For primary document see N80-14739 05-54)
Avail: NTIS HC A08/MF A01

A survey of the concepts of pilot fatigue is reviewed. The problem in defining the concept of fatigue and dealing effectively with fatigue is discussed. Factors such as task demands or protracted effort toward fatigue are investigated. Factors such as individual differences in personality, motivation, physical fitness and life style are considered in the investigation. A.W.H.

N80-14742# School of Aerospace Medicine, Brooks AFB, Tex. Crew Technology Div.
CONCEPTS OF STRESS
Richard E. McKenzie *In* AGARD Surv. of Methods to Assess Workload Aug. 1979 p 7-9 refs (For primary document see N80-14739 05-54)
Avail: NTIS HC A08/MF A01

A survey of studies on the concept of stress from flight fatigue is presented. The physiological and psychological factors resulting from stress are examined. Relaxation as an adaptive response to stress is discussed. The use of biofeedback as an adaptive strategy for stress is studied. A.W.H.

N80-14743# Italian Air Force Medical Service H. Q., Rome.
SOME CONSIDERATIONS CONCERNING METHODS TO EVALUATE AND ASSESS WORKLOAD IN AIRCRAFT PILOTS
Gaetano Rotondo *In* AGARD Surv. of Methods to Assess Workload Aug. 1979 p 11-12 refs (For primary document see N80-14739 05-54)
Avail: NTIS HC A08/MF A01

Methods for analyzing the various stressing and fatiguing factors that act on the body and psyche of aircrafts' pilots during their specific activity are examined. The variations in the urinary excretion of corticosteroids and especially catecholamine during stress and fatigue are discussed. A.W.H.

N80-14744# School of Aerospace Medicine, Brooks AFB, Tex. Crew Technology Div.
PHYSIOLOGIC ASPECTS OF WORKLOAD/FATIGUE/STRESS
Layne P. Perelli *In* AGARD Surv. of Methods to Assess Workload Aug. 1979 p 13-16 refs (For primary document see N80-14739 05-54)
Avail: NTIS HC A08/MF A01

The physiological mechanisms of the aircraft pilot reacting to the effects of workload, the effects of fatigue, or the effects of stress are described. The long term physiological indicators of stress, workload and fatigue recovered from pilots and measured as urinary metabolites are examined. The cardiac activity indicators, heart rate and heart rate variability, are discussed as a tool in evaluating pilot workload. A.W.H.

N80-14745# School of Aerospace Medicine, Brooks AFB, Tex. Crew Technology Div.
SOME INSIGHTS RELATIVE TO THE MAN-MACHINE SYSTEM: AN OVERVIEW OF TEN YEARS OF RESEARCH
Richard E. McKenzie and Bryce O. Hartman *In* AGARD Surv. of Methods to Assess Workload Aug. 1979 p 17-18 refs (For primary document see N80-14739 05-54)
Avail: NTIS HC A08/MF A01

The operator skills and the specific tasks involved in current operational aircraft, airborne weapons systems, and space systems are discussed in relation to pilot performance. The effects of fatigue and/or stress upon the pilot operating the systems are reviewed through past research methods. The relationship between information processing ability and aircrew performance is examined. A.W.H.

N80-14746# Virginia Polytechnic Inst. and State Univ., Blacksburg.
AIRCREW WORKLOAD ASSESSMENT TECHNIQUES
Walter W. Wierwille, Robert C. Williges, and Samuel G. Schiflett (NATC, Patuxent River, Md.) *In* AGARD Surv. of Methods to Assess Workload Aug. 1979 p 19-54 refs (For primary document see N80-14739 05-54)
Avail: NTIS HC A08/MF A01

A classification scheme is presented which summarizes a survey and analysis of aircrew workload assessment techniques relevant to inflight test and evaluation considerations. Two dimensions consisting of universal operator behaviors and workload assessment methodologies were used in the classification scheme. The universal operator behaviors were classified into categories including perceptual, mediational, communication, and motor processes; whereas the workload assessment methodologies were cataloged under the general categories of subjective opinion, spare mental capacity, primary task, and physiological measures. An applicability matrix based on this classification scheme is presented which summarizes existing research on workload assessment methodologies. Procedures are

described whereby this matrix is used as a guide for selecting candidate aircrew workload assessment measures for inflight evaluation. A brief overview of the various workload assessment techniques is presented along with a set of critical criteria that need to be considered in evaluating the feasibility of these measures for inflight environments. A.W.H.

N80-14747# Air Force Systems Command, Wright-Patterson AFB, Ohio. Human Engineering Div.
WORKLOAD ASSESSMENT METHODOLOGY DEVELOPMENT
Billy M. Crawford. *In* AGARD Surv. of Methods to Assess Workload Aug. 1979 p 55-67 refs (For primary document see N80-14739 05-54)
Avail: NTIS HC A08/MF A01

The development of a method to determine efficient crew compositions, appropriate assignments of duties and responsibilities to crew members, and effective allocations of functions and tasks among men, machines and computers is discussed. The use of the method to identify the critical periods in a task or mission during which the operator's performance is particularly prone to degradation or failure because of work overload stress is examined. Emphasis is placed on man computer interactions and information processing/decision making functions which are not adequately accounted for by conventional human performance metrics, task analysis, time and motion, and time line methods. A.W.H.

N80-14748# School of Aerospace Medicine, Brooks AFB, Tex.
QUANTITATIVE MILITARY WORKLOAD ANALYSIS
Richard A. Albanese. *In* AGARD Surv. of Methods to Assess Workload Aug. 1979 p 69-71 refs (For primary document see N80-14739 05-54)
Avail: NTIS HC A08/MF A01

A method of tradeoff analysis as applied to workload analysis in the military environment is discussed. It is suggested that workload studies be performed in a tradeoff setting which allows the analyst to estimate the return on investment he has earned through his proposed system modifications. The methodologies described employ mathematical modeling techniques, and it is reinforced that these techniques are an adjunct to, and not a replacement of, more traditional methods of workload analysis. K.L.

N80-14749# Army Aeromedical Research Lab., Fort Rucker, Ala.
VISUAL PERFORMANCE: A METHOD TO ASSESS WORKLOAD IN THE FLIGHT ENVIRONMENT
R. Simmons, M. Sanders, and K. Kimball. *In* AGARD Surv. of Methods to Assess Workload Aug. 1979 p 73-81 refs (For primary document see N80-14739 05-54)
Avail: NTIS HC A08/MF A01

A method of assessing the workload requirements imposed on the visual system is discussed. The results suggest that the theory is a valuable tool in testing and determining what the visual workload level should be for combat proficient pilots, how long pilots with varying degrees of proficiency should be expected to fly in the combat environment, and aircraft design requirements (such as stability) to reduce the onset of fatigue-induced errors. Additionally, the theory can be utilized to test and determine varying mission related workload, as well as the workload required by special equipment such as the night vision goggles, navigation equipment, and experimental flight displays. K.L.

N80-14750# Royal Aircraft Establishment, Bedford (England).
HANDLING QUALITIES, WORKLOAD AND HEART RATE
Alan H. Roscoe. *In* AGARD Surv. of Methods to Assess Workload Aug. 1979 p 83-91 refs (For primary document see N80-14739 05-54)
Avail: NTIS HC A08/MF A01

Examples are given of the use of heart rates to augment pilots' opinions of handling and workload during various flight trials. It is shown that this technique gives reasonably good indications of the workload generated by particular handling qualities. Raw data in the form of beat-to-beat heart rate are invaluable for revealing rapid and short duration changes in handling qualities which affect workload. K.L.

N80-14751# Office of Naval Research, Arlington, Va.
BRAIN WAVES AND THE ENHANCEMENT OF PILOT PERFORMANCE
G. H. Lawrence. *In* AGARD Surv. of Methods to Assess Workload Aug. 1979 p 93-102 refs (For primary document see N80-14739 05-54)
Avail: NTIS HC A08/MF A01

Aspects of brain wave research and brain-behavior relationships that are potentially useful in simulated aircraft crew stations are discussed. A pilot performance research paradigm for studying the use of brain waves is presented. K.L.

N80-14752# California Univ. at Los Angeles. Dept. of Psychology.
PUPILLOMETRIC METHODS OF WORKLOAD EVALUATION: PRESENT STATUS AND FUTURE POSSIBILITIES
Jackson Beatty. *In* AGARD Surv. of Methods to Assess Workload Aug. 1979 p 103-109 refs (For primary document see N80-14739 05-54)
Avail: NTIS HC A08/MF A01

The use of pupillometric measures in the evaluation of pilot workload is discussed. The innervation of the pupil is described with respect to its connections with brainstem activation systems. Modern methods for pupillometric measurement are described and a series of experiments describing pupillary response in a variety of information processing tasks is reviewed. K.L.

N80-14753# Dunlap and Associates, Inc., La Jolla, Calif.
AIRCREW PERFORMANCE RESEARCH OPPORTUNITIES USING THE AIR COMBAT MANEUVERING RANGE (ACMR)
Clyde A. Brictson and Anthony P. Ciavarelli. *In* AGARD Surv. of Methods to Assess Workload Aug. 1979 p 111-113 refs (For primary document see N80-14739 05-54)
(Contract N61339-77-C-0167)
Avail: NTIS HC A08/MF A01

Three years of aircrew performance measurement using the Navy's ACMR are presented as evidence of ACMR's research potential. Performance assessment methods used to evaluate pilot proficiency are described. The aircrew assessment methods are used to identify squadron performance differences, evaluate competitive exercises, and provide diagnostic training feedback to operational users. The use of continuously recorded quantitative measures from systems such as ACMR should stimulate more aircrew performance field research ideas. The availability of objective performance criteria promises to be of substantial benefit to both the operational user and the research community in such areas as pilot selection and training, fleet combat readiness, and pilot workload and stress. K.L.

N80-14754# Royal Air Force Inst. of Aviation Medicine, Farnborough (England).
SPEECH PATTERNS AND AIRCREW WORKLOAD
R. Cannings. *In* AGARD Surv. of Methods to Assess Workload Aug. 1979 p 115-127 refs (For primary document see N80-14739 05-54)
Avail: NTIS HC A08/MF A01

Research into the use of speech patterns for workload analysis is reviewed in terms of a simple speech production model. The applications of analysis techniques are considered. K.L.

N80-14755# National Aviation Facilities Experimental Center, Atlantic City, N. J.
AN EXPLORATORY STUDY OF PSYCHOPHYSIOLOGICAL MEASUREMENTS AS INDICATORS OF AIR TRAFFIC CONTROL SECTOR WORKLOAD
Richard E. McKenzie, Edward P. Buckley, and Kiriako Sarlanis. *In* AGARD Surv. of Methods to Assess Workload Aug. 1979 p 129-133 refs (For primary document see N80-14739 05-54)
Avail: NTIS HC A08/MF A01

The possibility of relating physiological measures to some aspects of the controller's task (ie. traffic density and the occurrence of aircraft conflicts) was explored. It was found that galvanic skin response changes in the subjects were more detectable using variations in measured amplitude as compared to frequency of galvanic skin response changes. K.L.

N80-14756# National Aviation Facilities Experimental Center, Atlantic City, N. J.
INDIVIDUAL AND SYSTEM PERFORMANCE INDICES FOR THE AIR TRAFFIC CONTROL SYSTEM
Edward P. Buckley, William F. OConnor, and Tom Beebe. *In* AGARD Surv. of Methods to Assess Workload Aug. 1979 p 135-136 (For primary document see N80-14739 05-54)
Avail: NTIS HC A08/MF A01

The relationships between field air traffic controller performance indices and system performance measures were examined. Performance criteria developed within the controller's home facility

where he controlled live traffic, and with a specially designed microsystem with simulated traffic were used. K.L.

N80-14767# Civil Aeromedical Inst., Oklahoma City, Okla. Aviation Physiology Lab.

WORKLOAD AND STRESS IN AIR TRAFFIC CONTROLLERS

Carl E. Melton *In* AGARD Surv. of Methods to Assess Workload Aug. 1979 p 137-144 refs (For primary document see N80-14739 05-54)

Avail: NTIS HC A08/MF A01

Data collected at 14 air traffic control facilities regarding air traffic controller (ATCS) workload and urinary stress indicator hormone excretion is reviewed. The data show a significant relationship between objective workload measures (radio transmission time and traffic counts) and indexes of catecholamine excretion. Mean epinephrine excretion by ATCS's at six air traffic control towers, ranging from very low to very high traffic density, was significantly ($R = 0.96$) related to annual traffic counts at those towers. The sympatho-adrenomedullary axis that prepares the organism for fight or flight is applicable to ATCS's. The question of underload, optimum load, and overload is discussed. K.L.

N80-14768# School of Aerospace Medicine, Brooks AFB, Tex. Crew Technology Div.

ASSESSMENT CORRELATES OF WORKLOAD AND PERFORMANCE

Richard E. McKenzie *In* AGARD Surv. of Methods to Assess Workload Aug. 1979 p 145-161 refs (For primary document see N80-14739 05-54)

Avail: NTIS HC A08/MF A01

Psychological, physiological, stress, and central nervous system correlates of assessment that may help in measuring and assessing human workload and performance are reviewed. Psychophysiological monitoring of central nervous function is discussed. K.L.

59 MATHEMATICAL AND COMPUTER SCIENCES (GENERAL)

N80-19809# Advisory Group for Aerospace Research and Development, Paris (France)
MODELING AND SIMULATION OF AVIONICS SYSTEMS AND COMMAND, CONTROL AND COMMUNICATIONS SYSTEMS
Jan. 1980 553 p refs Presented at the Meeting of the Avionics Panel, Paris, 15-19 Oct. 1979
(AGARD-CP-268, ISBN-92-835-0255-8) Avail: NTIS HC A24/MF A01

Simulation techniques and their applications to avionics and command, control, and communication systems associated with airborne operations are addressed. Modeling methodology, experimentation, validation, and applications are covered. Emphasis is on avionics and airborne command and control, including the range from large-scale force-effectiveness and air defense simulations through flight simulators and real time avionics simulations. For individual titles, see N80-19810 through N80-19847.

N80-19810# Syracuse Univ., N. Y. Dept. of Industrial Engineering and Operations Research
AN INTRODUCTION TO THE SELECTION AND USE OF SIMULATION LANGUAGES
Robert G. Sargent *In* AGARD Modeling and Simulation of Avionics Systems and Command, Control and Commun. Jan. 1980 4 p refs (For primary document see N80-19809 10-59)
Avail: NTIS HC A24/MF A01

An introduction to the selection and use of simulation languages for digital computers is given. The topics discussed are the hierarchy of computer languages and their relationship to simulation, the advantages and disadvantages of using simulation languages, the factors to consider in selecting simulation languages for an organization and a language for solving a specific problem, some characteristics of the simulation languages GASP, GPSS, SIMSCRIPT, SIMULA, and SLAM, and future developments in simulation languages. The emphasis is on discrete and combined simulation languages. J.M.S.

N80-19811# Syracuse Univ., N. Y. Dept. of Industrial Engineering and Operations Research
AN INTRODUCTION TO STATISTICAL ANALYSIS OF SIMULATION OUTPUT DATA
Robert G. Sargent *In* AGARD Modeling and Simulation of Avionics Systems and Command, Control and Commun. Jan. 1980 13 p refs Presented at the ACM 1976 Symp. on the Simulation of Computer Systems (For primary document see N80-19809 10-59)
Avail: NTIS HC A24/MF A01

Point and interval estimates (confidence intervals) of means for both terminal and steady state simulations are considered. The simple methods of replication, batch means, and regenerative cycles are presented in detail and applied to a model of a simple time shared computer system to illustrate their use. A brief discussion is included on sequential procedures and time series methods for obtaining these estimates. The advantages and disadvantages of the various methods are given, including specific recommendations as to when certain methods might be used. J.M.S.

N80-19812# Industrieanlagen-Betriebsgesellschaft m.b.H., Ottobrunn (West Germany)
REMARKS ON SIMULATION: OBJECTIVES, AREAS OF USE/POSSIBILITIES/LIMITATIONS: AN OVERVIEW
Hans M. Franke *In* AGARD Modeling and Simulation of Avionics Systems and Command, Control and Commun. Jan. 1980 27 p refs (For primary document see N80-19809 10-59)
Avail: NTIS HC A24/MF A01

An overview of the extensive application of computerized simulation to the study of flight mechanics is presented with special interest given to avionics and command and control and communication. Areas of use of simulation covered include the field of research, planning pre-design, assessment, and feasibility, the development phase, testing, and the training simulator. Systems analysis and systems engineering activities in the planning of new weapon systems are discussed in terms of the use of simulation. J.M.S.

N80-19813# Department of the Air Force, Washington, D.C. Tactical Systems Div.
REPRESENTING HUMAN THOUGHT AND RESPONSE IN MILITARY CONFLICT SIMULATION MODELS
Dennis K. Leedom *In* AGARD Modeling and Simulation of Avionics Systems and Command, Control and Commun. Jan. 1980 15 p refs (For primary document see N80-19809 10-59)
Avail: NTIS HC A24/MF A01

Conflict simulation models and the representation of human thought and response in such models are considered. The ideas presented relate to the modeling of conflict situations from single combat unit level up through theater force level. In particular, the use of such models for assessing the utility of tactical command and control (C2) systems is emphasized. J.M.S.

N80-19814# General Research Corp., Santa Barbara, Calif.
VERIFICATION AND VALIDATION OF AVIONIC SIMULATIONS
Sabina H. Saib *In* AGARD Modeling and Simulation of Avionics Systems and Command, Control and Commun. Jan. 1980 6 p (For primary document see N80-19809 10-59)
Avail: NTIS HC A24/MF A01

Avionic simulations require verification and validation so that the simulation results can be applied reliably to actual avionic systems. *Software design methods as well as currently available* automated aids for verification and validation are described. Reverification and revalidation of a simulation after changes are made is discussed. Simulations can be designed for ease of verification and validation. Guidelines to show how simulation software can be developed with verification in mind are presented. R.E.S.

N80-19815# Forschungsinstitut fuer Funk und Mathematik, Werthoven (West Germany)
OBJECTIVES FOR BUILDING AN EXPERIMENTAL CCIS
Ingrid Hollinde *In* AGARD Modeling and Simulation of Avionics Systems and Command, Control and Commun. Jan. 1980 10 p refs (For primary document see N80-19809 10-59)
Avail: NTIS HC A24/MF A01

The problem of integrating the command and control information systems (CCIS) into the C(2) process is presented and feasible strategies to develop CCISs are discussed. An experimental CCIS, the EMFIS, was developed and was used in WINTEX/CIMEX 79 to clarify the preconditions for the use of ADP-support in the C(2) process. The performance of the EMFIS *is described*. R.E.S.

N80-19816# Industrieanlagen-Betriebsgesellschaft m.b.H., Ottobrunn (West Germany)
SIMULATION OF OVERALL AIR DEFENSE COMMAND AND CONTROL
Reinhard Hutter *In* AGARD Modeling and Simulation of Avionics Systems and Command, Control and Commun. Jan. 1980 15 p refs (For primary document see N80-19809 10-59)
Avail: NTIS HC A24/MF A01

A computer model that quantifies the effect of early warning and command and control in terms of active air defense measures of effectiveness was developed. The model is described along with the main technical and operational procedures which will be followed in air defense in case of an air attack. The model is rather aggregated, highly input oriented, independent of specific systems and doctrines and thus offers flexibility of application to various technical and operational questions. The development status of other models is discussed. R.E.S.

N80-19817# Department of the Air Force, Washington, D.C. Tactical Systems Div.
THEATER AIR DEFENSE ENGAGEMENT SIMULATION-COMMAND/CONTROL/COMMUNICATIONS (TADENS-C(3)) AN APPROACH TO THEATER AIR DEFENSE MODEL/METHODOLOGY DEVELOPMENT
Urban H. D. Lynch *In* AGARD Modeling and Simulation of Avionics Systems and Command, Control and Commun. Jan. 1980 13 p (For primary document see N80-19809 10-59)
Avail: NTIS HC A24/MF A01

The theater air defense engagement simulation-command/control/communications (TADENS-C(3)) is a theater air defense model/methodology development whose goal is to timely produce a 'credible, agreeable, and usable' model/methodology to address

tactical (strategic) theater air defense and its associated problems/issues. The model development scope is presented. R.E.S.

N80-19818# Shape Technical Center, The Hague (Netherlands).
SIMULATION OF AIR DEFENCE OPERATIONS AND MULTIPLE AIR COMBAT
H. R. Wilhelm. *In* AGARD, Modeling and Simulation of Avionics Systems and Command, Control and Commun., Jan. 1980, 20 p. (For primary document see N80-19809 10-59)
Avail: NTIS HC A24/MF A01

The air defence system simulation model in use at the SHAPE Technical Centre is described. The model comprises detailed submodels for airborne and ground-based early warning sensors, command and control operations, ground-controlled intercepts, multiple air combat engagements, and electronic countermeasure operations. Modifications in hand will include the simulation of surface-to-air missile systems and will permit the interactive running of the model as a one-sided wargaming system with a battle manager commanding and controlling his air defence force via graphics displays. The computer configuration used in running the model is described and also the specific software methods employed. A three dimensional graphics facility was developed to facilitate the evolution and validation of tactics for modern fighter aircraft and future missiles. Additional validation methods were applied, such as the correlation of model results with live flying trails. A brief account of past and possible future applications is presented. R.E.S.

N80-19819# NATO Programming Centre, Tongeren (Belgium).
SIMULATION WITHIN MILITARY DEFENCE SYSTEMS FOR TRAINING AND EVALUATION
Hans-Jochen Wunschmann. *In* AGARD, Modeling and Simulation of Avionics Systems and Command, Control and Commun., Jan. 1980, 14 p. (For primary document see N80-19809 10-59)
Avail: NTIS HC A24/MF A01

The use of simulated radar pictures to support war games within the NATO Air Defense Ground Environment system is discussed. Simulation hardware and software are described along with the different phases of war gaming. K.L.

N80-19820# Institute of Aviation Medicine, Farnborough (England).
REAL-TIME SIMULATION: AN INDISPENSABLE BUT OVERUSED EVALUATION TECHIQUE
V. David Hopkin and A. J. McClumpha. *In* AGARD, Modeling and Simulation of Avionics Systems and Command, Control and Commun., Jan. 1980, 6 p., refs (For primary document see N80-19809 10-59)
Avail: NTIS HC A24/MF A01

Real time simulation is evaluated in relation to large man machine systems, particulary air traffic control systems. The limitations to using real time simulation to study computer assistance, system capacity, workloads, stress, boredom, and attitudes are discussed. K.L.

N80-19821# Elektronik-System G.m.b.H., Munich (West Germany).
DESIGN AND SIMULATION OF A C3 SYSTEM FOR SURVEILLANCE PURPOSE
Franz Herzmann and Helmut Sanders. *In* AGARD, Modelling and Simulation of Avionics Systems and Command, Control and Commun., Jan. 1980, 13 p., refs (For primary document see N80-19809 10-59)
Avail: NTIS HC A24/MF A01

Communications, command, and control problems associated with the operation of a surveillance network and weapon systems are discussed. Tracing and allocation algorithms are designed and improved by simulating network operation. Weapon system operation, including coordination and target allocation, is also simulated. The system performance is tested using radar derived data. K.L.

N80-19822# Royal Signals and Radar Establishment, Malvern (England).
SIMBOX: A GENERAL PURPOSE DEFENSE SYSTEMS SIMULATOR
B. Davy. *In* AGARD, Modeling and Simulation of Avionics Systems and Command, Control and Commun., Jan. 1980, 8 p. (For primary document see N80-19809 10-59)
Avail: NTIS HC A24/MF A01

A simulation tool of sufficient flexibility to meet the simulation requirements of a variety of systems is presented. The design principles of SIMBOX are discussed and its use in assessing radar performance, tracking algorithms, and data handling systems is illustrated. K.L.

N80-19823# Mitre Corp., Bedford, Mass.
THE APPLICATION OF MODELING AND SIMULATION TO THE DEVELOPMENT OF THE E-3A
A. R. Shanahan. *In* AGARD, Modeling and Simulation of Avionics Systems and Command, Control and Commun., Jan. 1980, 14 p. (For primary document see N80-19809 10-59)
Avail: NTIS HC A24/MF A01

The role of modelling and simulation in developing an airborne radar, communications, and command-control system is discussed. The modelling diversity required during different stages of system development is emphasized. K.L.

N80-19824# Analytic Sciences Corp., Reading, Mass.
E-3A NAVIGATIONAL COMPUTER SYSTEM REAL-TIME ENVIRONMENTAL SIMULATOR
Richard D. Healy and Samuel Newman. *In* AGARD, Modeling and Simulation of Avionics Systems and Command, Control and Commun., Jan. 1980, 8 p., refs. Prepared in cooperation with NADC, Warminster, Pa. (For primary document see N80-19809 10-59)
(Contract N62269-79-C-0020)
Avail: NTIS HC A24/MF A01

A software life-cycle support facility under development for the E-3A navigational computer system includes a real-time environmental simulator which is used to simulate both E-3A avionics and the operational environment so that software problems with the included AN/ARN-120 Omega Navigation Equipment (ONE) can be investigated and that the impact of software changes can be assessed by a simulated mission refly. The environmental simulator is a hybrid system hosted in two digital computers connected by a specially designed real-time digital data link. Real-time simulation software performs two distinct functions: provides computer-controlled analog and digital input data to the ONE and respond to ONE guidance outputs, and provides truth-model aircraft data which can be used as a precision navigation reference. Preliminary experience related to the design and construction of the environmental simulator for the software life-cycle support facility is presented, some of the practical problems encountered in developing the simulator are described, interim resolution and potential long-term solutions and current status are discussed. Particular emphasis is placed on describing procedures used for implementing the simulator development guidelines: maximum flexibility and minimum essential design. A.R.H.

N80-19825# Boeing Aerospace Co., Seattle, Wash.
A JTIDS PERFORMANCE MODEL FOR THE E-3A
James G. Taylor. *In* AGARD, Modeling and Simulation of Avionics Systems and Command, Control and Commun., Jan. 1980, 13 p., refs (For primary document see N80-19809 10-59)
Avail: NTIS HC A24/MF A01

The communications link performance model developed to predict performance of joint tactical information distribution system (JTIDS) links between the E-3A and other aircraft and ground stations is described. The JTIDS is a time division multiple access system operating in the radio frequency band 962 to 1213 MHz and employs spread spectrum techniques. The model includes the performance effects on the JTIDS wideband frequency hopping receiver due to both the E-3A dual antenna system and specular and diffuse multipath signals. Laboratory tests were conducted which provided receiver performance data for signals routed through dual antenna and multipath simulators. This simulator approach was also used in similar tests conducted by SHAPE Technical Centre for NATO. The results were essentially identical in the two test programs. A flight test program was conducted which validated the link performance model. This validated model has greatly reduced costly E-3A flight testing and has provided predictions of JTIDS performance over a variety of communication link scenarios and flight conditions. Author

N80-19826# Marconi Space and Defence Systems Ltd., Hillend (Scotland).
A MISSION TRAINING SIMULATOR FOR THE NIMROD MR MK 2 AND SOME ASPECTS OF THE DERIVATION AND VERIFICATION OF ITS SYSTEM MODELS
K. Wells. *In* AGARD, Modeling and Simulation of Avionics Systems and Command, Control and Commun., Jan. 1980, 6 p. (For primary document see N80-19809 10-59)
Avail: NTIS HC A24/MF A01

Three MK 1 simulators are undergoing a major avionics refit to reflect the changes in the RAF's Nimrod MR Mk 2. This refit necessitates the modification to Mk 2 standard of the two prime sensor systems, acoustics and radar. In addition, the navigation and central tactical systems are being updated. The modifications both to the acoustics and to the radar are discussed. The definition of operations requirement and engineering implementation specifications for both hardware and software are described. The need to verify models to reflect the continuously changing design baseline as a result of aircraft development and user experience is discussed. A.R.H.

N80-19827# Mitre Corp., Bedford, Mass.
APPLICATION OF COMPUTER SIMULATIONS TO DEVELOPMENT OF NATO E-3A AUTOMATIC TRACK INITIATION ALGORITHMS
E. S. Alvarez and C. J. Sworobowicz. *In* AGARD Modeling and Simulation of Avionics Systems and Command, Control and Commun., Jan. 1980, 21 p. (*For primary document see* N80-19809 10-59)
Avail: NTIS HC A24/MF A01

NATO E-3A airborne warning and control system will include the capability to initiate tracks automatically on targets of interest. Due to the complex and interacting nature of the automatic track initiation (ATI) process, development of a prototype ATI design must rely heavily on Monte Carlo computer simulations. Adaptable computer simulations were developed which provide the analyst with a versatile tool for evaluation of ATI design alternatives and performance sensitivities. Although the computer simulation was used for the E-3A ATI problem, it also has general application to the evaluation of overall tracking performance for the E-3A or for any track-while-scan system. The ATI design which evolved from this development effort utilizes a Kalman filter for track smoothing and prediction. A Kalman filter not only provides rapid and accurate determination of target position and velocity, but also provides estimates of tracking errors which can be used to advantage in the design of optimal adaptive correlation windows, maneuver detection thresholds, and track promotion/drop rules. Simulation results show that the ATI design provides excellent performance over a wide range of target conditions and target environments. A.R.H.

N80-19828# Defense Advanced Research Projects Agency, Arlington, Va.
AVIATION TRAINING USING VIDEO DISK TECHNOLOGY
Craig Fields and Steven Levin. *In* AGARD Modeling and Simulation of Avionics Systems and Command, Control and Commun., Jan. 1980, 2 p. Prepared in cooperation with Interactive Television Co., Arlington, Va. (*For primary document see* N80-19809 10-59)
Avail: NTIS HC A24/MF A01

Video disks are a new technology that provide inexpensive storage (65 cent/disk) and rapid access (as little as 1/8 sec.) to large numbers (54,000 pictures/disk side) of photographs. For a typical airport, it is possible to store on a video disk compressed movies showing all runway, take-off, landing, circling, and approach paths. When such a disk is viewed on a player and television controlled by a simple microprocessor, the pilot can vicariously fly himself around an airport, land, take-off, taxi and circle. The pilot sees an image with photographic realism, can choose his own path and speed, and can choose time of day or weather conditions for the simulation trip. Such a system is one hundred times less expensive than a conventional flight simulator. Author

N80-19829# Societe Nationale Industrielle Aerospatiale, Marignane (France). Div. Helicopteres
DESIGN OF A SIMULATOR FOR STUDYING THE HELICOPTER - SDVEH [CONCEPTION D'UN SIMULATEUR DE VOL D'ETUDE POUR HELICOPTER - SDUEH]
Jl. Mascle, G. Catani, M. Sellier, and Jp. Letouzey. *In* AGARD Modeling and Simulation of Avionics Systems and Command, Control and Commun., Jan. 1980, 13 p. In FRENCH (For primary document see N80-19809 10-59)
Avail: NTIS HC A24/MF A01

The conceptual stages in the design of a flight simulator (SDVEH), which will study the specific problems in the design and flight operations of military helicopters are reported. The principle characteristics of the flight simulator are delineated and points considered critical to the development of a helicopter program are discussed. The development and organization of the project are reported and a preliminary analysis of the exact needs of the SDVEH are presented. Transl. by A.W.H.

N80-19830# Institute for Defense Analyses, Arlington, Va.
COST-EFFECTIVENESS OF FLIGHT SIMULATORS FOR MILITARY TRAINING
Jesse Orlansky and Joseph String. *In* AGARD Modeling and Simulation of Avionics Systems and Command, Control and Commun., Jan. 1980, 13 p. refs (For primary document see N80-19809 10-59)
Avail: NTIS HC A24/MF A01

The cost and effectiveness of flight simulators used for military training are evaluated. Recent cost data of modern flight simulators are analyzed. A comparison of the skills learned in flight simulators and the effectiveness with which they are performed in actual flight versus the skills learned in actual flight only is discussed. Results show that pilots trained in the simulators use less flight time to perform various tasks than do those trained only in aircraft. A.W.H.

N80-19831# Le Materiel Telephonique, Trappes (France)
USING A LANGUAGE DEVELOPED FOR AIRCRAFT SIMULATORS [UTILISATION D'UN LANGAGE EVOLUE POUR LES SIMULATEURS D'AVIONS]
Michel G. Dreyfus. *In* AGARD Modeling and Simulation of Avionics Systems and Command, Control and Commun., Jan. 1980, 7 p. In FRENCH, ENGLISH summary (For primary document see N80-19809 10-59)
Avail: NTIS HC A24/MF A01

The advantages and disadvantages of flight simulator computers using assembler languages and simulation computers using FORTRAN are discussed. The impact of each method on the analytical and programming methods employed at each stage of program writing, debugging, and modification is reviewed. The consequences of computing power and memory capacity are also discussed. A.W.H.

N80-19832# Royal Aircraft Establishment, Farnborough (England)
SIMULATION OF A NIGHT VISION SYSTEM FOR LOW LEVEL HELICOPTER OPERATIONS
J. N. Barrett. *In* AGARD Modeling and Simulation of Avionics Systems and Command, Control and Commun., Jan. 1980, 24 p. (For primary document see N80-19809 10-59)
Avail: NTIS HC A24/MF A01

The development of night vision piloting aids to enable helicopters to operate at low altitude by night is discussed. An experiment which explored the problems and possibilities of a helmet mounted display for such helicopter night piloting tasks, using real time simulation techniques is described. The development of the helicopter simulation, and how the various components of the proposed night vision system were modelled and incorporated into the simulation are reported. The experimental design for the trials and how the limitations of the simulation were taken into account are discussed. A.W.H.

N80-19833# Institute for Defense Analyses, Arlington, Va. Systems Evaluation Div.
USE OF SIMULATION IN THE EVALUATION OF THE IFFN PROCESS
J. E. Freedman and S. H. Starr. *In* AGARD Modeling and Simulation of Avionics Systems and Command, Control and Commun., Jan. 1980, 20 p. ref (For primary document see N80-19809 10-59)
Avail: NTIS HC A24/MF A01

A program to evaluate the ability of the ISS to support the identification process in an operational environment is described. The role that modeling and simulation will play in the evaluation is emphasized. The types of tests that are to be employed to accomplish the program objectives are discussed. The primary test vehicle, a hybrid, geographically distributed testbed consisting of a central simulation facility, manned operational C-2 systems, and manned mission simulators, is described. The technical requirements for the testbed are summarized and the considerations underlying their formulation are examined. An example of a test design that considers the subphase of the program, where a programmed airborne early warning aircraft is employed in support of defensive counterair operations, is included. A.W.H.

N80-19834# Industrieanlagen-Betriebsgesellschaft m.b.H., Ottobrunn (West Germany)
AIR-TO-AIR ENGAGEMENT SIMULATION

Goetz Wunderlich and Roland Braun *In* AGARD Modeling and Simulation of Avionics Systems and Command, Control and Commun Jan 1980 14 p (For primary document see N80-19809 10-59)
Avail NTIS HC A24/MF A01

The development of an air to air engagement simulation multiduel model which considers the aircraft its avionics, armament, and the pilots behavior is discussed The model will also consider the phase prior to combat including the fighter allocation, combat air patrol, ground controlled intercept capability, influence of early warning systems, etc Assumptions, problems, and applications of the model are discussed A W H

N80-19835# Mitre Corp Bedford, Mass
THE MITRE INTERACTIVE COMMUNICATIONS ANALYSIS PROGRAM (MICAP)
John M Ruddy *In* AGARD Modeling and Simulation of Avionics Systems and Command, Control and Commun Jan 1980 22 p (For primary document see N80-19809 10-59)
Avail NTIS HC A24/MF A01

The MITRE interactive communications analysis program (MICAP), a user oriented computer program, is described The program provides complex communications system performance and cost analysis The program output, a graphical presentation of the data, permits system synthesis and modification through rapid and easy system parameter iteration to obtain a desired system performance measure The program structure and capabilities include cost/performance tradeoff analysis Examples of modeling and prediction of satellite communication performance are presented Applications to cost/performance tradeoffs and evaluation of architectural alternatives are discussed A W H

N80-19836# Societe Nationale Industrielle Aerospatiale, Toulouse (France)
NEW POSSIBILITIES OFFERED BY A RADIO-INERTIAL HYBRID GUIDANCE SYSTEM DIGITAL SIMULATION STUDY [NOUVELLES POSSIBILITIES OFFERTES PAR UN SYSTEME DE GUIDAGE HYBRIDE RADIO - INERTIEL ETUDIE EN SIMULATION NUMERIQUE]
D Buisson, J Irvoas, and J Grossin *In* AGARD Modeling and Simulation of Avionics Systems and Command, Control and Commun Jan 1980 25 p In FRENCH, ENGLISH summary refs (For primary document see N80-19809 10-59)
Avail NTIS HC A24/MF A01

A radio inertial guidance system was studied to increase the accuracy of aircraft guidance along the ILS beams and to ensure continuation of automatic landing in the event of a localizer transmitter failure Developments in the guidance system are discussed including the detection of the Loc beam centerline after an undetected failure in the monitoring of the Loc axis alignment with the runway axis A digital simulation study which demonstrated the system performance is described A W H

N80-19837# British Aerospace Aircraft Group, Brough (England)
THE ROLE OF THE AIRCRAFT MODEL IN AVIONIC SYSTEMS SIMULATION
J D Bannister and R Hicks *In* AGARD Modeling and Simulation of Avionics Systems and Command, Control and Commun Jan 1980 14 p refs (For primary document see N80-19809 10-59)
Avail NTIS HC A24/MF A01

The relevance and use of the aircraft model in avionics systems simulation is discussed The interaction between elements of the avionic systems, the vehicle dynamics and the outside world, and simulation is described The aircraft model is discussed to indicate the choice to be made in determining the level of complexity required to fulfill differing objectives Aircraft models of different types are described Some algorithms and solution techniques are presented along with an indication of the limitations inherent in the models Two contrasting simulations are discussed to show the significance of the aircraft model in relation to the avionic system simulation The first example illustrates the use of an aircraft model in a GP computer simulation of the interception of invading aircraft The second example discusses the aircraft model used in a pilot in the loop real time simulation of the avionics system for an attack aircraft In both examples practical considerations are included such as processor requirements and simulation system architecture A W H

N80-19838# Battelle Columbus Labs., Ohio
AVIONICS EVALUATION PROGRAM: SIMULATION MODELS FOR THE EFFECTIVENESS ANALYSIS OF AVIONICS
David Welp, Ken Almquist, and Larry Rainey *In* AGARD Modeling and Simulation of Avionics Systems and Command, Control and Commun Jan 1980 4 p Prepared in cooperation with AFAL, Wright-Patterson AFB, Ohio (For primary document see N80-19809 10-59)
Avail NTIS HC A24/MF A01

The avionics evaluation program (AEP) a library of seven detailed avionics performance assessment models all driven by a common, interactive software package is examined The AEP provides an efficient means for performing tradeoff analyses among cost, reliability, maintainability and performance of avionic configurations The models are the air to ground mission analysis program, target acquisition, weapon delivery survivability communications, air to air mission analysis, and dogfight analysis Each model is described A W H

N80-19839# British Aerospace Dynamics Group, Bristol (England)
SIMULATION FOR WHOLE LIFE DEVELOPMENT
R J Morrow and R Richards *In* AGARD Modeling and Simulation of Avionics Systems and Command, Control and Commun Jan 1980 11 p refs (For primary document see N80-19809 10-59)
Avail NTIS HC A24/MF A01

A special prupose, real time simulator suitable for whole life development of complex avionics control systems is described Software flexibility, a current equipment selling point, demands a reappraisal of previous equipment development procedures Problems with high speed information handling will occur during the development of new digital controllers when used for command and control, ESM and EW system are discussed The need to simulate those real world factors that load the information to the digital processing system under development R C T

N80-19840# Air Force Avionics Lab., Wright-Patterson AFB, Ohio
A SIMULATION SUPPORT SYSTEM, THE DEVELOPMENT TOOL FOR AVIONIC SYSTEMS AND SUBSYSTEMS
John C Ostgaard *In* AGARD Modeling and Simulation of Avionics Systems and Command, Control and Commun Jan 1980 11 p refs (For primary document see N80-19809 10-59)
Avail NTIS HC A24/MF A01

The simulation support facility required for the development and validation of the digital avionics information system are discussed The design requirements for an integrated simulation support system are given with emphasis on the following avionic system support, prototype system software support, prototype system hardware support, engineering studies, maintenance augmentation, and training assistance R C T

N80-19841# Industrieanlagen-Betriebsgesellschaft m b H., Ottobrunn (West Germany)
FIRE CONTROL FOR AIR-TO-AIR GUNNERY IN HIGH PERFORMANCE FIGHTER AIRCRAFT
Hans W Pongratz *In* AGARD Modeling and Simulation of Avionics Systems and Command, Control and Commun Jan 1980 13 p (For primary document see N80-19809 10-59)
Avail NTIS HC A24/MF A01

A survey on some of the aspects in air-to-air gunnery initiated by improvements in gun fire control are summarized The simulation models used in the TKF simulation for gun fire control and gun scoring are presented The necessary and the possible detail and accuracy of the implemented models is considered R C T

N80-19842# Electronique Marcel Dassault, St Cloud (France)
SIMULATION FOR INTEGRATION WITH DYNAMIC TESTS OF THE LOGICAL ELEMENTS OF PRINCIPAL ONBOARD COMPUTERS [SIMULATEUR POUR INTEGRATION AVEC TESTS DYNAMIQUES DES LOGICIELS DE CALCULATEURS ENTRAUX EMBARQUES]
E Bouthors *In* AGARD Modeling and Simulation of Avionics Systems and Command, Control and Commun Jan 1980 11 p In FRENCH (For primary document see N80-19809 10-59)
Avail NTIS HC A24/MF A01

A system is described which was designed to simulate the environment of onboard computers and to furnish control methods which permit the adjustment and validation of logical elements before the effective integration of computers in real equipment environments The essential characteristics of the system is to simulate the equipment environments, not at the level of their intrinsic operation, but at that of their interface with the computer in temporal, interactive, and information aspects The simulation is made by the fusion of operator information with information registered on magnetic tape This latter information simulates the different flight phases envisaged by tests while the operator

information recreates in real-time, the action of the pilot and equipment. The possibilities of operating slowly and step-by-step confer a particular efficiency to the simulation and adjustment and validation of logical elements. Transl. by A.R.H.

N80-19843# Draper (Charles Stark) Lab., Inc., Cambridge, Mass. Guidance and Navigation Advanced Programs Div.
CRUISE-MISSILE-CARRIER NAVIGATION REQUIREMENTS
George T. Schmidt and Roy H. Setterlund. *In* AGARD Modeling and Simulation of Avionics Systems and Command, Control and Commun. Jan. 1980 10 p refs (*For primary document see* N80-19809 10-59)
(Contract F33657-78-C-0473)
Avail: NTIS HC A24/MF A01

The modeling, simulation, and performance predictions used in determining aircraft avionics and transfer alignment requirements for a generic aircraft that would launch cruise missiles over water a considerable distance from a first TERCOM update area are discussed. The methodology used in allocating the allowable navigation errors between the CM guidance system and the cruise missile carrier aircraft avionics system is described. R.C.T.

N80-19844# *National Aerospace Lab., Amsterdam (Netherlands)*
A FLIGHT SIMULATION INVESTIGATION ON THE FEASIBILITY OF CURVED APPROACHES UNDER MLS GUIDANCE
L. J. J. Erkelens. *In* AGARD Modeling and Simulation of Avionics Systems and Command, Control and Commun. Jan. 1980 18 p refs (For primary document see N80-19809 10-59)
Avail: NTIS HC A24/MF A01

A simulation investigation concerning the possibilities of executing laterally curved approaches with a wide body type of aircraft in a microwave landing system environment is described. The approach path variables were: final approach intercept altitude and angle of the turn. An Earth fixed circular segment connected the straight preturn segment with the final segment. A flight director operating in the instrument landing system tracking mode, supplied with minor modifications in the roll bar drive, is used as the primary instrument for guidance. Additional provisions are made to enable the pilot to monitor the approach. A total number of about 450 curved approaches, performed by three pilots, are flown on the simulator under various weather conditions. In addition to tracking data, subjective information like pilot ratings and comments are gathered. Curved approaches, with turn angles up to 180 deg can be carried out safely, provided that the altitude at which the turn is completed is not less than 305 m (1000 ft). Special provisions are needed with respect to the flight director roll bar drive, in order to achieve accurate tracking on the curved segment in strong wind conditions. M.G.

N80-19845# Boston Univ., Mass.
MODELING AND FLIGHT SIMULATION OF AN ACTIVE CONFIGURED AIRCRAFT UNDER M.L.S. GUIDANCE
A. Danesi, S. Smolka, and U. Chinappi. *In* AGARD Modeling and Simulation of Avionics Systems and Command, Control and Commun. Jan. 1980 16 p Prepared in cooperation with Rome Univ., Italy (For primary document see N80-19809 10-59)
Avail: NTIS HC A24/MF A01

A mathematical formulation is presented to integrate the differential equations modeling a vehicle automatically guided along a curvilinear trajectory by a microwave landing system (M.L.S.). The augmented linear state equation, representing the open loop vehicle M.L.S. observer system, is given in standard phase variable form in which the altitude perturbations from the reference trajectory and numbers of its successive derivatives are assumed as state variables involved in a multifeedback flight control system. The state equation taken into consideration in system modeling handles separately the transfer function characteristics polynomial while the dynamical effects of the system zeros are included in the algebraic output equation relating the actual altitude perturbations to the state variables defined, in a rather fictitious fashion, in a state equation. The initial conditions to be imposed in the integration process must be consistent with the physical initial conditions on the actual trajectory considered in the problem at hand and for that purpose mathematical solution to the problem of transforming the initial conditions imposed on the physical state variables to the correspondent fictitious ones, is advanced. M.G.

N80-19846# Naval Air Development Center, Warminster, Pa.
MODELING THE HUMAN OPERATOR: APPLICATIONS TO SYSTEM COST EFFECTIVENESS
Norman E. Lane, Melvin I. Strieb (Analytics, Inc., Willow Grove, Pa.), and Walter Leyland. *In* AGARD Modeling and Simulation of Avionics Systems and Command, Control and Commun. Jan. 1980 13 p refs (For primary document see N80-19809 10-59)
Avail: NTIS HC A24/MF A01

A technique for predicting system effectiveness which includes a consideration of realistic operator/system interactions is described. Operator interface cost effectiveness analysis (OICEA) combines system modeling with cost projections to evaluate the cost benefits of alternative proposed designs within appropriate mission contexts. Major avionics variables are integrated into a cohesive approach which simulates hardware and software functions and the performance of an operator interacting with these components, using a model called the human operator simulator. OICEA allows for systematic variation of key factors that influence effectiveness, including degree and type of task automation, equipment and human reliability, scenarios and tactical doctrine, and operator characteristics. The OICEA methodology is summarized and applications to avionics and sensor improvements on a fixed wing antisubmarine warfare platform are documented. M.G.

N80-19847# Naval Air Development Center, Warminster, Pa.
PREDICTING FIELD OF VIEW REQUIREMENTS FOR VSTOL AIRCRAFT APPROACH AND LANDING
Paul M. Linton and Warren F. Clement. *In* AGARD Modeling and Simulation of Avionics Systems and Command, Control and Commun. Jan. 1980 17 p refs Prepared in cooperation with Systems Technology, Inc., Mountain View, Calif. (For primary document see N80-19809 10-59)
Avail: NTIS HC A24/MF A01

A rationale for quantitatively determining fixed-wing, vertical/short take-off and landing aircraft field of view requirements is developed. The interactions between human visual processes, the vehicle approach profile, and the operator flight path control performance are considered. A model specifies precise visual requirements for recovery aboard defined shipboard pads or forward sites. M.G.

60 COMPUTER OPERATIONS AND HARDWARE

Includes computer graphics and data processing
For components see *33 Electronics and Electrical Engineering*

N77-18760# Advisory Group for Aerospace Research and Development Paris (France)
COMPUTER APPLICATIONS
I J Gabelman ed (RADC, N Y) Feb 1977 87 p refs (AGARD-AR-100 ISBN-92-835-1237-6) Avail NTIS HC A05/MF A01

Solid state technical developments and their applications to satisfying NATO military requirements are described Author

N77-22822# Advisory Group for Aerospace Research and Development Paris (France)
MICROPROCESSORS AND THEIR APPLICATIONS
Mar 1977 159 p refs (AGARD-LS-87 ISBN-92-835-0191-8) Avail NTIS HC A08/MF A01

An overview of the microprocessor field is provided that surveys large scale integrated circuit technology for designing computer systems For individual titles, see N77-22823 through N77-22832

N77-22823# EMI Electronics Ltd , Hayes (England)
MICROCOMPUTERS AND THEIR APPLICATIONS
R C Sloan *In* AGARD Microprocessors and Their Applications Mar 1977 2 p (For primary document see N77-22822 13-60) Avail NTIS HC A08/MF A01

The microprocessor provides the system designer with the capability to design a custon computer system from a small number of low cost building blocks which can be easily interconnected to meet a particular requirement Such a system has all the advantages normally associated with LSI circuits, namely low volume and power consumption with high reliability At the present state of development, however, the simple microcomputer is not capable of matching the performance obtainable from a minicomputer and should not be considered as a direct replacement It is primarily intended to provide either a small computer capability (used directly or as a replicated element of a distributed system) or as a replacement for a hard wired logic system Since the effective speed of current microprocessor systems is slower than that achievable with hard wired logic, this limits their use to slower speed applications Author

N77-22824# ERA Ltd , Leatherhead (England)
PROGRAMING LANGUAGES AND BASIC PROGRAMMING TECHNIQUES
C D Nabavi *In* AGARD Microprocessors and Their Applications Mar 1977 7 p (For primary document see N77-22822 13-60) Avail NTIS HC A08/MF A01

Different categories of programming languages are discussed in general terms of their advantages and disadvantages, and their applicability to microprocessor programming is summarized The emphasis is more on comparing high level versus low level, rather than on comparing different languages at any given level Also considered are some of the basic techniques used in programming, and it is shown how various desirable features of a program such as clarity, reliability, ease of writing, etc can be improved by the use of macros, subroutines, and other similar techniques Some examples of how some of the benefits of structured programming can be introduced into existing assembler languages are given Author

N77-22825# INTEL Corp Ltd (England)
MICROCOMPUTER DESIGN AND FUTURE TRENDS IN MICROCOMPUTER COMPONENTS
In AGARD Microprocessors and Their Applications Mar 1977 9 p (For primary document see N77-22822 13-60) Avail NTIS HC A08/MF A01

The microcomputer offers the engineer a quite dramatic decrease in cost and a great increase in performance and versatility The reasons for this are obvious, first, the microcomputer is a large scale integrated circuit which is manufactured using mass production techniques which lead to very low cost Second, the microcomputer is a general purpose digital computer which can provide a system with a versatility which is unobtainable by any other means Read only memory technology has developed to such an extent that very large computer programs can be housed in read only memories which occupy just one or two integrated circuit chips It is estimated that by 1980 about 70% of all digital applications will be serviced by microcomputer components Author

N77-22826# ERA Ltd , Leatherhead (England)
MICROPROCESSOR SUPPORT SOFTWARE
C D Nabavi *In* AGARD Microprocessors and Their Applications Mar 1977 13 p (For primary document see N77-22822 13-60) Avail NTIS HC A08/MF A01

The importance of microprocessor support software is often underestimated by the average microprocessor user A description is given of the support software required to develop a microprocessor based system, how it is used, and what sort of features are considered essential The programs covered in detail are editors, assemblers, macroprocessors, high level languages, and debugging routines Several other useful utility programs are briefly mentioned, and the use of simulators is also discussed Finally a comparison is made of the ways in which such support software can be run on different systems such as prototyping units, minicomputers, timesharing systems etc Author

N77-22827# Carleton Univ Ottawa (Ontario) Dept of Electronics
INTERACTION BETWEEN LSI PROCESS TECHNOLOGY AND THE DESIGN OF MICROPROCESSOR SYSTEMS
Miles A Copeland *In* AGARD Microprocessors and Their Applications Mar 1977 15 p refs (For primary document see N77-22822 13-60)
Avail NTIS HC A08/MF A01

An overview of the interaction between LSI technology and microprocessors is given that includes a survey of the various LSI processes and how they relate to the manufacture of microprocessors The general nature and significance of an LSI process is outlined, and a description is given of important LSI technologies as well as fundamental LSI circuits Also considered are aspects of static versus dynamic logic and the significance of speed/power product in a LSI technology Author

N77-22828# INTEL Corp Ltd (England)
MICROPROCESSORS IN PROCESS CONTROL
Howard Kornstein *In* AGARD Microprocessors and Their Applications Mar 1977 8 p (For primary document see N77-22822 13-60)
Avail NTIS HC A08/MF A01

The ready availability of low cost digital computing elements in the form of microcomputers is having a significant effect on process control systems of all types because they remove the two main disadvantages of employing digital computers in control systems and introduce a few advantages of their own These include a reduction in system cost improved reliability, adaptability, self diagnosis and calibration, freedom from drift, interactiveness, and improved communications between both system and operator and between individual system elements Last, and by no means least, the performance and characteristics of the system are determined by the software This can easily be changed to modify or update the system at any time Author

N77-22829# Societe Francaise d'Equipments pour la Navigation Aerienne, Velizy-Villacoublay (France) Dept of Systems
THE USE OF MICROPROCESSORS IN CIVIL AVIATION DELAYED FLAP APPROACH SYSTEM
Thuy Phamduc and Daniel Gruaz *In* AGARD Microprocessors and Their Applications Mar 1977 32 p In FRENCH and ENGLISH (For primary document see N77-22822 13-60)
Avail NTIS HC A08/MF A01

The delayed flap approach (DFA) system is a typical example of a function which can be performed using microprocessors It helps to improve the landing procedure for commercial aircraft by reducing noise and saving fuel It is characterized by complex logic and a calculation function which uses division, multiplication, delays, etc Author

N77-22830# Royal Signals and Radar Establishment, Malvern (England)
USING A MICROPROCESSOR AS A COMPUTER INTERFACE CONTROLLER
F E Withers *In* AGARD Microprocessors and Their Applications Mar 1977 20 p refs (For primary document see N77-22822 13-60)
Avail NTIS HC A08/MF A01

The use of the Plessey MIPROC as an interface controller for the Computer Technology Ltd MODULAR ONE computer is

described The MIPROC is used to control graphic display units equipped with rolling ball and keyboard and other peripherals The MODULAR ONE can send commands to the MIPROC which cause the latter to take data from the MODULAR ONE store in processor hesitation mode Data from two successive 16 bit words are assembled by the MIPROC to form a 24 bit word which is put out to the peripherals on the MYRIAD highways, together with the appropriate control signals which are generated by the MIPROC Interrupt signals from the peripherals are dealt with by the MIPROC which interrupts the MODULAR ONE when necessary Programming of the MIPROC is in assembly code During development the MIPROC was operated in its prototyping system enabling easy debugging of the MIPROC program It was found to be possible to extend the MIPROC data bus and control signals into the MODULAR ONE cabinet A comparison between this approach and the alternative of using hard wired logic is considered Author

N77-22831# Carleton Univ Ottawa (Ontario) Dept of Electronics

INTERACTION BETWEEN MICROPROCESSORS AND CUSTOM LSI

Miles A Copeland *In* AGARD Microprocessors and Their Applications Mar 1977 11 p refs (For primary document see N77-22822 13-60)

Avail NTIS HC A08/MF A01

Custom LSI design fit in the context of microprocessors is considered A general overview is given of digital machines, under the categories of data processing, timing, and mode circuitry This was related to hardwired machines, ROM/PROM/PLA based machines, and the stored program machine The type of circuit is discussed which might interact with the microprocessor but has a specialized structure, finding rationalization in the function to be carried out, or in requirements beyond the microprocessor, such as speed Some examples of mixed analog/digital signal processing circuits are presented, such as an electrically programmable analog transversal filter and an electrically programmable optical image processor These circuits operate under the control of a stored program machine Author

N77-22832# Defence Research Information Centre, Orpington (England)

BIBLIOGRAPHY ON MICROPROCESSORS AND THEIR APPLICATIONS

R H Oseman, comp and R C Sloan, comp (EMI Electronics, Hayes, Engl) *In* AGARD Microprocessors and Their Applications (For primary document see N77-22822 13-60)

Avail NTIS HC A08/MF A01

This bibliography has been compiled to provide literature references on microprocessors and their application The purpose of this lecture series is to (1) enable systems designers to appreciate the potential and applicability of the technology in military and commercial fields, (2) enable designers responsible for system implementation to appreciate hardware and software design, (3) provide a current update in microprocessor technology for those working in this field both in industry and universities, and (4) provide an update of the techniques and potential for managers Author

N78-15720# Advisory Group for Aerospace Research and Development, Paris (France)

COMPUTER AIDED DESIGN: POSSIBILITIES, NECESSITIES AND APPLICATIONS IN THE DESIGN PROCESS

Dec 1977 32 p Two papers presented at the 45th AGARD Structures and Mater Panel Meeting, Voss, Norway, Sep 1977 (AGARD-R-662, ISBN-92-835-1267-7) Avail NTIS HC A03/MF A01

Computer aided design is considered in two documents as it is applied to the production of aircraft The use of the computer to aid the engineer in designing efficient structures and in preparing final drawings and releasing them to manufacturing was summarized Engineering activities such as design drafting, lofting, and structural analysis previously done by hand, can now utilize computer interactive graphics terminals An attempt was made to clarify the implications of a global view of the design and implementation of computer software in the business/industrial world Recommendations for priority attention to a few specific problems are made, drawing from the experiences of past and present cooperative efforts in this field Author

N79-20760# Advisory Group for Aerospace Research and Development, Paris (France)

COMPUTER AID IN THE PRODUCTION DESIGN OFFICE

Jan 1979 56 p In ENGLISH and partly in FRENCH Papers presented at the 47th Meeting of the AGARD Struct and Mater Panel, Florence, 25 26 Sep 1978 (AGARD-CP-250, ISBN-92 835-0229 9) Avail NTIS HC A04/MF A01

The requirements with respect to software and hardware from different points of view and the close relationship between CAD and CAM are presented The application of CAD to special systems and components of an aircraft is covered For individual titles, see N79-20761 through N79-20767

N79-20761# Computer Aided Design Centre, Cambridge (England)

GRAPHICAL NC SYSTEMS AS A BASIS FOR PROGRESS TOWARDS THE INTEGRATION OF DESIGN, PLANNING AND MACHINING

B Gott *In* AGARD Computer Aid in the Production Design Office Jan 1979 8 p (For primary document see N79-20760 11-60)

Avail: NTIS HC A04/MF A01

The systems described are concerned with piece parts on production and design for production Numerical control of programming, machining, and graphical methods in the computer aided and manufacture throughout all sectors of industry S E S

N79-20762# Societe Nationale Industrielle Aerospatiale, Marignane (France.)

A COMPUTER AIDED DESIGN AND FABRICATION SYSTEM ADAPTED TO THE DESIGN OF THREE DIMENSIONAL OBJECTS [UN SYSTEME DE CONCEPTION ET FABRICATION ASSISTEES PAR ORDINATEUR ADAPTE A LA CONCEPTION DES OBJECTS TRIDIMENSIONNELS]

Monique Slissa *In* AGARD Computer Aid in the Production Design Office Jan 1979 5 p In FRENCH (For primary document see N79-20760 11-60)

Avail: NTIS HC A04/MF A01

Computer aided design and fabrication relies on all the capabilities of a data processor to create a product at the least cost, as rapidly as possible, and to provide for modifications in the shortest period of time For its application, the Helicopter Division of Aerospatiale chose the design of three dimensional objects A FORTRAN program developed in the Scientific Information Service and used in industry since 1974, permits the creations and modification of simple and complex forms with the assistance of interactive graphic and alphanumeric screens Development proceeds by taking into consideration the experience acquired by users Favorable comparisons have been made with traditional methods In order to rationalize the management of the created objects, an introduction to a new type of data base management system is under study Transl by A R H

N79-20763# Avions Marcel Dassault-Breguet Aviation, Saint-Cloud (France).

DRAPO: A COMPUTER AIDED DESIGN AND FABRICATION SYSTEM [DRAPO: UN SYSTEME DE CONCEPTION ET DE FABRICATION ASSISTEES PAR ORDINATEUR]

Francis Bernard *In* AGARD Computer Aid in the Production Design Office Jan 1979 12 p (For primary document see N79-20760 11-60)

Avail: NTIS HC A04/MF A01

The search for maximum optimization in the construction of aircraft of greater and greater complexity led to the use of a totally integrated system of computerized design and fabrication Known as DRAPO, the system can be defined partly by the material adopted whose choice determines the mode of utilization, and partly by its principal functions form definition curves, surfaces, and volume The motivations and research objects prompting the use of the system are summarized Its principal aspects are described and its use is demonstrated in several examples. Transl by A R H

N79-20764# Vereinigte Flugtechnische Werke-Fokker G m b H , Bremen (West Germany)

SOME REQUIREMENTS FOR A COMMUNICATION SYSTEM GUIDING THE RELATIONS BETWEEN THE DESIGN ENGINEER AND A GENERAL DATA BASE

W Lehnert *In* AGARD Computer Aid in the Production Design Office Jan 1979 4 p (For primary document see N79-20760 11-60)

Avail: NTIS HC A04/MF A01

Complete support of the designer in all phases of the design process is provided A model for possible cooperation during the development of the communication system is described in order to achieve standardized components S E S

N79-20765# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (West Germany).

CAD FOR ELECTRIC SYSTEMS DESIGN

Guenter Broll *In* AGARD Computer Aid in the Production Design Office Jan. 1979 8 p (For primary document see N79-20760 11-60)

Avail: NTIS HC A04/MF A01

The large amount of paper work prepared by aircraft production for high performance aircraft design is presented. CAD is designed to meet the needs with respect to speed, reliability, and costs savings. The electric design data is defined by standards, supplier lists, and specifications. The data is converted into drawings and information for production to reach scheduled run times. S.E.S.

N79-20766# Aeritalia S.p.A., Torino (Italy).

AERITALIA POINT OF VIEW AND OBJECTIVES ON COMPUTER AIDED DESIGN

M. Castagneri *In* AGARD Computer Aid in the Production Design Office Jan. 1979 7 p (For primary document see N79-20760 11-60)

Avail: NTIS HC A04/MF A01

A analysis of the usage of computer aids in the design and manufacturing areas is presented. A guideline to improve and collect all the computer programs includes the following features: (1) to bulid up a system administrating a unique data base; (2) to optimize flow times, manpower requirements, and (3) to increase cost benefits. S.E.S.

N79-20767# British Aerospace Aircraft Group, Weybridge (England).

A DISCUSSION OF THE PRODUCTION DESIGN OFFICE BENEFITS OF C.A.D.

L. H. Dyson *In* AGARD Computer Aid in the Production Design Office Jan. 1979 4 p (For primary document see N79-20760 11-60)

Avail: NTIS HC A04/MF A01

Mathematical models representing the different trends in the aircraft industry are presented. The different design phases, design processes, improvements, production engineering, cost reductions, data bases are reported. S.E.S.

71 ACOUSTICS

Includes sound generation, transmission and attenuation

For noise pollution see *45 Environment Pollution*

N80-14858# Advisory Group for Aerospace Research and Development, Paris (France)

SPECIAL COURSE ON ACOUSTIC WAVE PROPAGATION

Aug 1979 224 p refs In ENGLISH, partly in FRENCH Presented at the Von Karman Inst., Rhode-Saint-Genese, Belgium, 28 May - 1 Jun 1979

(AGARD-R-686, ISBN-92-835-0248-5) Avail NTIS HC A10/MF A01

The propagation of acoustic waves in inhomogeneous and moving media of both unlimited and finite extent is discussed with particular emphasis on modelling of the phenomena involved and on prediction methods, as well as standardization aspects. Measurement techniques and data analysis are also considered. Applications of the material presented occur in aeroacoustics, industrial acoustics and atmospheric propagation. For individual titles, see N80-14859 through N80-14876.

N80-14859# Office National d'Etudes et de Recherches Aerospatiales, Paris (France).

A GENERAL SURVEY OF STUDIES ON ACOUSTIC WAVE PROPAGATION [APERCU GENERAL DES ETUDES SUR LA PROPAGATION DES ONDES ACOUSTIQUES]

M. Perulli *In* AGARD Special Course on Acoustic Wave Propagation Aug 1979 5 p refs In FRENCH Prepared jointly with Univ. de Technologie de Compiegne, France (For primary document see N80-14858 05-71)

Avail: NTIS HC A10/MF A01

A brief historical review of theoretical and experimental research in acoustic wave propagation is presented. Some of the different themes which must be addressed in order to increase the state of knowledge in this particular domain of acoustics concern popagation in ideal and nonideal media.

Transl. by A.R.H.

N80-14860# Southampton Univ. (England). Inst. of Sound and Vibration Research.

ACOUSTIC EQUATIONS IN MOVING FLUIDS

P. E. Doak *In* AGARD Special Course on Acoustic Wave Propagation Aug 1979 6 p refs (For primary document see N80-14858 05-71)

Avail: NTIS HC A10/MF A01

The full transport equations of mass, momentum and energy of an arbitrarily moving thermally inhomogeneous, fluid are considered and also appropriate definitions of 'acoustic motion' in such circumstances leading to the partial differential equations and boundary conditions governing such motion. The fundamental nature of the convective refractive, diffractive and diffusive effects of the fluid motion and thermal inhomogeneity on the acoustic motion is made evident. A classification is made of types of problems that have been and can be solved, and of the kinds of interactions that can occur between acoustic and other kinds of motions. Author

N80-14861# Von Karman Inst. for Fluid Dynamics, Rhode-Saint-Genese (Belgium)

FUNDAMENTALS OF SOUND REFLECTION AND REFRACTION IN INHOMOGENEOUS MEDIA

Roland Stuff *In* AGARD Special Course on Acoustic Wave Propagation Aug 1979 19 p refs (For primary document see N80-14858 05-71)

Avail: NTIS HC A10/MF A01

The historical development of geometrical acoustics is reviewed and sound wave propagation is examined including the effects of temperature and wind gradients. Analytical solutions of the wave equation are presented for an isothermally and a polytropically stratified still atmosphere and for an atmosphere with wind gradients and wind direction changes as well. These solutions are valid beyond the scope of geometrical acoustics. The dispersion of infrasound is also considered. A.R.H.

N80-14862# Southampton Univ. (England). Inst. of Sound and Vibration Research.

MATHEMATICAL TECHNIQUES FOR ACOUSTIC PROPAGATION PROBLEMS

P. E. Doak *In* AGARD Special Course on Acoustic Wave Propagation Aug 1979 7 p refs (For primary document see N80-14858 05-71)

Avail: NTIS HC A10/MF A01

The principal mathematical techniques for the solution of both steady state and transient acoustic propagation and boundary value problems, for both forced and free motion, are reviewed. These include separation of variables methods and the associated techniques for the resulting ordinary differential equations, Green function methods, Fourier, Laplace and other transform methods, finite element and other numerical methods, and certain special techniques including Wiener-Hopf. Emphasis is placed on the relative merits of the various methods for specific types of problems. Author

N80-14863*# National Aeronautics and Space Administration Langley Research Center, Hampton, Va.

DIRECTIVITY OF ACOUSTIC RADIATION FROM SOURCES

Donald L. Lansing *In* AGARD Special Course on Acoustic Wave Propagation Aug. 1979 11 p refs (For primary document see N80-14858 05-71)

Avail: NTIS HC A10/MF A01 CSCL 20A

The radiation properties of acoustic monopoles and dipoles are described, as well as the directivity of radiation from these sources in a free field and in the presence of an absorptive surface. The kinematic effects on source radiation due to translation and rotation are discussed. Experimental measurements of sound from an acoustic monopole in motion and the characteristics of helicopter rotor and propeller noise are reviewed. Several essential concepts required by noise control engineers making measurements of noise from moving sources in the proximity of the ground are introduced. A.R.H.

N80-14864# *Office National d'Etudes et de Recherches* Aerospatiales, Paris (France).

PROPAGATION IN DUCTS [PROPAGATION DANS LES CONDUITS]

M. Perulli *In* AGARD Special Course on Acoustic Wave Propagation Aug. 1979 23 p In FRENCH Prepared jointly with Univ. de Technologie de Compiegne, France (For primary document see N80-14858 05-71)

Avail: NTIS HC A10/MF A01

The study of acoustic wave propagation in ducts is accomplished by beginning with a wave equation in which the following come into play: duct geometry, the median heights and fluctuations characterizing the fluid, and the acoustic properties of the walls. Generally, this equation can be solved only by complex numerical methods and, to this day, only the particular cases which correspond to simple geometries can be treated analytically. Numerous physical properties are presented and the case is discussed for an infinite duct of any section but constant, in which a uniformly homogeneous fluid flows; the acoustic impedance of the walls can or can not be absorbent. An expression for the pressure field is given for different duct geometries (rectangular, annular, and cylindrical).

Transl. by A.R.H.

N80-14865# Office National d'Etudes et de Recherches Aerospatiales, Paris (France). Dept. de Genie Macanique.

PROPAGATION IN ACOUSTICALLY ABSORBENT MATERIALS

M. Perulli and P. E. Doak (Inst. of Sound and Vibration Research) *In* AGARD Special Course on Acoustic Wave Propagation Aug. 1979 6 p refs Prepared jointly with Southampton Univ., England (For primary document see N80-14858 05-71)

Avail: NTIS HC A10/MF A01

Models for representing the dynamics of porous and other acoustically absorbent materials are reviewed. Propagation in significantly absorbent materials widely used in practice, or commonly occurring, for example, as outdoor ground surfaces, is discussed. Non-linear high amplitude effects and mean flow effects are briefly described. A.R.H.

N80-14866# Southampton Univ. (England). Inst. of Sound and Vibration Research.

ACOUSTIC ENERGY

C. L. Morfey *In* AGARD Special Course on Acoustic Wave Propagation Aug 1979 7 p refs (For primary document see N80-14858 05-71)

Avail: NTIS HC A10/MF A01

Acoustic energy equations are shown to be a consequence of the linearized equations of motion. Definitions of acoustic

energy density and flux are given for sound fields in fluids at rest, and in various types of mean flow. Several applications to flow-acoustic problems are discussed, involving the transmission of sound through jets and shear layers and along lined flow ducts. Author

N80-14867# Southampton Univ. (England). Inst. of Sound and Vibration Research.

ABSORPTION OF SOUND WAVES IN THE ATMOSPHERE

C. L. Morfey. *In* AGARD Special Course on Acoustic Wave Propagation Aug. 1979 12 p refs (For primary document see N80-14858 05-71)

Avail: NTIS HC A10/MF A01

Absorption processes for sound waves in gases are described, with particular emphasis on atmospheric propagation over the frequency range 10 Hz to 10 to the 5th power Hz. The topics covered include molecular transport processes (viscosity, heat conduction and diffusion in mixtures); rotational relaxation in air; vibrational relaxation of N2 and O2 molecules in air and the influence of humidity; radiative heat transfer due to water vapor; viscothermal absorption due to suspended particles, and the additional effects arising from droplet evaporation in fogs. In each case, graphs or formulae for estimating atmospheric attenuation are provided, together with references to further information. Dissipative effects in nonlinear waves, sonic boom rise times in the atmosphere, and the spectral distortion of high-intensity noise are considered. A.R.H.

N80-14868*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

EXPERIMENTAL MEASUREMENTS OF MOVING NOISE SOURCES

L. Maestrello and T. D. Norum. *In* AGARD Special Course on Acoustic Wave Propagation Aug. 1979 12 p refs (For primary document see N80-14858 05-71)

Avail: NTIS HC A10/MF A01 CSCL 20A

The far-field pressure was measured from three different types of moving sources: a point monopole, a small model jet, and an aircraft. Results for the pressure time history produced by the point source show good agreement with those predicted analytically. Both actual and simulated forward motion of the model jet show reductions in noise levels with forward speed at all angles between the source and observer. Measurement with the aircraft over both an anechoic floor and over the ground yields a method for evaluating the transfer function for ground reflections at various angles between the moving aircraft and measurement position. A.R.H.

N80-14869# Southampton Univ. (England). Inst. of Sound and Vibration Research.

PROPAGATION FROM MOVING SOURCES IN FLOWS

C. L. Morfey. *In* AGARD Special Course on Acoustic Wave Propagation Aug. 1979 13 p refs (For primary document see N80-14858 05-71)

Avail: NTIS HC A10/MF A01

The theory of sound radiation from moving sources is outlined, first for uniform media and then for certain cases of nonuniform flow. Various applications are discussed which relate to aircraft noise in flight. K.L.

N80-14870*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va. Aeroacoustics Branch.

APPLICATIONS OF DIFFRACTION THEORY TO AEROACOUSTICS

Donald L. Lansing, Chen-Huei Liu, and Thomas D. Norum. *In* AGARD Special Course on Acoustic Wave Propagation Aug. 1979 12 p refs (For primary document see N80-14858 05-71)

Avail: NTIS HC A10/MF A01 CSCL 20A

The fundamentals of diffraction theory were reviewed and applied to several problems of aircraft noise generation, propagation, and measurement. The general acoustic diffraction problem is defined and the governing equations were set down. Diffraction phenomena are illustrated using the classical problem of the diffraction of a plane wave by a half-plane. Infinite series and geometric acoustic methods for solving diffraction problems are described. Four applications of diffraction theory are discussed: the selection of an appropriate shape for a microphone, the use of aircraft wings to shield the community from engine noise, the reflection of engine noise from an aircraft fuselage, and the radiation of trailing edge noise. K.L.

N80-14871# Centre National de la Recherche Scientifique, Marseilles (France). Dept. of Acoustics.

RANDOM PROPAGATION AND RANDOM SCATTERING

C. Gazanhes. *In* AGARD Special Course on Acoustic Wave Propagation Aug. 1979 11 p refs (For primary document see N80-14858 05-71)

Avail: NTIS HC A10/MF A01

The treatment of random propagation problems using geometrical optics, the Born approximation, the Rytov method, and parabolic equations is reviewed. The case of scattering by a cloud of random scatters is considered. K.L.

N80-14872# Centre National de la Recherche Scientifique, Marseilles (France). Dept. of Acoustics.

UNDERWATER ACOUSTIC PROBLEMS

C. Gazanhes. *In* AGARD Special Course on Acoustic Wave Propagation Aug. 1979 9 p refs (For primary document see N80-14858 05-71)

Avail: NTIS HC A10/MF A01

Basic principles which simplify underwater acoustics problems are reviewed. A static description of the medium is given, transmission loss is defined, and the effects of fluctuations in the medium on acoustical transmission are discussed. Propagation problems are considered from the ray and mode point of view. K.L.

N80-14873*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va. Inst. for Computer Application in Science and Engineering.

EXPERIMENTAL AND NUMERICAL RESULTS OF SOUND SCATTERING BY A BODY

L. Maestrello and A. Bayliss. *In* AGARD Special Course on Acoustic Wave Propagation Aug. 1979 12 p refs (For primary document see N80-14858 05-71)

Avail: NTIS HC A10/MF A01 CSCL 20A

The interaction of aerodynamic noise with a fuselage shaped body is discussed. A numerical technique is presented which permits the computation of the scattering of an acoustic source by a body at rest for frequencies of aeroacoustic interest. A parallel experiment is described which confirms the results of the computations. A numerical study of varying the geometry of the scattering is presented. In addition, the effect of forward motion on the mean velocity and static pressure profiles in the wake of such a body with a jet exiting from it is simulated. Experimental results are presented and a similarity law is given. K.L.

N80-14874# Technical Univ. of Denmark, Lyngby. Acoustics Lab.

FINITE-AMPLITUDE WAVE PROPAGATION

Leif Bjorno. *In* AGARD Special Course on Acoustic Wave Propagation Aug. 1979 15 p refs (For primary document see N80-14858 05-71)

Avail: NTIS HC A10/MF A01

The historical development of finite amplitude wave propagation in fluids is reviewed. The theoretical basis for the propagation of plane, cylindrical, or spherical finite amplitude waves through lossless, thermoviscous, or relaxing fluids is presented and characteristic features of the distortion course observed by finite amplitude waves in various regions of propagation are emphasized. Some experimental procedures and results are mentioned. K.L.

N80-14875# Technical Univ. of Denmark, Lyngby. Acoustics Lab.

NONLINEAR INTERACTION OF FINITE-AMPLITUDE SOUND WAVES

Leif Bjorno. *In* AGARD Special Course on Acoustic Wave Propagation Aug. 1979 10 p refs (For primary document see N80-14858 05-71)

Avail: NTIS HC A10/MF A01

The history and the fundamental theory of nonlinear interaction of finite amplitude sound waves is reviewed and the concept of parametric acoustic arrays is introduced. Low amplitude wave interactions in absorption and spreading-loss limited parametric transmitting arrays are discussed for continuous and pulsed primaries and for field points outside or inside the interaction region. High amplitude wave interactions leading to nearfield saturation limited parametric transmitting arrays are further treated for field points outside and inside the interaction region. The parametric receiving array for low and high amplitude pump waves is discussed and possibilities for obtaining an improvement of the parametric conversion efficiency for low and high amplitude wave interactions are given. K.L.

N80-14876# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Berlin (West Germany). Inst. fuer Experimentelle Stroemungsmechanik

AEROACOUSTIC MEASURING TECHNIQUES IN OR OUTSIDE TURBULENT FLOWS

Helmut V. Fuchs *In* AGARD Special Course on Acoustic Wave Propagation Aug. 1979 27 p refs (For primary document see N80-14858 05-71)

Avail: NTIS HC A10/MF A01

The motion of aerodynamic or acoustic sources relative to the fluid and/or the measuring instrument is discussed. Some practically important effects on the pressure and velocity fields in and outside the active source region are deduced from linearized wave equations with simple source functions. Limitations on fluctuating aerodynamic and acoustic pressure measuring techniques employing special microphone probes are discussed. Applications include: (1) the pressure pulsations induced in the near fields of jet, wake, and duct flows; and (2) the effects of source convection and forward speed on the far field radiation characteristics of jets or other aeroacoustic sources in motion.

K.L.

74 OPTICS

Includes light phenomena

N78-16801# Advisory Group for Aerospace Research and Development, Paris (France).
OPTICAL FIBRES, INTEGRATED OPTICS AND THEIR MILITARY APPLICATIONS
H. Hodara, ed. (Tetra Tech, Inc., Pasadena, Calif.) Oct. 1977 563 p refs Partly in ENGLISH and FRENCH Proc. of the Electromagnetic Wave Propagation Panel/Avionics Panel Joint Symp., held at London, 16-20 May 1977
(AGARD-CP-219, ISBN-92-835-0206-X) Avail: NTIS HC A24/MF A01

Developments in fiber and integrated optics are reviewed stressing their military applications, in areas of communication and data transmission. Emphasis is placed on avionics, electromagnetic wave propagation, end devices, coupling and propagation mechanisms, and optical cables and systems. For individual titles, see N78-16802 through N78-16851

N78-16802# Naval Electronics Lab. Center, San Diego, Calif.
REVIEW AND ASSESSMENT OF FIBER OPTICS FOR MILITARY APPLICATIONS
Henry F. Taylor *In* AGARD Opt. Fibres, Integrated Optics and Their Mil. Appl. Oct. 1977 18 p refs (For availability see N78-16801 07-74)
Avail: NTIS HC A24/MF A01

Component technology, system design considerations, and military applications of optical fiber communications are reviewed. The basic components include optical transmission lines, transmitters, receivers, repeaters, connectors, and bus couplers. Characteristics of these devices which have a particular bearing on military usage, such as environmental and radiation effects, are emphasized. Recent results representative of the state-of-the-*art in component technology* are indicated. Factors which affect the selection of components for a particular system are discussed. The most important of these are cable length, analog or digital signal bandwidth, system environment, reliability requirements and cost constraints. Some of the options available in selecting components to meet these system criteria include compound glass or silica fibers, fibers with step index or graded index profile, single fiber or multifiber cables, light emitting diode or injection laser sources, and PIN or avalanche photodiode detectors. Some of the military systems applications include digital point-to-point links and multi-terminal busses for ships, aircraft, and land bases, secure systems for voice and video, tactical land-line telemetry links, and undersea cables for transmitting sonar signals. In each application area, the proven or anticipated benefits of using fiber optics are discussed. Author

N78-16803# Bell Telephone Labs., Inc., Holmdel, N. J.
REVIEW OF INTEGRATED OPTICS
H. Kogelnik *In* AGARD Opt. Fibres, Integrated Optics and Their Mil. Appl. Oct. 1977 10 p refs (For availability see N78-16801 07-74)
Avail: NTIS HC A24/MF A01

A tutorial introduction and a review is given of the field of integrated optics and optical waveguide devices. Device principles and potential applications are discussed. The properties of dielectric waveguides are reviewed briefly and new materials and new fabrication techniques are mentioned. Research on waveguide modulators and switches with focus on devices made by titanium diffusion in lithium niobate is discussed. Mention is made of an experimental 4 x 4 switching network which was recently demonstrated in the laboratory. Other devices discussed are corrugated waveguide filters in which rejection bandwidth from 0.1 to 6 A were obtained. The use of waveguide techniques in semiconductor junction lasers is considered. Author

N78-16804# Service Technique des Telecommunications de l'Air, Paris (France).
THE FUTURE OF FIBER OPTICS WITH REGARD TO MILITARY AERONAUTICAL APPLICATIONS [L'AVENIR DES FIBRES OPTIQUES POUR LES APPLICATIONS AERONAUTIQUES MILITAIRES]
P. Lecat *In* AGARD Opt. Fibres Integrated Optics and Their Mil. Appl. Oct. 1977 9 p refs In FRENCH (For availability see N78-16801 07-74)
Avail: NTIS HC A24/MF A01

Some of the following items are discussed in detail: (1) the evolution of border materials, (2) the effect of electromagnetic perturbations on transmission lines, (3) transmission development by fiber optics, and (4) linkage feasibility by fiber optics. Transl. by B.B.

N78-16805# Naval Undersea Center, Kailva, Hawaii
RECENT PROGRESS IN OPTICAL FIBER CABLES FOR USE IN THE OCEAN
G. A. Wilkins and R. A. Eastley (Naval Electron. Lab. Center) *In* AGARD Opt. Fibres, Integrated Optics and Their Mil. Appl. Oct. 1977 17 p refs (For availability see N78-16801 07-74)
Avail: NTIS HC A24/MF A01

Physical and optical test results are given for several undersea, low loss, optical and electro-optical cable units. Diameters for these cables range from 1.0 mm to 17.5 mm, and all were designed to operate in environments of high tensile, bending and hydrostatic stresses. Design constraints necessary to isolate the optical fibers from such stresses are described. Design details and rationales are given for each cable unit. Continuing technical problems and probable solutions are discussed. Author

N78-16806# Royal Aircraft Establishment, Farnborough (England) Space Dept.
FIBRE-OPTICS FOR DEFENCE APPLICATIONS IN THE UK
B. Ellis and W. S. Nicol (Ministry of Defense, London) *In* AGARD Opt. Fibres, Integrated Optics and Their Mil. Appl. Oct. 1977 3 p refs (For availability see N78-16801 07-74)
Avail: NTIS HC A24/MF A01

The philosophy underlying the choice of particular types of fiber optic systems for military applications is discussed. Some existing and planned systems are described together with details of supporting component development. Author

N78-16807*# Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
A REVIEW OF NASA FIBER OPTICS TASKS
Alan R. Johnston *In* AGARD Opt. Fibres, Integrated Optics and Their Mil. Appl. Oct. 1977 14 p refs (For availability see N78-16801 07-74)
(Contract NAS7-100)
Avail: NTIS HC A24/MF A01 CSCL 20F

The status of on-going NASA tasks involving fiber optic data transmission, and related topics is given. Ground based applications, including a multiplexed wideband 2 km prototype link and a building-to-building video link, are described. In connection with the use of fibers in space, the effects to be expected from the space environment are touched on, particularly radiation darkening of fibers and temperature effects. Laboratory results on performance of fibers at cryogenic temperatures are also presented. Finally, some thoughts on future applications are given. Author

N78-16808# Technische Universitaet, Brunswick (West Germany) Inst. fuer Hochfrequenztechnik
FUNDAMENTAL MODE SIGNAL TRANSMISSION IN SINGLE- AND MULTIMODE FIBRES
K. Petermann and H.-G. Unger *In* AGARD Opt. Fibres, Integrated Optics and Their Mil. Appl. Oct. 1977 12 p refs (For availability see N78-16801 07-74)
Avail: NTIS HC A24/MF A01

Signal transmission in signal-mode operation of single and multimode fibers is considered. Choice of emission wavelength and of the refraction index profile is discussed in relation to residual distortion. It is shown that the propagation is distorted by random bends as introduced by the cabling process. Therefore a microbending loss occurs, which, however, becomes negligible as long as the fundamental mode spotsize is kept small. In addition the conversion of energy to higher order modes due to microbending and its reconversion distorts pulses in the fundamental mode. This pulse distortion is kept small by sufficiently attenuating the higher order modes or by inserting discrete mode filters. Simple analytic design considerations are given. Author

N78-16809# Polytechnic Inst. of New York, Farmingdale. Dept. of Electrical Engineering and Electrophysics.
BEAM EVOLUTION ALONG A MULTIMODE OPTICAL FIBER
S. Y. Shin and L. B. Felsen *In* AGARD Opt. Fibres, Integrated Optics and Their Mil. Appl. Oct. 1977 17 p refs (For availability see N78-16801 07-74)

(Contract F44620-69-C-0047, Grant NSF ENG-7522625)
Avail: NTIS HC A24/MF A01

Results for the phase and amplitude of the beam field as it progresses down the fiber via successive reflections from the core interface are presented. The analysis is performed by first formulating the fields generated in the fiber by a point source and then converting these fields to beam fields by assigning a complex value to the source coordinates. It is shown that paraxial Gaussian beam fields are calculable completely from corresponding point-source-excited fields in a geometric optical ray bundle. It is found that the beam projection on the fiber cross section refocuses between reflections but that the beam divergence increases when the number of reflections from the fiber wall is sufficiently large. Numerical results are presented for beams injected in a meridional plane. Author

N78-16810# ITT Electro-Optical Products Div., Roanoke, Va.
TESTING OF TENSILE STRENGTH OF OPTICAL FIBER WAVEGUIDES
C. Kao, M. Maklad, and J. E. Goell. *In* AGARD Opt. Fibres, Integrated Optics and Their Mil. Appl. Oct. 1977 3 p (For availability see N78-16801 07-74)
Avail: NTIS HC A24/MF A01

A procedure is developed which enables the tensile strength of an optical fiber waveguide to be predicted along its length. The influence of surface flaws on high stress concentration and failure of a stressed fiber in tension is considered along with fatigue or stress corrosion caused by moisture. The flaw distribution is characterized in order to define the statistical value of the fiber tensile strength of one test gauge length to that of another with known confidence limits. The test procedure consists of a short length test coupled with a proof test at about twice the service strength. For fibers made for high strength, this procedure allows high production yield as well as a guaranteed strength specification. For fibers made without special precautions, this procedure could be adopted, but the fiber yield may be unacceptably low. J.M.S.

N78-16811# Plessey Radar Ltd., Havant (England). Radar Research Centre
COLOUR MULTIPLEXING TECHNIQUES AND APPLICATIONS IN OPTICAL WAVEGUIDE LINKS
David A. Kahn. *In* AGARD Opt. Fibres, Integrated Optics and Their Mil. Appl. Oct. 1977 5 p refs (For availability see N78-16801 07-74)
Avail: NTIS HC A24/MF A01

The feasibility of color multiplexing is established by a review of the currently available components, namely sources, detectors, waveguides, and color splitting/combining devices. Operational systems employing color multiplexing are described. Finally, an assessment of the technique and the identification of the most likely application areas are given. Author

N78-16812# Communications Research Centre, Ottawa (Ontario)
AN EXPERIMENTAL OPTICAL-FIBER LINK FOR THE COMMAND AND CONTROL SYSEM 280
Elmer H. Hara and H. Claire Frayn. *In* AGARD Opt. Fibres, Integrated Optics and Their Mil. Appl. Oct. 1977 17 p (For availability see N78-16801 07-74)
Avail: NTIS HC A24/MF A01

The development of an experimental optical fiber link for the command and control system (CCS-280) for the DDH-280 destroyer escorts of the Canadian Navy is described. The viability of optical fiber transmission systems in combat action data systems such as the CCS-280 is demonstrated. The experimental optical fiber link, located between two situation display consoles, consisted of 31 channels transmitted the digital signals between the two consoles. Single optical fibers were used for each transmission channel, some of which carried time division multiplexed signals at a maximum bit rate of 10 Mb/s. The optical fibers were enclosed in an armored sheath to form a cable of approximately 2.5 cm in diameter and 4 m in length. Experimental trials were carried out on a land-based CCS-280. When acceptance tests established for the CCS-280 itself were applied to the optical link, the tests were satisfied with zero defects and the optical link performed satisfactorily under simulated combat conditions. Author

N78-16813# Naval Underwater Systems Center, New London, Conn.
MULTICHANNEL FIBER OPTIC SONAR LINK (FOSL-1)
Frederick C. Allard and Norman S. Bunker. *In* AGARD Opt. Fibres, Integrated Optics and Their Mil. Appl. Oct. 1977 7 p refs (For availability see N78-16801 07-74)
Avail: NTIS HC A24/MF A01

A fiber optic transmission line was designed, built, and tested at sea in an operational sonar system. This inboard transmission line conducts 52 channels from a preamplifier bank to a beamforming section. Plastic fiber optics is used in a 61-channel cable. Optical connectors are utilized at two levels. Commercially available electro-optical components are employed in the line driver and line receiver designs to achieve wide dynamic signal range with low distortion at low cost. The transmission line, designated FOSL-1 (Fiber Optics Sonar Link-No. 1) was designed as an initial step toward a military qualified subsystem. The utilization of established technologies, the modular construction, and ease of maintenance allow for extended hands off operation by sonar technicians who are not specially trained for fiber optics. Author

N78-16814# ITT Electro-Optical Products Div., Roanoke, Va.
A TWO KILOMETER OPTICAL FIBER DIGITAL TRANSMISSION SYSTEM FOR FIELD USE AT 20 Mb/s
T. A. Eppes, J. E. Goell, and R. J. Gallenberger (Naval Electronics Lab. Center). *In* AGARD Opt. Fibres, Integrated Optics and Their Mil. Appl. Oct. 1977 9 p (For availability see N78-16801 07-74)
Avail: NTIS HC A24/MF A01

A two-kilometer optical fiber digital transmission system for bit rates up to 20 Mb/s is described. The system includes a light emitting diode optical source, an avalanche photodiode receiver, and multifiber graded index cable. The data channel elements are connected via several field installable optical connectors. The design and performance of such components as transmitter modules, receiver modules, optical cable, and field installable optical connectors are discussed. Author

N78-16815# Shape Technical Center, The Hague (Netherlands) Communications Div.
COST MODEL FOR AN OPTICAL FIBRE COMMUNICATIONS SYSTEM
T. A. Alper. *In* AGARD Opt. Fibres, Integrated Optics and Their Mil. Appl. Oct. 1977 13 p refs (For availability see N78-16801 07-74)
Avail: NTIS HC A24/MF A01

A cost model is derived for an optical fiber communications system. The normalized costs of such systems is presented for several modulation schemes. Reasonable assumptions are used in developing the model and its application are confined to transmitters that have LED sources and use parabolic index fiber cables. For the purposes of calculation, a signal to noise ratio requirement of 70 db is assumed for analog systems, an error rate requirement of 10 to the -9th power is assumed for digital systems, and modulation rates are assumed not to exceed 100 Mbits/s. The costs per channel per kilometer for a typical short haul system and for a typical long haul system are derived to illustrate the use of the model. Author

N78-16816# Naval Electronics Lab. Center, San Diego, Calif.
A-7 ALOFT ECONOMIC ANALYSIS AND EMI-EMP TEST RESULTS
R. A. Greenwell and G. M. Holma. *In* AGARD Opt. Fibres, Integrated Optics and Their Mil. Appl. Oct. 1977 13 p refs (For availability see N78-16801 07-74)
Avail: NTIS HC A24/MF A01

Cost projections for three performance-equivalent cable alternatives: coaxial, twisted-shielded pair, and fibre optic were developed. These cost projections were generated by an approach which utilizes two techniques, one which computes very specific costs of research and development (R&D), investment, and operation and support (O&S) for the data transmission links, and the other which computes total weapon systems cost of R&D, investments, and O&S resulting from the inclusion of the field-operation systems. The results clearly indicated definite economic benefits with fiber optics. Tests were also performed to determine EMI susceptibility and EMP effects on fiber-optic and wire interconnects for the A-7 navigation and weapon delivery subsystem (NWDS). These tests were performed in the laboratory and on the aircraft. Results from the EMI and EMP tests have shown that the A-7 ALOFT fiber-optic subsystem is less susceptible to EMI and greatly reduces electromagnetic induction from an induced transient pulse. Author

N78-16817# Sperry Research Center, Sudbury, Mass.
DEVICE AND SYSTEM CONCEPTS FOR MULTIMODE SINGLE FIBER OPTICAL DATA LINKS
D. H. McMahon, A. R. Nelson, and H. Wichansky (Army ECOM, Fort Monmouth, N. J.) *In* AGARD Opt. Fibres, Integrated Optics and Their Mil. Appl. Oct. 1977 10 p. refs (For availability see N78-16801 07-74)
Avail: NTIS HC A24/MF A01

The principle of internal reflectance at grazing incidence is used to create devices for controlling guided multimode light by electro-optic means. The feasibility of multiple switching is demonstrated through the construction and evaluation of a variety of devices including modulators, couplexers, and multiplexers. Such devices add impetus to the growth of the multimode single fiber technology by presenting new opportunities for system design. Author

N78-16818# Naval Research Lab., Washington, D. C.
SINGLE MODE FIBER OPTICS AND INTEGRATED OPTICS FOR USE IN OPTICAL COMMUNICATIONS
T. G. Giallorenzi and A. F. Milton *In* AGARD Opt. Fibres, Integrated Optics and Their Mil. Appl. Oct. 1977 18 p. refs (For availability see N78-16801 07-74)
Avail: NTIS HC A24/MF A01

The status of components for use in single mode fiber and integrated optical communication systems is presented. The single mode coupling problems are stressed because couplers and splicers are the technological items which pace the implementation of single mode data transfer systems. Author

N78-16819# Laboratoire Central de Recherches Thomson-CSF, Orsay (France)
ELECTROOPTICAL ACTIVE COMPONENTS FOR GUIDED LIGHT
M. Papuchon *In* AGARD Opt. Fibres, Integrated Optics and Their Mil. Appl. Oct. 1977 8 p. refs (For availability see N78-16801 07-74)
Avail: NTIS HC A24/MF A01

Phase modulators, amplitude modulators, and switches that use the electro-optical effect are discussed. Waveguide fabrication through diffusion of titanium in LiNb13 crystals and component performance are considered. J.M.S.

N78-16820# Westinghouse Research Labs., Pittsburgh, Pa.
GIGA-HERTZ MODULATORS USING BULK ACOUSTO-OPTIC INTERACTIONS IN THIN FILM WAVEGUIDES
Gerald B. Brandt, M. Gottlieb, and R. W. Weinert *In* AGARD Opt. Fibres, Integrated Optics and Their Mil. Appl. Oct. 1977 9 p. refs (For availability see N78-16801 07-74)
Avail: NTIS HC A24/MF A01

When bulk acoustic waves are applied to an optical waveguide, several modulation effects are observed depending upon the type of wave (longitudinal or shear). Longitudinal sound waves frequency-shift the guided light, thus providing a means of modulating light in a wide variety of waveguide materials. Using thin film mosaic acoustic transducer technology, such modulation is demonstrated at frequencies in the gHz region. By segmenting the acoustic transducer electrodes, the same arrangement can be used for deflecting the light since the acoustic field sets up a time varying grating whose spatial frequency is set by the segment spacing. Theoretical frequency limitations on these devices do not appear to be important until approximately 30 gHz is reached, thus they are potentially useful for extremely wide-band data links. Experiments at 1.5 gHz show 30% bandwidth of acoustic modulation using optical heterodyne detection. Author

N78-16821# California Univ., Berkeley. Dept. of Electrical Engineering and Computer Sciences.
DISTRIBUTED-BRAGG-REFLECTOR INJECTION LASERS FOR INTEGRATED OPTICS
Shyh Wang *In* AGARD Opt. Fibres, Integrated Optics and Their Mil. Appl. Oct. 1977 18 p. refs (For availability see N78-16801 07-74)
(Contract N00014-75-C-0420, Grant NSF ENG-76-08292)
Avail: NTIS HC A24/MF A01

The underlying principles and the fabrication and operation of the distributed-Bragg-reflector (DBR) injection laser, a novel semiconductor laser which shows great promise as a source for integrated optics are described. The laser uses two corrugated waveguides at the ends as reflectors. First, the effect of periodic thickness variation on wave propagation is reviewed and the dispersion relation for the eigen Bloch wave is presented. This presentation is followed by a derivation of the reflection and transmission coefficients of the periodic-waveguide (or Bragg) reflector. Then the fabrication procedures and the operation of a DBR GaAs-Ga1-xAaxAs laser are described. The performance of the laser is analyzed and ways to optimize the design of the laser for single mode operation with appreciable output power are discussed. Finally, possible schemes for future integration with other optical components and for direct coupling into optical fibers are proposed. Possible ways to fine tune and to stabilize the laser wavelength are also suggested. Author

N78-16822# University Coll., London (England). Dept. of Electrical and Electronic Engineering.
MULTIMODE OPTICAL SYSTEMS-POWER COUPLING BETWEEN WAVEGUIDES
M. G. F. Wilson, C. W. Pitt, A. D. DeOliveira, and O. Parriaux *In* AGARD Opt. Fibres, Integrated Optics and Their Mil. Appl. Oct. 1977 9 p. refs (For availability see N78-16801 07-74)
Avail: NTIS HC A24/MF A01

Theoretical and experimental results are presented for multimode optical waveguide intersections fabricated by an ion-exchange technique. A simple ray theory is used to derive the power division and mode conversion, both of which are influenced greatly by the geometry in the intersection region. Author

N78-16823# Washington Univ., Seattle. Dept. of Electrical Engineering.
LASER-FIBER COUPLING WITH OPTICAL TRANSITION STRUCTURES
Gordon L. Mitchell and William D. Scott *In* AGARD Opt. Fibres, Integrated Optics and Their Mil. Appl. Oct. 1977 11 p. refs. Sponsored by Navy and NSF (For availability see N78-16801 07-74)
Avail: NTIS HC A24/MF A01

An optical transition fiber is used to couple between a diode laser and a single-mode fiber. Coupling optimization is detailed in terms of fiber size and refractive index. Fabrication techniques and material selecting parameters for rectangular fibers used to make the transitions are discussed. Author

N78-16824# Office of Naval Research, Arlington, Va.
AN INTEGRATED OPTICAL ANALOG-TO-DIGITAL CONVERTER
D. C. Lewis and H. F. Taylor (Naval Electronics Lab. Center, San Diego, Calif.) *In* AGARD Opt. Fibres, Integrated Optics and Their Mil. Appl. Oct. 1977 10 p. refs (For availability see N78-16801 07-74)
Avail: NTIS HC A24/MF A01

An electro-optic technique for analog to digital conversion based on an interferometric intensity modulator is analyzed. The advantages are compared with alternative methods. Potential military applications are discussed including signal processing for wideband radar and electronic warfare systems. J.M.S.

N78-16825# Consiglio Nazionale delle Ricerche, Florence (Italy). Istituto di Ricerca sulle Onde Elettromagnetiche.
THIN FILM INTEGRATED SIGNAL PROCESSORS
G. C. Righini, V. Russo, and S. Sottini *In* AGARD Opt. Fibres, Integrated Optics and Their Mil. Appl. Oct. 1977 14 p. refs (For availability see N78-16801 07-74)
Avail: NTIS HC A24/MF A01

Planar and hemispherical geodesic lenses are described. The aberrations of the hemispherical correlator were studied and numerical examples were carried out to verify its Fourier transform capabilities. Two and three level transmission filters were considered in the numerical simulation of pattern recognition operations. It is concluded that the hemispherical correlator can be used as an optical processor with aperture and field angles suitable for application to integrated optical circuits. J.M.S.

N78-16826# California Univ., Los Angeles. Electrical Sciences and Engineering Dept.
HOW DOES ONE INDUCE LEAKAGE IN AN OPTICAL FIBER LINK
C. Yeh and A. Johnston *In* AGARD Opt. Fibres, Integrated Optics and Their Mil. Appl. Oct. 1977 5 p. refs (For availability see N78-16801 07-74)
Avail: NTIS HC A24/MF A01

Nondestructive methods to induce the leakage of optical signals from optical fibers are discussed: (1) the index-matching-fluid method; (2) the temperature method; and (3) the bending

method Experiments were performed Results show that all three methods are effective in inducing leakage from plastic clad fibers while only the bending method is effective for glass-clad fibers Author

N78-16827# Centre National d Etudes des Telecommunications, Lannion (France)
STUDY AND RESULTS OF FIBER OPTICS TRANSFER FUNCTIONS [ETUDE ET RESULTATS DE LA FONCTION DE TRANSFERT DES FIBRES OPTIQUES]
R Bouille, J C Bizel, and M Guibert *In* AGARD Opt Fibres, Integrated Optics and Their Mil Appl Oct 1977 8 p refs In FRENCH (For availability see N78-16801 07-74)
Avail NTIS HC A24/MF A01

A method of obtaining the transfer function modulus of fiber optics was discussed It consists of utilizing two Fourier transformations at the speed of continuous luminous impulses Experimentation as well as results obtained of different types of fibers were reviewed It was concluded that the possibilities of linkage by fiber optics can be accomplished according to diverse numerical flow Transl by B B

N78-16828# Plessey Co Ltd Towcester (England) Allen Clark Research Centre
DETAIL RESOLUTION IN OPTICAL FIBRE INDEX PROFILING METHODS
W J Stewart *In* AGARD Opt Fibres, Integrated Optics and Their Mil Appl Oct 1977 2 p refs (For availability see N78-16801 07-74)
Avail NTIS HC A24/MF A01

The resolution of fine structure in fiber refractive index profiles by near field profiling methods was investigated experimentally and theoretically The standard near field method and a new improved method are treated The significance of this structure in affecting fiber bandwidth is described and the results qualitatively explained in resolution terms The concept of mode volume is introduced Author

N78-16829# Bell Telephone Labs, Inc Holmdel, N J
NOVEL TECHNIQUE FOR MEASURING THE INDEX PROFILE OF OPTICAL FIBERS
J A Arnaud and R M Derosier *In* AGARD Opt Fibres, Integrated Optics and Their Mil Appl Oct 1977 8 p refs (For availability see N78-16801 07-74)
Avail NTIS HC A24/MF A01

A novel technique for measuring the refractive index profile of optical fibers is demonstrated The method consists of illuminating a small area of the fiber core and measuring the total transmitted power The transmission of leaky modes is accounted for The index profiles of germania doped fibers obtained by this technique are compared to interferometric measurements The resolution is shown to be limited by wave optics effects Author

N78-16830# JENAER Glaswerk Schott and Gen Mainz (West Germany)
INFLUENCE OF THE REFRACTIVE INDEX PROFILE ON THE TRANSMISSION QUALITY OF GRADIENT INDEX OPTICAL FIBRES
G Gliemeroth, D Krause, N Neuroth, and F Reitmayer *In* AGARD Opt Fibres, Integrated Optics and Their Mil Appl Oct 1977 7 p refs (For availability see N78-16801 07-74)
Avail NTIS HC A24/MF A01

The problems occurring in the manufacture and investigation of fibers with the refractive index profile required by theory are described The fiber core consists of multi-component-glasses and is produced by the method of inside coating of a glass tube and subsequent collapsing and drawing The refractive index profile is determined by an interferometric method and by measuring the near field intensity distribution The pulse broadening is measured directly The influence of different profiles on the pulse broadening is demonstrated Typical properties of the fibers are given total loss 5 dB/km at the wavelength 850 nm pulse broadening 1 3 ns/km numerical aperture 0.2 0.3 Author

N78-16831# Queen Mary Coll London (England)
TRANSMISSION CHARACTERISTICS OF GRADED INDEX FIBRES
P J B Clarricoats J M Arnold and G Crone *In* AGARD Opt Fibres, Integrated Optics and Their Mil Appl Oct 1977 15 p refs (For availability see N78-16801 07-74)
Avail NTIS HC A24/MF A01

Computational methods by which the propagation characteristics of a fiber, hence the impulse response and system bandwidth may be determined are compared A computer program which determines for a model of a laser source the excitation of modes in an arbitrarily graded refractive index fiber is described Author

N78-16832# Consiglio Nazionale delle Ricerche Florence (Italy) Instituto di Ricerca sulle Onde elettromagnetiche
DISPERSION EVALUATION IN MULTIMODE FIBERS BY NUMERICAL TECHNIQUE: APPLICATION TO RING SHAPED AND GRADED INDEX WITH A CENTRAL DIP
A M Scheggi, P F Checcacci, and R Falciai *In* AGARD Opt Fibres, Integrated Optics and Their Mil Appl Oct 1977 16 p refs (For availability see N78-16801 07-74)
Avail NTIS HC A24/MF A01

A method is described which utilizes ray tracing techniques and modal relations to evaluate the dispersion characteristics of multimode optical fibers with various refraction index distributions The possibilities offered by the method are shown by application to fibers with index distribution ranging from the quasi step to the quasi parabolic shape Then the method is applied to ring profiles and graded index profiles with a central dip Dispersion equalization properties are observed for some types of ring profiles while the effect on the dispersion due to a central dip in a graded profile is examined by varying the depth and width of the dip Author

N78-16833# California Inst of Tech Pasadena
FINITE-BANDWIDTH PROPAGATION IN MULTIMODE OPTICAL FIBERS
B Crosignani, P DiPorto and C H Papas *In* AGARD Opt Fibres, Integrated Optics and Their Mil Appl Oct 1977 6 p (For availability see N78-16801 07-74)
Avail NTIS HC A24/MF A01

The propagation in a multimode optical fiber of a finite-bandwidth optical carrier modulated by a nonstationary signal is investigated The fluctuations of the field due to random mode-coupling are considered and the set of coupled equations describing their evolution is derived The propagation of a frequency-modulated signal is investigated A general theorem concerning the asymptotic behavior of mode-power fluctuations is obtained Author

N78-16834# Army Electronics Command Fort Monmouth N J
INJECTION LASER TRANSMITTER FOR LONG DISTANCE FIBER OPTICS COMMUNICATION
Ernst Schiel, Gerald Talbot, and Henry Kressel (RCA Labs Princeton, N J) *In* AGARD Opt Fibres, Integrated Optics and Their Mil Appl Oct 1977 10 p refs (For availability see N78-16801 07-74)
Avail NTIS HC A24/MF A01

The design and development of an injection laser transmitter *for a tactical long distance fiber optics communication link are* described The double heterostructure GaAlAs laser is configured in a triple stripe geometry which can feed the optical output power into a linear array of three fibers The laser structure was grown by the liquid phase epitaxial method and optimized for high peak power operation at a duty factor of ten percent (Average pulse repetition rate is 10 MHz and pulsewidth is 10 nsec) The laser chip is mounted in a prototype pill package, which is placed on a thermoelectric heater/cooler keeping the operational temperature of the laser at 15 C A special drive circuit utilizing a high power field effect transistor in the last stage was designed to drive the laser at a peak current of 2 A to obtain 250 mW peak output power Efficient coupling into graded index fibers was accomplished by lensing the fibers by a new technique Life tests on three lasers showed no degradation after 7000 hours of operation Author

N78-16835# Lincoln Lab Mass Inst of Tech Lexington
GaInAsP/InP DOUBLE-HETEROSTRUCTURE LASERS FOR FIBER OPTIC COMMUNICATIONS
J J Hsieh *In* AGARD Opt Fibres Integrated Optics and Their Mil Appl Oct 1977 p 35-1 35-7 refs (For availability *see N78-16801 07-74*)
Avail NTIS HC A24/MF A01

The performance of broad area and stripe geometry GaInAsP/InP double heterostructure diode lasers prepared by liquid phase epitaxy was studied These lasers have the advantage that exact lattice matching between the GaInAsP active region and the InP substract is possible for quaternary alloy compositions giving emission wavelengths over a range that includes 1.1-1.3 mm, the optimum region for optical communication systems utilizing

fused silica fibers. Continuous operation at room temperature was achieved in this region both for proton defined-stripe (PDS) and junction defined buried stripe (JDBS) lasers. Near field observations of the JDBS lasers show total optical confinement, with no spreading of the radiation outside the buried stripe for cw operation at 20% above threshold or for pulsed operation at 8 times threshold. Three PDS devices have logged over 2000, 1600 and 1200 hours of cw operation at room temperature without any degradation in output power, threshold current, or emission spectrum. Author

N78-16836# Laboratoire Central de Recherches Thomson-CSF, Orsay (France)
REPRODUCTION MANUFACTURING OF LASERS DIODES [REPRODUCTIBILITE DE FABRICATION DES DIODES LASERS]
E. Duda, J. C. Carballes, and J. Apruzzese. *In* AGARD Opt. Fibres, Integrated Optics and Their Mil. Appl., Oct. 1977, p. 36-1 - 36-9. refs (For availability see N78-16801 07-74)
Avail: NTIS HC A24/MF A01

The results of a study performed with the aim of improving the reproducibility of laser diodes are presented. The lasers diodes designed are of double heterostructure type, grown on GaAs substrates, they have an emitting stripe of 12 mm wide formed by a shallow proton implantation. At each important step of production (deposition of obraic contact, cleaving, sawing, bonding) tests were set up to check the quality of the operation. The influence of these operations on the characteristics of the lasers is discussed. The influence of the stresses induced during the process is pointed out. Criteria were derived to eliminate at an early stage the chips which exhibit insufficient characteristics for optical communication applications. As a general result a reduction in the dispersion of the performances was achieved for the lasers produced through these tests set up along the production line. Author

N78-16837# Naval Ocean Systems Center, San Diego, Calif.
PHYSICS AND TECHNOLOGY OF DEGRADATION IN GaAs LIGHT EMITTING DIODES
G. Zaesehmar. *In* AGARD Opt. Fibres, Integrated Optics and Their Mil. Appl., Oct. 1977, p. 37-1 - 37-7. refs (For availability see N78-16801 07-74)
Avail: NTIS HC A24/MF A01

Creep-induced lattice defects caused by thermal stress in the junction area are examined as a possible source for light emitting diode degradation. It is indicated that the increased number of lattice defects causes an increase in nonradiative recombination centers resulting in a shunt path which decreases the efficiency at constant current. A quantitative theory and experimental results are discussed. Author

N78-16838# Standard Telecommunication Labs. Ltd., Harlow (England)
RELIABLE SEMICONDUCTOR LASERS FOR WIDE BAND OPTICAL COMMUNICATION SYSTEMS
A. R. Goodwin, D. R. Selway, M. Pion, and W. O. Bourne. *In* AGARD Opt. Fibres, Integrated Optics and Their Mil. Appl., Oct. 1977, p. 38-1 - 38-8. refs (For availability see N78-16801 07-74)
Avail: NTIS HC A24/MF A01

The fabrication and performance characteristics of stripe geometry lasers are described. These lasers are shown to be suitable for use with small core single mode or graded-index fibers in systems requiring modulation at rates in excess of 250 Mbit/s. J.M.S.

N78-16839# Technische Universitaet, Munich (West Germany)
DESIGN AND FABRICATION OF GaAs LIGHT EMITTING DIODES FOR OPTICAL COMMUNICATION SYSTEMS WITH HIGH TRANSMISSION CAPACITY
W. Huber, J. Heinen, and W. Harth. *In* AGARD Opt. Fibres, Integrated Optics and Their Mil. Appl., Oct. 1977, p. 39-1 - 39-4 (For availability see N78-16801 07-74)
Avail: NTIS HC A24/MF A01

The physical mechanism of the time and frequency behavior of LED's is investigated. It is demonstrated that two time constants, the electron life time and the time constant due to the diode's space charge capacitance, govern the high frequency performance of a LED. A model is presented which describes the influence of the relevant technological LED parameters (layer structure, active area, active layer width and doping) on the time and frequency behavior by means of these time constants. The technological and physical factors, which represent the ultimate limitation of the modulation bandwidth, are discussed. Based upon this model the design concept of a practical LED with a very high modulation bandwidth is described. Measurements of the frequency characteristic, the light power output, and the spectral characteristic were carried out. In addition the AM-noise behavior is investigated. The transmission rate and the maximum length of an optical communication system using such high speed LED's is estimated. Author

N78-16840# Laboratoires de Marcoussis (France)
HIGH POWERED SILICON AVALANCHE DIODES FOR OPTICAL COMMUNICATION SYSTEMS [PHOTODIODES A AVALANCHE AU SILICIUM A GRANDE RAPIDITE POUR SYSTEMS DE COMMUNICATIONS OPTIQUES]
G. Ripoche and M. Britman. *In* AGARD Opt. Fibres, Integrated Optics and Their Mil. Appl., Oct. 1977, p. 40-1 - 40-16. refs (For availability see N78-16801 07-74)
Avail: NTIS HC A24/MF A01

Silicon avalanche photodiodes are the best detectors adapted to answer to the need of optical communications. Two diode structures were studied: (1) classical p-n junctions, and (2) p-n-p junctions obtained by high energy ion implantation. Each structure can be obtained by homogeneous substrate or epitaxial substrate studied performance functions. A description of utilization procedure for the two structures is presented along with results obtained concerning utility gain, sensitivity, and speed. The results are then compared with obtained data and surveyed in detail. Transl. by B.B.

N78-16841# Allen Clark Research Centre, Towcester (England)
THE RELIABILITY OF HIGH RADIANCE GaAs LEDS
S. D. Hersee. *In* AGARD Opt. Fibres, Integrated Optics and Their Mil. Appl., Oct. 1977, p. 41-7 - 41-11. refs (For availability see N78-16801 07-74)
Avail: NTIS HC A24/MF A01

Extended life testing of diffused junction LED's revealed that degradation is due to two independent processes. Evidence is presented which indicates that both of these processes are diffusion controlled. On the basis of these results the room temperature life time of a typical LED is predicted to be approximately 10 hours. Author

N78-16842# Laboratoire Central de Recherches Thomson-CSF, Orsay (France)
EMISSION MODULE OF A SEMICONDUCTOR LASER [MODULE D EMISSION A LASER SEMICONDUCTEUR]
A. Jacques and L. Dauria. *In* AGARD Opt. Fibres, Integrated Optics and Their Mil. Appl., Oct. 1977, p. 42-1 - 42-13. refs (For availability see N78-16801 07-74)
Avail: NTIS HC A24/MF A01

Problems regarding the design and the fabrication of an injection laser transmitter module are discussed. The emitter unit and the driving and control circuits are considered. Author

N78-16843# Laser Diode Labs., Inc., Metuchen, N.J.
INJECTION LASER SOURCES FOR FIBER OPTIC COMMUNICATIONS
Robert B. Gill. *In* AGARD Opt. Fibres, Integrated Optics and Their Mil. Appl., Oct. 1977, p. 43-1 - 43-13 (For availability see N78-16801 07-74)
Avail: NTIS HC A24/MF A01

The fabrication and performance characteristics of injection lasers and light emitting diodes currently being developed for use in fiber optics communication or data link systems are described. Emphasis is placed on device design and GaAs and GaAlAs epitaxial and wafer processing technology currently in use for the routine manufacture of commercial light emitting diodes and high duty cycle or CW room temperature injection laser diodes. Therefore, the device performance results which are discussed are typical of manufactured devices rather than the best results observed in the laboratory. While the processing technology which is described is based on the fabrication of cw room temperature laser diodes, the processing techniques detailed are also applicable to the manufacture of double heterojunction light emitting diodes as well as large optical cavity, high power, high duty cycle laser diodes. Author

N78-16844# University Coll., London (England). Dept. of Electrical Engineering
HOLOGRAPHIC ELEMENTS FOR PRACTICAL FIBRE BUNDLE COUPLERS

O D D Soares, A M P P Leite, and E A Ash *In* AGARD Opt Fibres. Integrated Optics and Their Mil Appl Oct 1977 p 44-1 - 44-13 refs (For availability see N78-16801 07-74)
Avail NTIS HC A24/MF A01

The use of a holographic element, which substantially reduces the sensitivity to tolerance errors in the manufacture of a coupler is discussed. The approach is based on the use of a hologram output window for the cable end, the coupling between the two windows proceeding by means of pseudo-plane waves. The effects is transfer the need for precision to the factory, the coupler to be assembled in the field being relatively undemanding. The system is applicable to bundles of fibers; preliminary experimental results for the coupling between one pair of fibers to another pair are described. Author

N78-16845# Allen Clark Research Centre, Towcester (England)
AN ADJUSTABLE BRANCHING COUPLER ATTENUATOR FOR MULTIMODE SINGLE FIBRE SYSTEMS
C Stewart and W J Stewart *In* AGARD Opt Fibres. Integrated Optics and Their Mil Appl Oct 1977 10 p refs (For availability see N78-16801 07-74)
Avail NTIS HC A24/MF A01

Two forms of the coupler/attenuator are studied. The first consists of a block of clear plastic material with an amplitude grating on one surface against which the fiber is pressed. The fiber assumes the shape of the grating which is approximately sinusoidal. Power from the fiber is coupled out into the plastic medium and may be detected at the end face. The second form of the device consists of a thin glass plate of about the same thickness as the fiber with a grating formed on one edge. The plate is shaped such that the emerging radiation from the coupling region is focussed on to a detector or another fiber. Results are reported for both types of coupler. Author

N78-16846# Laboratoire Central de Recherches Thomson-CSF, Orsay (France)
BIDIRECTIONAL CENTRAL COUPLERS FOR LINKS WITH OPTICAL FIBER BUNDLES
L Dauria and A Jacques *In* AGARD Opt Fibres. Integrated Optics and Their Mil Appl Oct 1977 11 p refs (For availability see N78-16801 07-74)
Avail NTIS HC A24/MF A01

A range of compatible and detachable devices for links with optical fiber bundles were developed including both components for point to point links (transmitter, receiver, connectors) and data distribution devices (3dB splitter, electrically tapped connector, mechanical multiple switch). Bidirectional central couplers having seven input/output terminals, compatible with all realized devices are described. Construction of two types of central couplers is described: assembled bundle coupler and separable bundle coupler (with linear central fiber and U central fiber). A technique using a central diffuser allows a significant and reproductible decrease of the maximum variation of the detected levels on the same detecting channel. Author

N78-16847# Laboratoires de Marcoussis (France)
T-COUPLER FOR MULTIMODE OPTICAL FIBERS
L Jeunhomme and J P Pocholle *In* AGARD Opt Fibres. Integrated Optics and Their Mil Appl Oct 1977 13 p refs Sponsored by Delegation Generale a la Recherche Sci et Tech (For availability see N78-16801 07-74)
Avail NTIS HC A24/MF A01

The device described allows the derivation of a variable amount of the light travelling in a multimode optical fiber without interruption of the transmission link. The principle of the optical fiber tap is to induce well controlled mode conversion between guided and radiation modes of the fiber, which can then leak out in a higher-index surrounding medium and reach a photodetector. The mode conversion is induced by bending the fiber in a sinusoidal way and the derivation ratio is adjusted by varying the amplitude of the sinusoidal deformation. The results presented concern the influence of the mechanical wavelength of the deformation, the radiation of the power derivated from the fiber and the influence of the device on the propagation characteristics of the fiber (far-field radiation pattern and impulse response). Results concerning the derivation ratio achievable with this device are also presented for both step-index and graded-index fibers. Author

N78-16848# Siemens A G, Munich (West Germany)
DATA BUS SYSTEM WITH SINGLE MULTIMODE FIBERS
F Auracher and H H Witte *In* AGARD Opt Fibres. Integrated Optics and Their Mil Appl Oct 1977 7 p refs Sponsored by Federal Dept of Res and Technol of the Federal Rep of Ger (For availability see N78-16801 07-74)
Avail NTIS HC A24/MF A01

The concept is reported of a single fiber data bus system in T-structure based on a new access coupler which is easy to fabricate and has a low insertion loss. The maximum possible number of terminals that can be supplied with an optimized system were calculated. Author

N78-16849# Standard Telecommunication Labs Ltd, Harlow (England)
AN OPTICAL FIBRE, MULTI-TERMINAL DATA SYSTEM FOR AIRCRAFT
J G Farrington and M Chown *In* AGARD Opt Fibres. Integrated Optics and Their Mil Appl Oct 1977 12 p refs Sponsored by Ministry of Defense (For availability see N78-16801 07-74)
Avail NTIS HC A24/MF A01

As a result of a study on the potential of optical fiber multiterminal data systems for avionics, a design approach was chosen which is expected to be a suitable basis for a wide range of applications. This is a time division multiplexing system which has features of being highly immune to problems of optical loss and multipath effects in optical highways having redundant paths, and of avoiding the need for any master terminal. This system approach is tailored to characteristics of optical fibers, and should lead to good integrity and ruggedness. A breadboard model of a terminal was demonstrated. Author

N78-16850# Hellermann Deutsch, East Grinstead (England)
FIBRES OPTICS CONVECTORS: HOT FORMING VERSUS EPOXY BONDING OF BUNDLES AND NEW TECHNIQUES WITH SINGLE FIBRES
R B Quarmby *In* AGARD Opt Fibres. Integrated Optics and Their Mil Appl Oct 1977 7 p ref (For availability see N78-16801 07-74)
Avail NTIS HC A24/MF A01

The requirements of fiber optics for military use are reliability, ease of maintenance and speed of both installation and repair. Various single and multichannel connectors and systems for cable-cable and cable-diode coupling can be made and with suitable design will withstand temperature cycling, humidity, vibration and shock to military standards. Until now fiber bundle cables were terminated by epoxy resin bonding but this technique has been inconvenient to apply in the field. A new dry technique was developed for hot forming the cable ends and details are given. The new process results in junctions of higher optical efficiency and it can be carried out with only a few minutes training in the use of the portable tools now available. Butt jointed single fiber connectors were made and have coupling losses in the order of 3db. Author

N78-16851# ITT Components Group Europe, Leeds (England)
FIBRE OPTICS INTERCONNECTION COMPONENTS
J D Archer *In* AGARD Opt Fibres. Integrated Optics and Their Mil Appl Oct 1977 8 p (For availability see N78-16801 07-74)
Avail NTIS HC A24/MF A01

A range of single fiber demountable connectors and active devices are described, and measured performances are compared with theoretical predictions. Author

81 ADMINISTRATION AND MANAGEMENT

Includes management planning and research

N79-12947# Advisory Group for Aerospace Research and Development, Paris (France)

SUGGESTED DATA ELEMENTS FOR RECORDING ON-GOING RESEARCH AND DEVELOPMENT EFFORTS: A MANAGEMENT INFORMATION SYSTEM

H E Sauter (DDC, Alexandria, Va.) Oct. 1978 11 p refs (AGARD-R-669, ISBN-92-835-1298-7) Avail NTIS HC A02/MF A01

Data elements integral to a Research and Development Management Information System are gathered from a sampling of operating systems, listed, and defined. A work unit level of reporting is defined, and its advantages are given. Working groups are established to develop a standardization of data elements.

S E S

82 DOCUMENTATION AND INFORMATION SCIENCE

Includes information storage and retrieval technology, micrography, and library science

For computer documentation see *61 Computer Programming and Software*

N77-28034# Advisory Group for Aerospace Research and Development, Paris (France)
MAXIMIZING EFFICIENCY AND EFFECTIVENESS OF INFORMATION DATA BANKS
Y M Braunstein (New York Univ.) May 1977 18 p refs Sponsored in part by NSF
(AGARD-R-657, ISBN-92-835-1243-x) Avail NTIS HC A02/MF A01

Principles are examined underlying the efficient and effective production, transfer, and use of information The cost savings and benefits that accrue to users from increased cooperation among the participants in the information transfer process are studied Cooperation between producers, intermediaries, and users is covered The impact of networking on information services is discussed Distinctions are made among computer, communication, and information networks Author

N77-34041# Advisory Group for Aerospace Research and Development, Paris (France)
SURVEY OF COMPUTER-ASSISTED WRITING AND EDITING SYSTEMS
P I Berman (Lockheed Electron Co., Plainfield, N J.) Jul 1977 65 p refs
(AGARD-AG-229) Avail NTIS HC A04/MF A01

The available technology for automating the preparation of technical and scientific documents was surveyed The range of possibilities inherent in such technology was demonstrated by reviewing a number of typical system configurations. Present trends in automated publishing systems are suggested and some qualitative guidelines for selecting and implementing such systems are provided. Author

N78-11873# Advisory Group for Aerospace Research and Development, Paris (France)
THE IMPACT OF FUTURE DEVELOPMENTS IN COMMUNICATIONS, INFORMATION TECHNOLOGY AND NATIONAL POLICIES ON THE WORK OF THE AEROSPACE INFORMATION SPECIALIST
Sep 1977 86 p refs Presented at the Technol Inform Panel *Specialists' Meeting*, Oslo, 22-23 Jun 1977
(AGARD-CP-225 ISBN 92 835 1254 5) Avail NTIS HC A05/MF A01

The main trends in communications and information technology were identified, the purpose was to assess the impact of these trends on the information specialist, and to consider what other developments might be desirable, particularly in relation to aerospace scientific and technical information For individual titles see N78-11874 through N78-11888

N78-11874# *Norwegian Center for Informatics*, Oslo
THE NORWEGIAN-SCANDINAVIAN SCIENTIFIC AND TECHNICAL INFORMATION SCENE
A Disch *In* AGARD The Impact of Future Develop in Commun, Inform Technol and Natl Policies on the Work of the Aerospace Inform Specialist Sep 1977 4 p refs (For availability see N78-11873 02-82)
Avail NTIS HC A05/MF A01

Norwegian technical information users were surveyed to assess their knowledge of present information channels and their preference and utilization of various information systems Cooperative efforts have been undertaken by Sweden, Norway, Denmark, Finland, and Iceland to promote the organization of Scandinavian technical documents J H

N78-11875# Norwegian Defence Research Establishment, Kjeller
THE SMALL NATIONS' NEEDS FOR SCIENTIFIC AND TECHNICAL INFORMATION: THE CASE OF NORWAY
Finn Lied *In* AGARD The Impact of Future Develop in Commun, Inform Technol and Natl Policies on the Work of the Aerospace Inform Specialist Sep 1977 5 p refs (For availability see N78-11873 02-82)
Avail NTIS HC A05/MF A01

The needs of small nations for scientific and technical information are considered, focusing on technical research in Norway, political goals and technical strengths of a country such as Norway are among the factors considered Also reviewed is the organization of Norwegian research and development, including funding mechanisms for such programs J H

N78-11876# *Norwegian Center for Informatics*, Oslo
INFORMATION 1990: A NORWEGIAN SCENARIO
Hans K Krog *In* AGARD The Impact of Future Develop in Commun, Inform Technol and Natl Policies on the Work of the Aerospace Inform Specialist Sep 1977 4 p refs (For availability see N78-11873 02-82)
Avail NTIS HC A05/MF A01

The Norwegian Centre for Informatics conducted a comprehensive study of the possible realistic developments in the field of scientific and technical information in Norway up to the year 1990 The major breakthrough will be in the extended use of computer on-line terminals, accessing external and internal data bases and data banks providing not only bits and pieces of information, but indeed also adding computer power to the handling and manipulation of these data directly from the office Electronic publication will be in its early stages making an impact especially in the scientifically advanced areas of basic and applied research breaking down further the geographical boundaries and the time delay obstacles to the free flow of information More time and money will be spent on information for the purpose of making better decisions and keeping abreast of the current developments in science and in business The leadtime in technological development will consequently be reduced In the information field more emphasis will be put on the quality of information and data accessible, both in content and in presentation Graphic information and illustrations will be part of the content in data bases and data banks Confidence limits and other quality stamps will be an integral part of the information provided Author

N78-11877# *Dansk Teknisk Oplysningstjeneste*, Copenhagen
SCANNET - EURONET: AIMS, POLICIES ORGANIZATION, SERVICES AND IMPACT EXPECTED
Kjeld Klintoe *In* AGARD The Impact of Future Develop in Commun, Inform Technol and Natl Policies on the Work of the Aerospace Inform Specialist Sep 1977 7 p refs (For availability see N78-11873 02-82)
Avail NTIS HC A05/MF A01

Two European information and documentation networks SCANNET (within the Scandinavian countries) and EURONET (an EEC cooperative), are assessed evaluating systems administration communications and equipment and services contributions to local political goals Both systems comprise national access points linked by telecommunication lines, data bases stored on host computers and a widely distributed group of terminal users Strategies for effective systems management are suggested J H

N78-11878# Gesellschaft Deutscher Chemiker, Weinheim (West Germany)
THE FUTURE OF PRIMARY SCIENTIFIC PUBLICATIONS
Helmut Gruenewald *In* AGARD The Impact of Future Develop in Commun, Inform Technol and Natl Policies on the Work of the Aerospace Inform Specialist Sep 1977 2 p (For availability see N78-11873 02-82)
Avail NTIS HC A05/MF A01

In order to overcome difficulties of primary literature and to improve and accelerate the flow of scientific information an integrated publication system is proposed whereby full papers are published in microform only For each paper entering the microform store a synopsis of about one printed page is published in the classical way i e in a synopsis journal Papers will continue to be refereed before they are accepted for publication Microform is offered to libraries for subscription, since it is impractical and undesirable for several reasons to establish 'manuscript banks' or 'depositary libraries' Such institutions would impede rather than enhance the flow of information Author

N78-11879# Capital Systems Group, Rockville, Md
INNOVATIONS IN INFORMATION TRANSFER: A PROGRAM TO STIMULATE CHANGE
William A Creager *In* AGARD The Impact of Future Develop in Commun, Inform Technol and Natl Policies on the Work of

the Aerospace Inform Specialist Sep 1977 11 p refs (For availability see N78 11873 02 82)
(Contract NSF C 950)
Avail NTIS HC A05/MF A01

A program to stimulate the introduction of beneficial change into the scientific and technical communication process has been operating for three years Concentrating initially on the primary dissemination component of the communication process, a guidebook for innovators was produced and distributed Various activities to expand the guidebook encourage the utilization of its contents and evaluate its usefulness were then undertaken The program experience and results to date are discussed, and plans for expanding the program into other areas of the scientific and technical information communication process are outlined Author

N78-11880# Hatfield Polytechnic (England)
PROSPECTS FOR FACSIMILE IN INFORMATION TRANSFER
R Barrett *In* AGARD The Impact of Future Develop in Commun, Inform Technol and Natl Policies on the Work of the Aerospace Inform Specialist Sep 1977 10 p refs (For availability see N78 11873 02 82)
Avail NTIS HC A05/MF A01

FACSIMILE was originally used primarily to transmit graphical images but the recent growth of information generation and dissemination has increased its potential FACSIMILE is now playing an increasingly important role in information transfer generally because of its accuracy, convenience and low labour requirements Although the majority of machines in operation are 3 6 minute analogue devices, machines capable of processing the information digitally in such a way that it can be transmitted in one minute or less are now on the market and the general introduction of such machines at an economic price will greatly increase the use of FACSIMILE In the United States computer switched FACSIMILE networks using store and forward techniques are becoming available which will eventually allow a mix of packet switched data and FACSIMILE In addition to providing a general point topoint FACSIMILE service such a network would have the capability to translate FACSIMILE transmissions between networks of incompatible machines Further developments in the store and forward field will allow the recording of FACSIMILE information in buffer stores with later transmission to automatically called receivers using cheap night communication rates These developments are reviewed and the prospects for FACSIMILE in information transfer systems are considered Author

N78-11881# Bell Telephone Labs, Inc Murray Hill N J
THE LIBRARY IN THE FUTURE
W Kenneth Lowry *In* AGARD The Impact of Future Develop in Commun Inform Technol and Natl Policies on the Work of the Aerospace Inform Specialist Sep 1977 4 p refs (For availability see N78 11873 02 82)
Avail NTIS HC A05/MF A01

Current information access patterns will be influenced greatly by new technological developments and by new perceptions of the information requirements of users Libraries will assume new roles and perform new functions if they are to become more than archives of recorded knowledge The library of the future will be an active communication device or it will wither and be essentially a warehouse operation There will be a need for better management control of library operations through system analysis and feedback techniques Library cooperative efforts using networking arrangements will proceed slowly in specific areas of library operations These and other matters concerning future library systems and services are discussed Author

N78-11882# International Translations Centre, Delft (Netherlands)
FROM ETC TO ITC, THE INTERNATIONAL TRANSLATIONS CENTRE
D VanBergeijk *In* AGARD The Impact of Future Develop in Commun Inform Technol and Natl Policies on the Work of the Aerospace Inform Specialist Sep 1977 4 p refs (For availability see N78 11873 02 82)
Avail NTIS HC A05/MF A01

The participation of a greater number of countries of the world in the further development of science and technology will probably make the language barrier stronger instead of weaker In many cases the scientists of these countries will not use international languages for the communication of their research results Translating by computer may be the solution for the future However human translating possibly machine aided will still be the most effective tool now International co operation is needed to make optimal use of existing scientific translations For this purpose the International Translations Centre (formerly the European Translations Centre) was founded in 1960 Possibilities for future expansion and international co operation are suggested for the near future and on a long term basis Author

N78-11883# Defense Documentation Center Alexandria Va
ASSESSMENTS OF DEFENSE INFORMATION AND DOCUMENTATION NEEDS
Hubert E Sauter *In* AGARD The Impact of Future Develop in Commun Inform Technol and Natl Policies on the Work of the Aerospace Inform Specialist Sep 1977 8 p refs (For availability see N78 11873 02 82)
Avail NTIS HC A05/MF A01

Historically the Defense Documentation Center DDC has been and still is a traditional document and bibliography oriented activity It is responsible for providing the appropriate data and documentation to increase the effectiveness of scientists engineers, and others within the Department of Defense and its contractor organizations, who manage by far the largest portion of the U S Government s budget for the research development test and evaluation program However it was realized within the past few years that the scope of the Center is too narrow to continue satisfying its user population in today s research and development community As a consequence formal studies were conducted to synthesize the predictions of user requirements as well as the forecasts and trends in information technology into a set of realistic well conceived and documented technical objectives for DDC programs in the next decade Author

N78-11884# Commission of the European Communities Luxembourg
DATA BASE SHARING IN THE EURONET ENVIRONMENT
G W P Davies *In* AGARD The Impact of Future Develop in Commun Inform Technol and Natl Policies on the Work of the Aerospace Inform Specialist Sep 1977 5 p (For availability see N78 11873 02 82)
Avail NTIS HC A05/MF A01

The EURONET information and documentation network is now in its implementation phase Detailed preparations are underway to offer users on line access to some 100 different data bases on over 20 host computers via EURONET This paper reviews the achievements to date and work in progress is reviewed including the general design features and installation of the telecommunications network data base developments a proposed common command language and multilingual aspects A provisional list of data bases to be made accessible through EURONET is presented together with the names of the host computers on which they will be mounted This assessment also reviews key principles and policies defining the framework within which EURONET services will operate and identifies factors affecting the sale of data base services Author

N78-11885# National Scientific and Technical Information Bureau, Paris (France)
THE NATIONAL SCIENTIFIC AND TECHNICAL INFORMATION BUREAU
J Michel *In* AGARD The Impact of Future Develop in Commun Inform Technol and Natl Policies on the Work of the Aerospace Inform Specialist Sep 1977 2 p (For availability see N78 11873 02 82)
Avail NTIS HC A05/MF A01

The Bureau National de L Information Scientifique et Technique (BNIST) has established a French national network of scientific and technological information divided into specialized realms, a policy of computerized information has been instituted BNIST has taken part in the creation of data banks the training of users, and research in the field of information science and technology The agency also coordinates efforts to disseminate news of scientific and technological advances to the general public Author

N78-11886# IDW, Frankfurt (West Germany)
TWO YEARS EXPERIENCE WITH AN INTEGRATED NATIONAL SCIENTIFIC AND TECHNICAL INFORMATION PROGRAMME
M Cremer *In* AGARD The Impact of Future Develop in Commun Inform Technol and Natl Policies on the Work of the Aerospace Inform Specialist Sep 1977 2 p (For availability see N78 11873 02 82)
Avail NTIS HC A05/MF A01

AD-A092 125 ADVISORY GROUP FOR AEROSPACE RESEARCH AND DEVELOPMENT--ETC F/G 15/7
AGARD INDEX OF PUBLICATIONS, 1977 - 1979.(U)
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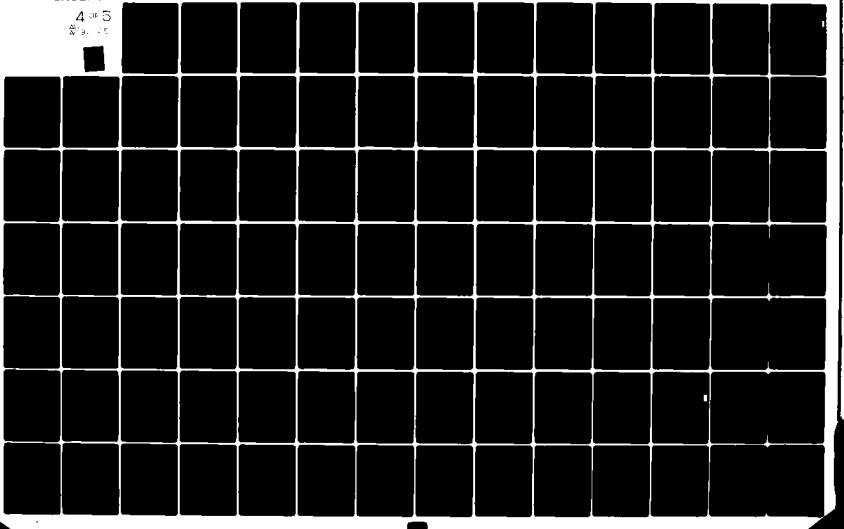

Problems of implementing a German federal information policy are recounted. Viewing information not only as a raw material but as a product or commodity brings economic factors into play. New technologies enabling the storage of more and more information put a national or international system into direct competition with the commercial interests of printing, publishing, and mass media. Problems such as these are considered in view of present European and worldwide information dissemination networks. J.H.

N78-11887# British Library, London (England). Dept. of Research and Development.
UK DEVELOPMENTS IN SCIENTIFIC AND TECHNICAL INFORMATION
John Gray *In* AGARD The Impact of Future Develop. in Commun., Inform. Technol. and Natl. Policies on the Work of the Aerospace Inform. Specialist Sep. 1977 5 p (For availability see N78-11873 02-82)
Avail: NTIS HC A05/MF A01

The most important UK developments over the last twenty years are reviewed. They relate to libraries as well as information services, and the paper demonstrates the extent to which decisions on development have been related to research. Many of the developments described are coordinated or stimulated by the new British Library. Special attention is given to the growth of library and information systems and networks, to literature back-up services and reviews of needs for further developments. Author

N78-11888# Illinois Univ., Urbana. School of Library Science.
PAPERLESS COMMUNICATION SYSTEMS: PUTTING IT ALL TOGETHER
F. W. Lancaster *In* AGARD The Impact of Future Develop. in Commun., Inform. Technol. and Natl. Policies on the Work of the Aerospace Inform. Specialist Sep. 1977 4 p refs (For availability see N78-11873 02-82)
Avail: NTIS HC A05/MF A01

Advances in computer science and in communications technology allow us to conceive of a global system in which reports of scientific discovery and technological development are composed, published, disseminated and used in a completely electronic mode. In a largely electronic world, the individual scientist will use an on-line terminal to collect notes, to compose reports, to build information files, to search data bases, and to converse with other individuals. A scenario for an information system of the year 2000 is suggested in this report, and mention is made of some technological and intellectual achievements that contribute to make the electronic system entirely possible. Author

N78-13968# Advisory Group for Aerospace Research and Development, Paris (France).
AGARD INDEX OF PUBLICATIONS, 1974 - 1976
Oct. 1977 401 p
(AGARD-index-74-76) Avail: NTIS HC A18/MF A01

Full bibliographic citations and abstracts for all the documents are given in the abstract section, which is organized in the 10 major subject divisions and 74 specific categories used by NASA in its abstract journals and bibliographies. The major subject divisions are listed in the Table of Contents, together with a note for each that defines its scope and provides any cross references. Category breaks in the abstract section are identified by category number and title and a scope note. Within each category, the abstracts are arranged by series and year. N10,000 series (STAR) items appear before X70,000 series items. Examples of typical citations with abstracts are given following the Table of Contents. Author

N78-22957# Advisory Group for Aerospace Research and Development, Paris (France).
THE APPLICATION OF INEXPENSIVE MINICOMPUTERS TO INFORMATION WORK
Mar. 1978 88 p refs Presented at Lecture Series held at Delft (Netherlands), 17-18 Apr. 1978 and at Ankara, 20-21 Apr. 1978
(AGARD-LS-92; ISBN-92-835-1276-6) Avail: NTIS HC A05/MF A01

The ways in which many computers are used in information work are outlined including examples of their use in editing and publishing information bulletins, selective dissemination of information, and retrospective retrieval and library housekeeping.

N78-22958# National Defence Headquarters, Ottawa (Ontario). Scientific Information Services.
USE OF MINICOMPUTERS IN OSIS
R. A. McIvor *In* AGARD The Appl. of Inexpensive Minicomputers to Inform. Work Mar. 1978 5 p (For availability see N78-22957 13-82)
Avail: NTIS HC A05/MF A01

The reasons for the choice of a minicomputer system by the information service are discussed, and a general outline of the system is given. Particular attention is given to the data-input system and the advantages and disadvantages of various options are discussed. Experiences with a variety of input methods are described. Some expected future developments are indicated. Author

N78-22959# Minnesota Univ., Minneapolis. Wilson Library
A SELECTION OF MINICOMPUTER SYSTEMS FOR BIBLIOGRAPHIC APPLICATIONS
Audrey N. Grosch *In* AGARD The Appl. of Inexpensive Minicomputers to Inform. Work Mar. 1978 8 p refs (For availability see N78-22957 13-82)
Avail: NTIS HC A05/MF A01

The selection of minicomputer systems for a wide range of potential bibliographic applications is considered from simple single dedicated library tasks such as circulation control through complex integrated library management or interactive retrieval systems. Basic assumptions and definition of a given system's capabilities, required functions, method of creation including design and development, and working environment are introduced. Minicomputer system development trends are highlighted to set in perspective a discussion of criteria for system selection. These criteria include the application and the determination of hardware, software, and general system factors having prime importance in system selection for bibliographic purposes. The minicomputer central processor, main memory, memory protection, peripheral devices, data communication interfaces, vendor supplied software, and instruction sets are discussed in light of bibliographic application. Other evaluative criteria such as vendor support, delivery and pricing schedules, and multiple vendor systems are briefly considered. Author

N78-22960# East Anglia Univ., Norwich (England) Library
CIRCULATION CONTROL
Christopher J. Aslin *In* AGARD The Appl. of Inexpensive Minicomputers to Inform. Work Mar 1978 11 p refs (For availability see N78-22957 13-82)
Avail: NTIS HC A05/MF A01

Examples of minicomputer circulation control systems are described to illustrate how the computer is utilized in different ways to cope with the problems of differing library requirements. Author

N78-22961# International Development Research Centre, Ottawa (Ontario).
THE IDRC'S MINICOMPUTER-BASED BIBLIOGRAPHIC INFORMATION SYSTEM
Faye A. Daneliuk *In* AGARD The Appl. of Inexpensive Minicomputers to Inform. Work Mar. 1978 9 p refs (For availability see N78-22957 13-82)
Avail: NTIS HC A05/MF A01

A minicomputer based information system developed to process bibliographic data, to provide many automatic procedures for managing library requirements, and to permit retrieval from several large data bases is described. The system is generalized to permit the creation of data bases of many different types, for example, data about projects, bibliographic data, and library accounting data. A fully interactive user language designed to enable the user to do anything from data entry to multiparameter retrieval or, for example, from generating a KWIC index to producing an accounting of outstanding book orders is discussed along with the file system, the text editor, and the sort/merge software. Author

N78-22962# Defence Research Information Centre, Orpington (England).
PRODUCTION OF AN ABSTRACTS JOURNAL
George W. Hart *In* AGARD The Appl. of Inexpensive Minicomputers to Inform. Work Mar. 1978 17 p refs (For availability see N78-22957 13-82)
Avail: NTIS HC A05/MF A01

Systems developed by information centers to produce an abstract journal with a minicomputer are described. Advantages the computer brings to the production of the abstract journal, including preparation of various types of indexes are emphasized. Other factors considered include form of input, processing procedures, and output equipment; contents and format of the journal; and source of software. J.M.S.

N78-22963# National Defence Headquarters, Ottawa (Ontario). Scientific Information Services.
SELECTIVE DISSEMINATION OF INFORMATION
R. A. McIvor *In* AGARD The Appl. of Inexpensive Minicomputers to Inform. Work Mar. 1978 3 p (For availability see N78-22957 13-82)
Avail: NTIS HC A05/MF A01

The preparation of search profiles and the role of the information scientist in their testing and maintenance are discussed in terms of a selective dissemination of information system (SDI). The methods of implementation of SDI programs, in particular the tradeoff between memory capacity and speed are included. A matching algorithm is described. Author

N78-22964# Lipman Management Resources Ltd., Maidenhead (England).
COST-EFFECTIVENESS IN LIBRARY AUTOMATION
J. H. Ashford *In* AGARD The Appl. of Inexpensive Minicomputers to Inform. Work Mar. 1978 6 p refs (For availability see N78-22957 13-82)
Avail: NTIS HC A05/MF A01

Development of minicomputer systems for library automation is discussed in terms of cost effectiveness. Factors characteristic of library needs are considered including: high volume and high complexity processes; the need to manage textual material where the meaning and use of the content are context dependent; and the requirement to install systems which are easy to use and robust for noncomputing users. Cost reduction and containment in the areas of circulation control, information retrieval, cataloguing, and management are examined. Collaboration among libraries in the development of library minicomputer systems and reusé of previously developed systems is proposed to reduce costs. J.M.S.

N78-22965# Minnesota Univ., Minneapolis. Wilson Library.
COMMERCIAL DATA BASE MANAGEMENT SYSTEM (DBMS) SOFTWARE IN LARGER MINICOMPUTER CONFIGURATIONS
Audrey N. Grosch *In* AGARD The Appl. of Inexpensive Minicomputers to Inform. Work Mar. 1978 10 p ref (For availability see N78-22957 13-82)
Avail: NTIS HC A05/MF A01

Data base management system (DBMS) software is compared to data management system (DMS) software and a brief historical overview of development and use is presented as a background to a discussion of DBMS and the design of online systems for libraries. Some questions are posed to help a given library determine whether it should use a DBMS approach in its online system within a minicomputer or conventional computing environment. The data structures supported, the language facilities, the minimal hardware configurations, and various other component features of several minicomputers are discussed. Various systems are compared from the standpoint of potential of bibliographic systems use. Author

N78-22966# Informatics, Inc., Woodland Hills, Calif.
FUTURE PROSPECTS FOR MINICOMPUTERS
Frank V. Wagner *In* AGARD The Appl. of Inexpensive Minicomputers to Inform. Work Mar. 1978 9 p refs (For availability see N78-22957 13-82)
Avail: NTIS HC A05/MF A01

The development of decentralized computing and its impact on information systems are described. Emphasis is placed on increasing efficiency and reducing costs in the information processing industry. As an example, a simplified and inexpensive minicomputer system is described. It is proposed to replace Gorsch's Law with 'The Principle of Decentralized Computing'. Author

N79-13926# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
MANUAL OF DOCUMENT PRACTICES APPLICABLE TO DEFENCE-AEROSPACE SCIENTIFIC AND TECHNICAL INFORMATION, VOLUME 1
S. C. Schuler Aug. 1978 70 p refs
(AGARD-AG-235-Vol-1; ISBN-92-835-1291-X) Avail: NTIS HC A04/MF A01

The problems and techniques associated with processing unpublished technical reports and related materials in defense and aerospace information centers are addressed. Practical guidelines are given for procuring, accessioning, abstracting, and indexing documents other than books and journals. The values of manual and automated systems are assessed. For individual titles, see N79-13927 through N79-13929.

N79-13927*# NASA Scientific and Technical Information Facility, Baltimore/Washington International Airport, Md. 21240.
ACQUISITION AND SOURCES
Philip F. Eckert (Informatics Inform. Systems Co.) *In* AGARD Manual of Doc. Pract. Appl. to Defence-Aerospace Sci. and Tech. Inform., Vol. 1 Aug. 1978 p 1-22 refs (For primary document see N79-13926 04-82)
Avail: NTIS HC A04/MF A01 CSCL 05B

Suggestions and ideas for acquiring documents or their surrogates for a planned or fledgling information system are offered. The problems of selectivity of documents or their surrogates, both in superabundant quantities, and duplicate checking are highlighted. Acquisitioning flow, a semiautomated duplicate search technique, and alerting methods for prospective documentation are described. Appendices include two category systems, selected definitions and acronyms, and a selected address list for document procurement. Author

N79-13928# Defense Documentation Center, Alexandria, Va. Defense Logistics Agency.
DESCRIPTIVE CATALOGING
Barbara P. Gladd, Olga G. Lucheka, and James C. Wade *In* AGARD Manual of Doc. Pract. Appl. to Defence-Aerospace Sci. and Tech. Inform., Vol. 1 Aug. 1978 p 23-44 refs (For primary document see N79-13926 04-82)
Avail: NTIS HC A04/MF A01

The functions and purposes of descriptive cataloging as applied to processing technical report literature are defined and the comparative merits of manual vs. automated systems are discussed. Descriptive data elements required for processing technical reports are listed and guidelines are given for using these elements in a system presently automated or which may be automated in the future. A conversion table is included to indicate the relationship to data elements used in conventional cataloging. The consolidated experience of large documentation centers in the United States was used to develop the guidelines. A.R.H

N79-13929# National Federation of Abstracting and Indexing Services, Philadelphia, Pa.
ABSTRACTING AND SUBJECT ANALYSIS
Toni Carbo Bearman *In* AGARD Manual of Doc. Pract. Appl. to Defence-Aerospace Sci. and Tech. Inform., Vol. 1 Aug. 1978 p 45-64 refs (For primary document see N79-13926 04-82)
Avail: NTIS HC A04/MF A01

A practical approach to abstracting and indexing in aerospace and defense documentation centers is presented for senior staff setting up a new system, as well as for junior staff interested in training assistance. Major subject areas covered include abstracting, subject and analysis, thesaurus development, and automation. Specific aspects such as definition and scope, types of indexes and abstracts, and relevant standards are discussed. Various techniques are summarized and references to authoritative texts are cited. A.R.H

N79-20912# Advisory Group for Aerospace Research and Development, Paris (France).
INFORMATION AND INDUSTRY
Jan. 1979 90 p refs In ENGLISH and FRENCH Meeting held in Paris, 18-19 Oct. 1978
(AGARD-CP-246; ISBN-92-835-0228-0) Avail: NTIS HC A05/MF A01

Industrial information requirements, mechanisms for information transfer, management considerations in information transfer, and representative national programs are presented. For individual titles, see N79-20913 through N79-20926.

N79-20913# British Library, London (England).
THE REQUIREMENTS OF INDUSTRY FOR TECHNOLOGICAL INFORMATION
Michael W. Hill *In* AGARD Inform. and Ind. Jan. 1979 10 p refs (For primary document see N79-20912 11-82)
Avail: NTIS HC A05/MF A01

Information systems in industry include the following requirements: (1) to give only the information the client wants; (2) to give immediately understandable and applicable answers; (3) to give answers quickly; (4) to be simple to use; (5) to involve only familiar technology; (6) to be readily accessible, preferably locally based; (7) to exploit existing tried, trusted, and respected channels; (8) to be stable; and (9) to charge fees which clients can readily afford. S.E.S.

N79-20914# Ministry of Economic Affairs, The Hague (Netherlands).
REQUIREMENTS IN SCIENTIFIC AND TECHNICAL INFORMATION (GOVERNMENT VIEWPOINT) [LES BESOINS EN INFORMATION SCIENTIFIQUE ET TECHNIQUE: LE POINT DE VUE DU GOUVERNEMENT]
S. C. Chambaud *In* AGARD Inform and Ind. Jan. 1979 3 p In FRENCH (For primary document see N79-20912 11-82)
Avail: NTIS HC A05/MF A01

Although the needs of industries for scientific and technical information vary according to the type of enterprise considered, governments can analyze and attempt to meet these needs. Three essential factors which influence the way in which an industry perceives its need for information are the type of industry, its domain of activity, and its status (growing, declining, or stationary). Industries need information concerning research and production methods, technical-juridical information covering patents and licensing, and technical-economic data related to commerce and marketing. Political intervention is required to meet social and economic objectives. Enterprises must be encouraged to innovate in order to strengthen the industrial fabric of the nation and contribute to the international community. All enterprises must be equally supplied with information needed. Transl. by A.R.H.

N79-20915# Ministry of Economic Affairs, The Hague (Netherlands).
REQUIREMENTS FOR LEGAL/ECONOMIC INFORMATION
J. M. vanPoelje *In* AGARD Inform. and Ind. Jan. 1979 4 p (For primary document see N79-20912 11-82)
Avail: NTIS HC A05/MF A01

Sources of information, kinds of collected information, distribution of information, communication with sources, and communication with users were examined as a means of supplying information in Dutch trade and industry. The Documentation Center of Economic Information Service is described. Publications and automation in information systems are presented. S.E.S.

N79-20916# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (West Germany)
LITERATURE MECHANISMS, INFORMATION MANAGEMENT IN INDUSTRIAL ORGANIZATIONS
Heinz Goehre *In* AGARD Inform. and Ind. Jan. 1979 11 p (For primary document see N79-20912 11-82)
Avail: NTIS HC A05/MF A01

Information transfer in industrial organizations, information requirements and technological action, channels of information transfer, barriers to information transfer, and information management in Germany are discussed. S.E.S.

N79-20917# Battelle Columbus Labs., Ohio.
COMPUTER MECHANISMS FOR INDUSTRY'S INFORMATION TRANSFER
John B. Fried *In* AGARD Inform. and Ind. Jan. 1979 5 p refs (For primary document see N79-20912 11-82)
Avail: NTIS HC A05/MF A01

The growth of computer systems in communication and information/data processing is discussed. The present status of data base storage and retrieval, teleconferencing, electronic messages, and conversational models were reviewed. On-line computer systems are described. S.E.S.

N79-20918# Pera, Melton Mowbray, Leicester (England).
TECHNOLOGY TRANSFER FOR MANUFACTURING INDUSTRIES
D. F. Galloway *In* AGARD Inform. and Ind. Jan. 1979 7 p (For primary document see N79-20912 11-82)
Avail: NTIS HC A05/MF A01

Technology which factories can best utilize, the time and cost of effecting technology transfer, the likely influence of human psychological factors in impeding technology transfer, and the influence the history and the incentives and disincentives of the plant and industry are predicted. The progression of improved manufacturing techniques form the initial stage of scientific possibility to the final stage of extensive profitable application in industry was studied. S.E.S.

N79-20919# Manchester Business School (England).
REVIEW OF SELECTED INFORMATION TRANSFER STUDIES
A. W. Pearson *In* AGARD Inform. and Ind. Jan. 1979 7 p refs (For primary document see N79-20912 11-82)
Avail: NTIS HC A05/MF A01

Factors which influence the transfer of information in research and development were examined. A wide range of sources of drawn upon to argue that the individual is the most important influence on the way in which information is used. The effectiveness of information transfer can be increased by examining the barriers to communication is presented. S.E.S.

N79-20920# King Research, Inc., Rockville, Md.
INFORMATION TRANSFER COST/BENEFIT ANALYSIS
Donald W. King and Nancy K. Roderer *In* AGARD Inform. and Ind. Jan. 1979 10 p refs (For primary document see N79-20912 11-82)
Avail: NTIS HC A05/MF A01

A framework for performing cost/benefit analysis of information transfer systems is provided. A cost model is developed for each of these components consisting of cost factors such as number of journal articles (for secondary information systems) and cost elements such as labor, equipment, supplies and so on. Improved performance and effectiveness is assumed to lead to increased benefits which can be measured in terms of value, social benefit and so on. S.E.S.

N79-20921# Association of Special Libraries and Information Bureaux, London (England).
EVALUATION OF INFORMATION SERVICES: RESEARCH AND REALITY
P. H. Vickers *In* AGARD Inform. and Ind. Jan. 1979 5 p refs (For primary document see N79-20912 11-82)
Avail: NTIS HC A05/MF A01

The state of the development of evaluation philosophy and methods are reviewed. The broad scope of evaluation techniques that are required for different types of systems and services is presented. The approach used in evaluating information services is described. The objectives of the service by careful analysis of the information requirements of the organization are defined. S.E.S.

N79-20922# National Research Council of Canada, Ottawa (Ontario). Technical Information Service.
INFORMATION AND ASSISTANCE SERVICES TO THE MANUFACTURING INDUSTRY IN CANADA
G. Kirouac *In* AGARD Inform. and Ind. Jan. 1979 5 p refs (For primary document see N79-20912 11-82)
Avail: NTIS HC A05/MF A01

The Technical Information Service (TIS) of the National Research Council is a technology transfer service to assist manufacturing industry. TIS is operated through field offices to ensure the most direct contact possible with industry. A question-and-answer service in the field of science and technology is provided. An engineering service to assist industry with its production problems is given. A program to keep industry abreast of new developments is offered. The benefits to industry and government, as well as a recent student program to extend the assistance already given by its regular staff are described. S.E.S.

N79-20923# Dansk Teknisk Oplysningstjeneste, Copenhagen.
A REVIEW OF TECHNOLOGICAL, TECHNICAL AND SCIENTIFIC INFORMATION SERVICES IN DENMARK, 1978
Kjeld Klintoe *In* AGARD Inform. and Ind. Jan. 1979 3 p refs (For primary document see N79-20912 11-82)
Avail: NTIS HC A05/MF A01

The structure of the Danish industry is described. The aims, objectives, programs, and working methods of technological information services for industry are presented. The person-to-person transfer of technological information was examined. S.E.S.

N79-20924# Bureau National de l'Information Scientifique et Technique, Paris (France).
NATIONAL PROGRAMS WITH RESPECT TO INDUSTRIAL INFORMATION [PROGRAMMES NATIONAUX EN MATIERE D'INFORMATION INDUSTRIELLE]

M. F. Morin *In* AGARD Inform. and Ind. Jan. 1979 4 p In FRENCH (For primary document see N79-20912 11-82)
Avail: NTIS HC A05/MF A01

Structures created by the French National Bureau of Scientific and Technical Information to meet the needs of small and medium-sized industries include the national orientation service (SOS-DOC) and the regional scientific and technical information agencies (ARIST). The SOS-DOC directs inquirers to organizations with competence for answering specific questions. Service is open to all persons involved in scientific and technical research including instructors, technicians, and the press. The resources available include technical industrial centers for documentation, laboratory, or technical assistance; public libraries, universities, and government agencies. Nine ARIST centers currently carry out, at the request of industries, searches of all available scientific and technical information sources on a regional, national, and international level. A summary of all data gathered is presented to the inquirer in the most economic and appropriate form, according to the nature of the request. Transl. by A.R.H.

N79-20826# Wilkinson (J. B.), Walton (England).
A NATIONAL PROGRAMME FOR UK
J. B. Wilkinson *In* AGARD Inform. and Ind. Jan. 1979 3 p refs (For primary document see N79-20912 11-82)
Avail: NTIS HC A05/MF A01

The policy of the National Industrial Information Agency is described. The following items are included: (1) use of public libraries as a universal access facility; (2) availability of Commercial information; (3) establishment of Standards and Specifications data banks; (4) industrial contribution; (5) promotion of training facilities; (6) promotion of corporate recognition of the value of the information resource; and (7) establishment of effective user representation. S.E.S.

N79-20826# Advisory Group for Aerospace Research and Development, Paris (France).
TRANSFERRING TECHNOLOGY TO INDUSTRY THROUGH INFORMATION
Louis Mogavero *In its* Inform. and Ind. Jan. 1979 6 p (For primary document see N79-20912 11-82)
Avail: NTIS HC A05/MF A01

A better understanding of the NASA transfer process, how it works, and the levels of effectiveness with which each element operates were studied. Similarities in technologies that generate economic benefits were examined. The role in guiding research and development, extracting its results, and packaging and disseminating the knowledge for specific uses in the industrial marketplace are presented. S.E.S.

N80-10861# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
MANUAL OF DOCUMENTATION PRACTICES APPLICABLE TO DEFENCE-AEROSPACE SCIENTIFIC AND TECHNICAL INFORMATION, VOLUME 2
S. C. Schuler, ed. Jul. 1979 124 p refs
(AGARD-AG-235-Vol-2) Avail: NTIS HC A06/MF A01

An introduction to the hardware and software of computer systems is given, followed by a description of the problems of the input of data, including the representation of characters and the choice of a character set. The different types of input and storage equipment are described and examples are given. Management and systems analysis problems are outlined in the project environment. Finally, there is a brief introduction to chemical structure input and storage techniques. Author

85 URBAN TECHNOLOGY AND TRANSPORTATION

Includes applications of space technology to urban problems; technology transfer; technology assessment; and surface and mass transportation.

For related information see *03 Air Transportation and Safety, 16 Space Transportation,* and *44 Energy Production and Conversion.*

N77-28048# Advisory Group for Aerospace Research and Development, Paris (France).

METHODS OF TECHNOLOGICAL FORECASTING

F. Hetman May 1977 43 p refs

(AGARD-R-655; ISBN-92-835-1240-5) Avail: NTIS HC A03/MF A01

Future research and technology forecasting are discussed. Projective, prospective, and decisional research are considered applied to airline operations, emphasizing the speed trends in various aircraft. J.A.M.

99 GENERAL

N79-25977# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
TECHNIQUES FOR DATA HANDLING IN TACTICAL SYSTEMS, 2
I. J. Gabelman, ed. Apr., 1979 355 p refs Proc. of the Avionics Panel Symp., Monterey, Calif., 18-21 Oct. 1978 (AGARD-CP-251; ISBN-92-835-0233-7) Avail: NTIS HC A16/MF A01

Thirty-two papers apportioned as follows: two on operational requirements; six on data acquisition, display and control; six on communications; four on tactical data processing hardware; six on applications programming; and eight on tactical systems. For individual titles, see N79-25978 through N79-26008.

N79-25978# Shape Technical Center, The Hague (Netherlands).
EXPLOITING TECHNOLOGY FOR OPERATIONAL DECISIONS
I. R. Mirman *In* AGARD Tech. for Data Handling in Tactical Systems, 2 Apr. 1979 6 p refs (For primary document see N79-25977 16-99)
Avail: NTIS HC A16/MF A01

The needs of the tactical decision maker, and to that end, rather than discuss technology per se, the needs of the C2 decision maker were addressed. The notion that C2 is a closed-looped, servo-like system with appropriate feedback was introduced. Past problems were, to a large degree, driven by acquisition of hardware prior to evolving a C2 process needed to achieve adequate opportunity to perform both the command and the control function. Additionally, the notion that C2 was heavily communications oriented have resulted in a huge input of data, not necessarily information. Little attention was given to the orderly process needed; defining of information needed to achieve a given decision. J.A.M.

N79-25979# Naval Air Systems Command, Washington, D. C.
AVIONICS TECHNOLOGY FOR TACTICAL DATA HANDLING
E. B. Beggs *In* AGARD Tech. for Data Handling in Tactical Systems, 2 Apr. 1979 8 p (For primary document see N79-25977 16-99)
Avail: NTIS HC A16/MF A01

Trends emerging in Naval Aviation are discussed, along with their impact on avionics community. New avionics concepts are discussed, with emphasis on the technical and managerial challenges which must be met to assure their successful implementation. These challenges include the software implementation of distributed network control and fault tolerance; NATO interoperability and standards; and logistic support. J.A.M.

N79-25980# Cranfield Inst. of Technology Bedfordshire (England). School of Electronic System Design.
SOME TRENDS IN DATA ACQUISITION DISPLAY AND CONTROL
John T. Shepherd *In* AGARD Tech. for Data Handling in Tactical Systems, 2 Apr. 1979 27 p refs (For primary document see N79-25977 16-99)
Avail: NTIS HC A16/MF A01

Active and passive sensor systems were reviewed, as well as the display and control technologies available. In particular, uncooled FLIR and microwave radiometry trends were examined in the field of data acquisition and CRTs, LLD arrays, liquid crystals, and plasma panels were considered in the display area. Examples were drawn from the fields of air-to-air combat and RPV control to illustrate the differences and similarities between tactical system requirements in different areas. These examples were also used to illustrate some of the outstanding problem areas. The need for standard system description languages and interface specification to aid the total system design is also described. J.A.M.

N79-25981# Air Force Avionics Lab., Wright-Patterson AFB, Ohio.
THE REAL-TIME TACTICAL RECONNAISSANCE DATA HANDLING PROBLEM
Henry Lapp *In* AGARD Tech. for Data Handling in Tactical Systems, 2 Apr. 1979 6 p refs (For primary document see N79-25977 16-99)
Avail: NTIS HC A16/MF A01

Target acquisition through classification tasks were analyzed and the machine processing and data screening techniques, that are applicable were examined. The data handling capabilities of an onboard operator and ground based image interpreter were compared. A philosophy of processing data to get information as early as possible in the data handling chain was examined in the context of ground exploitation and dissemination needs. Examples of how the various real-time sensors (screeners and processors) could fit into this data handling scenario are discussed. Specific unclassified DOD programs will be used to illustrate the credibility of this integrated approach. J.A.M.

N79-25982# Plessey Radar Ltd., Addlestone (England)
TACTICAL RADAR FOR AIR DEFENSE
R. N. Oldfield *In* AGARD Tech. for Data Handling in Tactical Systems, 2 Apr. 1979 16 p (For primary document see N79-25977 16-99)
Avail: NTIS HC A16/MF A01

A tactical radar system is described whose design is based on the wide use of digital data processing. These techniques have replaced analog and manual techniques in many areas, notably those of communications and radar control. In many respects, there was a shift away from the traditional approach of designing a radar and adding a data processing subsystem. In the AR3D system, the radar, data processing, and display and communications subsystems were designed together, with the data processing subsystem providing many control functions within the other two subsystems. This approach has resulted in the conversions from analog to digital signals on input (and vice versa on output) being moved closer to the input and output devices themselves (e.g. the radar, displays, air-ground-air radio equipment) making the overall system predominantly digital in nature, with consequential improvements in reliability, simplicity in manufacture and ease of deployment. J.A.M.

N79-25983# Mitre Corp., McLean, Va.
IMPROVEMENTS IN THE MAN-MACHINE INTERFACE FOR DATA ACQUISITION, DISPLAY AND CONTROL
Warren A. Manison *In* AGARD Tech. for Data Handling in Tactical Systems, 2 Apr. 1979 14 p refs (For primary document see N79-25977 16-99)
Avail: NTIS HC A16/MF A01

A method is discussed for improving the man-machine interface in civil and military data automation capabilities. The method combined existing hardware technology with innovative software features to provide an interactive capability responsive to the system user. Integral to the concept was the use of a touch entry device and a tabular display for message composition and entry. One or more tabular displays were used for the presentation of data forced to the position or requested by the user. Support software is discussed, including the use of implied logic designed to facilitate the message entry process, branching logic to guide or prompt the user in formatting messages for entry to the system, and display logic responsive to the needs of the position. Techniques for application of this technology to a real-time system like Air Traffic Control are described. Potential application to other types of systems was identified. J.A.M.

N79-25984# Fraunhofer-Gesellschaft, Karlsruhe (West Germany)
INTEGRATING SENSORY INFORMATION IN A MULTISENSOR SYSTEM FOR BATTLEFIELD SURVEILLANCE
D. Paul and T. Partman *In* AGARD Tech. for Data Handling in Tactical Systems, 2 Apr. 1979 7 p ref (For primary document see N79-25977 16-99)
Avail: NTIS HC A16/MF A01

This study prepared the development of an all-weather reconnaissance system for tactical ground to ground missions. At present, passive electrooptical sensors (TV, LLLTV, FLIR), active microwave sensors (tracking radar RATAC,3-D-radar), and a passive microwave radiometer were combined to form a multisensor system. Two problems were solved: (1) The display of information of the 3-D radar--this was done by showing a horizontal and a vertical slice of the spatial scene to the observer who can select the position of the slices, as well as the displayed depth range. (2) The integration of sensory information from the different sensors--this task essentially was solved by marking spatially corresponding regions in the different pictures by means of auxiliary lines. J.A.M.

N79-25985# Northrop Corp., Hawthorne, Calif. Electronics Div.
TACTICAL RECONNAISSANCE WITH IMAGE EXPLOITATION

Gary L. Wycoff *In* AGARD Tech for Data Handling in Tactical Systems, 2 Apr 1979 7 p refs (For primary document see N79-25977 16-99)
Avail: NTIS HC A16/MF A01

To practically and economically achieve the capability for exploitation of digital imagery in real time, the performance requirements of the ground processing facility must be carefully established. Examinations must be made of the need for various image handling techniques and the resulting benefit to the image interpreter. Through the selective use of current and planned technologies, an imagery exploitation cycle time of less than three minutes from receipt of imagery through report generation appears to be realistic. J.A.M.

N79-25986# Hughes Aircraft Co., Fullerton, Calif.
THE ROLE OF ADVANCED TECHNOLOGY IN TDMA SYSTEMS
Frank Amoroso and John D. Olsen *In* AGARD Tech. for Data Handling in Tactical Systems, 2 Apr 1979 23 p refs (For primary document see N79-25977 16-99)
(Contracts DAAB07-76-C-1750, F19628-75-C-0205)
Avail: NTIS HC A16/MF A01

The technology in two TDMA systems is reviewed, as well as Hughes' projections of impacts of technology trends on such systems. The signal processing techniques included direct sequence pseudonoise modulation, frequency hopping, interleaved forward error correction coding, and residual error detection coding. Circuit applications include (1) programmable matched filters for burst message preamble reception, (2) small sized, precise, agile, rapidly stabilizing, digitally controlled frequency synthesizers, (3) digital symbol demodulators, (4) surface acoustic wave devices, and (5) automated network management. J.A.M.

N79-25987# Rome Air Development Center, Griffiss AFB, N.Y.
MULTI-FUNCTION COMMUNICATIONS AND TACTICAL DATA LINKS
Henry J. Bush *In* AGARD Tech. for Data Handling in Tactical Systems, 2 Apr 1979 11 p refs (For primary document see N79-25977 16-99)
Avail: NTIS HC A16/MF A01

By integrating temporal and spatial signal processing, the multifunction communications requirements can be generally met with moderate bandwidths. By proper design, fully adaptive transceivers with a single spectrum signalling structure can be derived with multimission capabilities. Such transcdivers at moderate bandwidths were realizable by incorporating the new solid state, programmable, signal processing device technologies and microcomputer technology. The multimission capability led to large transceiver production buys and standardized the form, fit and function (F3) parameters. Moderate bandwidths with solid state implementation minimized these F3 parameters. A single spread spectrum signalling structure led to duplicity of circuits, increasing the use of mass production processes. All of these factors combined not only lead to low cost transceivers but also to lower overall vehicle costs. J.A.M.

N79-25988# Air Force Inst. of Tech., Wright-Patterson AFB, Ohio. Department of Electrical Engineering.
INTERACTION OF ANTENNA ARRAYS AND MODEMS IN TACTICAL LINKS
Stanley R. Robinson, Edward Raska, Jr., and Jurgen O. Gobien (Rome Air Development Center, Griffiss AFB, N.Y.) *In* AGARD Tech. for Data Handling in Tactical Systems, 2 Apr. 1979 11 p refs (For primary document see N79-25977 16-99)
Avail: NTIS HC A16/MF A01

The effect of the antenna array on a wideband signal was investigated, of special interest was signal distortion produced by the nulls of the array. An analytical model was developed to relate array characteristics and the matched filter output for a wideband coherent receiver. The distorted output was written as the sum of the desired autocorrelation function and its derivatives. If the signal is being nulled, the derivatives can easily predominate and distortion become severe. Results were specialized to the case of a pseudo-noise - coded carrier filtered by a four-element linear array. A comparison with experimental data was made, and several conclusions regarding receiver design and signal choice were drawn. J.A.M.

N79-25989# Kongsberg Vapenfabrikk A/S (Norway).
BUDOS: A MULTIPLEX DATA BUS TRANSMISSION SYSTEM
S. Oderud *In* AGARD Tech. for Data Handling in Tactical Systems, 2 Apr. 1979 12 p (For primary document see N79-25977 16-99)
Avail: NTIS HC A16/MF A01

The highway or serial date bus format is appropriate to systems where data sources and users are distributed. One interface specification STANAG 4156 and one data transmission system BUDOS under development will fulfill the requirement of STANAG 4156. The polling-contention type format used for this new system will give system advantages and then one bus data channel will give system redundancy and gradual degradation. The new data distribution system BUDOS will go onboard coast guard vessels under construction in NORWAY and will be used for ordinary point-to-point addressed data and broadcast transmission. J.A.M.

N79-25990# Admiralty Surface Weapons Establishment, Portsdown (England). Computer Div.
ADNET: AN EXPERIMENTAL INFORMATION DISTRIBUTION SYSTEM
T. D. Wells and M. G. Stainby *In* AGARD Tech. for Data Handling in Tactical Systems, 2 Apr. 1979 9 p (For primary document see N79-25977 16-99)
Avail: NTIS HC A16/MF A01

The ADNET (Action Data Net) is a laboratory-based feasibility model of a shipborne command and control system. It is intended to allow examination and solution of problems associated with the introduction of distributed computing techniques to Naval Systems in such a way as to allow flexibility of major weapon systems and reconfigurability of command functions. This paper describes the hardware implementation of the information distribution system around which ADNET is based. J.A.M.

N79-25991# Naval Air Development Center, Warminster, Pa.
THE APPLICATION OF STRUCTURED DESIGN AND DISTRIBUTED TECHNIQUES TO AVIONICS INFORMATION PROCESSING ARCHITECTURES
Louis A. Naglak and William M. Norr *In* AGARD Tech. for Data Handling in Tactical Systems, 2 Apr 1979 17 p refs (For primary document see N79-25977 16-99)
Avail: NTIS HC A16/MF A01

Structured design principles were used in the formulation of *a methodology for systems design and applied to the definition* of avionics processing architectures. The task was an effort to take advantage of technology advances in the computer field and structured support in software to reduce life cycle costs of avionics. A core avionics was defined and the design constraint imposed upon it discussed. The structured procedure and the way in which it was meant to take advantage of technology was explained. Impact of standard is presented and also a specified scheme for implementation. Alternatives for development and acquisition methods and contracting for a generic avionics score are presented. J.A.M.

N79-25992# GTE Sylvania, Inc., Needham Heights, Mass. Communication Systems Div.
TACTICAL AUTOMATED MESSAGE PROCESSING SYSTEMS
Ruth Nelson and Joseph Jarzembowski *In* AGARD Tech. for Data Handling in Tactical Systems, 2 Apr. 1979 7 p refs (For primary document see N79-25977 16-99)
Avail: NTIS HC A16/MF A01

Some possible approaches are discussed to providing tactical message handling services and their effects on the design of both the tactical and strategic systems. The message handling requirements for both large WWMCCS command centers and small battlefield centers were analyzed and the implementation constraints of tactical systems and differences in emphasis for the various systems were evaluated. If automated message handling is to meet its goal of improved writer-to-reader communications, it is imperative that both strategic and tactical systems designers consider the issues of allocation of functions and of tactical/strategic interoperability. J.A.M.

N79-25993# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
[A TERMINAL FOR THE COMMUNICATION OF TACTICAL ALPHANUMERIC INFORMATION] [TERMINAL DE COMMUNICATIONS TACTIQUES D'INFORMATIONS ALPHANUMERIQUES]
G. Joseph (Sintra France) *In its* Tech. for Data Handling in Tactical Systems, 2 Apr. 1979 18 p In FRENCH (For primary document see N79-25977 16-99)
Avail: NTIS HC A16/MF A01

A terminal integrated in the ATILA (automization of fire and artillery liason) system has one or more dialog posts (screens and alphanumeric keyboard). The operator in charge of targets, works on a grid whose format was designed to minimize human errors, reduce the time of formation, and increase the speed of evaluating decisions. The terminal serves to automize the fire, as a network for data transmission, a means of message transmission, and as an aide in command. Topics covered include the structure of the terminal, functional organization - environment conditions; the logic of the terminal; management of transmissions; and maintenance. The various networks of ATILA are illustrated. Transl. by A.R.H.

N79-25994# Le Materiel Telephonique, Boulogne-Billancourt (France).
NEW GENERATIONS OF TACAN MATERIALS [NOUVELLES GENERATIONS DE MATERIELS TACAN]
J. C. Joguet *In* AGARD Tech. for Data Handling in Tactical Systems, 2 Apr 1979 10 p In FRENCH (For primary document see N79-25977 16-99)
Avail: NTIS HC A16/MF A01

A fourth generation of onboard equipment is described which uses programmed logic and microprocessors in the processing of video signals. In addition, the development of UHF semiconductors makes possible the transistorization of the most powerful equipment. On board TACAN equipment which extracts signals form ground beacons which contain information about bearing and distance benefits especially from the new technologies. The advance from logic cables to programmed logic permits effective smoothing of data regarding navigational objective as well as calculation of the navigational objective itself. The logic is divided into four parts; three for processing (azimuth, distance, and navigation) and one management monitor which accounts for the different modes of operation. The principal advantage of the completely transistorized equipment, which uses the UHF transistors, is the reduction of power loss. Cooling by forced air is not required. Transl. by A.R.H.

N79-25995# Rome Air Development Center, Griffiss AFB, N.Y.
DATA PROCESSING OPPORTUNITIES 1980 - 1990
Alan R. Barnum *In* AGARD Tech. for Data Handling in Tactical Systems, 2 Apr 1979 8 p refs (For primary document see N79-25977 16-99)
Avail: NTIS HC A16/MF A01

The automation of Command and Control and the associated data processing interoperability problems are discussed. Discipline of the software programming environment, cognitive aids and knowledge based systems, and distributed data processing are described. S.E.S.

N79-25996# Royal Netherlands Navy, Nieuwe Haven (Netherlands). Centre for Automation of Weapon and Command Systems.
SOFTWARE FOR ROYAL NETHERLANDS NAVY
Johan B. F. Tasche *In* AGARD Tech. for Data Handling in Tactical Systems, 2 Apr. 1979 16 p refs (For primary document see N79-25977 16-99)
Avail: NTIS HC A16/MF A01

The experience gained by the in house development of real time software for large shipborne command and control systems for the Royal Netherlands Navy (RNLN) is presented. The RNLN's both feet-on-the deck approach to the problem of finding a path through the software engineering jungle is described. S.E.S.

N79-25997# General Research Corp., Santa Barbara, Calif.
RESOURCE ANALYSIS FOR DATA-PROCESSING SOFTWARE
Edward N. Dodson *In* AGARD Tech. for Data Handling in Tactical Systems, 2 Apr. 1979 11 p refs (For primary document see N79-25977 16-99)
Avail: NTIS HC A16/MF A01

Life cycle cost relationships for data processing software are summarized. Statistical analysis based upon actual experience on weapons and space programs is discussed. Cost estimates for the major phases of the software life cycle, and for major variations in software characteristics and acquisition-management concepts are presented. Specific impacts on software cost are described for (1) the effects of hardware capacity-constraints, (2) the effects of execution-time constraints, (3) choice of language type, and (4) use of structured programming procedures. S.E.S.

N79-25998# Admiralty Surface Weapons Establishment, Portsmouth (England).
'WORKING WITH TECHNOLOGY: DISTRIBUTED PROCESSING STANDARDS FOR THE EIGHTIES
B. R. Glaman, K. Jackson (Royal Signals and Radar Establishment, Malvern, England), R. C. Makin, D. Nairn, R. S. Newton (Royal Signals and Radar Establishment, Malvern, England), and T. D. Wells *In* AGARD Tech. for Data Handling in Tactical Systems, 2 Apr 1979 11 p (For primary document see N79-25977 16-99)
Copyright. Avail: NTIS HC A16/MF A01

A set of standards for the adoption of which should allow computer based military equipments from a variety of sources to be developed in compatible fashion is described. The increase in the current logistic and training problems of the Armed Forces without these standards is discussed. S.E.S.

N79-25999# Singer Co., Wayne, N.J.
PARNAS PARTITIONING
Austin J. Maher *In* AGARD Tech. for Data Handling in Tactical Systems, 2 Apr. 1979 11 p refs (For primary document see N79-25977 16-99)
Avail: NTIS HC A16/MF A01

The Parnas Partitioning technique and its application to avionic software by the use of examples was reviewed. The most successful use of the technique for weapon systems is described which required participation by the software design engineer, the systems design engineer, the customers project engineer, and the end user. The role of each of these participants is identified. S.E.S.

N79-26000# Rome Air Development Center, Griffiss AFB, N.Y.
HIGH ORDER LANGUAGE STANDARDIZATION
S. A. DiNitto, Jr. *In* AGARD Tech. for Data Handling in Tactical Systems, 2 Apr. 1979 8 p refs (For primary document see N79-25977 16-99)
Avail: NTIS HC A16/MF A01

The attempts at High Order Programming Languages (HOLs) in the software environment and within the military were reviewed. The reasons for this situation and the rational for approaches to HOL standardization are discussed from the historical, technical, and political standpoints. S.E.S.

N79-26001# Plessey Radar Ltd., Addlestone (England)
PROJECT WAVELL
R. J. Fairchild *In* AGARD Tech. for Data Handling in Tactical Systems, 2 Apr. 1979 10 p (For primary document see N79-25977 16-99)
Avail: NTIS HC A16/MF A01

A battlefield Command and Control Information System is described. The orgins of the requirement, the procurement policy, and the configuration and functions of the system are outlined. S.E.S.

N79-26002# RCA Government Systems Div., Moorestown, N.J. Advanced Programs Development.
MOBILE TACTICAL C TO 3RD POWER SYSTEMS
David Shore *In* AGARD Tech. for Data Handling in Tactical Systems, 2 Apr. 1979 5 p (For primary document see N79-25977 16-99)
Avail: NTIS HC A16/MF A01

A system with a modular van housing intelligent terminals, a miniprocessor with high density mass memories, multiplexed internal wiring to permit rapid changes of equipment, and an anti jam communication is presented. The requirements and baseline concepts of mobile tactical C3 are discussed. S.E.S.

N79-26003# Army Avionics Research and Development Activity, Fort Monmouth, N.J.
AIRBORNE DATA TRANSFER SYSTEM (ADTS)
Charles J. Stuppi, Jr. and Lockwood W. Reed *In* AGARD Tech. for Data Handling in Tactical Systems, 2 Apr. 1979 17 p (For primary document see N79-25977 16-99)
Avail: NTIS HC A16/MF A01

An advanced technology base for data information handling, handoff, and transfer subsystem for application to future Army aircraft systems is presented. A scout gunship target handoff scenario was designed. A computer which assimilates information from the Doppler Navigation System and Target Acquisition and Designation System and computes the UTM target coordinates is developed. Error detection and correction coding is used to assure high reliability of sending a message to reduce the probability of intercept by hostile forces. S.E.S.

N79-26004# Aeronautical Systems Div., Wright-Patterson AFB, Ohio.

PRECISION LOCATION STRIKE SYSTEM NEAR-REAL-TIME C TO THE 3RD POWER I FOR THE TACTICAL BATTLEFIELD
James T Bowen *In* AGARD Tech for Data Handling in Tactical Systems, 2 Apr 1979 6 p (For primary document see N79-25977 16-99)
Avail: NTIS HC A16/MF A01

An all weather, near-real-time, integrated target location and strike capability by the Precision Location Strike System (PLSS) is provided To achieve near-real-time communications, command and intelligence interface capability, the PLSS is developed with a Central Processing Communications element(CPCOM). S.E.S.

N79-26005# Kongsberg Vapenfabrikk A/S (Norway). Defense Products Div
MSI-80S: AN INTEGRATED SMALL-CRAFT FIRE CONTROL SYSTEM
F. A. Ostern *In* AGARD Tech for Data Handling in Tactical Systems, 2 Apr 1979 15 p (For primary document see N79-25977 16-99)
Avail: NTIS HC A16/MF A01

An Integrated Fire Control System developed for fast patrol boats in the Royal Norwegian Navy is presented. The specific threat, the philosophy behind the operations aspects, and the systems engineering of the fire control systems is discussed.
S.E.S.

N79-26006# Naval Weapons Center, China Lake, Calif.
JOINT TACTICAL INFORMATION DISTRIBUTION SYSTEM (JTIDS): WEAPON GUIDANCE AND WEAPON DELIVERY APPLICATIONS OF JTIDS
Claude E. Owen *In* AGARD Tech. for Data Handling in Tactical Systems, 2 Apr 1979 8 p (For primary document see N79-25977 16-99)
Avail: NTIS HC A16/MF A01

The application of the JTIDS, which is a secure communications system, and tactical data processing of key data within that system, to satisfy a tactical requirement of weapon delivery is discussed The capabilities of the JTIDS relative navigation to provide correlated time and position are described The task of the JTIDS in solving the weapon guidance problem is reported, by placing the target coordinates into the relative navigation grid.
S.E.S.

N79-26007# Le Materiel Telephonique, Boulogne-Billancourt (France)
DME TYPE DISTANCE MEASURING SYSTEMS: CURRENT STATUS AND FUTURE DEVELOPMENTS [LES SYSTEMES DE MESURE DE DISTANCE TYPE DME: ETAT ACTUEL ET DEVELOPPEMENTS FUTURS]
M. Schilliger *In* AGARD Tech. for Data Handling in Tactical Systems, 2 Apr. 1979 8 p refs In FRENCH (For primary document see N79-25977 16-99)
Avail: NTIS HC A16/MF A01

DME distance measurement, together with VOR, permits medium distance navigation. Its use is equally effective in landings with ILS and MLS. The principal capabilities of the system are reviewed and improvements in onboard equipment by the use of new technologies are discussed. Currently, the system is completely satisfactory, but, for the future, it may present some operational limitations which can easily be avoided. For example, the saturation of beacons is avoided by using the DME in a quasi-unique way; likewise, landing precision can be increased by the use of simple, phase-coded pulses, with the 200 supplementary channels being supplied at the same time. Precise navigation based on distance measurements is forseeable. Geographic data concerning each beacon can be transmitted on the DME channel Transl. by A.R.H.

N79-26008# Naval Air Development Center, Warminster, Pa.
TACTICAL INFORMATION EXCHANGE SYSTEM
James R. Bonanno *In* AGARD Tech. for Data Handling in Tactical Systems, 2 Apr. 1979 10 p (For primary document see N79-25977 16-99)
Avail: NTIS HC A16/MF A01

The Communication, Navigation, and Identification (CNI) requirements of military aircraft was satisfied by an implementation of the universally accepted black box approach. This conventional solution to an increasingly complex problem has inherent limitations which have given rise to the development of a totally new system architecture. This architecture is embodied in the Tactical Information Exchange System (TIES), and it is driven by the primary goals of improving reliability, maintainability, flexibility and reducing size and weight. The unique partitioning of the system takes advantage of the latest advances in digital and RF technology and insures against premature obsolescence Every attempt is made to share hardware resources by developing a family of multifunction programmable modules, including broadband RF components and an all digital general purpose signal processor. Efforts to date in the exploratory development program have resulted in a clear definition of the baseline architecture, fabrication of breadboard hardware for many of the key elements within the system, and theoretical analysis to evaluate various design alternatives Ongoing work in each of these areas continues towards the ultimate goal of total system integration and validation of the TIES concept for application in the next generation of Naval aircraft Author

X80-72335# Advisory Group for Aerospace Research and Development, Paris (France).
ADVANCED TECHNOLOGY TO COUNTER THE LOW ALTITUDE THREAT OTHER THAN AIRCRAFT MOUNTED RADAR, VOLUME 2 (U)
Nov. 1977 140 p This document is not available from the NASA STI Facility. All requests must be directed to AGARD Hq.
(AGARD-AR-103-Vol-2) NATO Secret report

An analysis is presented of the technologies available, their application in both conventional and unconventional ways, the recommended form of proposed R & D efforts and the priority accorded to each of them. A completely original concept developed by the Study Group based on a new philosophy for defense against attacks below the 300 meter level is reported. M.M.M

X80-72336# Advisory Group for Aerospace Research and Development, Paris (France).
ADVANCED TECHNOLOGY TO COUNTER THE LOW ALTITUDE THREAT, OTHER THAN AIRCRAFT MOUNTED RADAR, VOLUME 1 (U)
Nov. 1977 36 p This document is not available from the NASA STI Facility. All requests must be directed to AGARD Hq.
(AGARD-AR-103-Vol-1) *NATO Secret report*

An analysis is made of the threats during attacks at low altitudes. Current responses, an assessment of likely deficiencies in the 1980's and the future operational requirement trends are considered. M.M.M

X80-72337# Advisory Group for Aerospace Research and Development, Paris (France).
PROJECT 2000 OVERVIEW (U)
Dec. 1979 100 p This document is not available from the NASA STI Facility. All requests must be directed to AGARD Hq.
(AGARD-AR-160) NATO Secret report

Concepts are developed for NATO military systems that might be originated over the next two or three decades. For each of the system concepts an evaluation is made of the various sensor systems, delivery vehicles, and weapon systems, as appropriate, to identify the preferred approach in light of the expected threat, target characteristics, performance, and potential cost. Technologies requiring specific emphasis are identified and some of the technical and cost factors bearing on the applications of technologies to system design are highlighted. Author

X80-72338# Advisory Group for Aerospace Research and Development, Paris (France).
ATTACK OF SURFACE TARGETS, VOLUME 1 (U) Summary Report
Dec. 1979 84 p This document is not available from the NASA STI Facility. All requests must be directed to AGARD Hq.
(AGARD-AR-161-Vol-1) NATO Secret report

Concepts are discussed for NATO surface target attack systems to be developed over the next two or three decades. For each of the system concepts an evaluation is made of the various weapons and delivery vehicles in order to identify the preferred approach in light of the expected threat, target characteristics, performance, and potential cost. Technologies requiring specific emphasis in order to realize the preferred systems are identified. Author

X80-72339# Advisory Group for Aerospace Research and Development, Paris (France).
DEFENCE AGAINST MISSILES, VOLUME 1 (U) Summary Report
Dec. 1979 50 p This document is not available from the NASA STI Facility. All requests must be directed to AGARD Hq.
(AGARD-AR-162-Vol-1) NATO Secret report

Concepts are developed for NATO missile defense systems to be originated over the next two or three decades. For each of the system concepts an evaluation is made of the various weapons and delivery vehicles to identify the preferred approach in light of the expected threat, target characteristics, performance, and potential cost. Technologies requiring specific emphasis in order to realize the preferred systems are listed. Author

X80-72340# Advisory Group for Aerospace Research and Development, Paris (France).
DETECTION, LOCATION AND RECOGNITION OF GROUND TARGETS, VOLUME 1 (U) Summary Report
Dec. 1979 78 p This document is not available from the NASA STI Facility All requests must be directed to AGARD Hq.
(AGARD-AR-163-Vol-1) NATO Secret report

Concepts are developed for NATO ground target detection, location, and recognition systems to be originated over the next two or three decades. For each of the system concepts an evaluation is made of the various sensors and platforms in order to identify the preferred approach in light of the expected threat, target characteristics, performance, and potential cost. Author

X80-72341# Advisory Group for Aerospace Research and Development, Paris (France).
MAINTENANCE OF AIR OPERATIONS WHILE UNDER ATTACK WITH CHEMICAL AGENTS (U)
J. Ernsting, ed. Nov. 1979 234 p Presented at the Aerospace Med. Specialists' Meeting, Brussels, 22-26 Jan. 1979 This document is not available from the NASA STI Facility. All requests must be directed to AGARD Hq.
(AGARD-CP-264) NATO Secret report

Both on-the-ground and in-flight threats to air bases and aircrews are considered along with the level of protection required against chemical warefare agents and methods for their detection and monitoring. The principles of personal and collective protection are reviewed and practical experience with ergometric aspects of contamination control areas and donning and duffing procedures are described. Constraints on air operations arising from chemical defense measures are also discussed. Author

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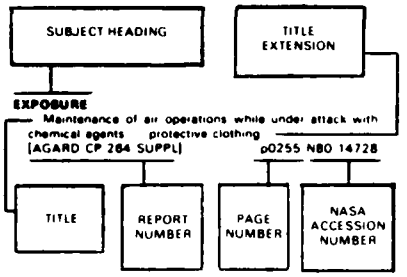

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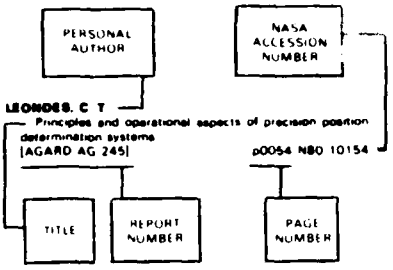

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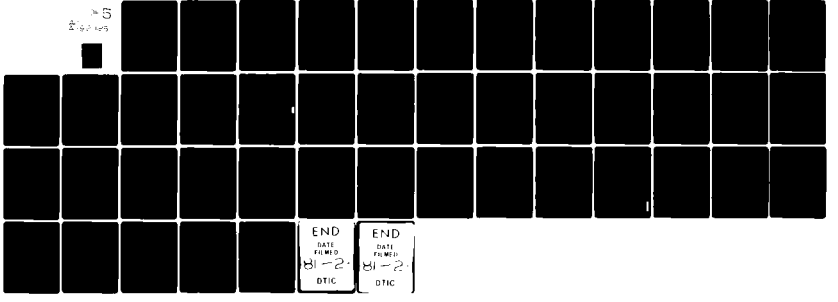

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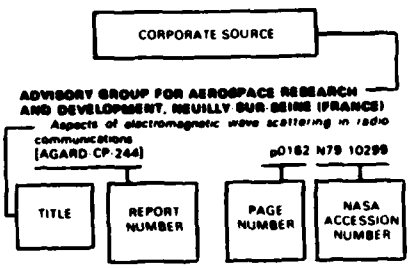

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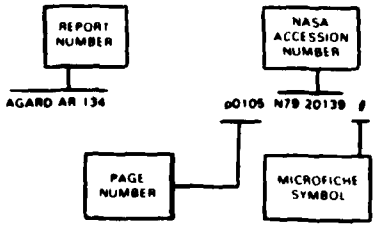

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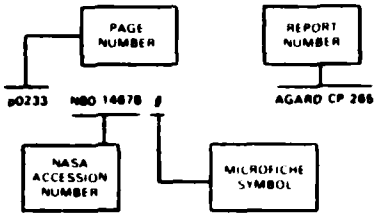

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