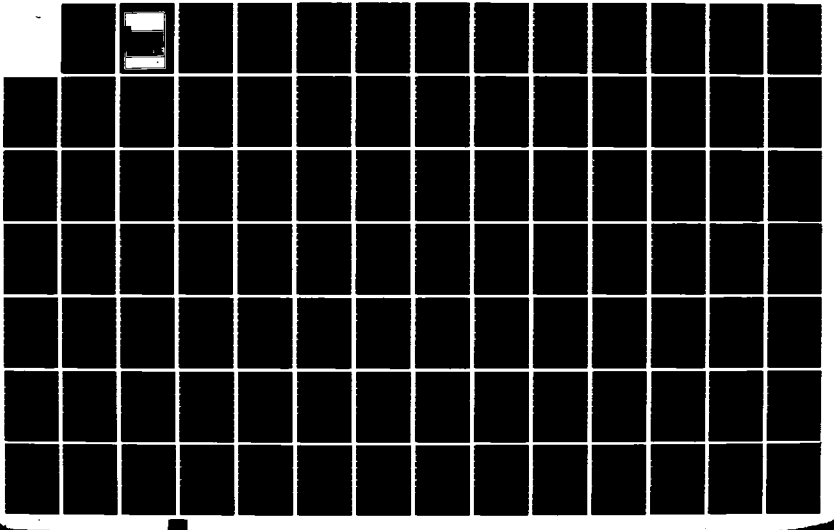
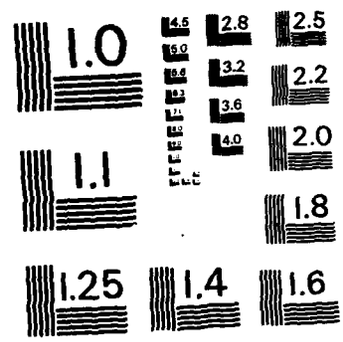
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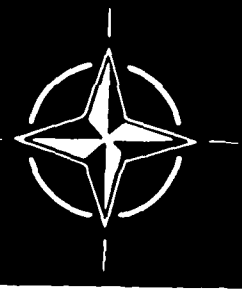
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AGARD INDEX OF PUBLICATIONS

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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 for the following purposes:

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- 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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Published January 1984

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ISBN 92-835-1462-9



Printed by Specialised Printing Services Limited
40 Chigwell Lane, Loughton, Essex IG10 3TZ

PREFACE

This volume provides abstracts and indexes for AGARD publications published during the period 1980 – 1982. By an arrangement with the U.S. National Aeronautics and Space Administration (NASA) in Washington, D.C., 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.

Five indexes -- Subject (based on *NASA Thesaurus* nomenclature), Personal Author, Corporate Source, Report/Accession Number, and Accession Number -- are included. Sample entries are shown on the first page of each index.

TABLE OF CONTENTS

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 48

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 60

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 64

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 74

Includes aircraft simulation technology.

For related information see also *18 Spacecraft Design, Testing and Performance* and *39 Structural Mechanics.*

06 AIRCRAFT INSTRUMENTATION 83

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 87

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 109

Includes aircraft handling qualities; piloting; flight controls; and autopilots.

09 RESEARCH AND SUPPORT FACILITIES (AIR) 118

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.

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13 ASTRODYNAMICS N.A.

Includes powered and free-flight trajectories; and orbit and launching dynamics.

14 GROUND SUPPORT SYSTEMS AND FACILITIES (SPACE) 127

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 127

Includes boosters; manned orbital laboratories; reusable vehicles; and space stations.

16 SPACE TRANSPORTATION N.A.

Includes passenger and cargo space transportation, e.g., shuttle operations; and rescue techniques.

For related information see also *03 Air Transportation and Safety* and *85 Urban Technology and Transportation.*

17 SPACECRAFT COMMUNICATION, 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 N.A.

Includes main propulsion systems and components, e.g., rocket engines; and spacecraft auxiliary power sources.

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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25 INORGANIC AND PHYSICAL CHEMISTRY N.A.
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For related information see also *77 Thermodynamics and Statistical Physics.*

26 METALLIC MATERIALS 138
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27 NONMETALLIC MATERIALS N.A.
Includes physical, chemical, and mechanical properties of plastics, elastomers, lubricants, polymers, textiles, adhesives, and ceramic materials.

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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) 144
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Includes product sampling procedures and techniques; and quality control.

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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) 188

43 EARTH RESOURCES N.A.
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 N.A.
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 193
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.
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48 OCEANOGRAPHY N.A.
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LIFE SCIENCES

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

51 LIFE SCIENCES (GENERAL) **193**
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Includes psychological factors; individual and group behavior; crew training and evaluation; and psychiatric research.

54 MAN/SYSTEM TECHNOLOGY AND LIFE SUPPORT **217**
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55 PLANETARY BIOLOGY **N.A.**
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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) **222**

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For related information see also *54 Man System Technology and Life Support.*

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

66 SYSTEMS ANALYSIS **233**
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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71 ACOUSTICS **N.A.**
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72 ATOMIC AND MOLECULAR PHYSICS **N.A.**
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73 NUCLEAR AND HIGH-ENERGY PHYSICS **N.A.**
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For space radiation see *93 Space Radiation.*

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75 PLASMA PHYSICS **N.A.**
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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 **243**
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82 DOCUMENTATION AND INFORMATION SCIENCE **246**
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83 ECONOMICS AND COST ANALYSIS **N.A.**
Includes cost effectiveness studies.

84 LAW AND POLITICAL SCIENCE **N.A.**
Includes space law; international law; international cooperation; and patent policy.

85 URBAN TECHNOLOGY AND TRANSPORTATION **N.A.**
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*.

GENERAL

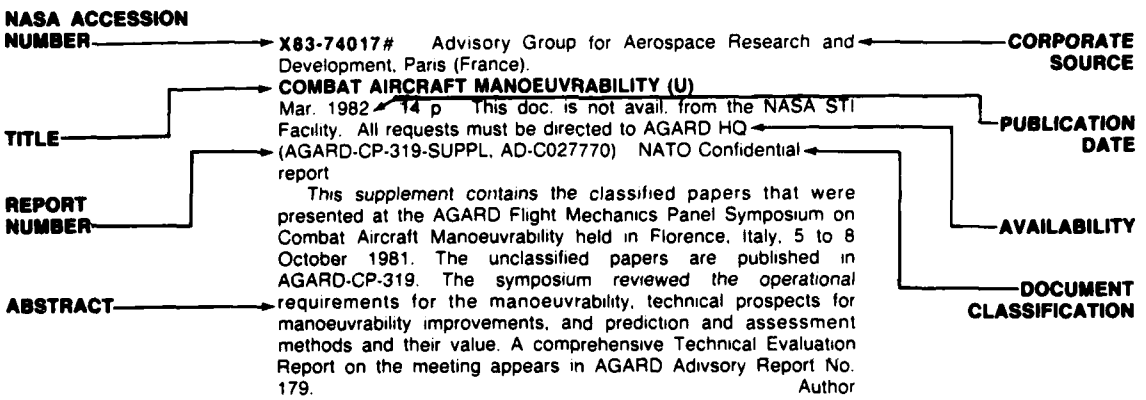
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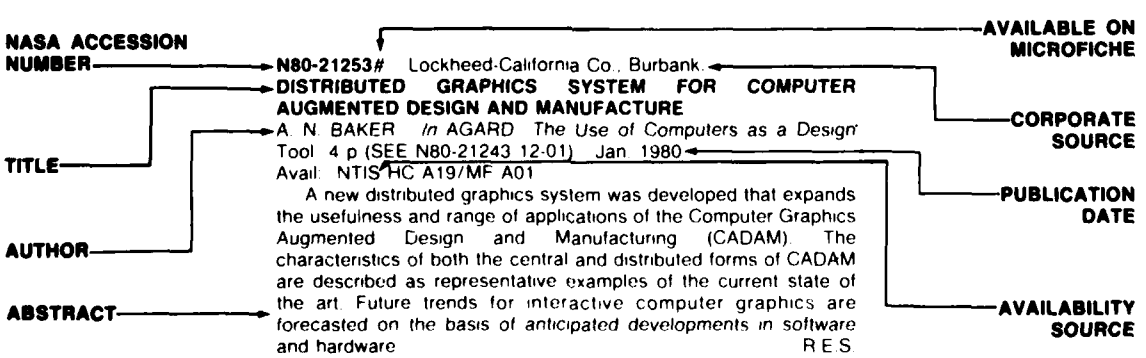
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AGARD INDEX OF PUBLICATIONS (1980–1982)

ABSTRACT SECTION

01

AERONAUTICS (GENERAL)

N80-21243# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
THE USE OF COMPUTERS AS A DESIGN TOOL
Jan. 1980 445 p refs Partly in ENGLISH and FRENCH Flight Mech. Panel Symp. held at Neubiberg, West Germany, 3-6 Sep. 1979
(AGARD-CP-280; ISBN-92-835-0256-6) Avail: NTIS HC A19/MF A01

The positive and negative aspects of computerized aircraft design are considered including the cost and technical effectiveness, the benefits, and the difficulties and limitations of the whole process. Topics covered include: specifications and assessment of requirements; computer aided design and computer graphics; computational aerodynamics and design; structural analysis and design; and propulsion and system design. For individual titles, see N80-21244 through N80-21275.

N80-21244# Industrieanlagen-Betriebsgesellschaft m.b.H., Ottobrunn (West Germany). Wehrtechnische Systeme.
THE USE OF COMPUTER AIDED DESIGN METHODS IN AIRBORNE SYSTEMS EVALUATION
P. EBELING and E. PFISTERER *In* AGARD The Use of Computers as a Design Tool 11 p (SEE N80-21243 12-01) Jan. 1980 refs
Avail: NTIS HC A19/MF A01

The application of computer aided design methods for predesign and evaluation purposes of airborne systems, especially in early phases, is considered. Two methods are presented. The first is the aircraft design computer program APFEL which is described in detail. The second application is the missile design program PROFET. Typical applications including some results are given.
J.M.S.

N80-21245# Air Force Flight Dynamics Lab., Wright-Patterson AFB, Ohio.
CRITERIA FOR TECHNOLOGY
R. L. HAAS *In* AGARD The Use of Computers as a Design Tool 12 p (SEE N80-21243 12-01) Jan. 1980 refs
Avail: NTIS HC A19/MF A01

A perspective on the use of computers in an approach to technology program planning is given. A rationale for cost benefit assessment of technology to form the foundations for the technology of systems is presented. An approach is defined which builds on techniques associated with computer aided design capability and is analogous in form to process control. A description of the basic process applied to a tactical fighter problem is discussed.
J.M.S.

N80-21246*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
AN ACCEPTABLE ROLE FOR COMPUTERS IN THE AIRCRAFT DESIGN PROCESS
T. J. GREGORY and L. ROBERTS *In* AGARD The Use of Computers as a Design Tool 7 p (SEE N80-21243 12-01) Jan. 1980 refs
Avail: NTIS HC A19/MF A01 CSCL 09B

Some of the reasons why the computerization trend is not wholly accepted are explored for two typical cases: computer use in the technical specialties and computer use in aircraft synthesis. The factors that limit acceptance are traced in part, to the large resources needed to understand the details of computer programs, the inability to include measured data as input to many of the theoretical programs, and the presentation of final results without supporting intermediate answers. Other factors are due solely to technical issues such as limited detail in aircraft synthesis and major simplifying assumptions in the technical specialties. These factors and others can be influenced by the technical specialist and aircraft designer. Some of these factors may become less significant as the computerization process evolves, but some issues, such as understanding large integrated systems, may remain issues in the future. Suggestions for improved acceptance include publishing computer programs so that they may be reviewed, edited, and read. Other mechanisms include extensive modularization of programs and ways to include measured information as part of the input to theoretical approaches.
J.M.S.

N80-21247# Royal Aircraft Establishment, Farnborough (England). Aerodynamics Dept.
THE USE OF COMPUTER BASED OPTIMIZATION METHODS IN AIRCRAFT STUDIES
B. EDWARDS *In* AGARD The Use of Computers as a Design Tool 27 p (SEE N80-21243 12-01) Jan. 1980 refs
Avail: NTIS HC A19/MF A01

Multivariate optimization (MVO) computer programs used in the field of aircraft design are considered. The constitution of such programs, which embody an optimization method as well as a mathematical model of aircraft design and operation comprised of aircraft design synthesis and performance analysis methods, is discussed in general terms. Techniques for using MVO programs are emphasized in an effort to show how the optimization method can be used to explore the model and cultivate an insight into its characteristics. A discussion of some possible applications for MVO programs is included.
J.M.S.

N80-21248# Technische Hogeschool, Delft (Netherlands). Dept. of Aerospace Engineering.
SOME FUNDAMENTAL ASPECTS OF TRANSPORT AIRCRAFT CONCEPTUAL DESIGN OPTIMIZATION
E. TORENBEEK *In* AGARD The Use of Computers as a Design Tool 22 p (SEE N80-21243 12-01) Jan. 1980 refs
Avail: NTIS HC A19/MF A01

Various design merit functions and program structures are discussed and program elements common to most design exercises are analyzed. Criteria are presented for optimum cruise conditions for aircraft with or without Mach number dependent drag polars and arbitrary propulsion systems. The constrained and unconstrained optima for design cruise speed and altitude, engine thrust, wing loading, and aspect ratio are presented in the form of generalized analytical expressions. They are based on closed-form equations for the payload weight fraction. A powerplant merit function is proposed, which can be used for assessing propulsion systems in the project study phase in isolation from the aircraft

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

design. The method gives clear insight into the design problem structure and is adaptable to arbitrary ground rules and different data bases. The tradeoff between mission requirements, technological factors, and (optimum) design characteristics is evident from the criteria presented. J.M.S.

N80-21249# Vereinigte Flugtechnische Werke-Fokker G.m.b.H., Bremen (West Germany).
SURVEY PAPER ON COMPUTER AIDED DESIGN
D. WEINHAUER *In* AGARD The Use of Computers as a Design Tool 2 p (SEE N80-21243 12-01) Jan. 1980
Avail: NTIS HC A19/MF A01

A review of a specialists' meeting on computer-aided design in production design is presented. Conclusions and proposals developed at the meeting are described. R.E.S.

N80-21250# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (West Germany).
COMPUTER GRAPHICS AND RELATED DESIGN PROCESS AT MBB
V. ANTL and W. WEINGARTNER *In* AGARD The Use of Computers as a Design Tool 19 p (SEE N80-21243 12-01) Jan. 1980
Avail: NTIS HC A19/MF A01

The CAD/CAM process and how it is realized is described. Examples of using computer graphics are given and then a description of the main system functions is presented. R.E.S.

N80-21251# Dornier-Werke G.m.b.H., Friedrichshafen (West Germany).
COMPUTER GRAPHICS, RELATED DESIGN AND MANUFACTURE PROCESS AT DORNIER
J. NAGEL, L. THIEME, and A. HARTER *In* AGARD The Use of Computers as a Design Tool 9 p (SEE N80-21243 12-01) Jan. 1980
Avail: NTIS HC A19/MF A01

A computer systems program which concerns the definition and machining of the general outer contour surfaces of an aircraft is described. R.E.S.

N80-21252# British Aerospace Aircraft Group, Warton (England).
COMPUTER GRAPHICS AND RELATED DESIGN PROCESSES IN THE UK
R. I. HACKING and B. REUBEN *In* AGARD The Use of Computers as a Design Tool 13 p (SEE N80-21243 12-01) Jan. 1980
Avail: NTIS HC A19/MF A01

The use of computer graphics in British aerospace engineering and its integration with manufacturing is described. R.E.S.

N80-21253# Lockheed-California Co., Burbank.
DISTRIBUTED GRAPHICS SYSTEM FOR COMPUTER AUGMENTED DESIGN AND MANUFACTURE
A. N. BAKER *In* AGARD The Use of Computers as a Design Tool 4 p (SEE N80-21243 12-01) Jan. 1980
Avail: NTIS HC A19/MF A01

A new distributed graphics system was developed that expands the usefulness and range of applications of the Computer Graphics Augmented Design and Manufacturing (CADAM). The characteristics of both the central and distributed forms of CADAM are described as representative examples of the current state of the art. Future trends for interactive computer graphics are forecasted on the basis of anticipated developments in software and hardware. R.E.S.

N80-21254# Societe Nationale Industrielle Aerospatiale, Marignane (France.)
THE ROLE OF INTERACTIVITY IN COMPUTER-ASSISTED DESIGN AND FABRICATION [LE ROLE DE L'INTERACTIVITE DANS LA CONCEPTION ET LA FABRICATION ASSISTEES PAR ORDINATEUR]
M. SLISSA *In* AGARD The Use of Computers as a Design Tool 3 p (SEE N80-21243 12-01) Jan. 1980 In FRENCH
Avail: NTIS HC A19/MF A01

Computer-assisted design and fabrication requires the use of alphanumeric and graphic conversational techniques to support the man machine dialog during the product creation process. The definition of work space, in the most general sense, is very important, for example, in the case of the design of three dimensional forms, where interactivity permits choice in real time. These principles are used in research and development at Aerospatiale Marignane, and especially in the Systrid 1 System design of three dimensional objects and the Sigma program used for the design of geometric forms at Aerospatiale Toulouse.
Transl. by A.R.H.

N80-21255# British Aerospace Aircraft Group, Brough (England).
A FRAMEWORK FOR DISTRIBUTED DESIGN COMPUTING
A. W. BISHOP *In* AGARD The Use of Computers as a Design Tool 10 p (SEE N80-21243 12-01) Jan. 1980 refs
Avail: NTIS HC A19/MF A01

Large, geographically dispersed design teams are now the norm in manufacturing industries [illegible]mputer systems are potentially useful for data storage, commu[illegible]ons, interactive design, administrative functions and numerica[illegible]ulations. A framework for the support of such applications sy[illegible]s in a dispersed environment against a background of rapidly [illegible]ng hardware is described. R.E.S.

N80-21256# Societe Nationale Industrielle Aerospatiale, Marignane (France.)
USING THE COMPUTER TO PRODUCE ELECTRIC SCHEMAS [LIASSE ELECTRIQUE ASSISTEE PAR ORDINATEUR]
J. P. PAUZAT *In* AGARD The Use of Computers as a Design Tool 6 p (SEE N80-21243 12-01) Jan. 1980 In FRENCH
Avail: NTIS HC A19/MF A01

In nine years of operation, an aircraft of the Airbus type generates 16,500 plans which include 7,000 schemas, 5,000 equipment lists, and 4,500 tables. The information processed in these plans is estimated at about 80,000 definitions for cables and their branchings, 20,000 equipment definitions, 3,000 modifications definitions, and 40 validation standards required by clients. The electric cable information management system used to assist in the definition, design, and diffusion of electric schemas is described. This system also take into account the requirements of exterior services which use the schemas for preparation, production, and control or for use after purchase of the aircraft. The system for the computerized design of electric cables is used to design electric schemas on an interactive basis, and adds to the information network all the data which supply the cable management information system. The design and application of both systems are discussed. Transl. by A.R.H.

N80-21257*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
USE OF ADVANCED COMPUTERS FOR AERODYNAMIC FLOW SIMULATION
F. R. BAILEY and W. F. BALLHAUS *In* AGARD The Use of Computers as a Design Tool 12 p (SEE N80-21243 12-01) Jan. 1980 refs Prepared in cooperation with Army Research and Technology Labs., Moffett Field, Calif.
Avail: NTIS HC A19/MF A01 CSCL 01A

The current and projected use of advanced computers for large-scale aerodynamic flow simulation applied to engineering design and research is discussed. The design use of mature codes run on conventional, serial computers is compared with the fluid research use of new codes run on parallel and vector computers. The role of flow simulations in design is illustrated by the application of a three dimensional, inviscid, transonic code to the Sabreliner 60 wing redesign. Research computations that include a more complete description of the fluid physics by use of Reynolds averaged Navier-Stokes and large-eddy simulation formulations are also presented. Results of studies for a numerical aerodynamic simulation facility are used to project the feasibility of design applications employing these more advanced three dimensional viscous flow simulations. M.G.

N80-21258# Avions Marcel Dassault-Breguet Aviation, Saint-Cloud (France).
THE USE OF THE COMPUTER IN THE DESIGN OF AERODYNAMIC CONFIGURATIONS [UTLIISATION DE L'ORDINATEUR POUR LE DESSIN DE CONFIGURATIONS AERODYNAMIQUES]
P. PERRIER *In* AGARD The Use of Computers as a Design Tool 17 p (SEE N80-21243 12-01) Jan. 1980 In FRENCH
Avail: NTIS HC A19/MF A01

The computer is of considerable assistance in both the optimization and evaluation of aerodynamic configurations with, however, very different degrees of efficiency, and very different methods of use. The operations used are not equivalent to those used for the analysis and synthesis usually alluded to in the development of an aircraft project. The general principles and the terminology used systematically in the design and definition of prototypes are presented along with the different levels of computation associated with each. Two relatively simple, concrete examples related to civil and military aircraft, are used to show the aid provided by computers in aerodynamic design. Developments which can be predicted for years to come are indicated, taking into account improved possibilities of computation. Transl. by A.R.H.

N80-21259# Aeritalia S.p.A., Torino (Italy).
WING DESIGN PROCESS BY INVERSE POTENTIAL FLOW COMPUTER PROGRAMS
L. FORNASIER *In* AGARD The Use of Computers as a Design Tool 14 p (SEE N80-21243 12-01) Jan. 1980 refs
Avail: NTIS HC A19/MF A01

The approach to wing design by inverse technique is illustrated. A brief review of the numerical tools employed in the design process is given and the involved technology is discussed in some detail. Finally, an application to a design study aimed to demonstrate potential improvements of supercritical wing technology is described. M.G.

N80-21260# Boeing Commercial Airplane Co., Seattle, Wash.
THE ROLE OF COMPUTATIONAL AERODYNAMICS IN AIRPLANE CONFIGURATION DEVELOPMENT
B. DILLNER and C. A. KOPER, JR. *In* AGARD The Use of Computers as a Design Tool 14 p (SEE N80-21243 12-01) Jan. 1980 refs
Avail: NTIS HC A19/MF A01

The role of computational aerodynamics in the design of aircraft configurations in steady flow conditions is explored through several examples. Subsonic high lift and wing strake designs, and transonic cruise wing designs are included. The use of these computer methods can substantially increase airplane performance capabilities, while reducing risk, flow time, and testing requirements. An assessment is made concerning the factors that have contributed to advancing computational aerodynamics. Deficiencies of existing programs are also noted with particular attention given to the user-system interface. M.G.

N80-21261# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (West Germany). Aircraft Div.
COMPUTATIONAL AERODYNAMIC DESIGN TOOLS AND TECHNIQUES USED AT FIGHTER DEVELOPMENT
P. SACHER, W. KRAUS, and R. KUNZ *In* AGARD The Use of Computers as a Design Tool 12 p (SEE N80-21243 12-01) Jan. 1980 refs
Avail: NTIS HC A19/MF A01

Various different numerical procedures to perform design trade-offs during fighter configuration development are discussed. An optimization cycle of techniques, necessary to cover the low speed range (high angle of attack), transonic speed (maneuvering capability), and the high speed supersonic region (maximum SEP) is described. Second stage optimization of components like direct design of wing, tail/canard, or maneuver devices is then presented giving further improvements of performance and leading finally to the definition of wind tunnel models. Experimental data compare well with predictions and emphasize the reliability of applied numerical methods. M.G.

N80-21262# Rockwell International Corp., Anaheim, Calif. Aircraft Div.
USE OF COMPUTERS IN THE AERODYNAMIC DESIGN OF THE HIMAT FIGHTER
R. D. CHILD, B. PANAGEAS, and P. GINGRICH *In* AGARD The Use of Computers as a Design Tool 19 p (SEE N80-21243 12-01) Jan. 1980 refs
Avail: NTIS HC A19/MF A01

The highly maneuverable aircraft technology remotely piloted research vehicle (HiMAT/RPRV) configuration was designed to achieve a high degree of transonic maneuverability. The performance goals for the advanced fighter concept were a sustained 8 g turn at Mach = 0.9, altitude of 9,144 meters, and a mission radius of 300 nautical miles. Additionally, supersonic acceleration capability would not be compromised. Preliminary trade studies established a 7,740 kilogram fighter baseline along with a 44 percent scale RPRV that would allow a low risk demonstration of the advanced technologies. Tests of the baseline configuration indicated deficiencies in the technology integration and design techniques. After substantial reconfiguring of the vehicle, with improvements in the analytical methods, the subcritical and supersonic requirements were satisfied. A high level of efficiency for subsonic conditions was realized with the linear theory-optimization techniques and variable camber system. Drag due to lift levels only 5 percent higher than 1/pi AR were obtained for the wind tunnel model at a lift coefficient of 1.0 for Mach numbers of up to 0.8. The transonic drag rise was progressively lowered with the application of nonlinear potential flow analyses. R.C.T.

N80-21263# Dornier-Werke G.m.b.H., Friedrichshafen (West Germany). Theoretische Aerodynamik.
NUMERICAL METHODS FOR DESIGN AND ANALYSIS AS AN AERODYNAMIC DESIGN TOOL FOR MODERN AIRCRAFT
W. SCHMIDT *In* AGARD The Use of Computers as a Design Tool 21 p (SEE N80-21243 12-01) Jan. 1980 refs
Avail: NTIS HC A19/MF A01

The application and validation of several computational aerodynamic methods in the design and analysis of transport and fighter aircraft is established. An assessment is made concerning methods that solve transonic flow and boundary layers on maneuver flaps, wings, inlets, and bodies. Capabilities of subsonic and supersonic aerodynamic methods are demonstrated by the inlet integration on the Alpha-Jet design, supersonic Rautenfluegelanalysis, subsonic and supersonic wing optimization for a fighter and high lift device analysis. The accuracy of transonic methods is demonstrated by comparison of computed results to experimental data for transport and fighter-type wing body combinations, axisymmetric inlet flowfields, two element airfoil systems and cascades. Special attention is given the capabilities of such methods to simulate wind tunnel effects. R.C.T.

N80-21264*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
MAINTENANCE OF NASTRAN (R) AS A STATE-OF-THE-ART COMPUTER PROGRAM
J. L. ROGERS, JR. *In* AGARD The Use of Computers as a Design Tool 12 p (SEE N80-21243 12-01) Jan. 1980 refs
Avail: NTIS HC A19/MF A01 CSCL 01B

The maintenance requirements for a large, general purpose, finite element computer program are presented. The program is maintained as state-of-the-art on three computer systems (IBM, CDC, and UNIVAC) with respect to both finite element and computer technology. There are four primary areas involved in the maintenance effort: (1) error correction; (2) incorporation of advances in technology; (3) documentation; and (4) new level generation. The complexity of the maintenance effort is compounded by the sizes of the program (400,000 lines of code) and the documentation (7000 pages divided into seven manuals). R.C.T.

N80-21265# Royal Aircraft Establishment, Farnborough (England).
A COMPUTER BASED SYSTEM FOR STRUCTURAL DESIGN, ANALYSIS AND OPTIMIZATION
A. J. MORRIS, P. BARTHOLOMEW, and J. DENNIS *In* AGARD The Use of Computers as a Design Tool 26 p (SEE N80-21243 12-01) Jan. 1980 refs
Avail: NTIS HC A19/MF A01

A modular computer program developed for the automated design of optimum structures subject to a variety of constraints is described. The program employs several complex optimization and duality techniques linked together by a control module which also provides a mechanism for interfacing the program with the commercially available structural analysis systems. Although this gives rise to a highly sophisticated program structure it is made simple to operate by the aid of a convenient command language which provides the communication link with the design engineer. R.C.T.

N80-21266# Dornier-Werke G.m.b.H., Friedrichshafen (West Germany). Structural Dynamics Dept.
STRUCTURAL OPTIMIZATION WITH STATIC AND AEROELASTIC CONSTRAINTS
D. MATHIAS, H. ROEHRLE, and J. ARTMANN *In* AGARD The Use of Computers as a Design Tool 11 p (SEE N80-21243 12-01) Jan. 1980 refs
Avail: NTIS HC A19/MF A01

An optimization program is presented which is based on the finite element method and, within the actual optimization step, works according to the gradient method. The DYNOPT computer program was applied to a clamped straight wing. The wing was statically loaded and had eccentric masses and rotational inertias representing rudders and actuators. These eccentricities ensured the coupling between the bending and torsional deformations. The minimum weight of the structure was obtained after 15 iteraction steps while all boundary conditions were observed. R.C.T.

N80-21267# Liege Univ. (Belgium). Aerospace Lab.
APPLICATIONS OF MIXED AND DUAL METHODS IN STRUCTURAL OPTIMIZATION
G. SANDER, C. FLEURY, and M. GERADIN *In* AGARD The Use of Computers as a Design Tool 14 p (SEE N80-21243 12-01) Jan. 1980 refs
(Contract AF-AFOSR-3118-77)
Avail: NTIS HC A19/MF A01

An approach to structural optimization is described in which the original problem is replaced with a new sequence of explicit approximate problems and solved using either primal or dual algorithms. A primal solution scheme yields a mixed method, with properties lying between those of the optimality criteria techniques and those of pure mathematical programming methods. A dual solution scheme leads to generalization of the optimality criteria approaches, with a rational procedure for identifying the strictly critical constraints (including the classical subdivision of the design variables into passive and active groups). The structural optimization problem consists of the weight minimization of a finite element model with fixed geometry and material properties. The transverse sizes of the structural member are the design variables. In the optimality criteria and mathematical programmings approaches, the behavior constraints are approximated using virtual load considerations and linearization with respect to the reciprocal design variables. Examples of applications of the mixed and dual methods to various structures are presented. These include cases with stress, displacement, or flexibility constraints, as well as frequency constraints. A.W.H.

N80-21268# Avions Marcel Dassault-Breguet Aviation, Saint-Cloud (France).
FINITE ELEMENTS AND THE OPTIMIZATION OF AERONAUTICAL STRUCTURES [ELEMENTS FINIS ET OPTIMISATION DES STRUCTURES AERONAUTIQUES]
C. PETIAU and G. LECINA *In* AGARD The Use of Computers as a Design Tool 16 p (SEE N80-21243 12-01) Jan 1980 refs In FRENCH; ENGLISH summary
Avail: NTIS HC A19/MF A01

An optimization method which minimizes weight by using a finite element model is described. The optimization parameters, multiplicative factors of the stiffness of linked finite elements, are discussed. The optimization constraints which can be of different types, including technological minimum thicknesses, limited displacements, and limitations on flutter speed and dynamic responses, are delineated. The optimization process is iterative with each iteration containing three steps. The three steps are reported. Two examples of the optimization method are presented: the optimization of a delta wing and the optimization of a carbon epoxy empennage. A.W.H.

N80-21269# Industrieanlagen-Betriebsgesellschaft m.b.H., Ottobrunn (West Germany).
NEW COMPUTER APPLICATIONS FOR SPECIAL STRUCTURAL PROBLEMS
J. MASSMANN *In* AGARD The Use of Computers as a Design Tool 23 p (SEE N80-21243 12-01) Jan. 1980
Avail: NTIS HC A19/MF A01

Characteristic properties of both the finite element and finite difference method are discussed concerning their efficient applicability for nonlinear dynamic structural analysis and design. Special features of the code are explained and their relevance is demonstrated in several examples concerning penetration and perforation problems, pressure distribution resulting from explosions in fluids, blast loading, and shock wave propagation. A.W.H.

N80-21270# Vereinigte Flugtechnische Werke G.m.b.H., Bremen (West Germany).
COMPUTER PROGRAMS FOR THE DESIGN AND PERFORMANCE EVALUATION OF NACELLES FOR HIGH BYPASS-RATIO ENGINES
R. SMYTH *In* AGARD The Use of Computers as a Design Tool 21 p (SEE N80-21243 12-01) Jan. 1980 refs
Avail: NTIS HC A19/MF A01

The use of the computer as a design tool for the different stages of nacelle development and integration with the airframe is discussed. Trends in propulsion system development and methods of calculation suitable for computerized work with nacelles are reported. The computer program developed for nacelle synthesis consists of an executive program which uses program modules based on the engine component breakdown. The main program modules are the geometrical requirements, the inlet definition, the nozzle and afterbody definition, and the flow calculation. Each program module and its function in the executive program is discussed. The use of the computer program for the performance evaluation of nacelles during the aircraft design process is described. A.W.H.

N80-21271*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
COMPUTERIZED SYSTEMS ANALYSIS AND OPTIMIZATION OF AIRCRAFT ENGINE PERFORMANCE, WEIGHT, AND LIFE CYCLE COSTS
L. H. FISHBACH *In* AGARD The Use of Computers as a Design Tool 15 p (SEE N80-21243 12-01) Jan. 1980 refs
Avail: NTIS HC A19/MF A01 CSCL 21E

The computational techniques are described which are utilized at Lewis Research Center to determine the optimum propulsion systems for future aircraft applications and to identify system tradeoffs and technology requirements. Cycle performance, and engine weight can be calculated along with costs and installation effects as opposed to fuel consumption alone. Almost any conceivable turbine engine cycle can be studied. These computer codes are: NNEP, WATE, LIFCYC, INSTAL, and POD DRG. Examples are given to illustrate how these computer techniques can be applied to analyze and optimize propulsion system fuel consumption, weight and cost for representative types of aircraft and missions. F.O.S.

N80-21272# British Aerospace Aircraft Group, Preston (England).
MATHEMATICAL MODELLING IN MILITARY AIRCRAFT WEAPON SYSTEM DESIGN
N. MITCHELL *In* AGARD The Use of Computers as a Design Tool 12 p (SEE N80-21243 12-01) Jan. 1980
Avail: NTIS HC A19/MF A01

One of the main tools used in weapon system design and analysis is the mathematical model, i.e., a complete mathematical representation of the aircraft weapon system, programmed for running on a digital computer. The main elements of a model are

described and the use of models is discussed in the chronological phases of weapon system design and development, including trials planning and analysis, with the associated model matching. Examples of the use of models to investigate and resolve design problems are given, including integrated modelling between several companies. There is a rapid growth in number and use of digital computers in aircraft weapon systems and some typical modelling input to the software of these airborne computers is discussed.
Author

N80-21273# British Aerospace Aircraft Group, Preston (England).
BACTAC: A COMBAT-WORTHY COMPUTERIZED OPPONENT
I. JONES *In* AGARD The Use of Computers as a Design Tool 14 p (SEE N80-21243 12-01) Jan. 1980 refs
Avail: NTIS HC A19/MF A01

The formulation and performance of a computerized opponent are described. The opponent is used at British Aerospace, Warton Division, for air combat simulation. Over a period of seven years, BACTAC has progressed from its initial state as a digital computer model of close combat without the man in the loop, to a versatile and tenacious interactive opponent for use in a single-dome, piloted, air combat simulator. The process of matching the mathematical model against fighter pilots in the simulator is described, together with an account of the learning which took place on both sides of the fight, and adjustment of tactics to the radically different performance of a new generation of aircraft and missiles. It is only in the combat simulator that fighter pilots and designers can investigate future generations of fighter aircraft. In this environment, BACTAC is proving its value to scientific research as a combat-worthy adversary, capable of exploiting the higher levels of performance and providing a known datum against which to rank pilots, competing aircraft and their weapon systems.
Author

N80-21274# Messerschmitt-Boelkow-Blohm G.m.b.H., Ottobrunn (West Germany).
INTERACTIVE AIDED DESIGN SYSTEM FOR AIRCRAFT DYNAMIC CONTROL PROBLEMS
W. J. KUBBAT, G. OESTERHELT, and U. KORTE *In* AGARD The Use of Computers as a Design Tool 18 p (SEE N80-21243 12-01) Jan. 1980
Avail: NTIS HC A19/MF A01

A computer aided design system is described for control law design and system synthesis. A short description of the available methods (continuous - discrete, time domain-frequency domain) is followed by an illustration of the practical work. The designer has access to the huge program system via a graphical CRT display and a keyboard. Selection of method (i.e., discrete vs. continuous complete vs. incomplete state feedback, optimal control vs. pole-placement, etc.) is followed by a dialogue designer-computer with immediate results presented in numerical and graphical form (plots, print-outs). Each result is stored and can be compared with any other one via dual plots. The system also allows for the input of disturbances like white or colored noise, ramps, steps, sine- and cosine-combinations. No practical restriction for the number of state variables is present. An example for aircraft application is included.
Author

N80-21275# Air Force Flight Test Center, Edwards AFB, Calif.
THE USE OF ADVANCED COMPUTER TECHNIQUES IN FLIGHT TEST EVALUATIONS
D. P. MAUNDER and R. E. LEE *In* AGARD The Use of Computers as a Design Tool 6 p (SEE N80-21243 12-01) Jan. 1980 refs
Avail: NTIS HC A19/MF A01

The uses of advanced computer techniques in flight test evaluations at the AFFTC were examined. Uses of the computer for real time mission control, integrated systems development, flutter testing, and postflight data analysis are emphasized.
F.O.S.

N80-30272 Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
MULTILINGUAL AERONAUTICAL DICTIONARY
1980 896 p In ENGLISH, FRENCH, DUTCH, GERMAN, GREEK, ITALIAN, PORTUGUESE, TURKISH, SPANISH, and RUSSIAN (LC-77-93566; ISBN-92-835-01666-7; AD-A095571) Avail: NTIS HC $123.50; Distributed In North America by NTIS, 5285 Port Royal Road, Springfield, Va., USA and Distributed Outside North America by AGARD, 7 rue Ancelle, 92200 Neuilly sur Seine, France

A multilingual dictionary to aid scientists, engineers, and translators in the field of aeronautics was developed. The dictionary contains an alphabetical list of English terms, accompanied by English language definitions and translations of each term into the nine other languages. Nine alphabetical lists of terms in the languages other than English are included, each term accompanied by a reference number, keyed to its English language equivalent. A list of English acronyms, abbreviations, and symbols is also included, each accompanied by its expansion in English. J.M.S.

N80-31326# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
MATHEMATICAL MODELING OF LINEAR AND NON-LINEAR AIRCRAFT STRUCTURES
Jul. 1980 38 p refs Presented at the Spring 1980 Meeting of the Struct. and Mater. Panel, Athens
(AGARD-R-687; ISBN-92-835-1365-7; AD-A089439) Avail: NTIS HC A03/MF A01

Mathematical modeling of aircraft structures were used to determine the flutter boundaries and the dynamics of the aircraft. Specific emphasis is placed on improving the theoretically obtained flexibility and mass distributions of a structure and analyzing the nonlinear behavior of wing stores configurations. For individual titles, see N80-31327 through N80-31328.

N80-31327# Vereinigte Flugtechnische Werke G.m.b.H., Bremen (West Germany).
OPTIMIZATION OF THE MATHEMATICAL MODEL OF A STRUCTURE
H. ZIMMERMAN *In* AGARD Math. Modeling of Linear and Non-Linear Aircraft Struct. p 1-14 (SEE N80-31326 22-01) Jul. 1980 refs
Avail: NTIS HC A03/MF A01

Adjustment algorithms are presented for improving the theoretically obtained flexibility or stiffness and mass distribution of such a structure by dynamic test or ground resonance test results. The necessary assumptions for the adjustment and the mathematical formalism for the adjustment procedure are given. Experiences gained and adjustment results obtained with these algorithms are reported on concentrating especially on one which uses only the measured and calculated eigenfrequencies. Proposals for improvements on the procedures and in the algorithms are also given.
R.C.T.

N80-31328# Aeritalia S.p.A., Torino (Italy).
EFFECTS OF NONLINEARITIES ON WING-STORE FLUTTER
G. DEFERRARI, L. CHESTA, O. SENSBURG (Messerschmitt-Boelkow-Blohm G.m.b.H., Munich), and A. LOTZE (Messerschmitt-Boelkow-Blohm G.m.b.H., Munich) *In* AGARD Math. Modeling of Linear and Non-Linear Aircraft Struct. p 15-32 (SEE N80-31326 22-01) Jul. 1980 refs
Avail: NTIS HC A03/MF A01

Findings from ground resonance tests and flight flutter tests are presented and an explanation for these test results is given. Calculations with linear assumptions (parameter variations) were made and the method of harmonic balance for finding these parameters was applied. It is shown that certain levels of excitation must be reached in order to make flight flutter tests reliable for establishing flutter clearance speeds.
R.C.T.

N80-31329# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
AIRCRAFT ASSESSMENT AND ACCEPTANCE TESTING
May 1980 195 p refs Lecture held in Gol, Norway, 5-6 Jun. 1980, in Athens, 9-10 Jun. 1980, and in Ankara, 12-13 Jun. 1980 (AGARD-LS-108; ISBN-92-835-0266-3; AD-A088530) Avail: NTIS HC A09/MF A01

The present state of the art of aircraft assessment and acceptance testing of production aircraft is reviewed. Emphasis is placed on the practical aspects of this technique in order to help the flight crews and organizations dealing with this activity. Flight test instrumentation methods are set forth that do not require the use of sophisticated ground and airborne instrumentation for data acquisition or large computers for data processing. Flight test techniques described illustrate ways to acquire acceptable results utilizing a minimum of instrumentation or no instrumentation. For individual titles, see N80-31330 through N80-31341.

N80-31330# Centre d'Essais en Vol, Bretigny-sur-Orge (France).
SOME COMMENTS ON THE PROBLEMS INVOLVED IN AIRCRAFT ASSESSMENT AND ACCEPTANCE TESTING
J. F. RENAUDIE *In* AGARD Aircraft Assessment and Acceptance Testing 26 p (SEE N80-31329 22-01) May 1980 refs
Avail: NTIS HC A09/MF A01

The objectives of assessment and acceptance tests and criteria for assessment are presented. The means, organization, and programs of flying, the technical programs of assessment and acceptance tests, and the technique of flight testing are also discussed. E.D.K.

N80-31331# Air Force Flight Test Center, Edwards AFB, Calif.
USAF DEVELOPMENT TEST AND EVALUATION
L. P. COLBURN *In* AGARD Aircraft Assessment and Acceptance Testing 13 p (SEE N80-31329 22-01) May 1980 refs
Avail: NTIS HC A09/MF A01

The test and evaluation of new weapon systems is an integral part of the total acquisition process. The major emphasis in the early development stages is placed on quantitative test and analysis to determine functional adequacy and specification compliance. Highly instrumented aircraft are used to provide data on aircraft performance, flying qualities, structural integrity, and subsystem operation. The management and test procedures used at the Air Force Flight Test Center to plan, conduct, and report on the development test and evaluation phase are presented. E.D.K.

N80-31332# British Aerospace Aircraft Group, Dunsfold (England).
SOME EXAMPLES OF PROCEDURES USED IN UK FOR ACCEPTANCE TESTING OF AIRCRAFT PRODUCED BY THE AIRCRAFT INDUSTRY UNDER GOVERNMENT CONTRACT
R. J. POOLE *In* AGARD Aircraft Assessment and Acceptance Testing 6 p (SEE N80-31329 22-01) May 1980 refs
Avail: NTIS HC A09/MF A01

The scope of the testing carried out on instrumented aircraft is illustrated in order to indicate the range of data that can be made available to bodies evaluating a production aircraft. Aircraft are flight tested to a production flight test schedule to ensure consistent handling and performance throughout the fleet and an example of the content of a schedule is presented. Tests include measurement of aerodynamic loading and inertia loading of the airframe structure, measurement of the aircraft stability and control characteristics, measurement of thrust and lift boundaries, takeoff, landing, climb, cruise, and descent performance, and determination of engine handling characteristics. E.D.K.

N80-31333# Societe de Fabrication d'Instruments de Mesure SFIM, Massy (France). Measurement and Recording Div.
A REVIEW OF FLIGHT TEST INSTRUMENTATION SYSTEMS FOR ACCEPTANCE TESTING OF THE PRODUCTION AIRCRAFT
C. ROBERT *In* AGARD Aircraft Assessment and Acceptance Testing 3 p (SEE N80-31329 22-01) May 1980
Avail: NTIS HC A09/MF A01

A definition is given of flight test instrumentation. Two cases considered are that the aircraft is fitted with a crash recording system and that no special recording means are available on the aircraft. A general description of present accident recording systems is presented. E.D.K.

N80-31334# Air Force Flight Test Center, Edwards AFB, Calif.
PERFORMANCE TESTING PRODUCTION AIRLINES
R. C. CRANE *In* AGARD Aircraft Assessment and Acceptance Testing 27 p (SEE N80-31329 22-01) May 1980 refs
Avail: NTIS HC A09/MF A01

A discussion of basic performance testing and data analysis concepts along with pretest information requirements are presented. Ground tests such as instrumentation calibrations, installed static thrust calibrations, and airplane gross weight and center of gravity checks are outlined. Flight tests which enable static source position error determination, as well as an assessment of takeoff, cruise, acceleration, and turning performance are discussed. Also described are tests that enable assessments of the engine handling characteristics of the airplane. The presentation and analysis of the data acquired during each type of tests are also outlined with emphasis on using test day data as opposed to test day data corrected to standard day conditions. E.D.K.

N80-31335# British Aerospace Aircraft Group, Dunsfold (England).
EVALUATION OF LONGITUDINAL CHARACTERISTICS INCLUDING STABILITY HANDLING AND CG RANGE
R. J. POOLE *In* AGARD Aircraft Assessment and Acceptance Testing 16 p (SEE N80-31329 22-01) May 1980 refs
Avail: NTIS HC A09/MF A01

Tests used by contractors to assess the longitudinal stability and control characteristics of an aircraft are enumerated to give an indication of the measured flight test data that can be made available to an evaluating body. Simple flight tests to obtain qualitative and quantitative data on static, maneuver and dynamic stability, low speed handling, turning performance and high Mach number effects during an evalaution are also described. E.D.K.

N80-31336# British Aerospace Aircraft Group, Dunsfold (England).
EVALUATION OF LATERAL AND DIRECTIONAL CHARACTERISTICS AND SPINNING BEHAVIOUR
R. J. POOLE *In* AGARD Aircraft Assessment and Acceptance Testing 12 p (SEE N80-31329 22-01) May 1980 refs
Avail: NTIS HC A09/MF A01

The lateral and directional handling characteristics that should be investigated during an evaluation of an aircraft already tested by a contractor and test techniques utilizing limited flight test instrumentation to gather quantitative data are described. An approach to the assessment of spin entry and recovery behavior is also presented. E.D.K.

N80-31337*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Center, Edwards, Calif.
FLIGHT RESEARCH TECHNIQUES UTILIZING REMOTELY PILOTED RESEARCH VEHICLES
R. D. REED *In* AGARD Aircraft Assessment and Acceptance Testing 15 p (SEE N80-31329 22-01) May 1980 refs
Avail: NTIS HC A09/MF A01

The use of the remotely piloted research vehicle (RPRV) in aeronautical research is surveyed. The flight test experience that has been acquired with several types of RPRV's including those with a pilot in the loop is emphasized. The approaches utilized range from the simplest and least expensive of vehicles, such as the Minisniffer, to the sophisticated highly maneuverable aircraft technology (HiMAT) RPRV. The advantages and disadvantages of RPRV's are discussed, as well as safety considerations. The ground rules set early in a program can profoundly affect program cost effectiveness and timeliness. M.G.

N80-31338# Air Force Flight Test Center, Edwards AFB, Calif.
QUALITATIVE ARMAMENT SUBSYSTEM ASSESSMENT
L. P. COLBURN *In* AGARD Aircraft Assessment and Acceptance Testing 16 p (SEE N80-31329 22-01) May 1980 refs
Avail: NTIS HC A09/MF A01

A qualitative approach to armament subsystem tests, the objectives which can be achieved, and analysis methods for the major aircraft weapon systems are addressed. It is concluded that a qualitative evaluation of the armament subsystem can provide the basis for determining the operational effectiveness and

suitability of the system for procurement. A substantial amount of information may be gathered to evaluate a weapon system without extensive or sophisticated instrumentation. Minimal aircraft and weapon range instrumentation requirements are detailed. M.G.

N80-31339# Aeroplane and Armament Experimental Establishment, Boscombe Down (England).
ELECTRO-MAGNETIC COMPATIBILITY
H. MAIDMENT *In* AGARD Aircraft Assessment and Acceptance Testing 6 p (SEE N80-31329 22-01) May 1980 refs
Avail: NTIS HC A09/M.F A01

The historical background to the growth in problems of electromagnetic compatibility (EMC) in UK Military aircraft is reviewed and the present approach for minimizing these problems during development is discussed. The importance of using representative aircraft for final EMC assessments is stressed, and the methods of approach in planning and executing such tests are also outlined. The present equipment qualification procedures are based on assumptions regarding the electromagnetic fields present within the airframe, and the nature of the coupling mechanisms. These cannot be measured with any certainty in representative aircraft. Thus EMC assessments rely on practical tests. Avionics systems critical to flight safety, and systems vital to mission effectiveness require test methods that provide a measure of the safety and performance margins available to account for variations that occur in production and service use. Some proven methods are available, notably for detonator circuits, but in most other areas further work is required. Encouraging process has been made in the use of current probes for the measurement of interfering signals on critical signal lines, in conjunction with complementary test house procedures, as a means for obtaining the safety margins required in flight and engine control systems. Performance margins for mission systems using digital techniques are difficult to determine, and there is a need for improved test techniques. The present EMC qualification tests for equipment in the laboratory do not guarantee freedom from interference when installed, and the results are limited in value for correlating with aircraft tests. M.G.

N80-31340# Aeroplane and Armament Experimental Establishment, Boscombe Down (England).
CHECKING OF COMMUNICATIONS AND RADIO NAVIGATION SYSTEMS
H. MAIDMENT *In* AGARD Aircraft Assessment and Acceptance Testing 24 p (SEE N80-31329 22-01) May 1980 refs
Avail: NTIS HC A09/MF A01

The testing of aircraft communications and radio navigation systems is addressed. Limited assessments need to take account of variations in ground station performance, and uncertainty regarding radio wave propagation conditions. Antenna performance can vary markedly in different aircraft to affect the radial coverage of all systems, or the accuracy achieved by direction finding equipment. Aircraft transmitting antenna characteristics can be quantified for a relatively modest outlay on ground station equipment, and subjective communications quality assessments can be enhanced by using suitable yet inexpensive voice recorders that are also useful for noting observed navigation data for subsequent analysis. An accompanying aircraft of known performance can provide a comparative basis for the assessment of range performance and provide the means for checking air to air modes. Test objectives should be related to the intended operational use of the aircraft, but need to be interpreted into schedules for use over standard test routes, that have the widest application for all classes of aircraft. An example is given of a possible schedule of tests and the form of analysis that might apply. M.G.

N80-31341# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick (West Germany). Inst. fuer Flugfuehrung.
PERFORMANCE OF NAVIGATION SYSTEMS
K. HURRASS *In* AGARD Aircraft Assessment and Acceptance Testing 16 p (SEE N80-31329 22-01) May 1980 refs
Avail: NTIS HC A09/MF A01

The radio navigation systems of VHF omnidirectional range/distance measuring equipment (VOR/DME) and the tactical air navigation system, as well as Doppler navigation and inertial navigation are described to show in which way and how far they can be used. Their error behavior is described especially and in detail. It is suggested that by combining various navigation systems, navigation accuracy can be greatly increased. One integrated system is dealt with and explained with the aid of flight tests. The system consists of a simple dead-reckoning system aided by DME distance measurements. Both systems are integrated by emans of a Kalman filter. The dead-reckoning system uses heading, true air speed, and an estimated velocity of the wind. The DME-interrogator is constantly switched over to frequencies of different ground stations (multiple DME). M.G.

N80-31342# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
THE APPLICATION OF DESIGN TO COST AND LIFE CYCLE COST TO AIRCRAFT ENGINES
May 1980 168 p refs Conf. held at Saint Louis, France, 12-13 May 1980 and London, 15-16 May 1980
(AGARD-LS-107; ISBN-92-835-0265-5; AD-A087977) Avail: NTIS HC A08/MF A01

The cost of design and development of weapon systems must include not only the cost of production but also deployment training, operational use, and support. The latest methodologies of cost/performance comparison and tradeoffs for aircraft engines are examined with emphasis on data collection, analysis, modelling and estimating all development and operations costs. Contractual provisions and the costs related to incentives for performance and reliability are included. For individual titles, see N80-31343 through N80-31349.

N80-31343# RAND Corp., Washington, D. C.
AN APPROACH TO THE LIFE CYCLE ANALYSIS OF AIRCRAFT TURBINE ENGINES
J. R. NELSON *In* AGARD The Appl. of Design to Cost and Life Cycle Cost to Aircraft Eng. 27 p (SEE N80-31342 22-01) May 1980 refs
Avail: NTIS HC A08/MF A01

A methodology derived from historical data for life cycle analysis of aircraft turbine engines is described and applied at the engine subsystem and aircraft systems levels. The methodology enables the weapon system planner to acquire early visibility of cost magnitudes, proportions, and trends associated with a new engine's life cycle, and to identify drivers that increase cost and can lower capability. The procedure followed was to develop a theoretical framework for each phase of the life cycle; collect and analyze data for each phase; develop parametric cost estimating relationships (CERs) for each phase; use the CERs in examples to ascertain behavior and obtain insights into cost magnitudes, proportions, and trends, and to identify cost drivers and their effects; and examine commercial experience for cost data and operational and maintenance practices. A.R.H.

N80-31344# Ministry of Defence, London (England).
DESIGN TO LIFE CYCLE COSTS INTERACTION OF ENGINE AND AIRCRAFT
E. J. JONES *In* AGARD The Appl. of Design to Cost and Life Cycle Cost to Aircraft Eng. 15 p (SEE N80-31342 22-01) May 1980
Avail: NTIS HC A08/MF A01

The distribution of life cycle costs for a typical combat aircraft between airframe, avionics and engine is discussed. Distribution of costs for the aircraft between development, production, initial support and operation and support is compared with the distribution for the engine. The effect of fleet size and service life upon the life cycle costs are indicated. The large commitment of life cycle costs early in the conceptual and feasibility phase of the program is indicated. The choice of engine is an example of this early commitment. The relative effect of the choice of single or twin engine installation of a derated engine or the use of an existing engine upon the engine life cycle costs, and the interaction with aircraft costs is discussed. The severe operating conditions for the engine of a combat aircraft are reviewed. Reduced support costs are not expected to give a large fold return on extra engine development investment. A.R.H.

01 AERONAUTICS (GENERAL)

N80-31345# Air Force Systems Command, Wright-Patterson AFB, Ohio. Aeronautical Systems Div.

PROGRESS ON THE US AIR FORCE APPROACH FOR THE PRACTICAL MANAGEMENT OF ENGINE LIFE CYCLE COSTS

R. E. STEERE, E. G. KOEPNICK, and R. A. DEAN *In* AGARD The Appl. of Design to Cost and Life Cycle Cost to Aircraft Eng. 10 p (SEE N80-31342 22-01) May 1980 refs

Avail: NTIS HC A08/MF A01

Efforts to more effectively influence the life cycle costs of newly acquired gas turbine power plants are reviewed. A combination of technical and business practice initiatives was undertaken or planned across the entire life cycle spectrum, i.e., from first entry with the exploratory development program through the decision to phase the product out of the active inventory. The status of technical and management activities is addressed and various business concepts and strategies being studied by the U.S. Air Force which complement the earlier initiatives as they impact engine life cycle costs are presented. The role of the USAF Propulsion System Program Office as the continuing focal point for these life cycle efforts is discussed. The ideas presented are not new as they have been employed successfully at one time or another on an individual basis in the development and support of military and commercial gas turbine power plants. What is new, is the systems management view of the life cycle process and what can be done practically today vs tomorrow to enhance engine life cycle costs in an integrated fashion. A.R.H.

N80-31346# Societe Nationale d'Etude et de Construction de Moteurs d'Aviation, Paris (France).

MILITARY ENGINE PROGRAMS WITH COST OBJECTIVES [PROGRAMMES DE MOTEURS MILITAIRE A OBJECTIES DE COUT]

C. FOURE *In* AGARD The Appl. of Design to Cost and Life Cycle Cost to Aircraft Eng. 28 p (SEE N80-31342 22-01) May 1980 In FRENCH

Avail: NTIS HC A08/MF A01

Approaches discussed include the analysis of value; reliability and maintainability studies; the direct operating cost of motor parts as considered by aircraft companies; and the management of efforts in technological progress. Topics covered include means for forecasting costs which are desirable to set at each phase of the program; the types of organization adapted to such programs; and possible action to be taken when the objectives are fixed or revised after initial definition, with or without modification of the definition. Economy measures related to the high cost of fuels and return from the value concept and tradeoffs are also examined. Transl. by A.R.H.

N80-31347# General Electric Co., Lynn, Mass. Aircraft Engine Group.

LOGISTICS FORECASTING FOR ACHIEVING LOW LIFE CYCLE COST

G. WALKER *In* AGARD The Appl. of Design to Cost and Life Cycle Cost to Aircraft Eng. 25 p (SEE N80-31342 22-01) May 1980 refs

Avail: NTIS HC A08/MF A01

The on condition maintenance concept (OCM) provides the potential for reduced life cycle costs (LCC) by fully utilizing potential parts life and reducing maintenance frequency. With the advent of OCM logistics requirements are heavily influenced by wearout characteristics and usage severity. In such cases more sophisticated forecasting methods are required which realistically represent the dynamics of the logistics system inherent in such a maintenance philosophy. If efficient logistics management is to be attained, such forecasting tools should also provide the capability to perform tradeoff studies on the cost effectiveness of alternative maintenance or logistics systems. The use of modelling methods which are proving practical in forecasting and tradeoff analyses and therefore in establishing an optimum logistics and support environment is explored. Methods discussed include the consideration of wearout characteristics where components exhibit an age related replacement rate, and also replacement of components which may have a specified maximum life in terms of operating cycles or mission severity. The use of engine history recorders and parts tracking systems and their impact on achieving optimum LCC is also discussed. A.R.H.

N80-31348# Rolls-Royce Ltd., Bristol (England). Aero Div.

THE APPLICATION OF DESIGN TO COST AT ROLLS-ROYCE

R. J. SYMON and K. J. DANGERFIELD *In* AGARD The Appl. of Design to Cost and Life Cycle Cost to Aircraft Eng. 17 p (SEE N80-31342 22-01) May 1980

Avail: NTIS HC A08/MF A01

Experience in evolving and applying a formal design to cost discipline is described in chronological order of the main events which occurred during the last five years with brief reference to the previous period. A new type of department was created to face the principal problem, that control of costs requires interactive links between the management disciplines at all levels. The way in which this group fits into the existing organization to ensure that effective cost control becomes part of the established routines is discussed. Comments are made on the nature of cost and its fundamental difference from the other parameters which the designer has traditionally managed. Conclusions likely to apply to any commercial manufacturing company are suggested and comments made regarding the future responsibility of engineers in determining the financial success of the companies for which they work. Complementary roles for management and financial accountants to support the new responsibilities of the engineers are also indicated. A.R.H.

N80-31349# Boeing Aerospace Co., Seattle, Wash. Systems Cost Analysis Div.

EVALUATING AND SELECTING THE PREFERRED AIR BREATHING WEAPON SYSTEM

F. A. WATTS *In* AGARD The Appl. of Design to Cost and Life Cycle Cost to Aircraft Eng. 16 p (SEE N80-31342 22-01) May 1980

Avail: NTIS HC A08/MF A01

The life cycle costs of three equally effective strategic forces are discussed with the objective of isolating the preferred air breathing component. Terms are defined, cost elements are reviewed, and an example is described in which various strategic forces containing advanced aircraft are compared and the preferred choice is dependent on whether least cost is measured by short term, long term, or intermediate budgetary considerations. A.R.H.

N81-26037# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).

COMPUTATION OF VISCOUS-INVISCID INTERACTIONS

Feb. 1981 524 p refs Symp. held at Colorado Springs, Colo. 29 Sep. - 1 Oct. 1980

(AGARD-CP-291; ISBN-92-835-0286-8; AD-A098428) Avail: NTIS HC A22/MF A01

Computational aircraft performance prediction is considered to be the final goal of aerodynamic research, especially in the field aircraft design. The flow fields generated airfoils were examined with emphasis on the parts of the flow where viscosity plays a major role - the boundary and shear layers. Adequate methods and algorithms to link the viscous and the inviscid parts of the flow were surveyed. Topics addressed include: unseparated flows and the thin-layer concept; turbulent strong interaction without extensive separated flow; and separated flows. For individual titles, see N81-26038 through N81-26068.

N81-26038# Office National d'Etudes et de Recherches Aerospatiales, Paris (France).

COMPUTATION OF FLOWS INCLUDING STRONG VISCOUS INTERACTIONS WITH COUPLING METHODS

J. C. LEBALLEUR *In* AGARD Computation of Viscous-Inviscid Interactions 36 p (SEE N81-26037 17-01) Feb. 1981 refs In FRENCH; ENGLISH summary

Avail: NTIS HC A22/MF A01

The approximation levels and concepts are outlined, as well as the generalized formulations of the viscous displacement for inviscid flow. The strongly interacting methods that are based on thin viscous layers approximations are discussed. A matching formulation of the viscous flow, calculated as a difference of the inviscid overlaying flow, is presented in order to approximate the normal pressure gradient inside of the layers, as well as to eliminate the supercritical behaviors, in the Crocco-Lees sense. This analysis uses simple viscous integral equations. Numerical techniques presently available for the coupling problem are reviewed. Results are presented for trailing-edge separation, and an approximation

method is presented to numerically analyze the viscous interaction under shock waves. T.M.

N81-26039# Royal Aircraft Establishment, Farnborough (England). Aerodynamics Dept.
A REVIEW OF METHODS FOR PREDICTING VISCOUS EFFECTS ON AEROFOILS AND WINGS AT TRANSONIC SPEEDS
R. C. LOCK *In* AGARD Computation of Viscous-Inviscid Interactions 32 p (SEE N81-26037 17-01) Feb. 1981 refs
Avail: NTIS HC A22/MF A01

Methods in which the problem of viscous-inviscid interaction is treated by assuming that the effects of viscosity are confined to thin boundary layers and wakes are reviewed. With this assumption, an iterative procedure is set up in which the inviscid flow is calculated first and the result used to specify the pressure distribution from which the development of the viscous layers can be determined. The inner boundary condition for the equivalent inviscid flow is then modified to allow for the displacement effect of the viscous layers; and the procedure is repeated until convergence is obtained. Two alternative mathematical models for the displacement effect were derived, valid to second-order accuracy. The principal methods that are currently available for the two dimensional problem (single airfoils) at transonic speeds and some of the corresponding methods for three dimensional wings or wing body combinations were reviewed. T.M.

N81-26040# Arizona Univ., Tucson.
INVISCID-VISCOUS INTERACTIONS IN THE NEARLY DIRECT DESIGN OF SHOCK-FREE SUPERCRITICAL AIRFOILS
H. E. NEBECK, A. R. SEEBASS, and H. SOBIECZKY (DFVLR, Goettingen, West Germany) *In* AGARD Computation of Viscous-Inviscid Interactions 10 p (SEE N81-26037 17-01) Feb. 1981 refs
Avail: NTIS HC A22/MF A01

A procedure for finding airfoil shapes that have desirable aerodynamic characteristics and that will be shock free at Mach numbers close to the highest values possible is described. The procedure accounts for overall inviscid-viscous interactions that are weak and includes the locally strong interaction at the trailing edge as incorporated in the Grumfoil algorithm. T.M.

N81-26041# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Goettingen (West Germany). Aerodynamische Versuchsantalt.
THE COUPLING OF A SHOCK BOUNDARY LAYER INTERACTION MODULE WITH A VISCOUS-INVISCID COMPUTATION METHOD
E. STANEWSKY, M. NANDANAN, and G. R. INGER (Virginia Polytechnic Inst. and State Univ.) *In* AGARD Computation of Viscous-Inviscid Interactions 14 p (SEE N81-26037 17-01) Feb. 1981 refs
Avail: NTIS HC A22/MF A01

A brief description of the present method and its components is presented. Results obtained with the combined boundary layer/shock boundary layer interaction code are compared with results from the complete viscous-inviscid method with corresponding data from boundary layer and surface pressure distribution measurements. Present results are, in addition, compared with data obtained by other methods. From the results discussed, it is shown that in transonic airfoil flow analysis it is generally necessary to incorporate a physically correct treatment of the interaction of a shock with the boundary layer. T.M.

N81-26042# Office National d'Etudes et de Recherches Aerospatiales, Paris (France).
VISCOUS-INVISCID COUPLED CALCULATIONS IN UNSTEADY TWO-DIMENSIONAL INCOMPRESSIBLE AND TRANSONIC FLOW
A. DESOPPER and R. GRENON *In* AGARD Computation of Viscous-Inviscid Interactions 21 p (SEE N81-26037 17-01) Feb. 1981 refs In FRENCH; ENGLISH summary
Avail: NTIS HC A22/MF A01

A calculation method in which viscous effects were taken into account was developed. It uses: for the inviscid flow calculation, a singularity method in incompressible flow or a small disturbances method in transonic flow; an integral method for the calculation of the unsteady boundary layer; and a coupling technique called 'coupling at the wall' not taking into account the problem of separation. Results obtained by this method are presented: in compressible flow for a supercritical profile with an oscillating flap and for a profile oscillating in pitch; and in transonic flow for a NACA 64 A 006 profile with an oscillating flap. These results show the influence of the viscous effects on the unsteady pressures, on the total force coefficients, on the strength and on the location of the shock waves. T.M.

N81-26043# Dornier-Werke G.m.b.H., Friedrichshafen (West Germany).
VISCOUS FLOW SIMULATION OF HIGH LIFT DEVICES AT SUBSONIC AND TRANSONIC SPEED
S. LEICHER *In* AGARD Computation of Viscous-Inviscid Interactions 15 p (SEE N81-26037 17-01) Feb. 1981 refs
Avail: NTIS HC A22/MF A01

A numerical method for the calculation of viscous flow over multicomponent airfoils is presented. The part of the code containing the viscous methods is decoupled from the inviscid one in order to be easily combined with any suitable inviscid method. The iterative use of both parts leads finally to a converged solution. The viscous part consists of a one parameter integral method for laminar boundary layers, a modified Nash integral method or the lag-entrainment method of Horton for turbulent boundary layers and a special integral procedure (optional) for confluent boundary layers. Laminar short and long separation bubbles as well as bubble burst were calculated. Transition can be either fixed or calculated using the Reynolds number criterion of Michel. Turbulent separation of bubble type as well as common trailing edge separation were simulated within the standard boundary layer methods by means of semi-empirical correlations. The numerical simulation of the viscous effects is made using either the displacement thickness concept (transonic, subsonic) or the equivalent source approach (subsonic only). T.M.

N81-26044# Vereinigte Flugtechnische Werke G.m.b.H., Bremen (West Germany).
FLOW COMPUTATION AROUND MULTI-ELEMENT AIRFOILS IN VISCOUS TRANSONIC FLOW
H. ROSCH and K. D. KLEVENHUSEN *In* AGARD Computation of Viscous-Inviscid Interactions 10 p (SEE N81-26037 17-01) Feb. 1981 refs
Avail: NTIS HC A22/MF A01

A singularity method is applied to multi-element airfoils in the physical plane for calculating both, the incompressible velocities and the incompressible potential and stream function along the contour of each element. The values of the computation were used to build an orthogonal grid in which the airfoil is mapped to a line in the streamline plane. The computational domain is this streamline plane wherein the full transonic potential equation is solved using a finite difference method. The influence of viscous effects were incorporated using the so called surface transpiration concept. The representation of the displacement effect of the boundary layer and wakes is based on the well known integral method and a trailing edge flow concept which includes normal pressure gradients and wake curvature effects. Comparisons of the theory with high Reynolds number experiments show the good agreement for pressure distribution and lift. T.M.

N81-26045# Royal Aircraft Establishment, Farnborough (England). Aerodynamics Dept.
CALCULATIONS OF TRANSONIC FLOW OVER WING/BODY COMBINATIONS WITH AN ALLOWANCE FOR VISCOUS EFFECTS
M. C. P. FIRMIN *In* AGARD Computation of Viscous-Inviscid Interactions 18 p (SEE N81-26037 17-01) Feb. 1981 refs
Avail: NTIS HC A22/MF A01

A viscous inviscid interaction scheme developed for aerofoils was generalised to account for the three dimensional effects of the boundary layers and wake over the wing of a wing/body combination. Two main elements make up the method: the RAE Mk 4 transonic small perturbation method which was modified to allow changes to be made to the boundary conditions over the wing and in the wake; and a three dimensional integral boundary layer method. The coupling of the two main elements of the method and the difficulties encountered in providing an adequate iterative scheme are discussed. Computing times are discussed in relation to the time required for the basic calculation for inviscid flow. Several examples are given of results obtained and comparisons

are shown between experimental measurements and results from the scheme. T.M.

N81-26046# Boeing Military Airplane Development, Seattle, Wash.
PLANAR TRANSONIC AIRFOIL COMPUTATIONS WITH VISCOUS INTERACTIONS
J. C. WAI and H. YOSHIHARA *In* AGARD Computation of Viscous-Inviscid Interactions 9 p (SEE N81-26037 17-01) Feb. 1981 refs
Avail: NTIS HC A22/MF A01

Green's lag entrainment integral boundary layer and wake equations are coupled to a transonic small disturbance potential equation to calculate flows with shock induced and aft separations. The shock boundary layer interactions is treated phenomenologically by incorporating a wedge ramp at the base of the shock to achieve an empirically defined post shock pressure. The remainder of the boundary layer and wake are treated by a coupled scheme where the boundary layer equations are used as boundary conditions along the airfoil and wake for the inviscid flow calculation. The procedure is illustrated for the case of the NASA Supercritical Airfoil 12 without separation and the case of the RAE 2822 with shock induced separation. T.M.

N81-26047# Grumman Aerospace Corp., Bethpage, N.Y.
TURBULENT INTERACTIONS ON AIRFOILS AT TRANSONIC SPEEDS: RECENT DEVELOPMENTS
R. E. MELNIK *In* AGARD Computation of Viscous-Inviscid Interactions 34 p (SEE N81-26037 17-01) Feb. 1981 refs
Avail: NTIS HC A22/MF A01

Developments in theoretical concepts for the analysis of viscid inviscid interactions on airfoils at transonic speeds are discussed. The overall weak interation between the boundary layer, wake and outer inviscid flow are considered as well as the strong local interaction at shock waves and trailing edges. Efforts to incorporate important wake displacement and wake curvature effects into an interacting boundary layer formulation are discussed. Progress in the development of local, large Reynolds number, asymptotic solutions for turbulent shock wave boundary layer and trailing edge interaction are described and related to Lighthill's two layer model of strong interactions. Reasons for the difference between laminar and turbulent strong interaction theories are discussed. Techniques are described for incorporating the local trailing edge solution into an interacting boundary layer formulation which includes a complete treatment of the wake. Theoretical predictions, obtained with this formulation, are compared with wind tunnel data to illustrate the accuracy that can be achieved with an interacting boundary layer formulation when the wake and trailing edge interaction effects are included in the theoretical model. R.C.T.

N81-26048# Office National d'Etudes et de Recherches Aerospatiales, Paris (France).
COMPUTATION OF VISCOUS FLOWS OVER AIRFOILS, INCLUDING SEPARATION, WITH A COUPLING APPROACH
J. C. LEBALLEUR and M. NERON *In* AGARD Computation of Viscous-Inviscid Interactions 15 p (SEE N81-26037 17-01) Feb. 1981 refs In FRENCH; ENGLISH summary
Avail: NTIS HC A22/MF A01

Viscous incompressible flows over single or multiple airfoils, with or without separation, were computed using an inviscid flow calculation, with modified boundary conditions, and by a method providing calculation and coupling for boundary layers and wakes, within conditions of strong viscous interaction. The inviscid flow is calculated with a method of singularities, the numerics of which were improved by using both source and vortex distributions over profiles, associated with regularity conditions for the fictitious flows inside of the airfoils. The viscous calculation estimates the difference between viscous flow and inviscid interacting flow, with a direct or inverse integral method, laminar or turbulent, with or without reverse flow. The numerical method for coupling determines iteratively the boundary conditions for the inviscid flow. For attached viscous layers regions, an underrelaxation is locally calculated to insure stability. For separated or separating regions, a special 'semi-inverse' algorithm is used. Comparisons with experiments are presented. A.R.H.

N81-26049# National Aerospace Lab., Amsterdam (Netherlands).
THE CALCULATION OF INCOMPRESSIBLE BOUNDARY LAYERS WITH STRONG VISCOUS-INVISCID INTERACTION
A. E. P. VELDMAN *In* AGARD Computation of Viscous-Inviscid Interactions 12 p (SEE N81-26037 17-01) Feb. 1981 refs
Avail: NTIS HC A22/MF A01

A quasisimultaneous method is described to calculate laminar, incompressible boundary layers interacting with an inviscid external flow. The essence of the method is the numerical treatment of the interactive boundary condition which models the behaviour of the outer flow; it is regarded as a relation between the pressure and the displacement thickness where both quantities are simultaneously treated as unknowns. This way the method avoids difficulties incurred when either direct or inverse methods are used, resulting in fast convergence of the iterative procedure involved. R.C.T.

N81-26050*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
A VISCOUS-INVISCID INTERACTION MODEL OF JET ENTRAINMENT
R. G. WILMOTH and S. M. DASH (Aeronautical Research Associates of Princeton, Inc.) *In* AGARD Computation of Viscous-Inviscid Interactions 15 p (SEE N81-26037 17-01) Feb. 1981 refs
Avail: NTIS HC A22/MF A01 CSCL 20D

A viscous-inviscid interaction model for predicting jet entrainment effects on axisymmetric, nozzle afterbodies at subsonic speeds is presented. The model is based on a displacement thickness correction to the inviscid jet boundary that accounts for mixing-induced streamline deflections in the inviscid region. The displacement correction is shown to be related to the local mass entrainment rate and, for thin mixing layers, the model is shown to be analogous to displacement models used in conventional boundary-layer interaction theory. A method is presented for computing the entrainment rate by an overlaid mixing layer model that accounts for the nonsimilar behavior and pressure gradients occurring in the near field region. An iterative scheme for coupling the model to analyses for the external inviscid flow, the external boundary layer, and the inviscid jet exhaust is also given. Results are presented that illustrate the qualitative behavior of the entrainment interaction under various flow conditions and that demonstrate the validity of the model by comparisons with experiment. R.C.T.

N81-26051# Centre d'Etudes et de Recherches, Toulouse (France). Dept. d'Aerothermodynamique.
THE ANALOGY OF SINGULARITIES IN DIRECT METHODS FOR CALCULATING STEADY THREE DIMENSIONAL AND UNSTEADY TWO DIMENSIONAL BOUNDARY LAYERS: ANALYSIS OF REVERSED MODES [ANALOGIE DES SINGULARITES DANS LES METHODES DIRECTES DE CALCUL DES COUCHES LIMITES TRIDIMENSIONNELLE STATIONNAIRE ET BIDIMENSIONNELLE INSTATIONNAIRE: ANALYSE DES MODES INVERSES]
J. COUSTEIX and R. HOUDEVILLE *In* AGARD Computation of Viscous-Inviscid Interactions 14 p (SEE N81-26037 17-01) Feb. 1981 refs In FRENCH; ENGLISH summary
Avail: NTIS HC A22/MF A01

The problem of occurrence of singularities in boundary layer equations, both in the unsteady two-dimensional and steady three-dimensional cases, is analytically studied by means of the global equations of momentum and entrainment. In the direct mode the velocity is given. It is shown that in opposition to the steady two-dimensional case, the occurrence of reversed flows does not generally create singularities, but indicates a downstream influence. In both cases, the analytical and numerical study shows that discontinuity lines can exist, corresponding to weak solutions of the equations, but these lines have no physical meaning. Particularly in the three-dimensional case they must not be confused with separation lines. The calculations in the inverse mode avoid any singularity. The velocity is then an unknown of the boundary layer problem. Such methods are useful to solve the coupling problem between viscid-inviscid flow and are also interesting to verify closure relations of calculation models in separated regions. Author

N81-26052# Flow Research, Inc., Kent, Wash.
A PHENOMENOLOGICAL MODEL FOR DISPLACEMENT THICKNESS EFFECTS OF TRANSONIC SHOCK WAVE-BOUNDARY LAYER INTERACTIONS
W. H. JOU and E. M. MURMAN *In* AGARD Computation of Viscous-Inviscid Interactions p (SEE N81-26037 17-01) Feb. 1981 refs
Avail: NTIS HC A22/MF A01

A simple algebraic model is developed to describe the shape of the viscous displacement thickness surface downstream of a weak normal shock wave (M sub 1 less than 1.3) interacting with a turbulent boundary layer. Theoretical information is used to construct the shape of a bump. The bump is then incorporated into inviscid transonic potential codes to model the strong interaction effects of the boundary layer in moving the shock wave forward and reducing its strength. Computed results compare favorably with two and three dimensional experiments. R.C.T.

N81-26053*# Michigan Univ., Ann Arbor. Dept. of Aerospace Engineering.
SIMPLE APPROXIMATIONS FOR THE ASYMPTOTIC DESCRIPTION OF THE INTERACTION BETWEEN A NORMAL SHOCK WAVE AND A TURBULENT BOUNDARY LAYER AT TRANSONIC SPEEDS
T. C. ADAMSON, JR. and A. F. MESSITER *In* AGARD Computation of Viscous-Inviscid Interactions 14 p (SEE N81-26037 17-01) Feb. 1981 refs
(Contract NSG-1326)
Avail: NTIS HC A22/MF A01 CSCL 01A

The asymptotic description of the interaction between a normal shock wave and a turbulent boundary layer is reviewed. The layers necessary in a rational analysis of the interaction are discussed with emphasis on the differences from an interaction with a laminar boundary layer, the uncoupling of solutions for the distribution of pressure and skin friction at the wall, and the role of the Reynolds shear stress in these solutions. The accuracy of asymptotic solutions in flows at Reynolds numbers of technical interest is discussed. Solutions for the distribution of pressure and skin friction at the wall and the shape of the shock are considered for the case where the flow is near separation. For the pressure and skin friction, it is possible to write two simplified partial solutions, one valid at the beginning of the interaction and one valid somewhat downstream of the shock wave. A solution composed of these two parts and a linear interpolation between them appears to give good comparison with experiment; one unknown constant, independent of the parameters of the interaction, must be found from experiment. The simplified relations are presented. Comparison of numerical computations with experimental data indicates a possible value for the constant and shows quite satisfactory results. R.C.T.

N81-26054# Karlsruhe Univ. (West Germany). Inst. fuer Stroemungslehre und Stroemungsmaschinen.
NORMAL SHOCK-TURBULENT BOUNDARY LAYER INTERACTION
R. BOHNING and J. ZIEREP *In* AGARD Computation of Viscous-Inviscid Interactions 8 p (SEE N81-26037 17-01) Feb. 1981 refs
Avail: NTIS HC A22/MF A01

A survey on investigations of the interaction between a weak normal shock and a two dimensional compressible turbulent boundary layer is presented. The theoretical results are compared with some measurements. An analytical model is presented which includes three domains: a thin viscous sublayer (which is different from the laminar sublayer) adjacent to the wall; an inviscid shear layer; and an inviscid transonic potential flow. With regional solutions in closed form, which are coupled iteratively, the pressure and velocity distribution in the boundary layer is obtained. The thickness of the viscous sublayer is an essential parameter of the whole interaction problem. A characteristic behavior of the gradient of the wall-shear-stress in flow direction is used to determine the thickness parameter. The result is confirmed by another independent analytical solution which we have derived recently using the method of matched asymptotic expansions. The theory includes the prediction of the incipient shock induced separation as a limiting case. With the condition of vanishing wall-shear-stress an analytical criterion follows from the explicit solution near the wall. A diagram is presented which yields the combination of Mach number and Reynolds number which will result in separation for a given wall curvature and shape factor of the undisturbed velocity profile. R.C.T.

N81-26055# Virginia Polytechnic Inst. and State Univ., Blacksburg.
SOME FEATURES OF A SHOCK-TURBULENT BOUNDARY LAYER INTERACTION THEORY IN TRANSONIC FLOW FIELDS
G. R. INGER *In* AGARD Computation of Viscous-Inviscid Interactions 26 p (SEE N81-26037 17-01) Feb. 1981 refs
Avail: NTIS HC A22/MF A01

The features of an approximate nonasymptotic triple deck theory of shock turbulent boundary layer interaction that accurately describes nonseparating two dimensional flows over a wide range of practical Reynolds numbers are described and its application as an element in the overall viscous flow analysis of the body is demonstrated. Two main aspects of the problem are examined: (1) the local interactive thickening and skin friction drop in the shock foot region, including the effects of the incoming boundary layer shape factor, wall curvature, an improved viscous ramp model of the interaction and an approximate prediction of incipient separation behavior, and (2) the significant influence of such interaction on the subsequent downstream turbulent boundary layer thickening, profile shape and skin friction behavior. Comparisons with experimental data are given and applications presented for both supercritical airfoils and transonic bodies of revolution. R.C.T.

N81-26056# National Aerospace Lab., Amsterdam (Netherlands).
COMPUTATIONAL ASPECTS AND RESULTS OF LOW SPEED VISCOUS FLOW ABOUT MULTICOMPONENT AIRFOILS
B. OSKAM *In* AGARD Computation of Viscous-Inviscid Interactions 14 p (SEE N81-26037 17-01) Feb. 1981 refs
Avail: NTIS HC A22/MF A01

The viscous flow about multicomponent airfoils were calculated solving incompressible potential flow and boundary layer problems iteratively. The presence of the shear layers was modeled in the potential flow by an outlaw boundary condition on the airfoil surface and the wake centerline. Example solutions show that high accuracy of the potential flow solution is required to justify the correction for viscous effects, especially near the wing trailing edge of a slotted configuration. The phenomenon of leading edge stall was also investigated. Turbulent boundary layer separation at 3 per cent chord, downstream of a laminar separation bubble, was found on the nose of a NACA 63-009 airfoil at high Reynolds number indicating the occurrence of turbulent leading edge stall. This phenomenon, being difficult to distinguish from laminar edge (short bubble) stall, occured at such a small scale that it is observed only if one obtains high resolution results. The importance of the wing wake of a slotted configuration was also examined. The results agree reasonably well at moderate angles of attack. At higher angles of attack it was found that the wing wake streaming along the upper surface of the flap is subjected to a large adverse pressure gradient. The associated extreme growth of the displacement thickness of the wing wake was found to be the major item determining the loss of lift due to viscous effects. R.C.T.

N81-26057# Douglas Aircraft Co., Inc., Long Beach, Calif. Aerodynamics Research.
SEPARATION AND REATTACHMENT NEAR THE LEADING EDGE OF A THIN AIRFOIL AT INCIDENCE
T. CEBECI, K. STEWARTSON (University Coll., London), and P. G. WILLIAMS (University Coll., London) *In* AGARD Computation of Viscous-Inviscid Interactions 13 p (SEE N81-26037 17-01) Feb. 1981 refs
Avail: NTIS HC A22/MF A01

The leading edge separation which occurs on thin airfoils with increasing angles of attack was calculated. A general method was developed in order to solve the simplified problem of a parabola at incidence. The boundary layer equations were solved, in finite difference form, with the Mechul method to allow the determination of the external velocity distribution and a Hilbert integral to allow the modification of the external velocity distribution by the displacement thickness. The results indicate, that if the separation is laminar, reattachment occurs in a very limited range of the reduced angle of attack. With prescribed transition, and an algebraic

eddy viscosity formulation, the trend of the results are in line with experiment and help to confirm that the solution method is appropriate for application to real airfoil geometries. R.C.T.

N81-26058# Centre d'Etudes et de Recherches, Toulouse (France). Dept. d'Aerothermodynamique.
THE LAMINAR SEPARATION WITH TRANSITION BUBBLE [BULBE DE DECOLLEMENT LAMINAIRE AVEC TRANSITION: ESSAI DE PREVISION AVEC COUPLAGE LOCAL]
C. GLEYZES, J. COUSTEIX, and J. L. BONNET *In* AGARD Computation of Viscous-Inviscid Interactions 16 p (SEE N81-26037 17-01) Feb. 1981 refs
Avail: NTIS HC A22/MF A01

Experimental results of a study of a leading edge separation bubble on a peaky airfoil are presented. Boundary layer measurements, mean velocity, and longitudinal turbulence intensity were carried out for several values of Reynolds number (10 to the 5th power R sub c to 10 to the 6th power). The transition process in a long bubble was also studied. Two calculation methods for short bubble are proposed. Both use a simple local viscid-inviscid interaction scheme. These results are compared to experimental results. A.R.H.

N81-26059# Stanford Univ., Calif. Dept. of Mechanical Engineering.
THE 1980-81 AFOSR-HTTM-STANFORD CONFERENCE ON COMPLEX TURBULENT FLOWS: COMPARISON OF COMPUTATION AND EXPERIMENT
S. J. KLINE *In* AGARD Computation of Viscous-Inviscid Interactions 22 p (SEE N81-26037 17-01) Feb. 1981 refs (Contract F49620-80-C-0027)
Avail: NTIS HC A22/MF A01

The goals of the conference are described as: (1) to reach consensus in the research community on trustworthy data sets that can be used as input for modeling of turbulence in complex flows and as the basis for standard trials for checking output of computations; (2) the creation of a data library on magnetic tape; and (3) comparison of the output of current methods of computation for turbulent flows for a set of basic test cases covering a broad range of flows. A discussion of some current difficulties in turbulence research and fluids engineering and a description of the conference and how it plans to ameliorate some of the difficulties are included. E.D.K.

N81-26060# Ruhr Univ., Bochum (West Germany). Inst. fuer Thermo- und Fluiddynamik.
THEORETICAL AND EXPERIMENTAL INVESTIGATIONS OF TWO DIMENSIONAL FLOWS WITH SEPARATED REGIONS OF FINITE LENGTH
K. GERSTEN, H. HERWIG, and P. WAUSCHKUHN *In* AGARD Computation of Viscous-Inviscid Interactions 13 p (SEE N81-26037 17-01) Feb. 1981 refs
Avail: NTIS HC A22/MF A01

Theoretical and experimental investigations of two dimensional incompressible flows containing separated regions of fluid length were conducted. Separation of both laminar and turbulent boundary layers were considered. In the case of laminar separation it was assumed that the separated free shear layer remains laminar. The separation bubbles were originated by backward facing steps with sharp or rounded edges or by dents in a flat plate. The flow along a flat plate having a backward facing step with sharp or rounded edges was generalized to flows in channels with sudden enlargements or to flows in diffusors, respectively. In all cases considered the theoretical modelling of the flow fields has taken into account the strong mutual viscous inviscid interaction between outer flow and separated flow region. All flow problems considered depend essentially on two or more independent Reynolds numbers. E.D.K.

N81-26061# Sandia Labs., Livermore, Calif.
TWO DIMENSIONAL SEPARATED FLOW: EXPERIMENT AND DISCRETE VORTEX DYNAMICS SIMULATION
W. T. ASHURST, F. DURST (Karlsruhe Univ.), and C. TROPEA (Karlsruhe Univ.) *In* AGARD Computation of Viscous-Inviscid Interactions 13 p (SEE N81-26037 17-01) Feb. 1981 refs
Avail: NTIS HC A22/MF A01

A laser Doppler anemometer (LDA) was used to measure the time averaged flow properties and their fluctuations in an open water channel test section. Experimental results include the flow and normal direction velocities (mean and root mean square), Reynolds shear stress, and separated flow length. The variation of the reattachment location was also obtained as a function of Reynolds number and flow expansion ratio. Flow visualization was employed to gain further understanding of the flow structure. Numerical results obtained with a method known as discrete vortex dynamics are described. This method provides a Lagrangian description of fluid flow in which the distribution of vorticity is discretized and its time dependent motion is calculated. Thus, unsteady flow phenomena can be included within this time dependent computational method. E.D.K.

N81-26062# Royal Aircraft Establishment, Farnborough (England).
THE DEVELOPMENT AND APPLICATION OF A METHOD FOR CALCULATING THE VISCOUS FLOW ABOUT HIGH LIFT AEROFOILS
D. J. BUTTER (British Aerospace Aircraft Group, Stockport, England) and B. R. WILLIAMS *In* AGARD Computation of Viscous-Inviscid Interactions 20 p (SEE N81-26037 17-01) Feb. 1981 refs
Avail: NTIS HC A22/MF A01

Methods for calculating each region of the flow and which are combined by an iterative procedure were developed. This modular approach means that improved approximations in a particular region can be easily inserted into the system. The method was programmed so that the calculations can be made in a wind tunnel and prediction compare well with the measurement of two dimensional flow on high lift wings. Applications of this method permit the effective design of the leading edge slat, slat/wing cut profiles, wing upper surface shrouds, and trailing edge flaps. It can be further used in the design of a flap system to optimize the gap and overlap of the various elements and also their deflection angles. E.D.K.

N81-26063*# Texas A&M Univ., College Station. Dept. of Aerospace Engineering.
A DIRECT INVERSE TECHNIQUE FOR LOW SPEED HIGH LIFT AIRFOIL FLOWFIELD ANALYSIS
L. A. CARLSON *In* AGARD Computation of Viscous-Inviscid Interactions 10 p (SEE N81-26037 17-01) Feb. 1981 refs (Contract NSG-1174)
Avail: NTIS HC A22/MF A01

A direct inverse method is presented for computing the flow about low speed airfoils under high lift massive separation conditions. On the lower surface the flowfield is determined using an iterative inviscid relaxation technique coupled to a laminar turbulent momentum integral boundary layer scheme direct boundary conditions. On the upper surface, the flowfield is also computed directly with viscous interaction up to the separation point, with the separation point and separated pressure level determined as part of the solution. Downstream of separation, inverse boundary conditions are utilized; and the flowfield and displacement surface are calculated. Typical results and comparisons with experimental data for GA(W)-2 and NACA 4412 airfoils are presented, including pressure distributions, lift, and drag coefficients versus angle of attack. E.D.K.

N81-26064# Bari Univ. (Italy). 1st. di Machine.
A SECOND ORDER ACCURATE NUMERICAL METHOD FOR SUPERSONIC INTERACTING BOUNDARY LAYER FLOW PAST A COMPRESSION CORNER
B. FORTUNATO *In* AGARD Computation of Viscous-Inviscid Interactions 14 (SEE N81-26037 17-01) Feb. 1981 refs
Avail: NTIS HC A22/MF A01

The supersonic interacting boundary layer equations are solved for laminar flow past a configuration with an interior compression corner region. The approach employs conformal coordinates to map the body geometry into stagnation point flow and uses the boundary layer scale laws to identify the principal terms of the compressible counterpart of the Navier-Stokes equations. A Levy-Lees type transformation is used in these coordinates to simplify the governing equations. The viscous-inviscid interaction law is given by evaluating the small perturbation theory inviscid flow past the displacement body obtained as the sum of the body surface plus the viscous displacement thickness. A fictitious time dependent term is introduced in the governing equations, that are

then relaxed using an alternating direction implicit technique. The numerical scheme is second order accurate in both the longitudinal and normal directions. E.D.K.

N81-26065# Centre d'Etudes Aerodynamiques et Thermiques, Poitiers (France).
COMPUTATION OF THE SHOCK-WAVE BOUNDARY LAYER INTERACTION WITH FLOW SEPARATION
P. ARDONCEAU, T. ALZIARY (Poitiers Univ.), and D. AYMER *In* AGARD Computation of Viscous-Inviscid Interactions 16 p (SEE N81-26037 17-01) Feb. 1981 refs
Avail: NTIS HC A22/MF A01

A method to compute the shock wave-boundary layer interaction is presented. The boundary layer concept is used to describe the viscous flow near the wall and the outer inviscid flow is calculated by a pressure turning relation for simplicity. The boundary layer equations are solved in finite difference form and the question of the existence and unicity of the solution is examined for the direct or inverse problem. From the aforementioned analysis together with viscous-inviscid matching considerations a particular choice is made for the matching variable. An algorithm is presented to converge the matched solution which implicitely includes the downstream condition necessary to close the interacting boundary layer problem. The algorithm makes use of a Newton linearization technique which is shown to provide a fast convergence. E.D.K.

N81-26066# Bari Univ. (Italy). 1st di Machine.
TOWARD A SPLINE TECHNIQUE FOR THE HIGH REYNOLDS NUMBER INTERACTION (TRIPLE DECK) PROBLEM
M. NAPOLITANO and G. VACCA *In* AGARD Computation of Viscous-Inviscid Interactions 15 p (SEE N81-26037 17-01) Feb. 1981 refs
Avail: NTIS HC A22/MF A01

The numerical solution of the asymptotic triple deck equations for supersonic as well as subsonic flow conditions is considered. The need for higher order numerical accuracy is pointed out and the fundamental steps necessary for developing a high order numerical method for the triple deck equations are followed thru. A fourth order accurate spline Cauchy integral solver is presented and an interesting matrix singularity problem connected with such a problem is analyzed. The intrinsic instability of spline techniques, as applied to the time-like variable for the case of parabolic partial differential equations, is removed and a procedure particulary suitable partial differential equations, is removed and a stable procedure particularly suitable for the triple deck (or interacting boundary layer) equations is presented and verified for a simple model problem. The logical steps necessary for combining all the above into a fourth order accurate spline triple deck solver are indicated. E.D.K.

N81-26067# Royal Aircraft Establishment, Farnborough (England). Aerodynamic Dept.
A THEORY OF THE SEPARATED FLOW PAST A SLENDER ELLIPTIC CONE AT INCIDENCE
S. P. FIDDES *In* AGARD Computation of Viscous-Inviscid 14 p Interactions (SEE N81-26037 17-01) Feb. 1981 refs
Avail: NTIS HC A22/MF A01

A method was been developed for calculating the laterally symmetric separated flow past a slender elliptic cone at incidence, including the calculation of the position of the separtion line when the boundary layer is laminar. The method falls into two parts; a vortex sheet model for the outer inviscid separated flow and a triple-deck model of the viscous-invsicid interaction of this external flow with a laminar boundary layer on the cone. A uniformly valid representation of the vortex sheet is adopted, which represents a considerable advance on previous techniques for calculating vortex sheets using slender body theory. The method is capable of calculating the shape of the cortex sheet, its vorticity distribution, the pressure distribution over the cone, etc. for an elliptic cone of arbitrary cross sectional eccentricity at incidence with specified, symmetric, separation positions. E.D.K.

N81-26068*# Analytical Methods, Inc., Bellevue, Wash.
PREDICTION OF AERODYNAMIC CHARACTERISTICS FOR WINGS WITH EXTENSIVE SEPARATIONS
B. MASKEW, B. M. RAO, and F. A. DVORAK *In* AGARD Computation of Viscous-Inviscid Interactions 15 p (SEE N81-26037 17-01) Feb. 1981 refs
(Contract NAS2-8788; N00014-78-C-0128; DAAG29-76-C-0019; DAAJ02-75-C-0036)
Avail: NTIS HC A22/MF A01

The development of a simple yet effective technique for modelling the effects of trailing edge separation is discussed. The model encloses the low energy region with free vortex sheets coupled with a potential flow panel method. The technique includes an interation cycle between viscous and potential flow routines and its development from the two dimensional case to the three dimensional case is discussed. A description of the potential flow panel method, which is based on an internal Dirichlet boundary condition, is included. E.D.K.

N81-28048*# *Advisory Group for Aerospace Research and* Development, Neuilly-Sur-Seine (France). Technical Information Panel.
THE PRODUCTION OF THE AGARD MULTILINGUAL AERONAUTICAL DICTIONARY USING COMPUTER TECHNIQUES
V. A. WENTE (NASA, Washington, D.C.), J. C. KIRSCHBAUM (InterAmerica Research Associates, Rosslyn, Va.), and J. H. KUNEY (Informatics Information Systems Co., Rockville, Md.) Apr. 1981 43 p Previously announced as N80-30272
(NASA-TM-82344; AGARD-R-684; ISBN-92-835-1384-3; AD-A100703) Avail: NTIS HC A03/MF A01 CSCL 01B

The AGARD Multilingual Aeronautical Dictionary (MAD) contained 7,300 technical terms defined in English but also translated into nine other languages. The preparation work was performed by some 250 scientists and engineers who were members of AGARD and involved the translation skills of staff in many of the NATO nations. Nearly all the compilation and setting work for the book was done by computer and automatic photo-composition. The purpose of this publication is to record how the task was approached in terms of management planning. T.M.

N81-29065# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
SUBSYSTEM TESTING AND FLIGHT TEST INSTRUMENTATION
Apr. 1981 320 p refs Partly in ENGLISH and FRENCH Symp. held at Geilo, Norway, 27-30 Oct. 1980
(AGARD-CP-299; ISBN-92-835-0290-6; AD-A101016) Avail: NTIS HC A14/MF A01

Topics covered include: navigation/attack systems testing, aircraft systems testing, environmental testing, and instrumentation techniques. Special emphasis is placed on the ever increasing need for onboard systems integration. For individual titles, see N81-29066 through N81-29090.

N81-29066# Armament Development and Test Center, Eglin AFB, Fla.
TACTICAL NAVIGATION SYSTEM TESTING
D. M. CARLSON *In* AGARD Subsystem Testing and Flight Test Instr. 13 p (SEE N81-29065 20-01) Apr. 1981
Avail: NTIS HC A14/MF A01

Three systems, the AN/ARN-101 Digital Modular Avionics System, the AN/AVQ-26 Pave Tack, and the Stores Management System are described along with the instrumentation used. A discussion of the simulation and integration efforts in these programs is presented. T.M.

N81-29067# British Aerospace Aircraft Group, Woodford (England).
FLIGHT TESTING AND INSTRUMENTATION OF AIRCRAFT NAVIGATION SYSTEMS
M. J. TAYLOR *In* AGARD Subsystem Testing and Flight Test Instr. 17 p (SEE N81-29065 20-01) Apr. 1981 refs
Avail: NTIS HC A14/MF A01

Experience gained in developing navigation systems for the 'Nimrod' series of aircraft over the past thirteen years led to the derivation and establishment of test methods which meet the needs

of the job. An account of the way in which flight trials on Nimrod Mk.1, Mk.2 and Mk.3 aircraft were formulated to meet the different operational patterns expected in service is presented along with the various choices of navigation system modes and the constraints imposed by test facility and air traffic limitations. The instrumentation of the aircraft, its navigation system and the navigation reference system are covered, together with the data analysis methods used. The philosophy of flight trials is discussed as influenced by all the above factors. T.M.

N81-29068# Centre d'Essais en Vol, Bretigny-sur-Orge (France).
SYSTEMS INTEGRATION OF AUTOMATIC FLIGHT CONTROL, NAVIGATIONAL CALCULATIONS, AND VISUAL CONTROL (CARAVELLE ALIS) [ESSAI D'UN SYSTEME INTEGRE DE PILOTAGE, NAVIGATION ET VISUALISATION (CARAVELLE ALLIS)]
A. KLOPFSTEIN *In* AGARD Subsystem Testing and Flight Test Instr. 11 p (SEE N81-29065 20-01) Apr. 1981 refs In FRENCH
Avail: NTIS HC A14/MF A01

The complexity of aircraft equipment has made it necessary to utilize onboard systems integration. An experimental integration system was installed in a Caravelle aircraft. It assures the integration of information from the automatic flight command system, the visual information gathered by the pilot, and the navigation and guidance calculations. Transl. by T.M.

N81-29069# Vereinigte Flugtechnische Werke G.m.b.H., Bremen (West Germany).
ONBOARD AND GROUND TEST OF AN AUTONOMOUS NAVIGATION SYSTEM BASED ON TERRAIN CORRELATION
H. D. LERCHE *In* AGARD Subsystem Testing and Flight Test Instr. 11 p (SEE N81-29065 20-01) Apr. 1981
Avail: NTIS HC A14/MF A01

The progress in microprocessor technology and digital data processing has caused a trend towards high sophisticated avionic systems with decentralized system architecture. The experience gained in developing and testing of a navigation system based upon terrain correlation is discussed. A dedicated ground based data management system and special test methods were developed to perform flight tests. Typical flight experiments are discussed. T.M.

N81-29070# Dornier-Werke G.m.b.H., Oberpfaffenhofen (West Germany).
ALIGNMENT OF A NAVIGATION AND ATTACK SYSTEM FOR THE ALPHA JET AIRCRAFT [MISE AU POINT DU SYSTEME DE NAVIGATION ET D'ATTAQUE DE L'AVION ALPHA-JET]
J. LANG *In* AGARD Subsystem Testing and Flight Test Instr. 9 p (SEE N81-29065 20-01) Apr. 1981 In FRENCH
Avail: NTIS HC A14/MF A01

A description of a navigation and attack system is presented along with its aims and operational principles. Test equipment is discussed which assure the desired flexibility for the flight tests. The principle task of alignment as well as ground support operations are outlined. Transl. by T.M.

N81-29071# British Aerospace Aircraft Group, Preston (England).
AIR TO GROUND WEAPON AIMING ACCURACY MEASUREMENT TECHNIQUES
H. M. MALLEY and C. J. DEWHURST *In* AGARD Subsystem Testing and Flight Test Instr. 12 p (SEE N81-29065 20-01) Apr. 1981
Avail: NTIS HC A14/MF A01

The flight clearance program for a modern air to ground weapon aiming system demands that extensive flight trials are carried out to demonstrate that the performance of the system meets its specification requirements. With the increasing complexity of weapon aiming systems in terms of the multiplicity of ranging methods and attack modes provided, ways of minimizing the flight trials requirements have to be considered. Trials methods and associated analysis techniques which are currently used and are designed to maximize the data available while minimizing the number of flight trials carried out, are described. T.M.

N81-29072# National Aerospace Lab., Amsterdam (Netherlands).
DATA ACQUISITION AND ANALYSIS SYSTEM AS A TRAINING DEVICE FOR SIMULATED CONVENTIONAL WEAPON DELIVERY
C. F. G. M. HOFMAN and J. BATENBURG (Royal Netherlands Air Force) *In* AGARD Subsystem Testing and Flight Test Instr. 10 p (SEE N81-29065 20-01) Apr. 1981 refs
Avail: NTIS HC A14/MF A01

A system, called Delivery and Impact Analysis System (DIAS) was developed and tested. This system, based on a photogrametric method, yields release conditions, the nominal weapon impact position and the weapon time of flight. Simulated attacks on a great variety of realistic targets can be evaluated and validated as there is no need to drop training weapons. Furthermore no ground based instrumentation in the target area is needed. The system consisting of an airborne data acquisition system installed in the aircraft and a ground based processing and analysis system at the airbase allows a debriefing of the pilot within half an hour after completion of the mission. DOE

N81-29074# Royal Aircraft Establishment, Farnborough (England). Instrumentation and Trials Dept.
GUN HARMONISATION USING THE SECTOR ACOUSTIC MISS DISTANCE INDICATOR
T. W. CHUBB *In* AGARD Subsystem Testing and Flight Test Instr. 8 p (SEE N81-29065 20-01) Apr. 1981 refs
Avail: NTIS HC A14/MF A01

The operating principles of the indicator are described and the performance limitations which determine the accuracy in both range measurement and quadrant determination are indicated. The application to air-to-air gun harmonization trials using this target system is described. T.M.

N81-29075# Centre d'Essais en Vol, Istres (France).
THE COMPATIBILITY OF THE ENGINE WITH THE OTHER SYSTEMS OF THE AIRPLANE [COMPATIBILITY DU MOTEUR AVEC LES AUTRES SYSTEMES DE L'AVION]
J. CONCHE *In* AGARD Subsystem Testing and Flight Test Instr. 14 p (SEE N81-29065 20-01) Apr. 1981 In FRENCH
Avail: NTIS HC A14/MF A01

The complexity of modern aircraft performance demands a close relationship between the design of aircraft engines and the aircraft itself. Several aspects of this integration of designs are discussed and include: aerodynamic compatibility; flexibility of the engine; and integration of tests for the engine and aircraft.
Transl. by T.M.

N81-29076# Aeritalia S.p.A., Torino (Italy). Combat Aircraft Group.
FUEL SYSTEM TESTING AND TEST INSTRUMENTATION
R. AIMO *In* AGARD Subsystem Testing and Flight Test Instr. 19 p (SEE N81-29065 20-01) Apr. 1981
Avail: NTIS HC A14/MF A01

Several aspects related to fuel system design requirements for high performance aircraft are discussed. Major emphasis is placed on safety, quality assurance, and performance factors. R.C.T.

N81-29077# Boeing Military Airplane Development, Seattle, Wash. Advanced Airplane Branch.
ADVANCES IN LANDING GEAR SYSTEMS
N. S. ATTRI and R. L. AMBERG (Boeing Commercial Airplane Co., Seattle) *In* AGARD Subsystem Testing and Flight Test Instr. 20 p (SEE N81-29065 20-01) Apr. 1981
Avail: NTIS HC A14/MF A01

A status of the development for some of the hardware components of landing gear is provided. Methods of system evaluation are discussed as well as the problems associated with validating expected performance. The relationship between functional landing gear subsystem and hardware components is also illustrated. R.C.T.

N81-29078# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
RESEARCH ON THE FUNCTIONAL LIMITS OF A HELICOPTER ROTOR: SPEED AND LOAD FACTOR [RECHERCHE DES LIMITES DE FUNCTIONNEMENT D'UN ROTOR D'HELICOPTERE EN VITESSE ET FACTEUR DE CHARGE]
B. CERTAIN and J. M. BESSE *In its* Subsystem Testing and Flight Test Instr. 13 p (SEE N81-29065 20-01) Apr. 1981 In FRENCH
Avail: NTIS HC A14/MF A01

Methods of testing the rotor aerodynamics are discussed and include in-flight monitoring and ground tests. Strain gages were utilized in the in-flight monitoring. Wind tunnel tests offered simulation of various aerodynamic loads. Of special interest was aerodynamic stalling and flutter. The data processing techniques are discussed in detail. Transl. by T.M.

N81-29079# Aeroplane and Armament Experimental Establishment, Boscombe Down (England).
ELECTRO-MAGNETIC COMPATIBILITY: THE DETERMINATION OF SAFETY FOR CRITICAL SYSTEMS
G. M. SMITH *In* AGARD Subsystem Testing and Flight Test Instr. 6 p (SEE N81-29065 20-01) Apr. 1981 refs
Avail: NTIS HC A14/MF A01

The problems of certification of the fitness of military aircraft to enter service have increased significantly with the introduction of electronic equipments into areas of the aircraft which directly relate to primary flight safety. The effects of self generated interference as well as effects due to the external environment are considered. The establishment of adequate margins of safety for these systems requires changes to equipment test methods and procurement procedures. The problems are reviewed and alternative approaches described. R.C.T.

N81-29080# Test Wing (6510th), Edwards AFB, Calif.
RELIABILITY AND MAINTAINABILITY EVALUATION DURING INITIAL TESTING
J. M. HOWELL *In* AGARD Subsystem Testing and Flight Test Instr. p (SEE N81-29065 20-01) Apr. 1981 refs
Avail: NTIS HC A14/MF A01

The significance of extensive reliability and maintainability evaluations of modern weapon systems is considered. Particular emphasis is given to the ability of such evaluation to ensure the highest quality weapon system is delivered to the user within existing acquisition cost and schedule constraints. The methodology and information available from these evaluations are discussed. R.C.T.

N81-29081# McKinley Climatic Lab., Eglin AFB, Fla.
UNIQUE TEST CAPABILITIES OF THE EGLIN AFB MCKINLEY CLIMATIC LABORATORY
R. D. TOLIVER *In* AGARD Subsystem Testing and Flight Test Instr. 10 p (SEE N81-29065 20-01) Apr. 1981 refs
Avail: NTIS HC A14/MF A01

Reports of natural environmental tests were compared with reports of testing accomplished at the climatic laboratory. It was determined that chamber tests are highly preferable to field tests in terms of time, cost, convenience, and precision. However, chamber tests often do not predict long term effects of environmental exposure. Most problems of simulated testing disappear when tests were performed on full scale, production of preproduction hardware. R.C.T.

N81-29082# Westland Helicopters Ltd., Yeovil (England).
DEVELOPMENT FOR HELICOPTER FLIGHT IN ICING CONDITIONS
D. GIBBINGS *In* AGARD Subsystem Testing and Flight Test Instr. p (SEE N81-29065 20-01) Apr. 1981
Avail: NTIS HC A14/MF A01

The requirement for airframe, intake and rotor deicing systems and the instrumentation considered necessary for safe flight development are discussed. The problems involved in carrying out icing and snow flight development as part of a full prototype development program are considered and some of the favored icing simulation test methods are addressed. R.C.T.

N81-29083# Centre d'Essais en Vol, Bretigny-sur-Orge (France).
METHODS OF TESTING AIRCRAFT PERFORMANCE UNDER ICING CONDITIONS AND ICE TECTION SYSTEMS [METHODES D'ESSAI DU COMPORTEMENT DES AERONEFS EN CONDITIONS GGIVRANTES ET DES SYSTEMES DE PROTECTION CONTRE LE GAVRAGE]
M. FRIENDLANDER *In* AGARD Subsystem Testing and Flight Test Instr. 9 p (SEE N81-29065 20-01) Apr. 1981
Avail: NTIS HC A14/MF A01

The aerodynamic effects on flight control were reviewed. Parameters that influence ice formation are discussed and include: the temperature of turbulent air; the water tension in each droplet; and the aerodynamic speed. The advantages and disadvantages of ground tests that simulate icing conditions are summarized and compared to inflight testing. Focus is placed on ice prevention systems for aircraft, especially helicopters. Transl. by T.M.

N81-29084# Centre d'Essais en Vol, Bretigny-sur-Orge (France).
THE INTERFACE ARRANGEMENT OF DIGIBAS SYSTEMS [L'INERFACE MESURE DES SYSTEMES DIGIBUS]
C. RAT *In* AGARD Subsystem Testing and Flight Test Instr. 9 p (SEE N81-29065 20-01) Apr. 1981
Avail: NTIS HC A14/MF A01

The use of the digibus throughout the Mirage 2000 program is discussed, in particular the important role that it plays in the weapons system of that aircraft. In order to use the large operational capacities of the aircraft, an important integration effort was made at the navigation room level in an effort to get the best compromise in presenting system parameters and commands to the pilot. These include heads-up high visualizations adapted to each phase of flight, multiplexed controls, and synthetic presentations of tactical situations. The use of a numerical bus is absolutely necessary *in carrying* such a program to completion. Topics covered include avionics and the numerical bus; technical aspects of the digibus; and the programmable numerical bus-visualization relation. Transl. by A.R.H.

N81-29085# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick (West Germany). Inst. fuer Flugmechanik.
PROGRAMMABLE MULTIPURPOSE FLIGHT TEST INSTRUMENTATION SYSTEM
R. KARMANN *In* AGARD Subsystem Testing and Flight Test Instr. 13 p (SEE N81-29065 20-01) Apr. 1981 refs
Avail: NTIS HC A14/MF A01

As a result of the increased use of flight control and stability augmentation systems, higher frequency contents of the control loops together with an increased amount of information provided by additional sensors have placed several demands on the flight test instrumentation. In order to achieve a reasonable relationship between costs and benefits a computer controlled flight test instrumentation system was developed. Through the modular construction of this device a wide field of applications is achieved. E.D.K.

N81-29086# Veatch (Donald W.), Tehachapi, Calif.
RECENT TRENDS IN FLIGHT TEST SIGNAL CONDITIONING
D. W. VEATCH *In* AGARD Subsystem Testing and Flight Test Instr. 9 p (SEE N81-29065 20-01) Apr. 1981 refs
Avail: NTIS HC A14/MF A01

Radical changes are pervading the whole data acquisition process. These changes are so dramatic in many areas that the impact on signal conditioning is often not being properly evaluated. Some of the changes in techniques being brought about by this technology as well as some of the more interesting hardware developments for specific conditioning tasks are discussed. E.D.K.

01 AERONAUTICS (GENERAL)

N81-29087# Royal Aircraft Establishment, Farnborough (England).
AN INVESTIGATION OF THE LINEAR AND ANGULAR VIBRATION ENVIRONMENTS OF TRIALS AIRCRAFT
G. L. WRAY and D. J. FLYNN *In* AGARD Subsystem Testing and Flight Test Instr. 28 p (SEE N81-29065 20-01) Apr. 1981
Avail: NTIS HC A03/MF A01

An investigation of the dynamic environment of trials aircraft based on the measurement of linear acceleration and angular velocity along and about the three principal airframe axes is described. The results, expressed in the form of power and cross spectral densities, are used to set up an empirical mathematical model of the dynamic environment of an aircraft for use in computer simulations of a strapdown inertial navigator. The application of the model to the simulation of strapdown system alignment in a nominally stationary vehicle is discussed. E.D.K.

N81-29088# National Aerospace Lab., Amsterdam (Netherlands).
A METHOD FOR MEASURING TAKE-OFF AND LANDING PERFORMANCE OF AIRCRAFT, USING AN INERTIAL SENSING SYSTEM
A. POOL, J. L. SIMONS, G. J. H. WENSINK, and A. J. L. WILLEKENS *In* AGARD Subsystem Testing and Flight Test Instr. 7 p (SEE N81-29065 20-01) Apr. 1981 refs
Avail: NTIS HC A14/MF A01

The start and landing with an inertial system (STALINS) method for measuring takeoff and landing trajectories is described and results of flight tests made in 1978 to 1980 are discussed. The method meets the requirements to which it was designed and a few improvements in the hardware and software are being finalized. The method is expected to be ready for operational use in the course of 1981. E.D.K.

N81-29089# Boeing Co., Seattle, Wash.
MICROWAVE SYSTEM FOR REAL TIME SPACE POSITION MEASUREMENT
W. J. IRWIN *In* AGARD Subsystem Testing and Flight Test Instr. 7 p (SEE N81-29065 20-01) Apr. 1981
Avail: NTIS HC A14/MF A01

A microwave airplane position system (maps) for measuring the space position of a flight test airplane and time correlating this position with other varying test parameters is discussed. Operational range is normally within 10 km of the test range of runway. A number of microwave transmitter/receiver (T/R) units are located at surveyed coordinates in an optimum ground pattern. Airborne equipment includes an interrogator, digital processor, data storage units, pilot's guidance indicators, and a quick look engineering station. The airborne system interrogates each ground T/R in serial fashion and computes slant range and range rate from the response. The computer performs position calculations in real time using a high speed Kalman filtering algorithm. Data are tape recorded, displayed to test engineers, and used to drive panel instruments which allow the pilot to follow a specific flight profile. E.D.K.

N81-29090*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Center, Edwards, Calif.
PRACTICAL ASPECTS OF INSTRUMENTATION INSTALLATION IN SUPPORT OF SUBSYSTEM TESTING
R. W. BOREK *In* AGARD Subsystem Testing and Flight Test Instr. 16 p (SEE N81-29065 20-01) Apr. 1981 refs
Avail: NTIS HC A14/MF A01

Some of the problems associated with using military specification MIL-W-5088H as a guideline for wire gage selection are discussed. Examples of proper use of this specification as a criterion for interfacing wire bundles and connectors are provided. The quantitative results of 22 projects that have used the technique known as sneak analysis are reviewed and examples are given. E.D.K.

N81-31105# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
DYNAMIC STABILITY PARAMETERS
May 1981 389 p refs Lecture Series held at Moffett Field, Calif., 2-5 Mar. 1981 and Rhode-Saint-Genese, Belgium, 16-19 Mar. 1981; sponsored in part by the von Karman Inst. for Fluid Dynamics
(AGARD-LS-114; ISBN-92-835-1385-1; AD-A103764) Avail: NTIS HC A17/MF A01

The impact of high angle of attack aerodynamics on dynamic stability characteristics of aerospace vehicles is reviewed. Analytical, wind tunnel, and flight test techniques used are surveyed.

N81-31106*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
AERODYNAMIC MATHEMATICAL MODELING - BASIC CONCEPTS
M. TOBAK and L. B. SCHIFF *In* AGARD Dyn. Stability Parameters 31 p (SEE N81-31105 22-01) May 1981 refs
Avail: NTIS HC A17/MF A01

The mathematical modeling of the aerodynamic response of an aircraft to arbitrary maneuvers is reviewed. Bryan's original formulation, linear aerodynamic indicial functions, and superposition are considered. These concepts are extended into the nonlinear regime. The nonlinear generalization yields a form for the aerodynamic response that can be built up from the responses to a limited number of well defined characteristic motions, reproducible in principle either in wind tunnel experiments or flow field computations. A further generalization leads to a form accommodating the discontinuous and double valued behavior characteristics of hysteresis in the steady state aerodynamic response. J.D.H.

N81-31107*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
IMPACT OF HIGH-ALPHA AERODYNAMICS ON DYNAMIC STABILITY PARAMETERS OF AIRCRAFT AND MISSILES
G. N. MALCOLM *In* AGARD Dyn. Stability Parameters 18 p (SEE N81-31105 22-01) May 1981 refs
Avail: NTIS HC A17/MF A01 CSCL 01A

The aerodynamic phenomena associated with high angles of attack and their effects on the dynamic stability characteristics of airplane and missile configurations are examined. Information on dynamic effects is limited. Steady flow phenomena and their effects on the forces and moments are reviewed. The effects of asymmetric vortices and of vortex bursting on the dynamic response of flight vehicles are reviewed with respect to their influence on: (1) nonlinearity of aerodynamic coefficients with attitude, rates, and accelerations; (2) cross coupling between longitudinal and lateral directional models of motion; (3) time dependence and hysteresis effects; (4) configuration dependencey; and (5) mathematical modeling of the aerodynamics. Author

N81-31108# National Aeronautical Establishment, Ottawa (Ontario). Unsteady Aerodynamics Lab.
REVIEW OF TECHNIQUES FOR DETERMINATION OF DYNAMIC STABILITY PARAMETERS IN WIND TUNNELS
K. J. ORLIK-RUECKEMANN *In* AGARD Dyn. Stability Parameters 28 p (SEE N81-31105 22-01) May 1981 refs
Avail: NTIS HC A17/MF A01

The basic principles of various methods of wind tunnel testing and the practical aspects of various techniques are discussed and illustrated by examples, descriptions, and sketches of existing apparatuses. Methods of measuring dynamic derivatives are reviewed. The measurement of reactions and of motion, rotary and half model techniques, derivatives due to translational acceleration and pure rotation, free model techniques, and control surface oscillation techniques are considered. J.D.H.

N81-31109# National Aeronautical Establishment, Ottawa (Ontario). Unsteady Aerodynamics Lab.

DIRECT FORCED-OSCILLATION TECHNIQUES FOR THE DETERMINATION OF STABILITY DERIVATIVES IN WIND TUNNELS

E. S. HANFF *In* AGARD Dyn. Stability Parameters 23 p (SEE N81-31105 22-01) May 1981 refs

Avail: NTIS HC A17/MF A01

The current state-of-the-art in the field of stability parameters measurement in wind tunnels using the direct forced oscillation technique is discussed. The principles on which the technique is based, and some typical wind tunnel apparatuses and instrumentation systems are briefly described. A rather detailed description of the data reduction procedures used at NAE to obtain both direct as well as cross and cross-coupling derivatives is given. An advanced dynamic calibrator with which the validity of the experimental and analytical procedures can be independently verified is described. Author

N81-31110# Royal Aircraft Establishment, Bedford (England). Dept. of Aerodynamics.

WIND-TUNNEL MEASUREMENT OF AERODYNAMIC DERIVATIVES USING FLEXIBLE-STING RIGS

C. O. OLEARY *In* AGARD Dyn. Stability Parameters 15 p (SEE N81-31105 22-01) May 1981 refs

Avail: NTIS HC A17/MF A01

Forced oscillation, flexible sting rigs are used by several establishments for wind tunnel measurement of aerodynamic derivatives. This paper describes the two multi-degree of freedom rigs at RAE Bedford and DFVLR. Aircraft models are mounted on stings with built in flexures and oscillations are excited in 2 or 3 degrees of freedom. The response is measured using strain gauges on the sting flexures. Measurements of lateral or longitudinal derivatives can be made. Details are given of the apparatus, technique and method of analysis. Current modifications to the RAE rig actuating system are described and differences in the RAE and DFVLR rigs are discussed. Results are presented, from low speed high angle of attack tests on a combat aircraft model which were made with a new semicircular sting support facility which allows testing up to an angle of 90 deg. A comparison is made of the derivative data from wind tunnel tests, the corresponding data from flight tests and some theoretical estimates for two configurations: a jet trainer and a transport aircraft.

Author

N81-31111*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

ROTARY AND MAGNUS BALANCES

G. N. MALCOLM *In* AGARD Dyn. Stability Parameters 26 p (SEE N81-31105 22-01) May 1981 refs

Avail: NTIS HC A17/MF A01 CSCL 01A

Two wind tunnel techniques for determining part of the aerodynamic information required to describe the dynamic bahavior of various types of vehicles in flight are described. Force and moment measurements are determined with a rotary-balance apparatus in a coning motion and with a Magnus balance in a high-speed spinning motion. Coning motion is pertinent to both aircraft and missiles, and spinning is important for spin stabilized missiles. Basic principles of both techniques are described, and specific examples of each type of apparatus are presented. Typical experimental results are also discussed. Author

N81-31112*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

CURVED-FLOW, ROLLING-FLOW, AND OSCILLATORY PURE-YAWING WIND-TUNNEL TEST METHODS FOR DETERMINATION OF DYNAMIC STABILITY DERIVATIVES

J. R. CHAMBERS, S. B. GRAFTON, and F. H. LUTZE (Virginia Polytechnic Inst. and State Univ.) *In* AGARD Dyn. Stability Parameters 13 p (SEE N81-31105 22-01) May 1981 refs

Avail: NTIS HC A17/MF A01 CSCL 01A

The test capabilities of the Stability Wind Tunnel of the Virginia Polytechnic Institute and State University are described, and calibrations for curved and rolling flow techniques are given. Oscillatory snaking tests to determine pure yawing derivatives are considered. Representative aerodynamic data obtained for a current fighter configuration using the curved and rolling flow techniques are presented. The application of dynamic derivatives obtained in such tests to the analysis of airplane motions in general, and to high angle of attack flight conditions in particular, is discussed. J.D.H.

N81-31113# Lockheed Missiles and Space Co., Sunnyvale, Calif.

SUPPORT INTERFERENCE

L. E. ERICSSON *In* AGARD Dyn. Stability Parameters 26 p (SEE N81-31105 22-01) May 1981 refs

Avail: NTIS HC A17/MF A01

The existing information about support interference is reviewed, with particular emphasis on dynamic interference effects and the special problems encountered at high angles of attack. Support interference effects are much more severe in dynamic than in static tests. The support interference is aggravated by a boat-tail or dome shaped base, or even by modest base shoulder roundness. The general conclusion is that asymmetric stings or sting-strut combinations should be avoided. For slender bodies at low angles of attack a transverse rod comes close to permitting the true dynamically destabilizing effect of a bulbous base to be measured whereas even a very slender sting will distort the near wake effect and produce an unconservatively high measure of the dynamic stability. At intermediate and high angles of attack the sting support is superior to the other support methods. In many cases half-model testing provides the means of avoiding most of the support interference effects. In some cases, as for a short blunt body such as the Viking configuration, the best approach appears to be to allow sting plunging, using a very slender sting. J.D.H.

N81-31114# National Aeronautical Establishment, Ottawa (Ontario). Unsteady Aerodynamic Lab.

APPLICATIONS OF HALF-MODEL TECHNIQUE IN DYNAMIC STABILITY TESTING

E. S. HANFF *In* AGARD Dyn. Stability Parameters 11 p (SEE N81-31105 22-01) May 1981 refs

Avail: NTIS HC A17/MF A01

The applications of the half model technique to oscillatory wind tunnel experiments are considered. The practical advantages and disadvantages of using the half model technique for dynamic stability testing are briefly stated and compared with those of its full model counterpart. Examples are given of various wind-tunnel dynamic experiments for which the half model technique is particularly suitable. Descriptions of pitching, plunging and dynamic calibrating apparatuses are given as well as a brief review of the data analysis required for the determination of direct derivatives using the free and forced oscillation technique. Methods of obtaining cross derivatives in the longitudinal plane are also indicated. J.D.H.

N81-31115# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick (West Germany). Inst. fuer Flugmechanik.

DETERMINATION OF AIRCRAFT DYNAMIC STABILITY AND CONTROL PARAMETERS FROM FLIGHT TESTING

P. G. HAMEL *In* AGARD Dyn. Stability Parameters 42 p (SEE N81-31105 22-01) May 1981 refs

Avail: NTIS HC A17/MF A01

The present state of the art of aircraft parameter identification (PI) techniques from flight test data and appraisal of current methods developed and applied to various aircraft configurations and flight conditions are reviewed. Practical aspects and results of PI techniques are emphasized. This is especially relevant for data correlation and for increasing confidence in static and dynamic wind tunnel prediction techniques. Recent experience for fixed and rotary wing aircraft PI are presented as well as identification results for extreme flight regimes. Information on pilot in the loop and closed loop aspects of aircraft PI are given with special reference to the interrelationship between stability and controllability. The application potential and experience of PI methods for dynamic wind tunnel testing and requirements necessary for gaining more insight and confidence in using static and dynamic wind tunnel data for flight/ground testing corelation are discussed. E.A.K.

N81-31116*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
ESTIMATION OF DYNAMIC STABILITY PARAMETERS FROM DROP MODEL FLIGHT TESTS
J. R. CHAMBERS and K. W. ILIFF (NASA. Hugh L. Dryden Flight Research Center) *In* AGARD Dyn. Stability Parameters 13 p (SEE N81-31105 22-01) May 1981 refs
Avail: NTIS HC A17/MF A01 CSCL 01C

The overall remotely piloted drop model operation, descriptions, instrumentation, launch and recovery operations, piloting concept, and parameter identification methods are discussed. Static and dynamic stability derivatives were obtained for an angle attack range from -20 deg to 53 deg. It is indicated that the variations of the estimates with angle of attack are consistent for most of the static derivatives, and the effects of configuration modifications to the model were apparent in the static derivative estimates. E.A.K.

N81-31117# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (West Germany).
ANALYTICAL DETERMINATION OF DYNAMIC STABILITY PARAMETERS
C. P. SCHNEIDER *In* AGARD Dyn. Stability Parameters 40 p (SEE N81-31105 22-01) May 1981 refs
Avail: NTIS HC A17/MF A01

The design of modern missiles for military use is characterized by compromises between flight stability and high maneuverability is discussed. High maneuverability yet stable flight performance requires secure missile control at high angles of attack and yaw, with possibly rapid changes of these angles and of the roll angle, and with coupled motions. The aerodynamic derivatives needed for performance predictions result from complex solutions of nonlinear and unsteady or quasisteady relations. Derivatives of longitudinal stability are discussed. For subsonic flow conditions, the derivatives of the missile components, are investigated at high angles of attack. The scope of performances of modern missiles includes high angle of attack maneuverability in supersonic flight. A prediction method based on the theory of indicial functions is outlined for slender wings. Possibilities of obtaining the stability derivatives of bodies at high angle of attack in supersonic flight are discussed. The application of solution methods using finite elements or paneling is presented. E.A.K.

N81-31118# Lockheed Missiles and Space Co., Sunnyvale, Calif.
AEROELASTICITY, INCLUDING DYNAMIC EFFECTS OF SEPARATED FLOW
L. E. ERICSSON *In* AGARD Dyn. Stability Parameters 27 p (SEE N81-31105 22-01) May 1981 refs
Avail: NTIS HC A17/MF A01

Static experimental data used to define the unsteady aerodynamics of separated flow, and how these are used to define the dynamic structural response are described. The static aeroelastic response and the structural divergence, are determined by using experimental results directly. However, this is not the case regarding the dynamic response of the structure. By using the static experimental data in pseudostatic analysis theory, the aerodynamic damping of an elastic vehicle including the often dominating effects of separated flow can be computed. The method was applied to predict the aeroelastic characteristics of the Saturn-Apollo and space shuttle launch vehicles. E.A.K.

N81-31119# Royal Aircraft Establishment, Farnborough (England).
CONTROL DERIVATIVES
A. J. ROSS *In* AGARD Dyn. Stability Parameters 11 p (SEE N81-31105 22-01) May 1981 refs
Avail: NTIS HC A17/MF A01

Two groups of dynamic parameters associated with control surfaces are discussed. The first group consists of the hinge moments which determine the dynamic response of the control surface to the control demand. The second group consists of the control derivatives which influence the dynamic response of the aircraft. The dynamic stability parameters of the aircraft with control system are dependent on the control characteristics, and examples are given to illustrate both this dependence and the typical variations of control derivatives with angle of attack and Mach number. Selected results for conventional control surfaces (flaps, elevator, aileron and rudder) and for other controls of current interest (horizontal and vertical canards and vectored thrust) are included. E.A.K.

N81-31120# National Aeronautical Establishment, Ottawa (Ontario).
SENSITIVITY OF AIRCRAFT MOTION TO CROSS COUPLING AND ACCELERATION DERIVATIVES
K. J. ORLIK-RUECKEMANN *In* AGARD Dyn. Stability Parameters 13 p (SEE N81-31105 22-01) May 1981 refs
Avail: NTIS HC A17/MF A01

Modern military aircraft are often designed to maneuver at relatively high angles of attack and therefore are subjected to conditions where the flow becomes highly asymmetric. They are sometimes equipped with direct lift or direct sideforce controls and therefore able to perform translational as well as the traditional rotational maneuvers. Under such flight conditions and maneuvers, certain derivatives that are negligible under symmetric, low angle of attack flight conditions may become large enough to be significant. These include certain static and dynamic cross coupling derivatives and derivatives due to translational acceleration. Most derivatives usually display strong nonlinearities at high angles of attack. E.A.K.

N81-31121*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
SOME APPLICATIONS OF AERODYNAMIC FORMULATIONS TO PROBLEMS IN AIRCRAFT DYNAMICS
L. B. SCHIFF and M. TOBAK *In* AGARD Dyn. Stability Parameters 15 p (SEE N81-31105 22-01) May 1981 refs
Avail: NTIS HC A17/MF A01 CSCL 01C

Two applications of mathematical modeling to aerodynamic problems are cussed. The first application is an investigation of the capacity of a nonlinear aerodynamic mathematical model to describe the aerodynamic reactions on an airfoil with a deflecting flap in transonic flow. Flow field computational methods are used to evaluate the nonlinear, unsteady aerodynamic data in terms of characteristic motions called for by the model. Histories of unconstrained motions of the flap are generated from the flap equations of motion, with the aerodynamic reactions specified by the mathematical model. In the second application wing rock is investigated. The most recent model accommodates experimental results wing rock by admitting the existence of aerodynamic hysteresis in the variation of the steady state rolling moment coefficient with roll angle is described. E.A.K.

N81-31122*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
APPLICATIONS OF DYNAMIC STABILITY PARAMETERS TO PROBLEMS IN AIRCRAFT DYNAMICS
J. R. CHAMBERS, D. J. DICARLO, and J. L. JOHNSON, JR. *In* AGARD Dyn. Stability Parameters 12 p (SEE N81-31105 22-01) May 1981 refs
Avail: NTIS HC A17/MF A01 CSCL 01C

The application and analysis of dynamic stability parameters were examined. The effects of wing leading edge modifications on the stalling and spinning characteristics of a single engine general aviation research airplane are evaluated. It is illustrated how dynamic stability parameters measured in wind tunnel tests are used to predict the spin resistance of this class of aircraft, and that autorotation criteria are derived from the relationships which exist between static and dynamic aerodynamic characteristics. E.A.K.

N81-31123# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (West Germany).
APPLICATION TO MISSILE DYNAMICS
C. P. SCHNEIDER *In* AGARD Dyn. Stability Parameters 11 p (SEE N81-31105 22-01) May 1981 refs
Avail: NTIS HC A17/MF A01

The connection between aerodynamic modelling and the equations of motion is explained. Simple missile motions are chosen to explain steady and dynamic stability. The influence of steady and dynamic (quasisteady) derivatives is estimated. Examples for the simulation of complicated flight motions caused by nonlinear unsteady forces and moments are selected and shown in diagrams. E.A.K.

N81-33137# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
THE IMPACT OF MILITARY APPLICATIONS ON ROTORCRAFT AND V/STOL AIRCRAFT DESIGN
Jun. 1981 264 p refs In ENGLISH and FRENCH Conf. held at Paris, 6-9 Apr. 1981
(AGARD-CP-313; ISBN-92-835-0294-9; AD-A106288) Avail: NTIS HC A12/MF A01

The technological status of rotorcraft and V/STOL aircraft were reviewed in light of operational possibilities and needs. Topics include operational experiences, present status of technology, future trends, and military mission effectiveness.

N82-13048# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
THE IMPACT OF NEW GUIDANCE AND CONTROL SYSTEMS ON MILITARY AIRCRAFT COCKPIT DESIGN
Aug. 1981 217 p refs In ENGLISH; partly in FRENCH Symp. held in Bad-Cannstatt, West Germany, 5-8 May 1981
(AGARD-CP-312; ISBN-92-835-0297-3; AD-A107356) Avail: NTIS HC A10/MF A01

The requirements and technologies involved in control systems were reviewed. Topics incude; displays; controls/displays system integration; automated systems/man interface; and cockpit systems evaluation. Emphasis is placed on the design of a cockpit layout with controls and displays that maximize the overall aircraft capability while keeping the pilot's workload within bounds by the use of more automation of system management. For individual titles, see N82-13049 through N82-13064.

N82-13049# Textron Bell Helicopter, Fort Worth, Tex. Human Factors and Cockpit Arrangement Group.
HOW THE HELICOPTER COCKPIT DESIGNER USES DIGITAL AVIONICS
J. H. EMERY *In* AGARD The Impact of New Guidance and Control Systems on Mil. Aircraft Cockpit Design 13 p (SEE N82-13048 04-01) Aug. 1981 refs
Avail: NTIS HC A10/MF A01

An overview of the approaches to helicopter cockpit design made possilbe through the application of advanced multiplex technology to cockpit displays and controls is presented. This technology enables the pilot to have more information available while, at the same time, reducing his workload, and provides for substantially improved cockpit management. One of the major research programs through which this technology was tailored for military helicopters is ADAS (Army Digital Avionics System). This program is discussed, along with Bell helicopter cockpit designs.
T.M.

N82-13050# Smiths Industries Ltd., Bishops Cleeve (England). Aerospace and Defense Systems.
ELECTRONIC FLIGHT DECK DISPLAYS FOR MILITARY TRANSPORT AIRCRAFT
R. A. CHORLEY *In* AGARD The Impact of New Guidance and Control Systems on Mil. Aircraft Cockpit Design 12 p (SEE N82-13048 04-01) Aug. 1981 refs
Avail: NTIS HC A10/MF A01

These display systems offer operational and economic advantages which can be realized in military as well as in civil aircraft. In particular, the flexibility of the display formats which can be provided, and the ease with which the information content can be changed, enable all the information required for the control of a transport aircraft to be displayed on the main panel, and go a long way towards making operation by a two-man crew possible. In addition, the flexibility of an electronic display system makes it feasible to minimize the effect of failures witin the display system to an extent which is impossible in the case of conventional instruments. Full realization of this capability, which calls for careful selection of the system architecture to be employed, may lead to a significant in mission success. A discussion of CRT displays is presented. T.M.

N82-13051# Aeronautical Systems Div., Wright-Patterson AFB, Ohi.. Directorate of Avionics Engineering.
COLOR CRT DISPLAYS FOR THE COCKPIT
H. L. WARUSZEWSKI *In* AGARD The Impact of New Guidance and Control Systems on Mil. Aircraft Cockpit Design 22 p (SEE N82-13048 04-01) Aug. 1981 refs
Avail: NTIS HC A10/MF A01

Color displays are currently being proposed for installation or are being installed in civilian and military aircraft cockpits. The complexity of designing a good color display is much greater than that of a monochromatic display. The human factors data and cockpit requirements needed to develop color cockpit displays so that requirements for a usable display can be generated are discussed. The color display technology was evaluated with respect to satisfying the established human factors requirements. Test methodologies need to be developed to determine compliance of the color displays to the specification requirement. Finally, the need for displays to be integrated into the cockpit using total cockpit human factors criteria to maximize the possible workload reduction and safety of the aircraft is discussed. T.M.

N82-13052# Thomson-CSF, Paris (France).
HEAD UP DISPLAYS
C. MAUREAU *In* AGARD The Impact of New Guidance and Control Systems on Mil. Aircraft Cockpit Design 7 p (SEE N82-13048 04-01) Aug. 1981
Avail: NTIS HC A10/MF A01

The displays present information to pilots without depriving them of a simultaneous external view. This implies that head-up dispdisplays are collimated displays. The problems involved with collimation are discussed and the possibility of head-up providing pilots with directional information is considered. T.M.

N82-13053# Army Avionics Research and Development Activity, Fort Monmouth, N. J.
INTEGRATION OF CONTROLS AND DISPLAYS IN US ARMY HELICOPTER COCKPITS
J. A. DASARO and C. T. ELLIOTT *In* AGARD The Impacts of New Guidance and Control Systems on Mil. Aircraft Cockpit Design 19 p (SEE N82-13048 04-01) Aug. 1981 refs
Avail: NTIS HC A10/MF A01

Expanded missions such as anti-armor, night surveillance, and air-to-air, coupled with the survivability requirement of nap-of-the-Earth flight, dictate the approach to cockpit design. This approach must apply the latest technological innovations in the areas of controls, displays multiplexing, and microprocessors to unburden the pilot. Space, weight, and cost constraints placed on the cockpit system designers must also be satisfied. The U.S. Army completed a full scale engineering development program in the area of cockpit integration, and is currently involved in a more ambitious exploratory development effort. An overview of these efforts to integrate the helicopter cockpit, including results of similation experiments and operational flight tests, is presented.
T.M.

N82-13054# Collins Radio Co., Cedar Rapids, Iowa. Government Avionics Div.
A STANDARD CONTROL DISPLAY UNIT FOR MULTI-AIRCRAFT APPLICATION
R. L. SWANSON and C. R. SCOUGTON *In* AGARD The Impact of New Guidance and Control Systems on Mil. Aircraft Cockpit Design 10 p (SEE N82-13048 04-01) Aug. 1981
Avail: NTIS HC A10/MF A01

The need for standardization of military hardware is well documented both within the US DOD and NATO. Standardization issues revolve mainly around interoperability, logistics, and life-cycle cost advantages. The issue of standardization and its suitability in the design of aircraft control/display units (CDU) is addressed. Potential benefits, requirements, and remaining problems associated with standardization of avionics control displays are discussed. Included is a discussion of a CDU that is currently being produced which has many of the features considered essential to the ultimate standard CDU. T.M.

N82-13055# British Aerospace Aircraft Group, Preston (England). Military Aircraft Div.
DEVELOPMENT OF A MINIATURISED DIGITAL THRUST DEMAND UNIT
A. KAYE *In* AGARD The Impact of New Guidance and Control Systems on Mil. Aircraft Cockpit Design 10 p (SEE N82-13048 04-01) Aug. 1981
Avail: NTIS HC A10/MF A01

Present generation analogue units were analyzed in order to produce design for the line replaceable units (L.R.U.S.). The elimination of the motion conversion chain, linear to angular, angular to linear is shown to afford significant savings in weight and volume. Angular motion and compliant force throttles, while creating maximum space saving, are shown to be ergonomically inferior to a linear input. An explanation of the operating principles of the linear stepper motor chosen as the auto-pilot prime mover is given with both the inherent advantages and disadvantages used to good effect in the overall design. Digital position encoding completes the design of the prototype unit and the results to date of the testing of this unit are given with recommendations for the design of a production unit. T.M.

N82-13056# Crouzet Aerospace and Systems, Valence (France).
USING VOICE CONTROL ONBOARD COMBAT AIRCRAFT [UTILISATION DE LA COMMANDE VOCALE A BORD DES AERONEFS DE COMBAT]
J. R. COSTER and J. M. MELOCCO *In* AGARD The Impact of New Guidance and Control Systems on Mil. Aircraft Cockpits Design 5 p (SEE N82-13048 04-01) Aug. 1981 In FRENCH
Avail: NTIS HC A10/MF A01

The use of the voice would be a valuable tool in resolving problems associated with pilot workload, in reducing the surface of the flight instrument system and the complexity of the man machine interface in high performance combat aircraft. A program established at the Laboratory of information for Mechanics and Engineering Sciences validates in aircraft environments the methods of speech recognition and synthesis developed in research laboratories. It is merely a matter of the universal recognition, at the acoustic level of isolated words pronounced by a single speaker. The techniques used are described. These include laboratory experiments involving an aeronautical dialog in a noisy environment and experimentation with a simulator of a vocal dialog applied to an aircraft with modern weapons and to the study of human factors. Experimentation also takes place in a flight simulator. Transl. by A.R.H.

N82-13057# Smiths Industries Ltd., Bishops Cleeve (England). Aerospace and Defence Systems.
COMMAND-RESPONSE DATA TRANSMISION TO MECHANICAL SYSTEMS MANAGEMENT EFFECT ON THE CREW/SYSTEM INTERFACE
I. MOIR (British Aerospace Aircraft Group)03(British Aerospace Aircraft Group), C. MOXEY, and P. A. LANCASTER *In* AGARD The Impact of New Guidance and Control Systems on Mil. Aircraft Cockpit Design 12 p (SEE N82-13048 04-01) Aug. 1981
Avail: NTIS HC A10/MF A01

The availability of low cost, high reliability micro-electronic digital devices digital data transmission systems an attractive proposition for aircraft data handling systems. Apart from the advantages of accuracy and high data rates which digital devices offer, significant improvements in system performanoe, weight and reliability are possible. Initially the use of digital data system was confined to aircraft avionics systems embracing navigation, weapon aiming and flight control functions. More recently the application techniques extended to the centralized control of mechanical system management. A example of an engine failure and shut-down in flight is given to demonstrate the interactive nature of data handling between two data buses and the effects upon advanced cockpit displays. A.R.H.

N82-13058# Naval Air Development Center, Warminster, Pa.
THE INTELLIGENT USE OF INTELLIGENT SYSTEMS: PROBLEMS IN ENGINEERING MAN/MACHINE SYMBIOSIS
J. HOPSON, W. ZACHARY (Analytics, Inc., Willow Grove, Pa.), and N. LANE *In* AGARD The Impact of New Guidance and Control Systems on Mil. Aircraft Cockpit Design 16 p (SEE N82-13048 04-01) Aug. 1981 refs
Avail: NTIS HC A10/MF A01

A methodology to structure the process of designing 'intelligent systems' was generated in the course of several specific projects undertaken to develop such systems for a variety of airborne platforms. The general goals of these projects are to improve system performance by enhancng the effectiveness of information management within the total avionics systems. Results from the studies are summarized and the knowledge gained is related to a systematic design/evaluation approach. A.R.H.

N82-13059# Centre d'Etudes et de Recherches de Medecine Aerospatiale, Paris (France).
MONOCULAR VISION AND TACTICAL FLIGHT ON THE HELICOPTER [VISION MONOCULAIRE ET VOL TACTIQUE SUR HELICOPTERE]
J. P. PAPIN, J. P. MENU, and G. SANTUCCI *In* AGARD The Impact of New Guidance and Control Systems on Mil. Aircraft Cockpit Design 14 p (SEE N82-13048 04-01) Aug. 1981 refs In FRENCH
Avail: NTIS HC A10/MF A01

The direction of eye movement of 7 pilots and 3 navigators was recorded in 8 hour helicopter flight during flight with obstacle missions. Each subject performed the mission while having variable conditions of monocular or binocular vision, with normal visual field or with the field reduced from 60 deg to 40 deg. Analysis of visual behavior concentrated on localization of viewing in relation to the cockpit and the object looked at. The localizations were analyzed in terms of passage from one object to another or m one zone to another in terms of the number of stops in different localizations and in terms of the total duration or method of the stops. Results show that (1) for a given condition, the subjects reacted in a relatively similar manner; (2) behavior was modified according to condition of vision: the more the field was reduced, the more the pilot increased his field of exploration and looked closer to the apparatus and to the instruments; (3) during stationary flights the behavior modification became amplified; and (4) monocular vision is more degrading of behavior reduction of the visual field. Transl. by A.R.H.

N82-13060# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick (West Germany). Inst. fuer Flugfuehrung.
EXPERIMENTAL INVESTIGATION OF A HELMET MOUNTED SIGHT/DISPLAY FOR HELICOPTER
R. BEYER, E. DANNEBERG, E. KOHNEN, and H. STEIN *In* AGARD The Impact of New Guidance and Control Systems on Mil. Aircraft Cockpit Design 11 p (SEE N82-13048 04-01) Aug. 1981
Avail: NTIS HC A10/MF A01

A helmet mounted sight/display (HMS/D) combined with an infrared camera and electronic instrument displays was investigated as a guidance aid for the low level flight of helicopters at night. The static and dynamic accuracy of the tracking mechanism which aligns the lines of sight of both the pilot and the camera was determined by means of a target and motion simulator. System performance was checked with a Bo 105 helicopter in low level flight at night. From the results obtained the importance of the HMS/D as an guidance aid becomes evident relative to other night vision/display systems. Author

N82-13061# Royal Aircraft Establishment, Farnborough (England). Flight Systems Dept.
USE OF A HELMET-MOUNTED MATRIX DISPLAY FOR PRESENTING ENERGY-MANEUVERABILITY INFORMATION DURING SIMULATED CLOSE COMBAT
D. N. JARRETT *In* AGARD The Impact of New Guidance and Control Systems on Mil. Aircraft Cockpit Design 10 p (SEE N82-13048 04-01) Aug. 1981 refs
Avail: NTIS HC A10/MF A01

Since continuous visual contact display (HMMD) with the enemy is essential in close combat the provision of this information on a

helmet-mounted diplay (HMMD) may be particularly useful. However, the (in) visibility of the image against a bright sky background, the increased helmet weight and other inconveniencing counter effects when coupled with the high attentional and physical demands of combat, may obviate any advantages of controlling the aircraft using the extra information. A series of exercises was set up to assess the HMMD in this application. The device was the subject of a flight trial in a light jet aircraft, and two studies were completed in the newly-commissioned RAE air combat simulator. These studies enabled pilots to become familiar with the device and the unusual display format, in order to assess their combined usefulness in a combat context. A.R.H.

N82-13062# Naval Air Test Center, Patuxent River, Md.
EVALUATION OF A PILOT WORKLOAD ASSESSMENT DEVICE TO TEST ALTERNATE DISPLAY FORMATS AND CONTROL HANDLING QUALITIES
S. G. SCHIFLETT, P. M. LINTON (Naval Air Development Center, Warminster, Pa.), and R. J. SPICUZZA (Systems Research Labs., Inc., Dayton, Ohio) *In* AGARD The Impact of New Guidance and Control Systems on Mil. Aircraft Cockpit Design 12 p (SEE N82-13048 04-01) Aug. 1981 refs
Avail: NTIS HC A10/MF A01

The utility of a workload assessment device to measure pilot workload for approach and landing formats and control stability variations was tested in in a modified NT-33 research aircraft. The feasibility of using an item-recognition task as a measure of sensory-response loading and reserve information processing capacity while flying precision approaches was established. Statistical treatment of the data indicates an appreciable increase in reaction time and errors with degraded handling qualities as compared to ground baseline measures and good handling qualities. The preliminary findings also reveal consistent trends toward the availability of more mental reserve capacity when flying predominantly pictorial/symbolic HUD configurations as compared to conventional HUD formats with scales and alphanumerics. A.R.H.

N82-13063# Air Force Wright Aeronautical Labs., Wright-Patterson AFB, Ohio.
TANKER AVIONICS AND AIRCREW COMPLEMENT EVALUATION
R. W. MOSS and G. J. BARBATO (Bunker-Ramo Corp., Dayton, Ohio) *In* AGARD The Impact of New Guidance and Control Systems on Mil. Aircraft Cockpit Design 18 p (SEE N82-13048 04-01) Aug. 1981 refs
Avail: NTIS HC A10/MF A01

A four phase effort addressing the control and display design issues associated with operating the SAC'S KC-135 tanker without the navigator crew position is discussed. Topics covered include the mission analysis phase during which the tanker's operational responsibilities were defined and documented; the design phase durng which alternative crew station design concepts were developed; the mockup evaluation phase which accomplished initial SAC crewmember assessment of cockpit designs; and the simulation phase which validated the usability of the crew system redesign. A recommended crew station configuration is examined and some of the philosophy underlying the selection of cockpit hardware and systems is discussed. A.R.H.

N82-13064# McDonnell Aircraft Co., St. Louis, Mo.
F/A 18 HORNET CREW STATION
E. C. ADAM *In* AGARD The Impact of New Guidance and Control Systems on Mil. Aircraft Cockpit Design 6 p (SEE N82-13048 04-01) Aug. 1981
Avail: NTIS HC A10/MF A01

The Hornet crew station design requirement was to essentially provide the capability contained in both the F-4 and A-7 weapon systems so as to perform both the fighter attack roles, make it operable by one pilot, and increase mission reliability by a combination of improved hardware reliability and functional redundancy. To put this requirement in perspective, the F/A-18 cockpit has 40% less usable area than any of its contemporaries. This area constraint necessitated extensive integration of the weapon system controls and displays. The resultant crew station features four miltipurpose cathoderay displays driven by two mission computers, an integrated upfront control panel, and numerous automatic functions on the stick and throttle. The rationale leading up to the configuration is described and a few examples of the one-man-operability features of the Hornet and how they would used by the pilot are presented. A.R.H.

N82-13065# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
AERODYNAMICS OF POWER PLANT INSTALLATION
Sep. 1981 510 p refs In ENGLISH and FRENCH Proc. of conf. held in Toulouse, 11-14 May 1981
(AGARD-CP-301; ISBN-92-835-0301-5; AD-A108300) Avail: NTIS HC A22/MF A01

The aerodynamic problems in power plant installation are surveyed and computational and design methodologies are presented. Combat aircraft intakes, afterbodies and nozzles, testing and analysis techniques, and installation aerodynamics of transport aircraft are addressed. For individual titles, see N82-13066 through N82-13098.

N82-13066# Air Force Wright Aeronautical Labs., Wright-Patterson AFB, Ohio.
PERFORMANCE OF HIGHLY INTEGRATED INLETS FOR SUPERSONIC AIRCRAFT
L. SURBER, J. SYBERG, and J. KONCSEK *In* AGARD Aerodyn. of Power Plant Installation 12 p (SEE N82-13065 04-01) Sep. 1981 refs Prepared in cooperation with Boeing Military Airplane Co., Seattle
Avail: NTIS HC A22/MF A01

Performance data obtained on several subsonic diffusers applicable to advanced supersonic tactical aircraft configurations were used to select a forebody-inlet model for proof-of-concept wind tunnel performance evaluation. Three of the diffusers were designed for high aspect ratio inlets having throat aspect ratios greater than seven. A fourth design incorporated a low aspect ratio inlet. Two of the high aspect ratio diffusers and the low aspect ratio diffuser incorporated duct bends typical of inlets substantially offset from the engine centerline. Preliminary tests of the high aspect of ratio diffuser produced high total pressure recovery coupled with relatively low flow distortion. Furthermore, the use of longitudinal vanes in one high aspect ratio diffuser provided reductions in engine face flow distortion with very little performance degradation. Proof-of-concept tests further investigated the performance of a high aspect ratio, side-mounted external compression supersonic inlet. Tests were performed in a 16-foot supersonic propulsion wind tunnel at Mach numbers of 1.6 to 2.2 over a -5 to 12 deg angle of attack range and sideslip angles from -8 to +8 deg. The results of these tests support the use of high aspect ratio inlets with sharp duct bends as a viable design option in future supersonic aircraft designs. M.G.

N82-13067*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
TOP-MOUNTED INLET SYSTEM FEASIBILITY FOR TRANSONIC-SUBSONIC FIGHTER AIRCRAFT APPLICATIONS
T. L. WILLIAMS, B. L. HUNT, D. B. SMELTZER, and W. P. NELMS *In* AGARD Aerodyn. of Power Plant Installation 17 p (SEE N82-13065 04-01) Sep. 1981 refs Prepared in cooperation with Northrop Corp., Hawthorne, Calif.
Avail: NTIS HC A22/MF A01 CSCL 01A

To inlet flow field and engine inlet performance data for an advanced fighter aircraft configuration were obtained over the Mach 0.6 to 2.0 range. The studies not only provided extensive data for the baseline arrangement, but also evaluated the effects of key aircraft configuration variables (inlet location, canopy-dorsal integration, wing leading-edge extension planform area, and variable incidence canards) on top inlet performance. In order to set these data in the context of practical aircraft systems top inlet performance is compared with that of more conventional inlet/airframe integrations. The results of these evaluations show that, for the top inlet configuration tested, relatively good inlet performance and compatibility characteristics are maintained during subsonic and transonic maneuver. However, at supersonic speeds, flow expansion over the forebody and wings causes an increase in local inlet Mach number subsequently reduces inlet performance levels. These characteristics infer that although top inlets many not pose a viable design option for aircraft requiring a high degree of supersonic maneuverability, they have distinct promise for

vehicles with subsonic and transonic maneuver capabilities.
M.G.

N82-13068# Royal Aircraft Establishment, Bedford (England). Aerodynamics Dept.
SOME RAE RESEARCH ON SHIELDED AND UNSHIELDED FUSELAGE MOUNTED AIR INTAKES AT SUBSONIC AND SUPERSONIC SPEEDS
J. A. ROSS, I. MCGREGOR, and A. J. PRIEST *In* AGARD Aerodyn. of Power Plant Installation 16 p (SEE N82-13065 04-01) Sep. 1981 refs
Avail: NTIS HC A22/MF A01

The incidence performance of fuselage-mounted intakes at subsonic and supersonic speeds is examined. The effects of simple changes in intake geometry, such as increasing contraction ratio and altering lower lip shape, are first considered; it is shown that such modifications can be beneficial at subsonic speeds, but drag penalties tend to limit their use at higher Mach numbers. Two intake locations that potentially offer a good degree of incidence shielding - underfuselage and understrake - are then examined. It is concluded that satisfactory performance can be obtained with an understrake installation, but a detailed study of strake shape, slots, splitter plates and boundary layer diverters must be made if the combinaion is to be successful over the whole of the intended flight envelope. However, for the configurations tested, the underfuselage location offers generally better intake performance lower technical risk. Finally, some results for a side-mounted staggered lip intake are presented, together with some two dimensional calculations of the mutual interference effects that occur between the upper and lower lips. It is suggested that an intake of this type can be competitive with an underfuselage installation. M.G.

N82-13069# National Gas Turbine Establishment, Pyestock (England).
PREDICTION AND MEASUREMENT OF TIME-VARIANT, THREE-DIMENSIONAL FLOWS IN MILITARY AIRCRAFT INTAKES
D. E. COLBOURNE and J. E. FLITCROFT *In* AGARD Aerodyn. of Power Plant Installation 18 p (SEE N82-13065 04-01) Sep. 1981 refs
Avail: NTIS HC A22/MF A01

The development of a computational method suitable for predicting the three dimensional flows within the diffuser sections of aircraft intakes is described. A fast method for automatic grid generation, application to ducts of any smoothly varying cross-sectional shape, is discussed. The development of a finite-volume, time-marching method for solving the flow equations is also described. The validity of the chosen techniques is discussed in the light of comparisons with analytical and empirical results. Empirical techniques were developed to examine flows in which viscous or time variant effects are dominant. A rotating yaw meter rake was developed to undertake detailed flow surveys at the exit of model diffusers, and results may be obtained from tests both in isolation and in the presence of a compressor. The development of instrumentation and data processing facilities for measuring instantaneous engine face total pressure distortion in small scale models is also described, together with the validation of this technique by comparison with results from a full-size replica of the intake tested under free-jet conditions. M.G.

N82-13070# British Aerospace Aircraft Group, Bristol (England).
EFFECTS OF INTAKE GEOMETRY ON CIRCULAR PITOT INTAKE PERFORMANCE AT ZERO AND LOW FORWARD SPEEDS
A. C. WILLMER, T. W. BROWN, and E. L. GOLDSMITH (RAE, Bedford, England) *In* AGARD Aerodyn. of Power Plant Installation 16 p (SEE N82-13065 04-01) Sep. 1981 refs Sponsored in part by Ministry of Defence
Avail: NTIS HC A22/MF A01

A series of experiments on circular cross-section pitot intakes at Mach numbers from 0 to 0.21 and angles of incidence and sideslip from 0 to 40 deg are presented. Measurements were made at the engine face of 72 pitot pressures, 4 unsteady pitot pressures, swirl angle at six positions, and boundary layer profiles at four positions. Static pressure distribution around the cowl lips and along the diffusers were also measured. Five cowl lips covering a range of contraction ratios and lip shapes were tested with both a straight and an S bend diffuser. The effect of inserting parallel section spacers between the cowl lip and the front of the subsonic diffuser and between the end of the subsonic diffuser and the engine face instrumentation and the effect of a thin lip slot upstream of the intake throat were evaluated. Results indicate that, lip losses may be decreased by increasing contraction ratio, fitting a lip slot or a forward spacer. Steady state flow distortion at the engine face is decreased by increasing lip contraction ratio or by fitting an aft extension. For the S duct tested, distortion levels are set by the diffuser as much as by incidence. Sideslip, however, lessens the distortions. M.G.

N82-13071# Institut de Mecanique des Fluides de Lille (France).
TRANSONIC FLOWS IN AN AIR INLET WITH LARGE INCIDENCE AND THE EFFECT OF A BLOWING TRAP [ECOULEMENTS TRANSSONIQUES DANS UNE PRISE D'AIR EN GRANDE INCIDENCE AT EFFET DE TRAPPE DE SOUFFLAGE]
A. DYMENT, P. GRYSON, and J. P. FLODROPS *In* AGARD Aerodyn. of Power Plant Installation 13 p (SEE N82-13065 04-01) Sep. 1981 refs In FRENCH
Avail: NTIS HC A22/MF A01

Flow in a bidimensional air intake with large incidence was studied under conditions in which the upstream flow was subsonic and the internal flow could be regulated. The phenomena following flow separation were examined, especially the homogenization of the internal flow. A device for improving mogenization which involves a natural deflection accomplished by a scoop designed to guide the captivated air was tested. The universal aspect of internal flow was studied using probes in different sections. The unsteady phenomena were analyzed from ultra high speed visualizations and the mean flow was characterized from classic visualization. The insertion of the deflector appreciably improved the performance of the air intake. The coefficient of output (sigma) and the total mean pressure (P sub tm) were considerably improved at the level of the compressor. While the use of the scoop to guide the air towards the slot had only a weak influence on sigma and P sub tm at the compressor level, it brought an appreciable gain in the speed of homogenization of the internal flow.
Transl. by A.R.H.

N82-13072# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (West Germany). Theoretical Aerodynamics Dept.
CALCULATION OF TRANSONIC AIR-INTAKES USING A COMPUTER PACKAGE FOR INVISCID AND BOUNDARY LAYER FLOWS
C. W. LUCCHI *In* AGARD Aerodyn. of Power Plant Installation 4 p (SEE N82-13065 04-01) Sep. 1981 refs
Avail: NTIS HC A22/MF A01

A finite-element method was developed to solve the full potential equation for transonic flows in a two dimensional engine intake. Since the full potential equation is expressed in the psi-formulation, a successive line over-relaxation algorithm was developed to solve the system of non-linear algebraic equations. Stability in the supersonic domain was obtained using Hafez's artificial compressibility method. Herring-Mellor's finite-difference code was incorporated to compute two dimensional compressible laminar-turbulent boundary layers. A fixed transition or Dunham's transition criterion may be chosen. The inviscid method was tested on a few single profiles, such cases having been computed exhibiting difficulties expected to occur in the calculation of two-dimensional intakes; high leading-edge suction peaks and strong shocks. Computations carried out on a two dimensional Tornado-like air-intake are discussed. A.R.H.

N82-13073# Aeritalia S.p.A., Torino (Italy). Combat Aircraft Group.
SUBSONIC MILITARY AIRCRAFT ENGINE INTAKE: AN INTEGRATED THEORETICAL EXPERIMENT DESIGN
G. BERTOLONE and L. FORNASIER *In* AGARD Aerodyn. of Power Plant Installation 17 p (SEE N82-13065 04-01) Sep. 1981 refs
Avail: NTIS HC A22/MF A01

Two numerical codes were developed for the simulation of the engine intake-induced flow field in two dimensional transonic and three dimensional subsonic cases. Both codes were obtained by modification of existing codes suitable for the computation of the

exterior flow past airfoils (by a finite element method) and about three dimensional arbitrary configurations (by a panel method). Computed results and comparison with experimental data pertinent to the analysis of a single bifurcated intake proved usefulness of the present numerical schemes for engineering applications. Engine face auxiliary doors design and side intakes diverter shape optimization was studied. Following an extensive testing program performed on a static model, the engine face auxiliary doors with annular air admission into the primary long type duct appeared to be a good alternative to the classical solution placed at the main inlet entry. Diverter geometry influence both on aerodynamics, in terms of drag coefficient, and intake performance, in terms of distortion coefficient, was investigated by testing a low speed model. R.J.F.

N82-13074# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (West Germany). Unternehmensbereich Flugzeuge.

THE DESIGN AND DEVELOPMENT OF THE TORNADO ENGINE AIR INTAKE

C. P. STOCKS (British Aerospace, Warton, England) and N. C. BISSINGER *In* AGARD Aerodyn. of Power Plant Installation 21 p (SEE N82-13065 04-01) Sep. 1981 refs

Avail: NTIS HC A22/MF A01

The design and development of the Tornado aircraft supersonic intake is described. Critical aerodynamic design areas are outlined with special emphasis on compatibility. The intakes were designed to satisfy the conflicting requirements of greater than Mach 2 operation and a very wide incidence operating envelope at subsonic speeds. The problem of design loads is reviewed as well as the theory and operation of the automatic control system. Propulsion system behavior in flight and some examples of intake-airframe interaction are described. R.J.F.

N82-13075# Air Force Wright Aeronautical Labs., Wright-Patterson AFB, Ohio.

INTEGRATION OF ADVANCED EXHAUST NOZZLES

D. L. BOWERS and J. A. LAUGHREY *In* AGARD Aerodyn. of Power Plant Installation 14 p (SEE N82-13065 04-01) Sep. 1981 refs

Avail: NTIS HC A22/MF A01

Attributes of both axisymmetric and nonaxisymmetric advanced nozzles and their incorporation into an aircraft to improve cruise performance, maneuverability and short takeoff and landing operation are discussed. It was concluded that when used as a trimming device, advanced exhaust nozzles with thrust vectoring can provide significant aircraft cruise drag reduction. The aftbody/nozzle installation for advanced airframes and exhaust nozzles must be approached very carefully to demonstrate an installed drag benefit. For maneuver, advanced thrust vectoring exhaust nozzles show advantages at high angle of attack. Improved turn rate and instantaneous maneuver performance can be provided by utilizing these advanced exhaust nozzles in advanced aircraft. For short takeoff and landing aircraft advanced exhaust nozzles with both thrust vectoring and thrust reversing may be necessary. Thrust vectoring up to 60 degrees (or higher) and a propulsive lift control system may be required. R.J.F.

N82-13076# Rolls-Royce Ltd., Bristol (England). Installation Aerodynamics Group.

THE SUBSONIC PERFORMANCE OF PRACTICAL MILITARY VARIABLE AREA CONVERGENT NOZZLES

L. R. HARPER IN AGARD Aerodyn. of Power Plant Installation 11 p (SEE N82-13065 04-01) Sep. 1981 refs

Avail: NTIS HC A22/MF A01

Performance considerations involved in the selection of a variable area nozzle for reheated engines for combat aircraft are discussed. The main emphasis is on dry operation at subsonic speeds since drag, weight, leakage and other penalties in this regime can prevent an aircraft attaining its design radius of action. Zero-base nozzles are compared with a moving shroud nozzle which has a substantial annular base area in dry setting. The moving shroud nozzle, as used on the RB199 engine in the Tornado MRCA, is very competitive with zero base nozzles in terms of overall performance. It is light, mechanically simple, reliable, and its short length permits a target type thrust reverser to be used. It is concluded that this type of nozzle is the optimum choice for combat aircraft until further technology advances permit substantial improvements in the overall performace of the more sophisticated nozzles. R.J.F.

N82-13077# Motoren- und Turbinen-Union Muenchen G.m.b.H. (West Germany).

COMPARISON OF DIFFERENT NOZZLE CONCEPTS FOR A REHEATED TURBOFAN

H. GRIEB, R. VEDOVA, H. ENDERLE, and H. NAGEL *In* AGARD Aerodyn. of Power Plant Installation 15 p (SEE N82-13065 04-01) Sep. 1981 refs Sponsored in part by German Ministry of Defence

Avail: NTIS HC A22/MF A01

Several concepts of convergent and convergent/divergent nozzles are investigated and compared in view of performance, weight, complexity and the influence on afterbody drag of combat aircraft. The influence of different nozzle cooling concepts on thrust, with subsequent cooling air requirements, is investigated. The optimum ratio of exit area/throat area of convergent/divergent nozzles dependent on nozzle concept and nozzle pressure ratio is identified. The performance comparison shows that fully variable convergent/divergent nozzles promise some advantages against the simple convergent nozzle at high nozzle pressure ratios. However, the higher weight and complexity of convergent/divergent nozzles lead to the conclusion that the choice of convergent/divergent nozzles for reheated turbofan engines in combat aircraft is not generally justified. J.D.H.

N82-13078# Air Force Wright Aeronautical Labs., Wright-Patterson AFB, Ohio. Aero Propulsion Lab.

ADVANCED EXHAUST NOZZLE TECHNOLOGY

R. J. GLIDEWELL and R. E. WARBURTON (Pratt and Whitney Aircraft Group, West Palm Beach, Fla.) *In* AGARD Aerodyn. of Power Plant Installation 11 p (SEE N82-13065 04-01) Sep. 1981 refs

Avail: NTIS HC A22/MF A01

Turbine engine exhaust nozzle technology, including nonaxisymmetric nozzles, thrust reversing, and thrust vectoring was investigated. Trade studies to determine the impact of these developments on the thrust-to-weight ratio and specific fuel consumption of an advanced high performance, augmented turbofan engine are reported. Results are presented in a manner which provides a understanding of the sources and magnitudes of differences in the basic elements of nozzle internal performance and weight as they relate to conventional axisymmetric nozzle technology. These comparisons are presented for three categories of nozzle functional capability: jet area and exit area control, thrust reversing, and thrust vectoring. J.D.H.

N82-13079# Air Force Wright Aeronautical Labs., Wright-Patterson AFB, Ohio.

A NUMERICAL INVESTIGATION OF EXHAUST PLUME TEMPERATURE EFFECTS ON NONAXISYMMETRIC NOZZLE/AFTERBODY PERFORMANCE

K. M. PEERY (Boeing Military Airplane Co., Seattle) and D. L. RUSSELL *In* AGARD Aerodyn. of Power Plant Installation 11 p (SEE N82-13065 04-01) Sep. 1981 refs

(Contract F33615-79-C-3018)

Avail: NTIS HC A22/MF A01

A two dimensional Navier-Stokes flow analysis procedure is used to simulate the single expansion ramp nozzle (SERN) flow field in an attempt to understand the effect of exhaust total temperature on the nozzle flow field. Steady state solutions were obtained using an explicit time-dependent method utilizing efficiency-improvin techniques such as body-fitted mesh, coupled computational regions, wall functions, automatic alignment of mesh with mixing layers, and vectorized execution on a CRAY I computer. The temperature-dependent specific heat capacities and the effect of exhaust total temperature on the nozzle flow characteristics. A normal shock on the expansion ramp was evident in the SERN experimental data that was not predicted with the 2-D analysis. This shock was present whether the exhaust total temperature was hot or cold and its position was dependent on the total temperature. The capabilities and some of the problems of applying Navier-Stokes flow analysis procedure to computing viscous nozzle flows are demonstrated. The importance of measuring upstream conditions in flow experiments is emphasized if the data is to be utilized for explanation of flow variations which occur or for flow analysis validation. J.C.H.

N82-13080# Aircraft Research Association Ltd., Bedford (England).
A REVIEW OF THE EFFECT OF REYNOLDS NUMBER ON AFTERBODY DRAG
O. M. POZNIAK *In* AGARD Aerodyn. of Power Plant Installation 21 p (SEE N82-13065 04-01) Sep. 1980 refs
Avail: NTIS HC A22/MF A01

The reported effects of a change in Reynolds number or boundary layer thickness on the afterbody drag of axisymmetric bodies and military type aircraft are reviewed. The significance of different Mach number regimes and of boattail steepness combinations is considered. At subsonic Mach numbers and in the absence of flow separations, significant but compensating pressure changes are found such that there is little effect on the afterbody pressure drag of complete afterbodies. In the presence of flow separations, the effects of Reynolds number tend to be small when the location of the flow separation is fixed as a result of a sudden change in the boattail contour, but on afterbodies with more continuous contours, the location of the point of separation can be affected; conflicting factors are then involved and the afterbody drag can increase or decrease by modest amounts, or remain unaffected by Reynolds number changes. Significant increases in drag for increases in Reynolds number have been consistently reported for high subsonic Mach numbers above the drag rise. J.D.H.

N82-13081# Societe Nationale d'Etudes et de Construction de Moteurs d'Aviation, Moissy-Cramayel (France).
A DEVICE FOR SIMULATING AT A COMPRESSOR BENCH AN AIR INLET WITH LARGE INCIDENCE [DISPOSITIF DE SIMULATION AU BANC COMPRESSEUR D'UNE PRISE D'AIR A GRANDE INCIDENCE]
B. DELAHAYE and G. LARUELLE (ONERA, Chatillon, France) *In* AGARD Aerodyn. of Power Plant Installation 15 p (SEE N82-13065 04-01) Sep. 1981 refs In FRENCH; ENGLISH summary
Avail: NTIS HC A22/MF A01

Increased maneuverability requirements for modern fighter aircraft involve an extensive inlet-engine compatibility analysis. Therefore, during the early stages of compressor development, the engine designer must estimate the surge margin loss resulting from inlet dynamic distortion over the complete flight envelope. A bell-mouth with varying lip thickness and a level-edged duct were designed to simulate the large vortices generated in an inlet at high angle of attack in a compressor test facility; the simulator was tested in a wind tunnel at ONERA and validated in a compressor test facility at SNECMA's Villaroche test center. The flow at the inlet/engine interface plane was characterized in the wind tunnel both for a 1/4 scale cylindrical duct at a Mach number of 0.6 and angles of attack up to 40 degrees and for different versions of the simulator in static conditions. Thereafter, a 30 degree level edged duct was tested at SNECMA with a full scale transonic fan stage. Scaling rules for acquisition time and frequency are used to compare the measurement in front of the fan with the results obtained in the subscale wind tunnel model. Author

N82-13082# Avions Marcel Dassault-Breguet Aviation, Saint-Cloud (France).
AN ACQUISITION AND ANALYSIS SYSTEM FOR DYNAMIC TESTS OF AIR INLETS [SYSTEME D'ACQUISITION ET D'ANALYSE POUR ESSAIS DYNAMIQUES D'ENTREES D'AIR]
P. PERRIER, B. DELAHAYE (SNWCMA, Moissy Cramayel, France), and G. LARUELLE (ONERA, Chatillon, France) *In* AGARD Aerodyn. of Power Plant Installation 14 p (SEE N82-13065 04-01) Aug. 1981 refs In FRENCH
Avail: NTIS HC A22/MF A01

Improving the flight domain of combat aircraft leads to operations involving a much large variation of unsteady aerodynamic characteristics at the engine inlet than in the past. To determine if the augmentation will be effectively acceptable for compressors and engines of the future, sufficient knowledge of flows must be acquired. This entails measuring a sufficient number of unsteady flow characteristics; however, the number of measurements made must be limited because of cost as well as because of the possibility of instantaneous or deferred processing. This sequence of measurements takes into account necessary compromises. Cooperation is needed among the aircraft designer, the engine designer, and the research organization so that the work of each can complement that of the others, and an economy of means and a homogeneity of methods for analyzing and interpreting the results is possible. Transl. by A.R.H.

N82-13083# Volvo Flygmotor A.B., Trollhaettan (Sweden). Aerodynamics Dept.
A SYNTHESIS METHOD FOR ESTIMATING MAXIMUM INSTANTANEOUS INLET DISTORTION BASED ON MEASURED INLET STEADY STATE AND RMS PRESSURES
R. BORG *In* AGARD Aerodyn. of Power Plant Installation 12 p (SEE N82-13065 04-01) Sep. 1981 refs
Avail: NTIS HC A22/MF A01

A synthesis method based on steady state and root mean square (RMS) pressure measurements was developed using a simple mathematical computer model which estimates the maximum value of an engine distortion index. The estimated values obtained with the computer model were correlated with actual measured maximum instantaneous distortion values from several different tests and it is indicated tha the method is useful in a inlet airframe engine configuration development program. The method is a tool for screening configurations before final selection and commitment to more expensive testing. The synthesis method is also complemented with extreme value analysis of the computer generated distortion data to evaluate the likely increase in maximum distortion index with increased time of observation. E.A.K.

N82-13084# Fluidyne Engineering Corp., Minneapolis, Minn.
MODEL TESTING TECHNIQUES FOR MEASURING INLET DRAG
J. S. HOLDHUSEN and J. L. GRUNNET *In* AGARD Aerodyn. of Power Plant Installation 8 p (SEE N82-13065 04-01) Sep. 1981 refs
Avail: NTIS HC A22/MF A01

Two methods of measuring inlet drag in transonic flow are described. In the first method, a flow through nacelle is tested in a transonic wind tunnel. Capture ratio is varied by installing individual annular blockers in the nacelle. Corrections for the drag force exerted by the captured streamtube are determined from blow through tests in a static test stand. In the second method, drag is determined directly using a special rig which has a variable loss throttle. The thrust exiting the control surface is determined by a choked ASME nozzle. The advantages and disadvantages of the two methods are compared. E.A.K.

N82-13085# National Defence Headquarters, Ottawa (Ontario). Directorate of Science and Technology.
COMPRESSOR STALL INDUCING INSTALLATION EFFECTS OF AN ENGINE CONTROL PARAMETER FOR THE CF-5 AIRCRAFT
W. L. MACMILLAN, D. M. RUDNITSKI, and W. GRABE *In* AGARD Aerodyn. of Power Plant Installation 17 p (SEE N82-13065 04-01) Sep. 1981 Prepared in cooperation with National Research Council of Canada, Ottawa
Avail: NTIS HC A22/MF A01

Compressor stall problems with CF-5 aircraft powered by two J85-CAN-15 engines were investigated. One major cause for compressor stalls as improper operation of the engines' control system under low temperature conditions was identified. It is demonstrated that this control system malfunction is the result of engine installation effects, which produce an erroneous compressor inlet temperature signal to the main fuel control unit. The degree of signal error for several flight conditions, such as level flight, high angles of attack, aircraft stalls, and weapons delivery profiles are identified. It is found that temperature errors are greater at high angles of attack where severe compressor inlet distortion acts cumulatively in reducing the stall margin under this flight condition. E.A.K.

N82-13086# Vereinigte Flugtechnische Werke G.m.b.H., Bremen (West Germany).
THE ROLE AND IMPLEMENTATION OF DIFFERENT NACELLE/ENGINE SIMULATION CONCEPTS FOR WIND-TUNNEL TESTING IN RESEARCH AND DEVELOPMENT WORK ON TRANSPORT AIRCRAFT
B. EWALD and R. SMYTH *In* AGARD Aerodyn. of Power Plant Installation 35 p (SEE N82-13065 04-01) Sep. 1981 refs
Avail: NTIS HC A22/MF A01

Different experimental methods and their specific roles in various stages of research and development were investigated. The main problem is the simulation and calibration of the propulsion system. Different simulation methods are: flow through nacelles, powered nacelles (blowing, turbine powered simulators (TPS), ejector powered), inlet models. The TPS represent the most advanced simulation of the high bypass ratio engine in model scale. A large part of the wind tunnel tests still have to rely upon flow through nacelles. A novel flow through nacelle with a variable plug is presented. It is shown that the combination of flow through nacelles and TPS can be efficiently used in the windtunnel investigation of propulsion system effects for transport aircraft. E.A.K.

N82-13087# Office National d'Etudes et de Recherches Aerospatiales, Paris (France).
WIND TUNNEL TESTS OF POWERED MODELS: A COMPARISON OF TWO METHODS OF SIMULATING THE JETS OF JET ENGINES [ESSAIS EN SOUFFLERIE DE MAQUETTES MOTORISEES; COMPARAISON DE DEUX METHODES DE SIMULATION DES JETS DES REACTEURS]
J. P. BECLE and R. PERIN (SNIAS, Toulouse) *In* AGARD Aerodyn. of Power Plant Installation 18 p (SEE N82-13065 04-01) Sep. 1981 refs In FRENCH
Avail: NTIS HC A22/MF A01

Two methods for simulating engine jets were developed at ONERA. The so-called blowing jets were previously mounted for studying the Concorde. The second method, which uses small air breathing turbines was recently installed for Airbus family aircraft. Tests were conducted on semi-models mounted on a balance with six components traversed by the flow from the engine. An original mounting permits the same measurement means to be used for any principle of power or type of test used (fixed point or wind tunnel test). The installations, means of measurement, and methods of using the results are described. The respective advantages of each type of power simulation are considered from the viewpoints of complexity, duration, and precision of measurements obtained. Transl. by A.R.H.

N82-13088# Aircraft Research Association Ltd., Bedford (England).
WIND TUNNEL TEST AND ANALYSIS TECHNIQUES USING POWERED SIMULATORS FOR CIVIL NACELLE INSTALLATION DRAG ASSESSMENT
A. E. HARRIS and E. C. CARTER *In* AGARD Aerodyn. of Power Plant Installation 16 p (SEE N82-13065 04-01) Sep. 1981 refs
Avail: NTIS HC A22/MF A01

Full span and semi-span wind tunnel model tests and powered nacelle calibration techniques are discussed in the context of civil nacelle installation drag assessment and optimization. In order to achieve the accuracy required for drag analysis it is necessary to determine the installed net thrust of the powered nacelle simulator to the equivalent of at least one aircraft drag count. This implies stringent control of mass flow and thrust accounting and imposes the need for consistency of approach in the wind-on and calibration tests where thrust and mass flow coefficients must be known to 0.1% to 0.2% accuracy. This need for high confidence in the data at all stages of analysis led to a methodology in which the measured data is combined in various ways to enhance confidence in its final use. Experiences obtained in the use of a Mach simulation tank (MST) for the calibration of turbine powered simulator units are discussed. The MST is used to obtain simultaneous mass flow and thrust calibrations with representative internal nacelle conditions in the presence of a quiescent exhaust environment. Practical problems associated with the design of balance and airfeed arrangements are discussed along with the use of blown and turbine powered simulators. B.W.

N82-13089# Rolls-Royce Ltd., Derby (England).
ESTABLISHMENT OF AN EXPERIMENTAL TECHNIQUE TO PROVIDE ACCURATE MEASUREMENT OF THE INSTALLED DRAG OF CLOSE COUPLED CIVIL NACELLE/AIRFRAME CONFIGURATIONS, USING A FULL SPAN MODEL WITH TURBINE POWERED ENGINE SIMULATORS
G. PUGH and A. E. HARRIS (Aircraft Research Association Ltd., Bedford, England) *In* AGARD Aerodyn. of Power Plant Installation 9 p (SEE N82-13065 04-01) Sep. 1981 refs
Avail: NTIS HC A22/MF A01

Definition and optimization of installed thrust/drag in civil nacelle installation design and development was studied. As a means of validating the calibration and thrust/drag analysis techniques bodied transport, Lockheed L1011, having high bypass ratio RB 211 turbofan engines with two alternative exhaust system designs was used. Wind tunnel model representation comprised a full span simulation with underwing mounted turbine powered engine simulators. Calibration techniques included the use of a Mach simulation tank in which concurrent mass flow and thrust calibrations were conducted in a quiescent exhaust environment. Data presented includes nacelle thrust and discharge coefficients, installed drag comparisons, and, finally, model to flight correlations. B.W.

N82-13090# National Aerospace Lab., Amsterdam (Netherlands).
EVALUATION OF AN EXPERIMENTAL TECHNIQUE TO INVESTIGATE THE EFFECTS OF THE ENGINE POSITION ON ENGINE/PYLON/WING INTERFERENCE
J. A. J. VANENGELEN, B. MUNNIKSMA, and A. ELSENAAR *In* AGARD Aerodyn. of Power Plant Installation 13 p (SEE N82-13065 04-01) Sep. 1981 refs
Avail: NTIS HC A22/MF A01

A flexible experimental technique to study the effect of a variation of engine position for a range of test conditions was evaluated. In this test an underwing mounted 3/4 fancowl engine was investigated at six different positions as a free flow nacelle and as a strut mounted blown nacelle. Pressure and balance force measurements were made. Some typical aspects of the aerodynamic interference are discussed, notably the value of free flow nacelle measurements. Also a comparison of balance weighed and integrated pressure forces is presented. Results indicate that accurate simulation of the engine nozzle geometry is of prime importance for an investigation concerning engine/airframe integration. Nevertheless, tests on a free flow nacelle may still be useful for the selection of the most favourable engine position. A reasonable correlation was established between interference forces as obtained from pressure integration and balance measurements. However, the pressure forces tend to underestimate the balance forces. For a flexible pathfinder test, interference forces derived from pressure integration only appear to be very useful for the determination of trends in interference effects. B.W.

N82-13091# Office National d'Etudes et de Recherches Aerospatiales, Paris (France).
STUDIES OF AIR INLETS AT REYNOLDS NUMBERS COMPARABLE TO FLIGHT IN ONERA'S F1 AND S1MA WIND TUNNELS [ESSAIS DE PRISES D'AIR A DES NOMBRES DE REYNOLDS COMPARABLES AU VOL DANS LES SOUFFLERIES F1 ET S1MA DE L'ONERA]
J. LEYNAERT *In* AGARD Aerodyn. of Power Plant Installation 12 p (SEE N82-13065 04-01) Sep. 1981 refs In FRENCH
Avail: NTIS HC A22/MF A01

The pressurization of the subsonic F1 wind tunnel at ONERA's Fauga-Mauzac Center was a benefit in wind tunnel tests of the air intakes of Airbus-type aircraft on a large scale at a Reynolds number near that of flight. The same model can thus be tested up to a Mach number near 1 in the S1MA wind tunnel at the Modane Center. Air intakes of military aircraft can likewise be studied in the two wind tunnels at high Reynolds numbers. The apparatus used, the methods of measurement, and the means of calibrating and control used to assure valid results are presented. Transl. by A.R.H.

N82-13092# British Aerospace Aircraft Group, Hertfordshire (England). Research Dept.
THE INFLUENCE OF CLOSED-COUPLED, REAR FUSELAGE MOUNTED NACELLES ON THE DESIGN OF AN ADVANCED HIGH SPEED WING
R. D. LAUGHER *In* AGARD Aerodyn. of Power Plant Installation 17 p (SEE N82-13065 04-01) Sep. 1981 refs
Avail: NTIS HC A22/MF A01

The design approach aimed at integrating the effect of the nacelle into the basic wing design is described. Particular attention is drawn to the design risk associated with the modified inner wing supercritical flow development when nacelles are not represented in the transonic design calculations. Experimental test results are described which demonstrate the general success of the design technique. Finally, some results are presented from theoretical investigations in which an attempt was made to simulate the interference effect of the nacelle on the wing supercritical flowfield. A technique was developed whereby the nacelle and intake streamtube are replaced by an equivalent interfering body, which is derived from subcritical flow interference pressures. Results show that this technique provides a simple, cost effective tool for the supercritical design of a wing operating in the influence of a rear nacelle. M.D.K.

N82-13093# Royal Netherlands Aircraft Factories Fokker, Schiphol-Oost. Aerodynamics Dept.
AERODYNAMIC ASPECTS OF A HIGH BYPASS RATIO ENGINE INSTALLATION ON A FUSELAGE AFTERBODY
N. VOOGT, J. VANHENGST, and J. T. V.D.KOLK (NRL) *In* AGARD Aerodyn. of Power Plant Installation 10 p (SEE N82-13065 04-01) Sep. 1981 refs
Avail: NTIS HC A22/MF A01

The design process used in shaping rear fuselage mounted large diameter engine nacelles, pylons, and fuselage for a transport type aircraft is described. The objective was to suppress the local velocity levels and pressure gradients to avoid aerodynamic interference drag of the nacelle-pylon-fuselage combination in high speed cruise flight. Shapes of fuselage afterbody, nacelle, and stubwing were modified in a design-by-analysis process involving iterative and three dimensional singularity methods for inviscid subsonic flow. Windtunnel tests confirmed the adequacy of these methods. M.D.K.

N82-13094# Societe Nationale Industrielle Aerospatiale, Toulouse (France). Service Aerodynamique Theorique.
A NUMERICAL METHOD FOR STUDYING NACELLE-JET-AIRFOIL INTERACTION IN INVISCID THREE-DIMENSIONAL FLOW [UNE METHODE NUMERIQUE POUR L'ETUDE DE L'INTERACTION NACELLE-JET-VOILURE EN ECOULEMENT TRIDIMENSIONEL NON VISQUEUX]
G. LEGALL, J. BOUSQUET, and M. YERMIA *In* AGARD Aerodyn. of Power Plant Installation 13 p (SEE N82-13065 04-01) Sep. 1981 refs In FRENCH
Avail: NTIS HC A22/MF A01

The nacelle-jet-airfoil interaction is a complex three dimensional phenomena which is addressed in two simplified hypotheses: the fluid is incompressible and inviscid. Under these two hypotheses, the propulsive configuration is modeled by air intake with flow control and a propulsive jet with control of the pressure generator. A method of singularities is used which considers the sources and doublets of constant density and doublets of linear density on a flat panel. The equations which govern the problem constitute a nonlinear system which is divided into a linear part and a quadratic part. These two parts are solved iteratively by the Gauss-Seidel method and the Newton method. The free boundaries of the flow are also calculated by an iterative process which is integrated into the two preceding methods. Some practical results are proposed in two and three dimensional flow. Comparison with tests permits evaluation of the advantage of the simplified hypotheses. Transl. by A.R.H.

N82-13095# Vereinigte Flugtechnische Werke G.m.b.H., Bremen (West Germany).
CALCULATION OF WING-BODY-NACELLE INTERFERENCE IN SUBSONIC AND TRANSONIC POTENTIAL FLOW
K. D. KLEVENHUSEN, H. JAKOB, and H. STRUCK *In* AGARD Aerodyn. in Power Plant Installation 8 p (SEE N82-13065 04-01) Sep. 1981 refs
Avail: NTIS HC A22/MF A01

A calculation method especially for transport aircraft wing design with consideration of wing/body or engine/airframe interference was developed. A hybrid method, consisting of a combination of panel method and finite difference method, is an improvement of a well proved analogy method. The panel method is of higher order using linear source and doublet distributions. The transonic flow region is removed from the entire flow field and the panel method is used for calculating boundary values for the subsequent finite difference method. The finite difference method solves the full potential equation in streamline coordinates. E.A.K.

N82-13096*# Boeing Military Airplane Development, Seattle, Wash.
PREDICTION OF SUBSONIC AIRCRAFT FLOWS WITH JET EXHAUST INTERACTIONS
D. W. ROBERTS *In* AGARD Aerodyn. of Power Plant Installation 12 p (SEE N82-13065 04-01) Sep. 1981 refs
(Contract NAS2-10100)
Avail: NTIS HC A22/MF A01 CSCL 02A

A numerical procedure to calculate the flow fields resulting from the viscous inviscid interactions that occur when a strong jet exhaust and aircraft flow field coupling exists was developed. The approach divides the interaction region into zones which are either predominantly viscous or inviscid. The flow in the inviscid zone, which surrounds most of the aircraft, is calculated using an existing potential flow code. The viscous flow zone, which encompasses the jet plume, is modeled using a parabolized Navier-Stokes code. The procedure features the coupling of the zonal solutions such that sufficient information is transferred between the zones to preserve the effects of the interactions. The zonal boundaries overlap and the boundary conditions are the information link between zones. An iteration scheme iterates the coupled analysis until convergence has been obtained. E.A.K.

N82-13097# Douglas Aircraft Co., Inc., Long Beach, Calif.
PROP-FAN INTEGRATION AT CRUISE SPEEDS
H. R. WELGE *In* AGARD Aerodyn. of Power Plant Installation 14 p (SEE N82-13065 04-01) Sep. 1981 refs
Avail: NTIS HC A22/MF A01

The aerodynamic installation features of a highly loaded turboprop (prop fan) on an aircraft for flight at Mach 0.8 are discussed. The aerodynamic flow environment in which the prop fan must operate is shown for both wing and aft-fuselage installations using advanced surface panel methods. The effects of prop fan slipstream parameters on the drag of a supercritical wing are presented indicating that only small drag penalties occur. Drag reductions are possible by tailoring the local wing section to account for the rotor induced flow. Using these inputs, an integrated wing/nacelle is shown. E.A.K.

N82-13098*# Boeing Commercial Airplane Co., Seattle, Wash. New Product Development Dept
AIRFRAME-PROPULSION SYSTEM AERODYNAMIC INTERFERENCE PREDICTIONS AT HIGH TRANSONIC MACH NUMBERS INCLUDING OFF-DESIGN ENGINE AIRFLOW EFFECTS
R. M. KULFAN and A. SIGALLA *In* AGARD Aerodyn. of Power Plant Installation 23 p (SEE N82-13065 04-01) Sep 1981 refs
(Contract NAS1-14623)
Avail: NTIS HC A22/MF A01 CSCL 02A

The transonic speed regime for airplanes at conditions where inlet spillage takes place is discussed. A wind tunnel test program to evaluate aerodynamic performance penalties associated with propulsion system installation and operation at subsonic through low supersonic speeds was conducted. The accuracy of analytic methods for predicting transonic engine airframe interference effects was assessed. Study variables included Mach number, angle of attack, relative nacelle location, and nacelle mass flow ratio. Results include test theory comparisons of forces as well as induced pressure fields. Prediction capability of induced shock wave

strength and locations is assessed. It was found that large interference forces due to engine location and flow spillage occur at transonic speeds, that theory explains these effects; and that theory can predict quantitatively these effects. E.A.K.

N82-17086# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
TACTICAL AIRBORNE DISTRIBUTED COMPUTING AND NETWORKS
Oct. 1981 415 p refs Partly in ENGLISH and FRENCH Meeting held in Roros, Norway, 22-25 Jun. 1981
(AGARD-CP-303; ISBN-92-835-0302-3; AD-A109274) Avail: NTIS HC A18/MF A01

Distributed processing and its application to avionic systems are discussed. For individual titles, see N82-17087 through N82-17120.

N82-17087# Georgia Inst. of Tech., Atlanta. School of Information and Computer Science.
DISTRIBUTED DATA PROCESSING: WHAT IS IT?
P. H. ENSLOW, JR. *In* AGARD Tactical Airborne Distributed Computing and Networks 10 p (SEE N82-17086 08-01) Oct. 1981 refs
(Contract N00014-79-C-0873)
Avail: NTIS HC A18/MF A01

Distributed processing is presented as the means to obtain improvements in a number of areas of system performance. Utilizing a list of these desired improvements as the motivational factors, the key design characteristics of systems that delivers a major proportion of these improvements are presented. J.D.H.

N82-17088# Ferranti Ltd., Bracknell (England). Computer Systems Div.
THE EFFECT OF INCREASINGLY MORE COMPLEX AIRCRAFT AND AVIONICS ON THE METHOD OF SYSTEM DESIGN
J. T. MARTIN *In* AGARD Tactical Airborne Distributed Computing and Networks 5 p (SEE N82-17086 08-01) Oct. 1981
Avail: NTIS HC A18/MF A01

The evolution of aircraft and their associated avionics is described. The evolutionary progress is considered as starting from a simple low speed aircraft with rudimentary flight instruments and sighting systems, through the interconnection of some of these systems and progressing to recent avionic systems with centralized digital computing. It is shown how the changes in aircraft systems, from the simple analog connection of a few systems, through the analog sensor/interface box/centralized digital system, to the sensor producing digital outputs/interface box/centralized digital system, have produced comparatively small changes in the methodology used for the design of these systems. The move to systems containing distributed processing interconnected by digital highways is shown to be revolutionary rather than evolutionary and to require a new approach to the system design problem so as to reap the maximum advantage from the available computing capability. Author

N82-17089# Naval Air Systems Command, Washington, D. C. Control and Guidance Research and Technology Group.
A TUTORIAL ON DISTRIBUTED PROCESSING IN AIRCRAFT/AVIONICS APPLICATIONS
B. A. ZEMPOLICH *In* AGARD Tactical Airborne Distributed Computing and Networks 11 p (SEE N82-17086 08-01) Oct. 1981
Avail: NTIS HC A18/MF A01

An overview of the state of the art in real time distributed processing as applied to aircraft/avionics is presented. Definitions and concepts are presented starting with the total aircraft as a real time distributed computer-controlled system. The relationship of aircraft mission and avionic system architectures is discussed. Overall system architectural considerations are identified and their impact upon a real time distributed computer-controlled system is detailed. A top-down hierarchical, architectural structure is presented. This top-down structuring is described in terms of the logical functional decomposition of the system as follows: total aircraft/avionic system partitioning of aircraft/avionic subsystems, interconnect bus structure (network), system-wide processing architecture, subsystems definition, and computer systems.
Author

N82-17090# Rensselaer Polytechnic Inst., Troy, N. Y. Electrical, Computer, and Systems Engineering Dept.
PERFORMANCE STUDY OF A DISTRIBUTED MICROPROCESSOR ARCHITECTURE FOR USE ABOARD MILITARY AIRCRAFT
K. G. SHIN and C. M. KRISHNA *In* AGARD Tactical Airborne Distributed Computing and Networks 13 p (SEE N82-17086 08-01) Oct. 1981 refs
Avail: NTIS HC A18/MF A01

An analysis of the performance of the Distributed Microprocessor Airborne Computing System (DMACS) developed at Rensselaer Polytechnic Institute is presented. The DMACS consists of a number of quasi-independent computer subsystems loosely coupled in a highly decentralized structure that yet exhibits high cogency as a system. Some important parameters in the system such as job scheduling and starting delays, bus access delay, and system reliability are studied. In order to highlight the implications of the design options chosen, the structure of the DMACS and that of the Draper Laboratory's Fault-Tolerant Multiprocessor (FTMP) system are compared and the impact of structure on performance is discussed qualitatively. Author

N82-17091# British Aerospace Aircraft Group, Brough (England).
THE DEVELOPMENT OF ASYNCHRONOUS MULTIPROCESSOR CONCEPTS FOR FLIGHT CONTROL SYSTEM APPLICATIONS
S. M. WRIGHT and J. G. BROWN *In* AGARD Tactical Airborne Distributed Computing and Networks 11 p (SEE N82-17086 08-01) Oct. 1981 refs Sponsored in part by RAE
Avail: NTIS HC A18/MF A01

The use of multiple microprocessors, each functionally dedicated and running asynchronously with a short program cycle time, is described. This approach promises benefits in a number of areas; ease of generating/proving high integrity software, reduced propagation delays, reduced hardware/software synchronization overheads, retention of classical feedback control design techniques, and extendable processing power. A flight dynamics research program using a RAE Hunter aircraft converted to fly-by-wire is discussed. This program has identified a need for a flexible digital flight control processor for such research and has provided a focus and stimulus for multiprocessor studies. The development of digital full authority flight control computer for this specific application, with a view to installation in the aircraft, is discussed. J.D.H.

N82-17092# Elektronik-System G.m.b.H., Munich (West Germany).
FUNCTIONAL VERSUS COMMUNICATION STRUCTURES IN MODERN AVIONIC SYSTEMS
K. BRAMMER and A. WEIMANN *In* AGARD Tactical Airborne Distributed Computing and Networks 11 p (SEE N82-17086 08-01) Oct. 1981 refs
Avail: NTIS HC A18/MF 01

The implications of the increase in functional and communication interfaces on avionic system structures are analyzed. Especially the passage from functional design to implemented communication structure of the airborne electronic system is scrutinized. The distributed organization of an avionic system, the realization of which is greatly simplified by bus type intrasystem signal transmission, is compared to the conventional hierarchical system organization. Advantages and drawbacks of both organizations are reviewed especially with respect to interface efficiency, cabling requirements, and the typical topology of avionic systems. J.D.H.

N82-17093# Air Force Wright Aeronautical Labs., Wright-Patterson AFB, Ohio. Flight Dynamics Lab.
CONTINUOUS RECONFIGURATION IN A MULTI-MICROPROCESSOR FLIGHT CONTROL SYSTEM
S. L. MAHER and S. J. LARIMER *In* AGARD Tactical Airborne Distributed Computing and Networks 9 p (SEE N82-17086 08-01) Oct. 1981 refs
Avail: NTIS HC A18/MF A01

A microprocessor based flight control system design is presented. This system is characterized by a collection of cooperatively autonomous distributed microcomputers interconnected by an arbitrary number of common serial multiplex busses. Each processor in the system independently determines its assignments using a simple algorithm that dynamically

redistributes system functions from processor to processor in a never-ending process of reconfiguration. This approach offers several potential benefits in terms of system reliability, and the architecture in general incorporates many state of the art features which promise improved system throughput, expandability, and above all, ease of programming. The Continuously Reconfiguring Multi-Microprocessor Flight Control System (CRM2FCS) represents a significant data point in multiprocessor control system research. Promising ideas from a variety of references have been included and integrated in its design. J.D.H.

N82-17094# FGAN, Wachtberg-Werthhoven (West Germany).
EXPERIENCES WITH THE EXPERIMENTAL FFM-MCS
H. V. ISSENDORFF *In* AGARD Tactical Airborne Distributed Computing and Networks 8 p (SEE N82-17086 08-01) Oct. 1981 refs
Avail: NTIS HC A18/MF A01

The FFM-Multicomputer System (FFM-MCS), built up to investigate the utilization of microprocessor based computing networks for the various requirements of embedded data processing and control in military systems is described. Being designed as an adaptable building block system the FFM-MCS serves as a testbed for research on distributed data processing. A general method for the design of process networks followed by the adaption of adequate hardware networks is discussed. Several types of messages are introduced for efficient and safe communication between autonomous process modules. Some improvements of the hardware building block system are presented. J.D.H.

N82-17095# Royal Aircraft Establishment, Farnborough (England). Flight Systems Dept.
SAVANT: A DATABASE MANIPULATION TECHNIQUE FOR SYSTEM ARCHITECTURE DESIGN VERIFICATION AND ANALYSIS
A. A. CALLAWAY *In* AGARD Tactical Airborne Distributed Computing and Networks 9 p (SEE N82-17086 08-01) Oct. 1981 refs
Avail: NTIS HC A18/MF A01

The SAVANT (System Architecture Verification and Analysis Technique), a computer program developed to provide a tool for automatic system design verification and analysis is described. Its application is oriented towards loosely-coupled bus connected systems but is not exclusively confined to these. Flexibility has been built into the program to characterize aspects of the system architecture. The SAVANT program provides the facilities for interactively initiating, extending, modifying, filing, and retrieving the data base, which represents various facets of the system under investigation, and for configuring a system from the data base information. The system thus configured can be analyzed in a number of ways and the analyses performed suggest how the basic information should be modified in order to correct errors and inconsistencies or to improve efficiency. A consistent system can be further modified and tuned, although SAVANT still checks the validity of all operations performed. Finally, the user is able to 'firm up' the system when it has reached a satisfactory state, producing design requirements and a system description in a form which can input as a schedule to a bus control processor.
Author

N82-17096# Research Triangle Inst., Research Triangle Park, N.C.
SIGNAL PROCESSING WITH SYSTOLIC ARRAYS
R. W. PRIESTER, K. BROMLEY, H. J. WHITEHOUSE, and J. B. CLARY *In* AGARD Tactical Airborne Distributed Computing and Networks 11 p (SEE N82-17086 08-01) Oct. 1981 refs
(Contract N66001-80-C-0118)
Avail: NTIS HC A18/MF A01

Systolic arrays are formed by providing nearest-neighbor interconnections between a large number of elemental processors to form either a one or two dimensional array. With the possible exception of boundary elements, each processing element performs identical computations in synchronism with other elements in the array. Important problems for which systolic arrays hold potential are mentioned and the systolic array processor definition, in a number of its forms, are reviewed. When applied to strongly band-limited matrices, systolic array processors can be characterized as highly efficient from the standpoint of both hardware utilization and algorithm time. However, as the bandwidth becomes large, this high performance is degraded. A data transformation which, when applied to an n x n dense matrix, results in an improved banded structure with attendant hardware savings is introduced and evaluated. Some efficient testability features of these processors which can be exploited concurrently are summarized. B.W.

N82-17097# Naval Air Systems Command, Washington, D. C. Control and Guidance Research and Technology Group.
ECONOMIC CONSIDERATIONS FOR REAL-TIME NAVAL AIRCRAFT/AVIONICS DISTRIBUTED COMPUTER CONTROL SYSTEMS
B. A. ZEMPOLICH *In* AGARD Tactical Airborne Distributed Computing and Networks 10 p (SEE N82-17086 08-01) Oct. 1981
Avail: NTIS HC A18/MF A01

Economic considerations for Distributed Computer Control Systems (DCCS) are discussed. Centralized, distributed and federated processing architectures are used as the primary set of systems alternatives from which economic factors are developed. The economic impact of subsequent logistic support for standardized computer hardware and software versus non-standard products is identified. System considerations such as reliability, maintainability, availability, built-in-test, fault tolerance, and redundancy are examined from the standpoint of resources available to design and develop the DCCS, and also from the viewpoint of economic impact of failure of the DCCS to perform as expected. The economic impact of external factors such as the rate of technology advancement, technology independence, limited production runs, and the general lack of economic leverage upon the market are examined and related to the life-cycle support requirements of the DCCS. Author

N82-17098# Ferranti Ltd., Bracknell (England). Computer System Div.
FUNCTIONAL DOCUMENTATION. A PRACTICAL AID TO THE ORDERLY SOLUTION OF THE SYSTEM DESIGN PROBLEM
J. J. MARTIN *In* AGARD Tactical Airborne Distributed Computing and Networks 18 p (SEE N82-17086 08-01) Oct. 1981
Avail: NTIS HC A18/MF A01

A method of breaking down a Customer Requirement in an orderly manner so as to produce progressively more detailed design levels such that at any one stage of the System Design the particular part of the design under consideration can firstly be easily understood and secondly comparatively isolated from the other parts of the design is described. The most important characteristic of the design methodology is that the Requirement is considered in purely Functional terms until a highly detailed level of the design is reached. An example of this design methodology and the technique of Functional Documentation is given and the advantages that can accrue from a sensible use of the design methodology are discussed. Author

N82-17099# British Aircraft Corp., Preston (England). Aircraft Group.
A CONSISTENT APPROACH TO THE DEVELOPMENT OF SYSTEM REQUIREMENTS AND SOFTWARE DESIGN
A. O. WARD *In* AGARD Tactical Airborne Distributed Computing and Networks 16 p (SEE N82-17086 08-01) Oct. 1981 refs
Avail: NTIS HC A18/MF A01

Some of the problems encountered in the development of system and software requirements are discussed and generalized solutions suggested. A specific approach is described, the SAFRA Project, including extensions into the area of software design. This approach embraces the use of a methodology, Controlled Requirements Expression (CORE) interfaced with a computer based System Description Language for storage and automatic analysis. Software design assumes the use of a MASCOT rationalized executive and CORAL as the implementation language. Experimental procedures for the automatic extraction of CORAL programmes from detailed requirements held on a data base are discussed. Author

N82-17100# Dornier-Werke G.m.b.H., Friedrichshafen (West Germany).
A PEARL SOFTWARE SYSTEM FOR MULTI-PROCESSOR SYSTEMS
P. ELZER and H. J. SCHNEIDER *In* AGARD Tactical Airborne Distributed Computing and Networks 6 p (SEE N82-17086 08-01) Oct. 1981 refs
Avail: NTIS HC A18/MF A01

A High-Order-Language-System based on PEARL to program Multi-Processor-Systems in an airborne or similar environment was developed. It was necessary to minimize the overhead produced by the operating system. The generated code was optimized to a very high efficiency with respect to time and memory. Originally the aim of PEARL was process-control. Due to the application area here, subsetting of PEARL was possible. This was done with high efficiency of code and a smaller modular operating system in mind. On the other hand extensions to allow distributed processing were implemented. It exists on a host-computer and is written in FORTRAN for portability. The system was successfully used in several applications. Author

N82-17101# Georgia Inst. of Tech., Atlanta. School of Information and Computer Science.
DISTRIBUTED AND DECENTRALIZED CONTROL IN FULLY DISTRIBUTED PROCESSING SYSTEMS
P. H. ENSLOW, JR. *In* AGARD Tactical Airborne Distributed Computing and Networks p 16 (SEE N82-17086 08-01) Oct. 1981 refs
(Contract F30602-78-C-0120)
Avail: NTIS HC A18/MF A01

A number of the characteristics of a distributed and decentralized control system and some of its operational features are identified and discussed. Extremely loose coupling, both physical and logical, is an essential characteristic of an FDPS. This mode of organization and operation is quite different from the control of centralized systems. Various models of control that may provide these features and the operational characteristics of those models are described. B.W.

N82-17102# INRIA, Rocquencourt (France).
RECOVERY IN DISTRIBUTED PROCESSING SYSTEMS
L. SVOBODOVA *In* AGARD Tactical Airborne Distributed Computing and Networks 9 p (SEE N82-17086 08-01) Oct. 1981 refs
Avail: NTIS HC A18/MF A01

A powerful control abstraction called an atomic action was developed as a general mechanism for controlling access to shared distributed data. In order to preserve consistency of the system, if an atomic action fails, all of its effects are undone; thus if a long complex computation is reprsented as an atomic action, an important amount of possibly useful work might be lost. The proposed scheme which facilitates selective internal recovery from detected errors, mode failures, and communication failures employes nested atomic action. When an atomic action terminates, its results are not made permanent until the outermost atomic action is committed, but they survive local model failures. Each subtree of nested atomic actions is recoverable (undoable) individually, thus making it possible to switch to an alternative algorithm, service, or physical mode upon a failure. Finally, a recovery point is established in stable storage as part of a remote request, so that work done outside of the requesting node is not lost if this node fails. Author

N82-17103# Massachusetts Univ., Amherst. Dept. of Electrical and Computer Engineering.
GENERALIZED POLLING ALGORITHMS FOR DISTRIBUTED SYSTEMS
J. K. WOLF *In* AGARD Tactical Airborne Distributed Computing and Networks 9 p (SEE N82-17086 08-01) Oct. 1981 refs
(Contract NSF ESC-79-21140)
Avail: NTIS HC A18/MF A01

A polling algorithm for a distributed system is an algorithm which can be simultaneously run at all terminals in a network and which has as its aim the determination of which terminals have a positive response to a specific query. Of particular interest is the situation where one expects very few of the terminals to respond positively and where a terminal signifies a negative response by not transmitting at all. In such a case it is inefficient to poll the terminals in a round robin manner. A more efficient procedure is to group the terminals into subsets in which all terminals in a subset are queried simultaneously. Then if all respond negatively no further queries need be addressed to that subset. If the responses from the terminals in the subset are mixed than this subset is further subdivided into smaller subsets until the responses of all the terminals are determined. Two distinct algorithms for polling are considered. In both algorithms, the terminals of the network are represented by leaves in a binary tree and the subsets are subtrees in the overall tree. The two systems differ in the assumptions made regarding the types of responses sent and how the responses are interpreted. The performance of these two schemes are compared with each other and with ordinary round robin polling. Author

N82-17104# Boeing Military Airplane Development, Seattle, Wash. Digital Flight Controls Research Dept.
STAGE-STATE RELIABILITY ANALYSIS TECHNIQUE
A. D. STERN *In* AGARD Tactical Airborne Distributed Computing and Networks 7 p (SEE N82-17086 08-01) Oct. 1981 refs
Avail: NTIS HC A18/MF A01

An advanced flight control system reliability analysis technique must properly account for the defined success criteria, redundancy level, redundancy management, technique, system dependencies, and failure detection coverage. The stage state reliability analysis technique properly accounts for these factors. It is also computationally simple such that triplex redundant systems have been analyzed using an early 1970's desktop computer. This method is well suited for analysis by the system architect. The process begins with a system block diagram showing all element connections. A success logic diagram is then written reflecting all possible success states. The probability of success equation is written directly from the logic diagram and evaluated by substituting the probability expression for each system element. Multiple success criteria can be applied to one problem formulation simply by deleting those states which do not satisfy the success criterion. Author

N82-17105*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
METHODOLOGY FOR MEASUREMENT OF FAULT LATENCY IN A DIGITAL AVIONIC MINIPROCESSOR
J. C. MCGOUGH, F. SWERN, and S. J. BAVUSO *In* AGARD Tactical Airborne Distributed Computing and Networks 18 p (SEE N82-17086 08-01) Oct. 1981 refs Prepared in cooperation with Bendix Corp., Teterboro, N.J.
(Contract NAS1-15946)
Avail: NTIS HC A18/MF A01 CSCL 01D

Using a gate level emulation of a typical avionics miniprocessor, fault injection experiments were performed to (1) determine the time to detect a fault by comparison monitoring, (2) forecast a program's ability to detect faults and (3) validate the fault detection coverage of a typical self test program. To estimate time to detect, six programs ranging in complexity from 6 to 147 instructions, were emulated. Each program was executed repetitively in the presence of a single stuck at fault at a gate node or device pin. Detection was assumed to occur whenever the computed outputs differed from the corresponding outputs of the same program executed in a nonfaulted processor. Histograms of faults detected versus number of repetitions to detection were tabulated. Using a simple model of fault detection, which was based in an analog with the selection of balls in an urn, distributions of time to detect were computed and compared with those obtained empirically. A self test program of 2,000 executable instructions was designed expressly for the study. The only requirement imposed on the design was that it should achieve 95% coverage. The program was executed in the presence of a single stuck-at fault at a gate node on device pin. The proportion of detected faults are tabulated. In all experiments faults were selected at random over gate nodes or device pins. Author

N82-17106*# SRI International Corp., Menlo Park, Calif. Computer Science Lab.

HIERARCHICAL SPECIFICATION OF THE SIFT FAULT TOLERANT FLIGHT CONTROL SYSTEM

P. M. MELLIAR-SMITH and R. L. SCHWARTZ *In* AGARD Tactical Airborne Distributed Computing and Networks 15 p (SEE N82-17086 08-01) Oct. 1981 refs

(Contract NAS1-15428)

Avail: NTIS HC A13/MF A01

The specification and mechanical verification of the Software Implemented Fault Tolerance (SIFT) flight control system is described. The methodology employed in the verification effort is discussed, and a description of the hierarchical models of the SIFT system is given. To meet the objective of NASA for the reliability of safety critical flight control systems, the SIFT computer must achieve a reliability well beyond the levels at which reliability can be actually measured. The methodology employed to demonstrate rigorously that the SIFT computer meets as reliability requirements is described. The hierarchy of design specifications from very abstract descriptions of system function down to the actual implementation is explained. The most abstract design specifications can be used to verify that the system functions correctly and with the desired reliability since almost all details of the realization were abstracted out. A succession of lower level models refine these specifications to the level of the actual implementation, and can be used to demonstrate that the implementation has the properties claimed of the abstract design specifications. Author

N82-17107# Litton Technische Werke, Freiburg (West Germany).

RECONFIGURATION: A METHOD TO IMPROVE SYSTEMS REALIABILITY

J. SZLACHTA *In* AGARD Tactical Airborne Distributed Computing and Networks 8 p (SEE N82-17086 08-01) Oct. 1981

Avail: NTIS HC A18/MF A01

A system with hardware and software reconfiguration capabilities was developed to improve the reliability of a flight-augmentation computer. The system consists of a network of n redundant computers, linked via m serial buses. A two computer processing units and two or more input/output drivers. A fault in one of the components of the redundant computers causes a hardware reconfiguration which replaces the faulty component by its still functioning twin. If a redundant computer fails altogether, all tasks allocated to it are transferred to one of the still working computers of the network. This is made possible by loading dormant copies of the tasks into at least one other computer of the initial system. These dormant copies are periodically supplied with the program status of the active copy. Author

N82-17108# Societe d'Applications Generales d'Electricite et de Mecanique, Paris (France).

A RECONFIGURABLE CHANGE NETWORK FOR DISTRIBUTED PROCESS CONTROL [RESEAU D'ECHANGE RECONFIGURABLE POUR CONTROLE DE PROCESSUS REPARTI]

C. MERAUD and B. MAUREL (Societe. Anonyme de Telecommunications) *In* AGARD Tactical Airborne Distributed Computing and Networks 10 p (SEE N82-17086 08-01) Oct. 1981 refs In FRENCH

Avail: NTIS HC A18/MF A01

A highly reliable, high output system of change is described which permits decentralized exchange between the diverse equipment onboard an aircraft or other type of vehicle in order to integrate and reconfigure the functions, no matter how critical. Very large scale integration and fiber optics which are insensitive to electromagnetic perturbations made possible a performing decentralized solution by incorporating intelligence in a universal type linking module called the subsystem interface. For the traditionally programmed mechanism for generating change, a dynamic mechanism immediately adapted to modification, is substituted which permits a great degree of synchronization. Transl. by A.R.H.

N82-17109# Norwegian Defence Research Establishment, Kjeller.

PROTOCOL LEVEL MODULES FOR COST EFFECTIVE STANDARD COMPUTER COMMUNICATION

O. HVINDEN, Y. LUNDH, and O. SANDHOLT *In* AGARD Tactical Airborne Distributed Computing and Networks 8 p (SEE N82-17086 08-01) Oct. 1981 refs

Avail: NTIS HC A18/MF A01

A set of microcomputer modules for implementation of network front-end, gateway and specilized host computers are being developed. A highly modular design approach is taken. One or more of these protocol modules may be interconnected to constitute the units referred to. A 'library' of tested hardware sub modules is established, new modules may quickly be developed using these sub modules. A framework for unified protocol implementation and protocol interconnection is defined. This includes a real time operating system kernel with functions for buffer management, timing, pseudo parallel process execution and process communication. Author

N82-17110# Centre National de la Recherche Scientifique, Toulouse (France). Lab. d'Automatique et d'Analyse des Systemes.

RETRANSMISSION STRATEGIES FOR ERROR CONTROL IN PACKET TRANSMISSION PROTOCOLS [LES STRATEGIES DE RETRANSMISSION POUR LE CONTROLE D'ERREUR DANS LES PROTOCOLES DE TRANSFERT DE DONNEES]

G. JUANOLE *In* AGARD Tactical Airborne Distributed Computing and Networks 8 p (SEE N82-17086 08-01) Oct. 1981 refs In FRENCH

Avail: NTIS HC A18/MF A01

Packet transmission is based on a hierarchial model in which each of several levels uses the services of a lower level. This approach, which is essential for good visualization of the different functions necessary for transmission, also allows for the distinction of two levels in error control. A higher level is related to control on packet aerial (implemented by mechanisms of numbered packets, of responses to numbered packets, and to retransmission of nondischarged numbered packets). The lower level is related to the contents of numbered packets to responses (implemented by error detecting codes). These two levels clearly and precisely define different retransmission strategies. Two classes of strategies are defined: when the retransmission is due uniquely to a temporization which is implemented in the higher level, or when the retransmission is equally implemented following errors detected by the inferior level. In each class, different strategies are defined which result from different possible modalities. Transl. by A.R.H.

N82-17111# British Aerospace Aircraft Group, Brough (England). Avionics Systems Div.

PRACTICAL ASPECTS WHICH APPLY TO MIL-STD-1553B DATA NETWORKS

I. MOIR (Smiths Industries Aerospace and Defense Systems Co., Cheltenham, England) and P. A. DUKE *In* AGARD Tactical Airborne Distributed Computing and Networks 10 p (SEE N82-17086 08-01) Oct. 1981

Avail: NTIS HC A13/MF A01

The data bus offers many potential advantages over hardwired or dedicated data transmission systems in the design of Avionic Systems. Systems are interconnected by a single or redundant twisted pair of wires via standard interfaces, so reducing inter system wiring and the types and numbers of interfaces. The quantity of data transferred no longer has a direct influence on the inter system wiring and distributed computing becomes feasible. However in spite of the obvious advantages of a data bus system there are certain limitations which could be the source of much heartache to the system designer. Problems may result from transmission delays, digital sampling noise and the fundamental upper limit on data item-data rate product. Also, since interconnection between systems is via a common path, faults in the communication medium can have serious consequences, and therefore the use of redundancy and error correction techniques need to be employed. A stores management and weapon aiming system is discussed. Author

N82-17112# Fraunhofer-Inst. fuer Informations- und Datenverarbeitung, Karlsruhe (West Germany).
THE TRAFFIC FLOW IN A DISTRIBUTED REAL TIME COMPUTING SYSTEM (RDC-SYSTEM) WITH A FIBER-OPTIC RINGBUS SYSTEM
D. HEGER and R. BAEHRE *In* AGARD Tactical Airborne Distributed Computing and Networks 14 p (SEE N82-17086 08-01) Oct. 1981 refs
Avail: NTIS HC A18/MF A01

The new generation of automatic systems is essentially characterized by distributed multi-computer systems. The architecture is based on distributed microcomputer stations linked together by a bus system. These systems give much more design alternatives than conventional single or multicomputer systems, the danger of obtaining bottle necks of system performance is considerably greater than it was by using functional modules operating independently and simultaneously. Therefore, mathematical modelling of bus-linked multicomputer systems and the experimental evaluation of these models is online operation by means of measurements is of increasing importance. The 'really distributed control computer' system, and the traffic flow on its fiber optic ringbus system are described. Author

N82-17113# Draper (Charles Stark) Lab., Inc., Cambridge, Mass.
DISPERSED SENSOR PROCESSING MESH PROJECT
V. A. MEGNA *In* AGARD Tactical Airborne Distributed Computing and Networks 14 p (SEE N82-17086 08-01) Oct. 1981 refs
Avail: NTIS HC A18/MF A01

The F-8 dispersed sensor processing mesh project is an exploratory program involved in the development and test of the concept of a network communication structure. The elements of the structure are a bus controller and a number of nodes all of which are interconnected by multiple data flow paths. This structure is proposed as the communication medium between the subsystems of a distributed avionic system. In order to test and establish a data base for this proposed communication structure, the elements that comprise it must be designed and built. These elements are not just the hardware that is inherent to the structure, they also include the algorithms mechanized in the bus controller's software, the operating characteristic of the network, and the communication protocol used. The design and associated decisions made during the development of the network hardware and software are considered. A.R.H.

N82-17114# Hughes Aircraft Co., Fullerton, Calif.
NEXT GENERATION MILITARY AIRCRAFT WILL REQUIRE HIERARCHICAL/MULTILEVEL INFORMATION TRANSFER SYSTEMS
J. W. MCCUEN *In* AGARD Tactical Airborne Distributed Computing and Networks 8 p (SEE N82-17086 08-01) Oct. 1981 refs
Avail: NTIS HC A18/MF A01

Changes in avionic subsystems and mission roles of next generation aircraft require new concepts in data transfer. New aircraft need total airframe/weapon system integration which means new approaches must be developed for the interconnection of avionic subsystems. Effort has begun to develop a Military Standard (MIL-STD) which will define the requirements for a high speed data bus network. The standard shall characterize a higher order information transfer system (ITS) that will interconnect avionic systems, that contain their own multiplex ITS, into a fully integrated data complex. The higher order ITS shall employ an operational protocol that will provide subsystems and common sensors, independence and fault isolation by distributed control of the common data bus. Author

N82-17115# Bendix Corp., Teterboro, N. J. Flight Systems Div.
SIFT: AN ULTRA-RELIABLE AVIONIC COMPUTING SYSTEM
K. MOSES *In* AGARD Tactical Airborne Distributed Computing and Networks 10 p (SEE N82-17086 08-01) Oct. 1981
Avail: NTIS HC A18/MF A01

Software implemented fault tolerance (SIFT) is an ultra-reliable computing system which is based on a multiprocessor architecture that achieves fault tolerance by replicating computing tasks among processing units. Error detection and system configuration are performed by software to maintain the operational integrity of the computing system. The high speed inter-computer communication system required for operation realized by dedicated serial links arrayed in a star connection. Software algorithms are used for failure detection by means of voting, failure isolation to the faulty processor, and reconfiguration after fault detection. Frame synchronization between processors is employed to reduce data skew and minimize false alarms. The architecture of SIFT, its hardware implementation, and the test stand used for evaluation. Potential applications of this technique to current and anticipated ultra-reliable electrical flight control systems are given. A.R.H.

N82-17116# Naval Weapons Center, China Lake, Calif. Facility Engineering Branch.
STATE-OF-THE-ART COMPUTER MONITORING EQUIPMENT
H. G. NELSON *In* AGARD Tactical Airborne Distributed Computing and Networks 6 p (SEE N82-17086 08-01) Oct. 1981 refs
Avail: NTIS HC A18/MF A01

In any tactical airborne computing system, it is crucial for developers and maintenance personnel to know in considerable detail what is happening in side the computer on a real-time basis. This is especially true for a distributed system. A hardware monitor, called SOVAC (software validation and control), that provides a high-capacity, real-time, user-selective 'window' that gives visibility into the internal workings of the tactical computer is described. Author

N82-17117# Royal Aircraft Establishment, Farnborough (England).
INTEGRATED CONTROL OF MECHANICAL SYSTEM FOR FUTURE COMBAT AIRCRAFT
G. W. WILCOCK, P. A. LANCASTER, and C. MOXEY *In* AGARD Tactical Airborne Distributed Computing and Networks 16 p (SEE N82-17086 08-01) Oct. 1981 refs Prepared in cooperation with British Aerospace, Warton Sponsored in part by Procurement Executive MOD
Avail: NTIS HC A18/MF A01

Various techniques for the application of digital control to aircraft utility systems were investigated. It is shown that the prefered approach utilizes a number of distributed processors and terminals that interface with the utility components. Analysis performed to data shows a weight saving of approximately 100 Kg (i.e. 50%), and a pilot workload reduction of the order of 4:1, may be achieved in a twin engine combat aircraft. A.R.H.

N82-17118# Avions Marcel Dassault-Breguet Aviation, Saint-Cloud (France).
MIRAGE 2000 WEAPONS SYSTEMS ARCHITECTURE [ARCHITECTURE DU SYSTEME D'ARMES DU MIRAGE 2000]
S. CROCE-SPINELLI, B. VANDECASTEELE, and J. F. FERRERI *In* AGARD Tactical Airborne Distributed Computing and Networks 18 p (SEE N82-17086 08-01) Oct. 1981 In FRENCH
Avail: NTIS HC A18/MF A01

The architecture for the Mirage 2000 weapon system, which represents an advanced generation digital system, is described from the following viewpoints: (1) the digital equipment; (2) the distribution of among the equipment; (3) the digital links; and (4) the inflight monitoring of the system. The principal on which the design is based, the methods of development, and the tests required are analyzed. The inherent flexibility of the system permits its adaptation to different operational requirements, and to different possible versions. Transl. by A.R.H.

N82-17119# McDonnell Aircraft Co., St. Louis, Mo.
F/A-18A TACTICAL AIRBORNE COMPUTATIONAL SUBSYSTEM
T. V. MCTIGUE *In* AGARD Tactical Airborne Distributed Computing and Networks 14 p (SEE N82-17086 08-01) Oct. 1981 refs
Avail: NTIS HC A18/MF A01

The F/A-18A Hornet tactical computer subsystem consists of two central mission computers and a number of distributed processors embedded in various sensor and display subsystems. This distributed processing system is interconnected by and communicates over a MIL-STD-1553A serial 1 MHz command/response multiplex network. The distributed processing system architecture is discussed and the rationale is presented for the partitioning of the computational tasks between the central mission computers and the distributed processors embedded in the sensor subsystems. The salient features of the central mission

computer and the distributed processors are discussed along with a description of the functional operation of the interconnecting MIL-STD-1553A multiplex communications system. The development process for the Operational Flight Program (OFP) for the Central mission computers is described and the support facilities which were used for the software integration and validation are discussed. A.R.H.

N82-17120# Naval Weapons Center, China Lake, Calif. F-18 Facility Branch.
F/A-18 WEAPONS SYSTEM SUPPORT FACILITIES
T. F. ONEILL *In* AGARD Tactical Airborne Distributed Computing and Networks 7 p (SEE N82-17086 08-01) Oct. 1981
Avail: NTIS HC A18/MF A01

The U.S. Navy is currently acceptance-testing the McDonnell Douglas F/A-18 aircraft. Since the F/A-18 is so much more complex than any aircraft current deployed, more sophisticated support tools will be required. The main support tool is to be a weapons system support facility including all of the hardware and software necessary to test, modify, and validate all of the avionics hardware, software, and firmware. A distributed processing approach is used in the facility, which contains several minicomputers and super minicomputers. Author

N82-22154# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
DYNAMIC ENVIRONMENTAL QUALIFICATION TECHNIQUES
Dec. 1981 245 p refs Partly in ENGLISH; one in FRENCH
Proceedings of the 53rd Meeting of the Structures and Mater. Panel, Noordwijkerhout, Netherlands, 27 Sep. - 2 Oct. 1981 (AGARD-CP-318; ISBN-92-835-0306-6; AD-A112553) Avail: NTIS HC A11/MF A01

The state of the art of dynamic qualification techniques and test methods for military aircraft with external stores are reviewed, including consideration of the rationale and interpretation of existing standards. The determination of environmental inputs from various sources and their application to specific aircraft and store configurations, including helicopters, are covered. Presentations were also given on the development of vibration analysis techniques and the evaluation of possible improvements in prediction methods and establishment of criteria. For individual titles, see N82-22155 through N82-22171.

N82-22155# Air Force Wright Aeronautical Labs., Wright-Patterson AFB, Ohio. Combined Environments Test Group.
DEVELOPMENT AND USE OF DYNAMIC QUALIFICATION STANDARDS FOR AIR FORCE STORES
A. H. BURKHARD and O. F. MAURER *In* AGARD Dyn. Environ. Qualification Tech. 7 p (SEE N82-22154 13-01) Dec. 1981 refs
Avail: NTIS HC A11/MF A01

The cataloging and standardization act for the standardization of items, materials, and engineering practices in the defense industry is discussed. Formal procedures for generating, updating, and utilization of these documents are presented. The advantages of standardization leading to simplification of procurement, development, and production processes by fostering uniformity, direct comparability, interchangeability of standardized objects are outlined. The state of the art of test techniques and procedures are considered. E.A.K.

N82-22156# Cape Warwick Ltd., Warwick (England). Environmental Engineering Div.
PROBLEMS IN THE GROUND SIMULATION OF DYNAMIC RESPONSES INDUCED IN EXTERNALLY CARRIED STORES DURING FLIGHT
J. HOMFRAY *In* AGARD Dyn. Environ. Qualification Tech. 24 p (SEE N82-22154 13-01) Dec. 1981 refs
Avail: NTIS HC A11/MF A01

The difficulties encountered in testing stores over a wide frequency band are described. This wide frequency range has lead to vibration tests using single point excitation with an electrodynamic shaker, to cover the low frequency regime, and tests using distributed acoustic excitation to cover the middle and high frequency regimes. Both types of test are discussed and the particular difficulties encountered with large, comparatively low density thin skinned stores are emphasized. Shortcomings inherent in the current techniques are highlighted and the validity of MIL-STD-810C as a means of determining test levels in the absence of flight data is examined. It is concluded that the current two part test technique is not particularly realistic when applied to the large thin skinned stores. E.A.K.

N82-22157# Centre d'Essais Aeronautique Toulouse (France).
PROGRESS IN ELABORATING TEST PROGRAMS FOR A MECHANICAL ENVIRONMENT [PROGRESS DANS L'ELABORATION DES PROGRAMMES D'ESSAIS D'ENVIRONNEMENT MECANIQUE]
M. COQUELET *In* AGARD Dyn. Environ. Qualification Tech. 16 p (SEE N82-22154 13-01) Dec. 1981 refs In FRENCH
Avail: NTIS HC A11/MF A01

Whether aircraft equipment is placed in external stores or in another part of the aircraft, it is subject to ambient vibration created by flight (caused by the engine, aerodynamics, or the use of weapons). The engineer is thus faced with the problem of qualifying various equipment with regard to vibratory constraints. The procedures to be applied for qualification and the degree of severity to be adopted to cover the use of the equipment are considered. Maximum spectral densities are shown for the Airbus A300, Transvall C160, Carvelle, Alphajet, the new generation Atlantic, and the Mirage 2, Mirage F1, and Mirage 2000 aircraft. Recommendations made regarding Aero norms 612 and change proposals for MIL-STD-810 are discussed. Transl. by A.R.H.

N82-22158# British Aerospace Aircraft Group, Preston (England). Specialist Functions, Stress Office.
QUALIFICATION OF EQUIPMENT FOR GUNFIRE INDUCED VIBRATION
A. PEACOCK *In* AGARD Dyn. Environ. Qualification Tech. 22 p (SEE N82-22154 13-01) Dec. 1981 refs
Avail: NTIS HC A11/MF A01

A method to ensure that the Tornado MK1 aircraft equipment withstand gunfire induced vibrations is described. The derivation of test spectra from rig and aircraft measurements is explained. Test failures and in-service malfunctions are reviewed. A comparison with Mil specification is made. E.A.K.

N82-22159# General Dynamics/Fort Worth, Tex.
DYNAMIC QUALIFICATION TESTING OF F-16 EQUIPMENT
H. E. NEVIUS and W. J. BRIGNAC *In* AGARD Dyn. Environ. Qualification Tech. 15 p (SEE N82-22154 13-01) Dec. 1981
Avail: NTIS HC A11/MF A01

Vibration prediction methods and qualification test procedures are presented for F-16 equipment. Measured vibration levels are also compared to the predictions. The most severe vibratory environment is produced by the muzzle blast pressure during gunfiring. Gunfiring vibration was measured during the YF-16 prototype program which indicated a correlation between vibration levels and distance from the gun port. Vibration data are presented verifying this relationship. Nongunfiring random vibration test levels are shown for F-16 airframe zones. The prediction procedures were based on a relationship between vibration and dynamic pressure using measured data from other aircraft. Vibration levels were measured on fuselage mounted stores. Other measured dynamic environments are presented which include wing tip missile response to store ejection from wing pylons and to jet wake encounter, and buffet response at high-angles-of-attack. Author

N82-22160# McDonnell-Douglas Corp., St. Louis, Mo. Structural Dynamics Sect.
DEVELOPMENT OF VIBRATION QUALIFICATION TEST SPECTRA FOR THE F-15 AIRCRAFT
G. R. WAYMON *In* AGARD Dyn. Environ. Qualification Tech. 19 p (SEE N82-22154 13-01) Dec. 1981 refs
Avail: NTIS HC A11/MF A01

The vibration test spectra used for an F-15 Eagle were based on analytical predictions combined with measured data from similar aircraft. The low frequency vibration below approximately 50 Hertz results primarily from aircraft response to gusts, buffet, landing, and taxi excitation. Vibration at higher frequencies is primarily associated with acoustical excitation and gunfire. The airplane was divided into regions of comparable vibration levels. The test levels were derived using the predicted spectra and applying factors to define a performance and an endurance test. The F-15 flight

measured data were used to update these predictions for the present test spectra. Author

N82-22161# British Aerospace Aircraft Group, Kingston-upon-Thames (England).
EQUIPMENT VIBRATION QUALIFICATION FOR HARRIER AND HAWK AIRCRAFT
D. C. THORBY *In* AGARD Dyn. Environ. Qualification Tech. 7 p (SEE N82-22154 13-01) Dec. 1981 refs
Avail: NTIS HC A11/MF A01

Equipment for later versions of the Harrier and all versions of the Hawk aircraft were cleared for flight vibration using test procedures based on the current British Standard. The rationale used in applying this Specification, and the flight vibration test procedures are briefly outlined from a practical viewpoint. Author

N82-22162# Industrieanlagen-Betriebsgesellschaft m.b.H., Ottobrunn (West Germany).
ACOUSTIC NOISE TEST AS PART OF THE DYNAMIC QUALIFICATION PROGRAM IN AEROSPACE
G. BAYERDOERFER *In* AGARD Dyn. Environ. Qualification Tech. 7 p (SEE N82-22154 13-01) Dec. 1981
Avail: NTIS HC A11/MF A01

The mechanisms of noise generation for the purpose of acoustic qualification tests are described. Special emphasis is given to the modal density of acoustic noise fields in enclosures, such as reverberation chambers. A test program shows that for small components a sufficient modal density can be achieved in relatively small test chambers. Where applicable small chambers are favorable because of the lower test costs. Author

N82-22163# Messerschmitt-Boelkow-Blohm G..n.b.H., Munich (West Germany). Aircraft Div.
VIBRATION QUALIFICATION OF EXTERNAL A/C STORES AND EQUIPMENT
M. STEININGER and G. HAIDL *In* AGARD Dyn. Environ. Qualification Tech. 14 p (SEE N82-22154 13-01) Dec. 1981 refs
Avail: NTIS HC A11/MF A01

Prediction methods for a first assessment of vibration levels and spectra are described and application results are compared with measured vibration environment in relevant flight conditions. Signal nature and analysis technique are examined. The technique for a representative dynamic environment simulation in the laboratory especially for external store configurations is described. Different mounting and excitation methods as well as selection of shaker control reference signals are compared and discussed. Requirements for test facilities, mounting rigs and shaker capabilities are also presented. E.A.K.

N82-22164# Vereinigte Flugtechnische Werke-Fokker G.m.b.H., Bremen (West Germany). Abt. Dynamik/Aeroelastik.
AIRCRAFT FUEL TANK SLOSH AND VIBRATION TEST
H. ZIMMERMANN *In* AGARD Dyn. Environ. Qualification Tech. 11 p (SEE N82-22154 13-01) Dec. 1981
Avail: NTIS HC A11/MF A01

A dynamic qualification test for a subsonic and a supersonic external drop tank for a European fighter is presented. The test rig and the specimens are described and the measuring results are discussed. It is shown that for the supersonic tank as well as for the subsonic tank a certain slosh angle an eigenfrequency of the rig increases the amplitudes at the excitation position and the accelerations on the tank. For the subsonic tank it seems that an eigenfrequency is excited for the nose down position of the tank. The qualification requirements are examined. It is proposed that instead of using an arbitrary vibration amplitude and frequency for excitation, frequency ranges and amplitudes which are averaged out of flight measurements at the tank attachment points on the aircraft be used and that the demand for a certain input amplitude at the top of the attachment bulkheads and an output amplitude at the bottom of the attachment bulkheads be deleted. E.A.K.

N82-22165# Army Aviation Research and Development Command, St. Louis, Mo. Structures and Aeromechanics Div.
THE STRUCTURAL DYNAMIC INTERFACE REQUIRED FOR DEVELOPING HELICOPTER TARGET ACQUISITION SYSTEMS
S. T. CREWS *In* AGARD Dyn. Environ. Qualification Tech. 9 p (SEE N82-22154 13-01) Dec. 1981 refs
Avail: NTIS HC A11/MF A01

A brief description of the helicopter vibration environment is given. Two development programs were used as examples to show how vibration sensitive target acquisition systems can be interfaced to a helicopter. The systems are the Target Acquisition Data System/Pilot Night Vision System mounted to the nose of the Army's new Advanced Attack Helicopter and the Stand-Off Target Acquisition System mounted underneath the Army's BLACK HAWK helicopter. The qualification strategy and specific testing performed and to be performed are included. Author

N82-22166# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (West Germany).
APPROACH IN DYNAMIC QUALIFICATION OF LIGHT HELICOPTER STORES AND EQUIPMENTS
D. BRAUN and J. STOPPEL *In* AGARD Dyn. Environ. Qualification Tech. 8 p (SEE N82-22154 13-01) Dec. 1981 refs
Avail: NTIS HC A11/MF A01

Problems occurring in connection with the dynamic qualification of equipment and external stores for light military helicopters are evaluated. Special features of the helicopter vibratory environment are discussed. Some general recommendations for the procedure of dynamic qualification for use with helicopters are given. The approach for dynamic qualification of relatively heavy equipment is presented using the example of combining the MBB BO 105 helicopter with HOT anti-tank missile launchers. To obtain a basic understanding of the dynamic behavior of the helicopter with external stores preliminary dynamic calculations were made. Shake tests were done with the separated external stores and flight test vibration measurements were obtained. Test results are presented with regard to the harmonic main rotor excitation. M.D.K.

N82-22167# Westland Helicopters Ltd., Yeovil (England). Dynamics Dept.
THE DYNAMIC QUALIFICATION OF EQUIPMENT AND EXTERNAL STORES FOR USE WITH ROTARY WINGED AIRCRAFT
G. M. VENN *In* AGARD Dyn. Environ. Qualification Tech. 11 p (SEE N82-22154 13-01) Dec. 1981
Avail: NTIS HC A11/MF A01

The dynamic regime imposed on helicopter-borne stores and equipment, highlighting the differences between the rotary and fixed-wing environments are outlined. The need for helicopter requirements to be addressed in particular is discussed. The influence of a number of contributory factors to the dynamic environment arising from varying military applications covering both land and sea operation is also discussed. The dynamic criteria for design and testing are given, explaining the particular influence of discrete sinusoidal forcing on the helicopter environment. The evolution of these standards and their consolidation through flight and service experience is explained. Some views on the future development of dynamic qualification criteria for rotary-winged aircraft are also outlined. M.D.K.

N82-22168# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Goettingen (West Germany). Inst. of Aeroelasticity.
APPLICATION OF MODAL SYNTHESIS TECHNIQUES FOR THE DYNAMIC QUALIFICATION OF WINGS WITH STORES
E. BREITBACH *In* AGARD Dyn. Environ. Qualification Tech. 22 p (SEE N82-22154 13-01) Dec. 1981 refs
Avail: NTIS HC A11/MF A01

Dynamic qualification as well as flutter clearance of modern combat aircraft were studied using modal coupling methods. Emphasis was placed on how to deal with special phenomena due to nonlinearities, in particular combinations of backlash and dry friction, in the connecting parts between wing, pylon and store which may significantly infringe on the validity of the linear mathematical models as used in ground and flight vibration testing. M.D.K.

N82-22169# Boeing Military Airplane Development, Seattle, Wash. Structural Dynamics Dept.
STOL AIRCRAFT STRUCTURAL VIBRATION PREDICTION FROM ACOUSTIC EXCITATION
B. F. DOTSON and J. PEARSON (AFWAL) *In* AGARD Dyn. Environ. Qualification Tech. 20 p (SEE N82-22154 13-01) Dec. 1981 refs
Avail: NTIS HC A11/MF A01

A method was developed to improve environment vibration prediction methods, particularly in the lower frequency range where high acoustic excitation is expected on STOL aircraft. A rigorous mathematical spectral analysis approach was used which simulated the structure with finite element models (FEM) and used measured and calculated acoustic input data for the forcing function. Calculated and measured vibrations levels were compared on a medium sized Upper Surface Blowing (USB) STOL aircraft. The development of a method for prediction of the external acoustic environment of USB flap-type STOL aircraft was also accomplished. The method compares favorably with actual measurements and represents a significant improvement in acoustic prediction methods for aircraft with USB type flaps. The method includes scaling factors for engine size, thrust, aircraft size, and other parameters. Finally, noise and vibration levels were predicted on a small STOL aircraft and later compared to measured data. Author

N82-22170# Royal Aircraft Establishment, Farnborough (England). Aerodynamics Dept.
GUNFIRE BLAST PRESSURE PREDICTIONS
R. M. MUNT, A. J. PERRY, and S. A. MOORSE *In* AGARD Dyn. Environ. Qualification Tech. 20 p (SEE N82-22154 13-01) Dec. 1981 refs
Avail: NTIS HC A11/MF A01

A scheme for predicting the blast pressures from aircraft guns is presented which extends existing theory. The predictions correlate well with some experimental measurements of gun blast pressures in free space. Blast pressures were also measured experimentally on a surface in the vicinity of the muzzle of a 7.62 mm rifle but these could only be satisfactorily predicted in regions where the classical theory of regular reflection of shock waves could be applied. These results are discussed in relation to the surface blast pressures from aircraft mounted guns. Author

N82-22171# Grumman Aerospace Corp., Bethpage, N.Y.
DEVELOPMENT OF A TAPED RANDOM VIBRATION TECHNIQUE FOR ACCEPTANCE TESTING
J. DEVITT, R. POKALLUS, J. POPOLO, and E. BAIRD *In* AGARD Dyn. Environ. Qualification Tech. 6 p (SEE N82-22154 13-01) Dec. 1981
Avail: NTIS HC A11/MF A01

The use of random vibration as a screen for latent workmanship problems normally found in avionic equipment, proved to be significantly more effective than the sinusoidal form of excitation normally employed. This was demonstrated and is now required for acceptance testing by various DoD agencies. The results of a program to develop an economical technique for generating random vibration utilizing an audio tape deck indicate that compensating factors can be developed to account for the variations that exist in generically identical equipment. Using these factors, synthetic random tapes were generated. Author

N82-22172# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
MAINTENANCE IN SERVICE OF HIGH TEMPERATURE PARTS
Jan. 1982 162 p refs Meeting held at Noordwijkerhout, Netherlands, 27 Sep. - 2 Oct. 1981
(AGARD-CP-317; AD-A112549) Avail: NTIS HC A08/MF A01

The problem areas in the inspection, repair, and life extension and prediction of gas turbine engine parts are addressed. For individual titles, see N82-22173 through N82-22186.

N82-22173# Ministry of Defence, London (England).
MILITARY MAINTENANCE POLICIES AND PROCEDURES FOR HIGH-TEMPERATURE PARTS. WILL THEY BE ADEQUATE?
R. B. G. HEDGECOCK *In* AGARD Maintenance in Serv. of High Temp. Parts 7 p (SEE N82-22172 13-01) Jan. 1982 refs
Avail: NTIS HC A08/MF A01

The problems involved in developing engine parts maintenance policies which incorporate life estimation, inspection, repair and containment of costs are examined. Computer-based engine usage monitoring systems and a low cycle atigue counter are described along with assembled and unassembled engine inspection procedures and repair techniques. M.G.

N82-22174# Dayton Univ., Ohio. Graduate Materials Engineering Program.
ENGINE DEPOT MAINTENANCE REPAIR TECHNOLOGY
J. A. SNIDE and W. J. SCHULZ (AFWAL) *In* AGARD Maintenance in Serv. of High Temp. Parts 19 p (SEE N82-22172 13-01) Jan. 1982 refs
Avail: NTIS HC A08/MF A01

The scope and mission of the two USAF engine Air Logistics Centers are described. The various processes and organizational structure to identify repair technology requirements are discussed. Approaches to transition and implementation of new technology into a repair depot environment are described. Specific examples of technology developments described are: braze repair, laser metrology, electrophoretic, coatings, sputtered MCrAlY overlay coating and inlet guide vane vibration damping. Author

N82-22175# Naval Aircraft Materials Lab., Fleetlands (England).
MAINTENANCE PROBLEMS IN GAS TURBINE COMPONENTS AT THE ROYAL NAVAL AIRCRAFT YARD, FLEETLANDS
F. J. PLUMB *In* AGARD Maintenance in Serv. of High Temp. Parts 13 p (SEE N82-22172 13-01) Jan. 1982 refs
Avail: NTIS HC A08/MF A01

The work of the engine repair facility at Fleetlands and the major problems found in the overhaul and repair of helicopter and marine gas turbines are discussed. Remedies for component reserviceability, developments to obtain longer service lives, and the techniques employed are discussed. Author

N82-22176# KLM Royal Dutch Airlines, Amsterdam (Netherlands). Propulsion Systems Dept.
MAINTENANCE EXPERIENCE WITH CIVIL AERO ENGINES
J. P. STROOBACH *In* AGARD Maintenance in Serv. of High Temp. Parts 3 p (SEE N82-22172 13-01) Jan. 1982
Avail: NTIS HC A08/MF A01

The trends in high temperature parts maintenance concept developments are reviewed, indicating the constant activities to optimize the maintenance cost of the propulsion system. As a result of the escalating trends in material and fuel prices, the presently applied maintenance concepts require a more sophisticated condition control in order to comply with the need to find the optimum operating time of each individual engine. With the introduction of the new generation of civil aircraft (Airbus A310) a mutual goal between the engine manufacturer and the airline was defined to develop mathematical programs, based on actual recorded conditions, in order to control the behavior of the engine, aiming at an optimum use of the propulsion system. M.G.

N82-22177# Pratt and Whitney Aircraft Group, West Palm Beach, Fla. Government Products Div.
ENGINE COMPONENT RETIREMENT FOR CAUSE
J. A. HARRIS, JR., C. G. ANNIS, JR., M. C. VANWANDERHAM, and D. L. SIMS *In* AGARD Maintenance in Serv. of High Temp. Parts 9 p (SEE N82-22172 13-01) Jan. 1982 refs
Avail: NTIS HC A08/MF A01

An engine part retirement for cause (RFC) procedure is discussed which would allow safe utilization of the full life capacity of each individual component. Since gas turbine rotor components are prime candidates and are among the most costly of engine components, adoption of a RFC maintenance philosophy could result in substantial engine systems life cycle cost savings. Two major technical disciplines must be developed and integrated to realize these cost savings: fracture mechanics and nondestructive evaluation. The methodology and development activity required to integrate these disciplines that provide a viable RFC system for use on military gas turbine engines is discussed. The potential economic benefits of its application to a current engine system are also illustrated. M.G.

N82-22178# Rolls-Royce Ltd., Derby (England). Dept. of Materials Engineering.
DEFECTS AND THEIR EFFECT ON THE BEHAVIOR OF GAS TURBINE DISCS
R. H. JEAL *In* AGARD Maintenance in Serv. of High Temp. Parts 15 p (SEE N82-22172 13-01) Jan. 1982
Avail: NTIS HC A08/MF A01

Unless the method used to life fatigue critical components like gas turbine discs allows assessment of defect presence and behavior, the risk of serious failure is dramatically increased. A method is discussed where defect behavior can be assessed as part of a total life approach to disc behavior prediction and is explained together with the effects of differing defect types. Such an approach gives realistic manufacturing standards and controls and leads directly to an 'on condition life' approach. Author

N82-22179# Elbar B.V., Lomm (Netherlands).
A TITANIUM SILICON COATING FOR GAS TURBINE BLADES
G. H. MARIJNISSEN *In* AGARD Maintenance in Serv. of High Temp. Parts 8 p (SEE N82-22172 13-01) Jan. 1981 refs
Avail: NTIS HC A08/MF A01

High temperature corrosion in industrial and marine gas turbines is the result of the increased inlet gas temperature of the turbine, which improves the economy, and the use of cheaper fuels, which contain more impurities. In order to reduce high temperature corrosion, a Ti-Si coating was developed on the laboratory scale. With this coating on In 738, a number of corrosion tests were performed. For further development of the coating, and for a better understanding of the behavior and degradation of the coating, insight into the corrosion mechanisms is required. On the basis of the laboratory development, the Ti-Si coating was further developed to produce an industrial coating, Elcoat 360, for use on hot components in gas turbines made of different nickelbase superalloys. Furthermore, other corrosion and oxidation tests were performed, as a result of which the behavior and the degradation of the coating is now better understood. Tests with Elcoat 360 in *gas turbines are still running.* Author

N82-22180# Office National d'Etudes et de Recherches Aerospatiales, Paris (France).
THE INFLUENCE OF PROTECTIVE TREATMENT ON THE MECHANICAL PROPERTIES OF SUPERALLOY PARTS [INFLUENCE DES TRAITEMENTS DE PROTECTION SUR LES PROPRIETES MECANIQUES DES PIECES EN SUPERALLIAGE]
J. M. HAUSER, C. DURET, and R. PICHOIR *In* AGARD Maintenance in Serv. of High Temp. Parts 11 p (SEE N82-22172 13-01) Jan. 1982 refs In FRENCH
Avail: NTIS HC A08/MF A01

The high temperature environment of aircraft turbine engines requires the use of protective coatings for engine parts. These coatings are particularly necessary when the composition of the superalloys used and associated heat treatment are chosen in order to obtain the best mechanical properties. The durability of these components is determined not only by the mechanical properties of the protected heat resistance alloys, but equally by the resistance of the coating to oxidation and corrosion. To restore this protection can pose diverse problems and, in certain cases, constitute an additional factor in reducing fatigue life. These aspects are considered and illustrated by results obtained from aluminium coatings applied to IN 100 and IN 738LC superalloys. Factors inherent i to t elaboration of the protection are also considered.
Transl. by A.R.H.

N82-22181# Societe Nationale d'Etude et de Construction de Moteurs d'Aviation, Paris (France). Dept. Materiaux et Procedes.
TURBINE STATOR PARTS REPAIR BY DIFFUSION BRAZING
Y. HONNORAT and J. LESGOURGUES *In* AGARD Maintenance in Serv. of High Temp. Parts 12 p (SEE N82-22172 13-01) Jan. 1982 In FRENCH; ENGLISH summary
Avail: NTIS HC A08/MF A01

With very close surfaces (maximum gap of approximately 50 micrometer for superalloys), bonding areas obtained by diffusion brazing have the same properties as the parent material. This technique is successfully applied for repair of fine cracks affecting turbine vanes after operation. However, a technique was developed to eliminate those defects which exceed maximum tolerated gaps. This process, called, diffusion brazing repair (RBD), allows bonding without geometrical limits from pre-alloyed powders. While diffusion brazing produces homogeneous bonding, the chemical composition of the repaired area after RBD processing is slightly *different from* that of the part. But, rough part properties can be maintained in the bonding area, provided that operating parameters of the RBD cycle are adequately selected. The two techniques may have various repair applications which are considered. Author

N82-22182# Canadian Westinghouse Co., Ltd., Hamilton (Ontario).
REJUVENATION OF USED TURBINE BLADES BY HOT ISOSTATIC PRESSING AND REHEAT TREATMENT
K. L. CHEUNG, C. C. LEACH, K. P. WILLETT, and A. K. KOUL (National Research Council of Canada) *In* AGARD Maintenance in Serv. of High Temp. Parts 6 p (SEE N82-22172 13-01) Jan. 1982 refs
Avail: NTIS HC A08/MF A01

Gas turbine blades operating at high temperature and stress experience microstructural transformations which eventually lead to their replacement. The occurrence of creep beyond allowable limits is a major cause of turbine blade replacement. Microstructure and properties of many superalloys can be restored by reheat treatment. This restoration is only partially effective if internal creep voids are present. Hot isostatic pressing is a process which can be used to heal such creep voids and, in conjunction with the reheat treatment, provides a viable method for the rejuvenation of used turbine blades. Author

N82-22183# Chromalloy Div.-Oklahoma, Midwest City.
HIP PROCESSING: POTENTIALS AND APPLICATIONS
W. J. VANDERVET *In* AGARD Maintenance in Serv. of High Temp. Parts 16 p (SEE N82-22172 13-01) Jan. 1982 refs
Avail: NTIS HC A08/MF A01

From its inception as a means of gas pressure bonding nuclear fuel assemblies, hot isostatic pressing (HIP) today finds a wide variety of uses from cermet cutting tool manufacture, to the production and rejuvenation of gas turbine hardware. The results obtained on complete engine sets of Inconel X-750, Udimet 500 and Rene' 100 turbine blades indicate that HIP processing is capable of restoring new or near new creep properties and low cycle fatigue properties to used blades. The process should be applicable to most superalloys; nevertheless, recent work emphasized the need for preproduction process parameter verification to establish optimum cycles which take into account both the metallurgical and mechanical aspects of superalloys.
A.R.H.

N82-22184# National Physical Lab., Teddington (England).
REGENERATION OF THE CREEP PROPERTIES OF A CAST NI-CR-BASE ALLOY
H. R. TIPLER *In* AGARD Maintenance in Serv. of High Temp. Parts 6 p (SEE N82-22172 13-01) Jan. 1982 refs
Avail: NTIS HC A08/MF A01

The effectiveness of hot isostatic pressing (hipping) as a means of removing the damage which accumulates during creep was investigated by testing specimens for times up to 85% of their rupture life (approximately 9000h or 900h) applying a hipping treatment and then continuing the creep test, under the same conditions, to failure. A comparison of the properties of material tested to rupture without interruption and material tested to rupture after hipping at some stage during secondary or tertiary creep shows that improvements of up to 55% in the rupture life can be obtained by the use of this regenerative treatment and that the creep resistance is also restored. The practical implications of the work relate to the application of regenerative treatments to extend the life of gas turbine components removed from service during periodic overhaul. Author

N82-22185# Motoren- und Turbinen-Union Muenchen G.m.b.H. (West Germany).
REPAIR AND REGENERATION OF TURBINE BLADES, VANES AND DISCS
H. HUFF and J. WORTMANN *In* AGARD Maintenance in Serv. of High Temp. Parts 7 p (SEE N82-22172 13-01) Jan. 1982 refs
Avail: NTIS HC A08/MF A01

The repair of incipiently cracked turbine components is essentially limited to non-rotating parts. Repairs to rotating parts are carried out on low-stressed areas, such as seals, only. In this

case, weld build-up has proved to be a suitable process. Stator vanes can be high-temperature brazed following reduction annealing. However, problems are encountered when it comes to making sure of the complete removal of oxides. A highly promising method for increasing the reliability of turbine blades that have been in service lies in their regeneration by heat treatment or HIP-processing. Results to date are so positive that the use of regenerated blades may be a reality in the near future. However, a prerequisite for the use of these repair procedures is a guarantee of reliability and a knowledge of the stresses that occur during operation. A.R.H.

N82-22186# Elbar B.V., Lomm (Netherlands).
A NEW APPROACH TO THE WELDABILITY OF NICKELBASE, AS-CAST AND POWDER METALLURGY SUPERALLOYS
M. H. HAAFKENS and J. H. G. MATTHEY *In* AGARD Maintenance in Serv. of High Temp. Parts 13 p (SEE N82-22172 13-01) Jan. 1982 refs
Avail: NTIS HC A08/MF A01

Crack formation in the HAZ associated with the welding of high gamma' content nickelbase superalloys is due mainly to the shrinkage, which takes place during precipitation of the gamma'. Crack formation can be prevented by controlling the cooling rate during welding of these alloys. On the basis of measurements, which illustrate the relationships between a given cooling rate after welding, the partial effects of the elements Co, Cr, Al and Ti on the weldability were calculated, and this allowed a modified weldability diagram for nickelbase superalloys to be established. Simple hardness measurements appear to give really useful results for crack-free TIG welding, plasma welding, friction welding and EB welding of nickelbase superalloys. Small differences in chemical composition and the degree of homogeneity of the gamma-gamma' structure can have a decisive effect on the welding behavior of superalloys. Author

N82-22187# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
COMBAT AIRCRAFT MANOEUVRABILITY
Dec. 1981 242 p refs In ENGLISH and FRENCH Proceedings of the Flight Mechanics Panel Symp., Florence, 5-8 Oct. 1981 (AGARD-CP-319; ISBN-92-835-0304-X; AD-A112310) Avail: NTIS HC A11/MF A01

The symposium reviewed the operational requirements for combat aircraft maneuverability, technical prospects for maneuverability improvements, and prediction and assessment methods and their value. For individual titles, see N82-22188 through N82-22205.

N82-22188# Service Techniques des Programmes Aeronautiques, Paris (France). Section Etudes Generalles.
A REVIEW OF RECENT AGARD SYMPOSIA ON THE ANGLE OF MANEUVERABILITY OF COMBAT AIRCRAFT [RETROSPECTIVE DE RECENTS SYMPOSIUMS AGARD SOUS L'ANGLE DE LA MANOEUVRABILITE DES AVIONS DE COMBAT]
J. M. DUC (Service des Recherches/Groupe 6) and M. VERGNE *In* AGARD Combat Aircraft Maneuverability 50 p (SEE N82-22187 13-01) Dec. 1981 refs In FRENCH
Avail: NTIS HC A11/MF A01

The notion of maneuverability, in terms of flight mechanics, as it was treated at meetings of the Fluid Dynamics and Fluid Mechanics Panels during the past ten years is reviewed. Each point discussed is illustrated by graphics taken from previously cited AGARD proceedings. Operational needs, hopes for improvement, methods for prediction, and methods for evaluation of flight qualities at high incidence are examined. A.R.H.

N82-22189# Royal Netherlands Air Force, Soesterberg.
REVIEW OF PRACTICAL EXPERIENCE ON COMBAT AIRCRAFT MANEUVERABILITY
A. W. HENNI *In* AGARD Combat Aircraft Maneuverability 8 p (SEE N82-22187 13-01) Dec. 1981
Avail: NTIS HC A11/MF A01

Based upon practical experience in both air to air and air to ground operations with F-84F, F-104G, and NF-5 fighter aircraft, an assessment is given of the importance of combat aircraft maneuverability. In air to ground operations the effect of limited maneuverability on tactics is treated in terms of speed/altitude and maneuverability requirements during ingress/egress and weapon delivery, in relation to attack effectiveness and survivability against enemy defenses. For air to air operations the parameters that influence the outcome of a maneuvering flight are identified. The relation between maneuverability and tactics is discussed. It is concluded that the impact of maneuverability on mission effectiveness becomes less prominent at increasing total number of air to air capable aircraft, fighting in a limited airspace. Dependent on the type of operation, desirable improvements in maneuverability are discussed with emphasis on turn performance (at low speeds), rapid speed changes and direct force generation. In this context human tolerance limits are taken into account. It is stressed that the main problems confronting a fighter pilot in the Central European environment are not related to maneuverability but to the availability of military subsystems. M.G.

N82-22190# Naval Air Systems Command, Washington, D. C.
THE MILITARY FLYING QUALITIES SPECIFICATION, A HELP OR A HINDRANCE TO GOOD FIGHTER DESIGN
R. C. AHARRAH and R. J. WOODCOCK (AFWAL, Wright-Patterson AFB, Ohio) *In* AGARD Combat Aircraft Maneuverability 13 p (SEE N82-22187 13-01) Dec. 1981 refs
Avail: NTIS HC A11/MF A01

Based on experience with Air Force and Naval aircraft, the current qualities specification is evaluated for application to a future fighter design. Analog and digital fly by wire flight control system having multiple redundancy levels and significant control law variation are discussed. Some specific observations are shared on the following topics with regard to the flying qualities in general and the specification in particular time delays, force commands, forward loop integration, high gains, signal blending, equivalent systems, pilot location, high angle of attack, roll performance, and systems integration. In addition, some general observations are made on the use of MIL-P-8785B, and a Navy conducted survey on the effectiveness of the flying qualities specification is discussed. M.G.

N82-22191# Systems Technology, Inc., Hawthorne, Calif.
DEVELOPMENT OF A TENTATIVE FLYING QUALITIES CRITERION FOR AIRCRAFT WITH INDEPENDENT CONTROL OF SIX DEGREES OF FREEDOM: ANALYSIS AND FLIGHT TEST
R. H. HOH, T. T. MYERS, and I. L. ASHKENES *In* AGARD Combat Aircraft Maneuverability 12 p (SEE N82-22187 13-01) Dec. 1981 refs
(Contract F33615-78-C-3616)
Avail: NTIS HC A11/MF A01

A tentative flying qualities specification for aircraft having direct force effectors that allow independent control over the horizontal and vertical degrees of freedom is presented. Since the primary problem with developing flying qualities for such aircraft is their unconventional responses as reflected in a very incomplete data base. A limited flight test of a direct force control (OFC) aircraft was performed. The requirements are based on fundamental aspects of OFC pilot/vehicle dynamics to insure universal applicability. A bandwidth hypothesis is described which makes the fundamental assumption that the primary factor in the pilot's evaluation of a DFC mode is his ability to exert tight control to minimize errors and thereby achieve improved closed loop tracking performance. The bandwidth is a measure of the maximum frequency at which such closed loop tracking can take place without threatening stability. It follows that airplanes capable of operating at a large value of bandwidth will have superior performance. M.G.

N82-22192# Dornier-Werke G.m.b.H., Friedrichshafen (West Germany).
EXPERIMENTAL FLIGHT TEST PROGRAMS FOR IMPROVING COMBAT AIRCRAFT MANEUVERABILITY BY MANEUVER FLAPS AND PYLON SPLIT FLAPS
D. JACOB, D. WELTE, and H. WONNENBERG *In* AGARD Combat Aircraft Maneuverability 11 p (SEE N82-22187 13-01) Dec. 1981 refs
Avail: NTIS HC A11/MF A01

Two flight test programs with the Alpha-Jet as test vehicles are described. In the first program the standard wing of the aircraft was replaced by a transonic wing with maneuver flaps. Wind tunnel and flight test results are presented which show the increase in

performance and maneuverability based on the improved drag polars and buffet limits. In the second program pylon split flaps were to provide flat turn and side step maneuvers by an alternating deflection of the four left or right split flaps. A drag modulation mode is ralized by symmetrical deflection of all eight flaps. M.G.

N82-22193*# Purdue Univ., Lafayette, Ind. School of Aeronautics and Astronautics.

MULTIVARIABLE CLOSED LOOP CONTROL ANALYSIS AND SYNTHESIS FOR COMPLEX FLIGHT SYSTEMS

D. K. SCHMIDT *In* AGARD Combat Aircraft Maneuverability 13 p (SEE N82-22187 13-01) Dec. 1981 refs

(Contract NAG4-1; AF-AFOSR-0042-72)

Avail: NTIS HC A11/MF A01

A flight control system analysis and synthesis method is presented that is intended to be especially suitable for application to vehicles exhibiting complex dynamic characteristics. For such vehicles quantitative handling qualities specifications are not usually available. Howver, handling qualities objectives are specifically introduced in this method via the hypothesis of correlation between pilot ratings and the objective function of an optimal control model of the human pilot. Further, since augmentation and pilot operate in parallel, simultaneous determination of the augmentation and pilot model gains is required. Desirable augmented dynamics are obtained for a variety of complex systems and the method is experimentally verified in the case of simple pilot damper gain selection for optimum pitch tracking performance. M.G.

N82-22194# General Dynamics/Fort Worth, Tex. Engineering Div.

INTEGRATION OF AVIONICS AND ADVANCED CONTROL TECHNOLOGY

M. E. WADDOUPS and C. A. ANDERSON *In* AGARD Combat Aircraft Maneuverability 4 p (SEE N82-22187 13-01) Dec. 1981

Avail: NTIS HC A11/MF A01

Two seemingly exclusive requirements, low cost tactical fighters and night under the weather operations, are being merged by means of advanced technology. The key operational problem is forced by the extremely difficult timeline for low altitude, high speed, air to surface weapon delivery. The inherent economy of single seat operation can be developed by automation. The key technological problems are caused by the lack of volume in a small fighter. In order to achieve automation of the required tasks, flight path control and sensor interfaces must be developed. Based upon emerging hardware and software technology, flight control and avionic subsystems can be optimized and integrated to achieve capability previously unavailable to small fighters. R.J.F.

N82-22195# Royal Aircraft Establishment, Farnborough (England). Flight Systems Dept.

ENHANCED PILOTING CONTROL THROUGH COCKPIT FACILITIES AND A.C.T.

D. J. WALKER (British Aerospace P.L.C., Brough, U.K.) and P. W. J. FULLAM *In* AGARD Combat Aircraft Maneuverability 6 p (SEE N82-22187 13-01) Dec. 1981 refs

Avail: NTIS HC A11/MF A01

Total loop control, advanced cockpits, and other aspects of advanced flight control technology are discussed. General maneuvering, force sidestick, depressed roll axis, a nonlinear pitch controller and carefree maneuvering are discussed. R.J.F.

N82-22196*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

THE DEVELOPMENT OF CRYOGENIC WIND TUNNELS AND THEIR APPLICATION TO MANEUVERING AIRCRAFT TECHNOLOGY

E. C. POLHAMUS and R. F. BOYDEN *In* AGARD Combat Aircraft Maneuverability 12 p (SEE N82-22187 13-01) Dec. 1981 refs

Avail: NTIS HC A11/MF A01

The cryogenic wind tunnel and its potential for advancing maneuvering aircraft technology is discussed. A brief overview of the cryogenic wind tunnel concept and the capabilities and status of the Langley cryogenic facilities is given, as is a review of the considerations leading to the selection of the cryogenic concept such as capital and operating costs of the tunnel, model and balance construction implications, and test condition. Typical viscous, compressibility and aeroelastic effects encountered by maneuvering aircraft are illustrated and the unique ability of the cryogenic wind tunnels to isolate and investigate these parameters while simulating full scale conditions is discussed. The status of the Langley cryogenic wind tunnel facilities is reviewed and their *operating envelopes* described in relation to maneuvering aircraft research and development requirements. The status of cryogenic testing technology specifically related to aircraft maneuverability studies including force balances and buffet measurement techniques is discussed. Included are examples of research carried out in the Langley 0.3 meter transonic cryogenic wind tunnel to verify the various techniques. R.J.F.

N82-22197# Institut de Mecanique des Fluides de Lille (France).

STATE OF THE ART AND RECENT PERSPECTIVES ON THE STUDY OF THE LOSS OF CONTROL AND SPIN [ETAT DE L'ART ET PERSPECTIVES NOUVELLES RELATIVES A L'ETUDE DE LA PERTE DE CONTROLE ET DES VRILLES]

M. G. VANMANSART and D. R. TRISTRANT *In* AGARD Combat Aircraft Maneuverability 18 p (SEE N82-22187 13-01) Dec. 1981 refs In FRENCH; ENGLISH summary

Avail: NTIS HC A11/MF A01

Some experimental and analysis methods which contribute to aircraft behavior prediction at high angles and during stall-spin are discussed. A brief review of the methods, their limitations and the expected results, is given, illustrated with a few examples. R.J.F.

N82-22198# Office National d'Etudes et de Recherches Aerospatiales, Paris (France).

APPLICATION OF THE THEORY OF BIFURCATIONS TO THE STUDY OF THE LOSS OF CONTROL IN COMBAT AIRCRAFT [APPLICATION DE LA THEORIE DS BIFURCATIONS A L'ETUDE DES PERTES DE CONTROLE SUR AVION DE COMBAT]

P. GUICHETEAU *In* AGARD Combat Aircraft Maneuverability 13 p (SEE N82-22187 13-01) Dec. 1981 refs In FRENCH

Avail: NTIS HC A11/MF A01

Aircraft motion can be described in a rigorous manner by a nonlinear differential system, depending on parameters, joining variables of state (incidence, side-slip, speed ...) and variable control (positioning of rudders) by means of equations of flight mechanics and an aerodynamic model. The proposed method consists of determining the stability limits of the system, and of predicting the evolution of that which becomes unstable. It is based on the theory of bifurcation of nonlinear differential systems. A.R.H.

N82-22199# Vought Corp., Dallas, Tex. Aerodynamics Div.

PREDICTIONS OF AERODYNAMIC CHARACTERISTICS OF HIGHLY MANEUVERABLE CONFIGURATIONS

W. B. BROOKS and T. D. BEATTY *In* AGARD Combat Aircraft Maneuverability 6 p (SEE N82-22187 13-01) Dec. 1981 refs

Avail: NTIS HC A11/MF A01

The ability of a variety of currently available methods to predict the lateral/directional characteristics of arbitrary configurations is discussed. The programs surveyed generally had either nonlinear or arbitrary body capability, but not both. Published comparisons between the hypersonic arbitrary body program and experimental data suggested a direct extension of the commonly used Allen-Jorgenson cross flow analogy to arbitrary bodies. Though useful, this extension of the Allen-Jorgenson method did not include dynamic pressure losses on aft lifting surfaces. An examination of a nonlinear approach which computes the forces on a combined body/separated region contour and corrects these forces by an empirical momentum deficit in the separated region was begun. For axisymmetric bodies the method reduces to the standard Allen-Jorgenson cross flow approach. Two potentially major advantages over the Allen-Jorgenson method are that the method does provide a model for predicting body fin interaction and that the method is extendable to arbitrary bodies. R.J.F.

N82-22200# British Aerospace Aircraft Group, Preston (England). Aerodynamics Dept.
AEROELASTIC TAILORING FOR CONTROL AND PERFORMANCE: ARE REQUIREMENTS COMPATIBLE?
D. BOOKER *In* AGARD Combat Aircraft Maneuverability 4 p (SEE N82-22187 13-01) Dec. 1981 refs
Avail: NTIS HC A11/MF A01

The variations of camber and twist along a wing required for optimum performance in low 'g' (cruise) and high 'g' (combat) flight are discussed. It is shown that a wing with active leading edge and trailing edge maneuverer devices scheduled with angle of attack, and structurally tailored to control aeroelastic bending and torsion, can approach optimum performance. However the torsional stiffness of such a wing may be too low for satisfactory roll control at high airspeeds in supersonic flight. Some compromise to performance is implied if torsional stiffness has to be increased to provide adequate control capability. Author

N82-22201# Northrop Corp., Hawthorne, Calif. Aircraft Div.
TAIL CONFIGURATIONS FOR HIGHLY MANEUVERABLE COMBAT AIRCRAFT
W. E. FELLERS, W. S. BOWMAN, and P. T. WOOLER *In* AGARD Combat Aircraft Maneuverability 18 p (SEE N82-22187 13-01) Dec. 1981
Avail: NTIS HC A11/MF A01

The drag due to lift, maximum lift, and stability and control characteristics of tailless, canard, and aft tail configurations of highly maneuverable combat aircraft, using both aerodynamic surfaces and vectored thrust for pitch control are evaluated. The same low aspect ratio wing planform was used on all the configurations. Control configured vehicle concepts were employed. Variable wing camber employing leading edge and trailing edge flaps was used to reduce profile drag. The center of gravity was located as far aft as allowed by the stability and control criteria, in order to reduce subsonic and supersonic trim drag. The critical pitch control criterion was found to be the providing of adequate nose down pitch acceleration in the angle of attack region near maximum lift. The aft center of gravity limits for both tailless and canard configurations without pitch thrust vectoring were required to be forward of the optimum location for minimum subsonic maneuver trim drag. The aft tail configuration was not limited in this manner. In addition it could attain a higher subsonic maximum lift. It also had a greater design flexibility since the aft center of gravity limit could be influenced by the tail area. For these reasons it was the preferred configuration. B.W.

N82-22202# Avions Marcel Dassault-Breguet Aviation, Saint-Cloud (France).
EVALUATION OF AIRCRAFT IN SIMULATED COMBAT: COMPUTER AGAINST COMPUTER OR COMPUTER AGAINST HUMAN PILOT [EVALUATION D'AVIONS EN COMBAT SIMULE CALCULATEUR CONTRE CALCULATEUR OU CALCULATEUR CONTRE PILOTE HUMAIN]
J. PEDOTTI and Y. HIGNARD (Centre Electronique de l'Armement) *In* AGARD Combat Aircraft Maneuverability 14 p (SEE N82-22187 13-01) Dec. 1981 refs In FRENCH
Avail: NTIS HC A11/MF A01

A program was developed for simulating one aircraft in combat with another. The adaptive logic of aerial maneuvers (LAMA) program was validated by theoretical studies and by pilot/model tests on the CELAR simulator. The program permits either an entirely numerical model or a simulation of interactive hostility against a pilot on a simulator. Not only does the program provide a means for studying new weapons systems, it also provides a hostile performer for training pilots. A.R.H.

N82-22203# Grumman Aerospace Corp., Bethpage, N.Y. Research Dept.
THE ASSESSMENT OF AIRCRAFT COMBAT EFFECTIVENESS USING A NEW COMPUTATIONAL METHOD
M. FALCO and G. CARPENTER *In* AGARD Combat Aircraft Maneuverability 11 p (SEE N82-22187 13-01) Dec. 1981 refs Sponsored in part by Army Aviation Research and Development Command
Avail: NTIS HC A11/MF A01

A computational method for the assessment of aircraft combat effectiveness in the design concept phase is discussed. The approach employs a stochastic learning method, in conjunction with dynamic simulation, to derive aircraft maneuver strategies in the form of a feedback control based upon a discretized set of threat visual or warning system cues. The derived strategies maximize either survival probability of kill probability in the one on one setting. Computational results are presented for selected aircraft designs in missile and gun combat. B.W.

N82-22204# McDonnell-Douglas Corp., St. Louis, Mo. Operations Analysis Dept.
EVALUATION OF DIRECT FORCE MODE FIGHTERS BY COMBAT SIMULATION
C. H. GUTHRIE *In* AGARD Combat Aircraft Maneuverability 13 p (SEE N82-22187 13-01) Dec. 1981
Avail: NTIS HC A11/MF A01

Advanced fighter concepts which have been significantly influenced by air combat simulation are discussed. Both man in the loop and digital combat simulation are excellent tools for developing and screening advanced fighter concepts. One important application is the evaluation of fighters with high authority aerodynamic and propulsive controls. Manned and digital air combat simulations showed that high authority controls substantially increase combat effectiveness when used both for enhance large scale maneuverability and for automatic pointing of the fuselage. Digital simulation showed that fighters with high authority direct force modes require lower sustained load factors than conventional designs for a constant level of effectiveness in close in combat. Therefore, fighters with direct force modes can be lighter and less expensive than conventional aircraft. In a manned simulation of close in combat, single fighters with several levels of aerodynamic and propulsion control authority were flown against two threat fighters of equal instantaneous sustained turn rate capability and with identical avionics and armament. For the fighter configured with the highest authority controls, many measures of engagement control and effectiveness were double those of the conventional (baseline) fighter. B.W.

N82-22205# British Aerospace Aircraft Group, Preston (England).
THE STUDY OF COMBAT AIRCRAFT MANEUVERABILITY BY AIR TO AIR COMBAT SIMULATION
A. G. BARNES *In* AGARD Combat Aircraft Maneuverability 9 p (SEE N82-22187 13-01) Dec. 1981
Avail: NTIS HC A11/MF A01

Air to air combat by ground based simulation and its contribution to the design, development and operational use of combat aircraft is evaluated. The merits of different aircraft/missile combinations can be assessed under controlled conditions with pilot involvement. Parameters which influence maneuverability, such as sustained turn rate, attained turn rate, and SEP can be easily varied, and translated into combat success. The relative importance of these parameters are discussed in the light of experimental results. B.W.

N82-23150# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
FLUID DYNAMICS OF JETS WITH APPLICATIONS TO V/STOL
Jan. 1982 433 p refs Proceedings of Symp. held at Lisbon, 2-5 Nov. 1981
(AGARD-CP-308; ISBN-92-835-0308-2) Avail: NTIS HC A19/MF A01

The fluid dynamics of vertical and short take-off and landing aircraft which employ thrust vectoring or lift augmentation were discussed. Jet interactions with neighboring surfaces, jet structure and development, wind tunnel simulation, injection and thrust augmentation, and theoretical models were considered. For individual titles, see N82-23151 through N82-23181.

N82-23151# Surrey Univ., Guildford (England). Dept. of Mechanical Engineering.
SOME ASPECTS OF JET DYNAMICS AND THEIR IMPLICATIONS FOR VTOL RESEARCH
L. J. S. BRADBURY *In* AGARD Fluid Dyn. of Jets with Appl. to V/STOL 26 p (SEE N82-23150 14-01) Jan. 1982 refs
Avail: NTIS HC A19/MF A01

Some of the problems associated with jet interference on VTOL aircraft are discussed. The jet interference that arises in hovering both in and out of ground effect is considered first and the factors that influence the entrainment that is responsible for the

interference are discussed. In paticular, it is shown that the flow in the initial region of a jet is strongly affected by circumferential variations in the jet nozzle flow angle and that this might account for some of the anomolous results for the decay of jets issuing from VTOL models. The possible use of Reichardt's method for studying the behavior of nonuniform jets is also discussed. The problem of jet interference in transition is next examined and the basis on which model tests are currently carried out is briefly reviewed. The dynamics of jet interference in transition are then considered in more detail and it is suggested that unlike interference in hovering, transition interference might well be accounted for on the basis of a potential flow model of the jet in a cross flow. Some experimental evidence in support of this notion is examined and a few examples of comparisons between predicted and experimental pressure distributions around a single jet issuing from a flat plate are given. Author

N82-23152# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).

JET INTERACTIONS WITH NEIGHBORING SURFACES

J. BARCHE *In* AGARD Fluid Dyn. of Jets with Appl. of V/STOL 18 p (SEE N82-23150 14-01) Jan. 1982 refs

Avail: NTIS HC A19/MF A01

Current knowledge and prediction methods for jet interactions with neighboring surfaces are briefly reviewed with special attention to transport and V/STOL aircraft. Examples of primary and secondary interference phenomena are reviewed. Subsonic and sonic jets from zero forward speed up to the transonic flight regime were considered. Problems of transport aircraft design and military jet V/STOL aircraft are discussed. The interaction problems discussed indicate that the phenomena are well understood. Prediction capabilities are still limited, due to difficulties in the theoretical modeling of three dimensional turbulent flows. Some specific problems can be handled on the basis of potential/theoretical flow, provided that the boundary conditions are properly given. J.D.

N82-23153# Coimbra Univ. (Portugal). Dept. of Science and Technology.

INTERACTION OF SIMPLE AND MULTIPLE JETS WITH A PLANE SURFACE

A. R. J. BORGES (Univ. Nova de Lisboa) and D. X. VIEGAS *In* AGARD Fluid Dyn. of Jets with Appl. to V/STOL 13 p (SEE N82-23150 14-01) Jan. 1982 refs

Avail: NTIS HC A19/MF A01

The shear stress field produced by simple and multiple circular jets impinging on a plane surface with either normal, oblique, or parallel incidence was studied. The mean shear stress distribution produced by a single normal jet was measured with a Preston tube. A law for the radial variation of tau sub w is proposed for the wall jet region. Measurements of the shear stress fluctuations with a hot film sensor showed that the intensity of the fluctuations is small compared with the shear stress mean value. An erosion technique was employed to evaluate the shear stress field. The calibration of the technique for sand particles was done in the flow produced by a normal jet. The variation of tau sub w and lines of constant shear stress were obtained for oblique and parallel impingement. In the latter case a dual jet arrangement was also considered. An analytical model, based on Reichardt inductive theory of free turbulence, is developed for the description of the mean properties of the flow produced by single and dual jets parallel to the plane. Author

N82-23154# Laval Univ. (Quebec). Dept. de Genie Mechanique.

THE REATTACHMENT OF TWO JETS ON THEMSELVES [RECOLLEMENT DE DEUX JETS SUR EUX-MEMES]

C. BOURQUE *In* AGARD Fluid Dyn. of Jets with Appl. to V/STOL 12 p (SEE N82-23150 14-01) Jan. 1982 refs In FRENCH

Avail: NTIS HC A19/MF A01

The reattachment of two incompressible turbulent jets on themselves was studied experimentally and theoretically. These jets with different amounts of movement issue from nozzles with initial directions somewhat separated by a solid wall. They then encircle before meeting a dead zone with depression or with pressure, according to the relative initial direction of the jet. Experimentally, the position of the dead point corresponding to reattachment was determined by different values of the geometric parameter. The velocity profile in the resulting jet was measured and the direction as well as the position of this jet was determined. Theory gives the position of the point of reattachment in dead water, between the initial jets and the development of the resulting jet. Transl. by A.R.H.

N82-23155# Instituto Superior Tecnico, Lisbon (Portugal). Dept. of Mechanical Engineering.

JETS IMPINGING NORMALLY AND OBLIQUELY TO A WALL

S. R. B. ARAUJO, D. F. G. DURAO, and F. J. C. FIRMINO *In* AGARD Fluid Dyn. of Jets with Appl. to V/STOL 10 p (SEE N82-23150 14-01) Jan. 1982 refs

Avail: NTIS HC A19/MF A01

An experimental study of a developing jet impinging normally and obliquely on a smooth wall is presented. A laser Doppler anemometer incorporating a frequency shift device was used to measure the mean and fluctuating velocity components in the free jet and wall jet regions. Twelve nozzle diameters downstream of a 14.0 mm diameter nozzle, the jet had mean velocity profiles which were found to have reached similarity with a center line turbulence intensity of around 20%. A circular plate was placed at this location and the radial and circumferential development of the wall jet was analysed for impinging angles from 0 to 20 degrees. The values of the maximum velocity and of the distance from the wall to the location where the velocity is half the maximum velocity depend on radial distance and impinging and circumferential angles. The opposite is true for the nondimensionalized mean velocity profiles which are independent from those parameters. In the fully developed wall jet, the turbulence intensity was always in excess of 30%, and the location of minimum normal stress coincided with that of maximum mean velocity. The velocity probability distributions show the large influence that the outer layer of free turbulent mixing has on the boundary layer region adjacent to the plate. The rate of growth of radial wall jets is smaller than that of radial free jets. Author

N82-23156# Southampton Univ. (England). Dept. of Aeronautics and Astronautics.

AN INVESTIGATION OF INCLINED JETS IN A CROSSWIND

P. TAYLOR and D. J. WATKINS *In* AGARD Fluid Dyn. of Jets with Appl. to V/STOL 14 p (SEE N82-23150 14-01) Jan. 1982 refs Sponsored in part by SERC

Avail: NTIS HC A19/MF A01

The interference characteristics of a turbulent inclined jet exhausting into a turbulent subsonic crosswind were investigated. Results are presented of the variation in jet paths (based on the maximum total pressure), the lift loss, and the pressure distribution on a flat plate through which the jet exhausts. The angle of inclination of the jet to the crosswind direction has varied from 90 to 15 deg. It was found that the lift loss, the jet deflection, the jet penetration, and the rate of total pressure decay along the jet path decreased as the jet inclination was reduced from the position normal to the crosswind. The center of pressure moved downstream. A jet exhausting at an angle of 15 deg to the crosswind has received considerable attention recently and results are presented of the variation with increasing momentum ratio of the pressure distribution on the flat plate through which the jet exhausts, the lift loss, the jet paths, and surface oil flow. Similarity laws are applied to the lift loss, jet path, and center of pressure as a function of momentum ratio, geometry, and angle of inclination. J.D.

N82-23157# Louisiana State Univ., Baton Rouge. Dept. of Mechanical Engineering.

AN EXPERIMENTAL INVESTIGATION OF AN UPPER SURFACE BLOWING CONFIGURATION

G. D. CATALANO, J. B. MORTON, and R. R. HUMPHRIS *In* AGARD Fluid Dyn. of Jets with Appl. of V/STOL 14 p (SEE N82-23150 14-01) Jan. 1982 refs Prepared in cooperation with Virginia Univ.

Avail: NTIS HC A19/MF A01

The effects of both a flat and a curved wall on the one, two, and three point statistical properties of a coflowing turbulent jet are documented. Mean velocities, turbulent intensities, auto- and cross-velocity correlating functions, auto- and cross-velocity spectra, and isocorrelation contours are determined by use of a laser Doppler velocimeter with phase locked loop processor

Pressure field coherence and phase angle function as well as pessure velocity correlations are made using a condensor type microphone/recorder. The effects of varying ratios of the nozzle exit plane mean velocity to the outer tunnel flow speed is noted. The confining surfaces serve to radically change the flow pattern of the expanding turbulent jet. The curved wall has the effect of rapidly increasing the turbulence in the potential core region and disrupting the large scale turbulent structure of the jet. The pressure velocity correlation functions indicate a strong coupling among the turbulent velocity, species concentration fluctuations, and pressure fluctuations in the jet near field. Author

N82-23158# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (West Germany). Aircraft Div.

AN EXPERIMENTAL AND THEORETICAL INVESTIGATION OF THE INTERACTION BETWEEN THE ENGINE JET AND THE SURROUNDING FLOW FIELD WITH REGARD TO THE PRESSURE DRAG ON AFTERBODIES

A. ZACHARIAS *In* AGARD Fluid Dyn. of Jets with Appl. to V/STOL 22 p (SEE N82-23150 14-01) Jan. 1982 refs

Avail: NTIS HC A19/MF A01

In order to clarify the interaction between rotationally symmetric engine jets and afterbody configurations, the dependence of the jet characteristics (i.e., the plume effect and the entrainment) and the afterbody pressure drag on the jet parameters, the free stream Mach number, and the afterbody geometry was analyzed. Extensive tests were carried out in the high subsonic Mach number range on three different afterbodies at Reynolds numbers from 500,000 to 1,300,000. The nozzle pressure ratio and the temperature ratio of the model jets were varied in the range (1.0) 1.2 to 2.4 and 1.0 to 2.86 respectively. Measurements were then carried out to determine the static pressure and temperature distribution as well as the boundary layer profiles over the surface of the models. At the same time, the pressure and temperature profiles in the jet were determined in several planes behind the jet exhaust plane. Empirical equations are presented which show the dependence of the plume effect, the entrainment, and the afterbody pressure drag on the jet parameters, the free stream Mach number, and the afterbody geometry. With the aid of a finite element method and theoretical potential flow model for jet simulation, a numerical procedure was developed which allows the pressure drag on rotationally symmetric afterbodies to be calculated with due allowance for the effects of the engine jets. Comparison of the theoretical and experimental results shows satisfactory agreement. J.D.

N82-23159# Ecole Centrale de Lyon (France). Lab. de Mechanique des Fluides.

STRUCTURE AND DEVELOPMENT OF TURBULENT JETS

J. MATHIEU and G. CHARNAY *In* AGARD Fluid Dyn. of Jets with Appl. to V/STOL 23 p (SEE N82-23150 14-01) Jan. 1982 refs

Avail: NTIS HC A19/MF A01

The behavior and the modeling of turbulent jet flow are surveyed. The essential ideas are discussed in connection with industrial and aeronautical applications. After an introduction of the quasi-equilibrium state related to the length and time scales, the coherent structures and spreading processes are analyzed. Specific topics considered are the intermittency in the axial region, the characteristics of the production centers of the turbulent kinetic energy, the round and plane jet, the acoustic properties with their interactions with the turbulent structure, the initial conditions, and the phenomena in the stagnation region of an impinging jet. A general review of modeling methods precedes examination of computations carried out in physical space and of the large eddy simulation approach. J.D.

N82-23160# Imperial Coll. of Science and Technology, London (England). Dept. of Mechanical Engineering.

A ROW OF JETS IN A CROSSFLOW

Z. A. KHAN, J. J. MCGUIRK, and J. H. WHITELAW *In* AGARD Fluid Dyn. of Jets with Appl. to V/STOL 11 p (SEE N82-23150 14-01) Jan. 1982 refs Sponsored in part by Science Research Council and Rolls-Royce Ltd.

Avail: NTIS HC A19/MF A01

Measurements and calculations for the flow downstream of a row of round jets discharging vertically into a confined horizontal cross stream are reported. No impingement of the jets occurs on the upper wall even for larger pitch to diameter ratios (S/D) and smaller tunnel height to diameter (H/D) values. Although jet spreading rates are similar for both S/D ratios studied, the rapid loss of individual jet identity for the smaller value is illustrated by differences in the measured velocity contour shapes on the farthest downstream cross plane. The calculated results were obtained by solving the steady three dimensional elliptic form of the Reynolds equations with a two equation model of turbulence. The effect of grid refinement is examined. Results for lower S/D ratios are shown to be sensitive to changes in boundary conditions. Comparison with the measured data shows good agreement for the larger S/D, but only certain features are well predicted for the lower value. The influence of the blockage parameter on flow development is quantified. J.D.

N82-23161# Queen Mary Coll., London (England).

EXPERIMENTAL INVESTIGATION OF INITIALLY PLANAR JETS INCLINED TO AN EXTERNAL FLOW

Y. PONTIKIS, R. A. FEIK, and A. D. YOUNG *In* AGARD Fluid Dyn. of Jets with Appl. to V/STOL 13 p (SEE N82-23150 14-01) Jan. 1982 refs

Avail: NTIS HC A19/MF A01

The development of a jet emerging from a full span narrow slit at the trailing edge of a thin aerofoil in a wind tunnel was examined. The jet could therefore be regarded as two dimensional. Three angles of jet inclination to the main flow were tested (10, 20 and 30 deg) and two values of the ratio of the undisturbed stream velocity to the jet exit velocity (0.21 and 0.33). Half the slit was then blocked resulting in a finite span jet with a streamwise edge, and the development and rolling up of the edge region was studied for a jet inclination angle of 30 deg. The measurement covered mean flow and turbulence characteristics. The mean velocity distributions in the two dimensional jets showed a ready tendency to similarity with distance downstream from the jet exit, but the turbulence characteristics in the upper and lower halves showed significant differences consistent with the known effects of streamline curvature. The finite jet assumed a dumbbell shape in section, the edge region growing inwards with distance downstream. There were significant differences between the mean velocity and streamwise vorticity distributions and their peaks followed markedly different loci. Author

N82-23162# Jet Propulsion Lab., California Inst. of Tech., Pasadena.

RESONANT ENTRAINMENT OF A CONFINED PULSED JET

P. G. PARIKH *In* AGARD Fluid Dyn. of Jets with Appl. to V/STOL 10 p (SEE N82-23150 14-01) Jan. 1982 refs

Avail: NTIS HC A19/MF A01

The discovery of a resonant entrainment phenomenon associated with a confined, pulsed jet flow is reported. It was found that a confined jet, when pulsed at an organ pipe resonant frequency of the confinement tube, experiences greatly enhanced entrainment and mixing near the exit end of the confinement tube. Both visual and quantitative evidence of this phenomenon is presented. The effect should be of considerable interest in ejector and combustor design, both of which benefit from any enhancement in mixing between a primary and a secondary flow. Author

N82-23163# Technische Hochschule, Aachen (West Germany). Inst. fuer Luft- und Raumfahrt.

FLOWFIELD AND NOISE SOURCES OF JET IMPINGEMENT OF FLAPS AND GROUND SURFACE

G. NEUWERTH *In* AGARD Fluid Dyn. of Jets with Appl. to V/STOL 7 p (SEE N82-23150 14-01) Jan. 1982 refs

Avail: NTIS HC A19/MF A01

On the basis of experimental results it is shown that, in an undisturbed free jet of high subsonic speed as well as in a jet deflected by externally blown flaps (EBF), there are ordered turbulence structures. First, a feedback mechanism which develops at small distances between nozzle and stagnation point on the flaps and which amplifies the turbulence structures is explained. It is subsequently shown that the interaction of the jets and EBF generates a strong noise. Even without feedback both the undisturbed free jet and the jet deflected by EBF have the maximum levels in the noise spectrum at the Strouhal numbers of the natural ordered turbulence structures. Author

N82-23164# Trondheim Univ. (Norway). Inst. for Mekanikk.
THE NEAR FIELD OF A PLANE TURBULENT JET
L. N. PERSEN *In* AGARD Fluid Dyn. of Jets with Appl. to V/STOL 18 p (SEE N82-23150 14-01) Jan. 1982 refs Sponsored in part by Royal Norwegian Council for Scientific and Industrial Research
Avail: NTIS HC A19/MF A01

A series of experiments performed in the near field of the nozzle producing a plane turbulent jet is described. The jet opening is varied in size and geometry, the exit velocity is varied, and the measuring device is varied from an ordinary pitot tube to the double hot-wire anemometer whereby also the Reynolds stresses could be measured. The experimental data are considered in the light of theoretical considerations which start out with an examination of the classical boundary layer approach. The conclusion is drawn that information must be extracted from the complete set of equations governing the problem. For this purpose the Neuber three function approach is applied to gain insight into the relations governing the Reynolds stresses. The concept of self-similarity is discussed and it is shown why the concept used by Townsend applies only in the far field of the jet. The concept introduced by Bradbury and Riley of two different regions of similarity is not supported by the present approach. It is shown that the data in the near field suggest a correlation which has the linear spreading of the jet as an asymptotic behavior. A new concept of propagation of disturbances is applied to the distribution of the Reynolds stresses. J.D.

N82-23165*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
JET V/STOL WIND-TUNNEL SIMULATION AND GROUNDPLANE EFFECTS
R. J. MARGASON *In* AGARD Fluid Dyn. of Jets with Appl. to V/STOL 21 p (SEE N82-23150 14-01) Jan. 1982 refs
Avail: NTIS HC A19/MF A01 CSCL 01A

The pretest preparation necessary to define the objectives of an appropriate investigation into the jet V/STOL wind tunnel simulation and ground plane effects were examined. Low speed wind tunnel testing of V/STOL aircraft concepts to determine the aerodynamic propulsion interaction effects during the transition between hover and wingborne flight is a necessary step in the development cycle of this type of aircraft. Powered models are normally used to determine the aerodynamic performance characteristics. Several factors which influence the selection of the model concept and the engine simulator are discussed. Some of the test techniques important for this class of aircraft model are examined. Wind tunnel wall effects important to this aircraft testing with special emphasis on groundplane effects are reviewed. E.A.K.

N82-23166*# McDonnell-Douglas Corp., St. Louis, Mo. Aerodynamics Dept.
THE MODELING AND PREDICTION OF MULTIPLE JET VTOL AIRCRAFT FLOW FIELDS IN GROUND EFFECT
D. R. KOTANSKY *In* AGARD Fluid Dyn. of Jets with Appl. to V/STOL 20 p (SEE N82-23150 14-01) Jan. 1982 refs (Contract NAS2-9646; NAS2-10184; N62269-76-C-0086; N00014-79-C-0130)
Avail: NTIS HC A19/MF A01 CSCL 01A

An engineering methodology based on an empirical data base and analytical fluid dynamic models was developed for the prediction of propulsive lift system induced aerodynamic effects for multiple lift jet VTOL aircraft operating in the hover mode in and out of ground effect. The effects of aircraft geometry, aircraft orientation (pitch, roll) as well as height above ground are considered. Lift jet vector and splay directions fit the airframe, lift jet exit flow conditions, and both axisymmetric and rectangular nozzle exit geometry are also accommodated. The induced suckdown flows are computed from the potential flowfield induced by the turbulent entrainment of both the free jets and wall jets in ground effect and from the free jets alone out of ground effect. The methodology emphasized geometric considerations, computation of stagnation lines and fountain upwash inclination, fountain upwash formation and development, and fountain impingement on the airframe. E.A.K.

N82-23167# Grumman Aerospace Corp., Bethpage, N.Y.
EVALUATION OF THE EFFECTS OF MODEL SCALE AND TEST TECHNIQUE ON JET-INDUCED EFFECTS
S. G. KALEMARIS *In* AGARD Fluid Dyn. of Jets with Appl. to V/STOL 11 p (SEE N82-23150 14-01) Jan. 1982
Avail: NTIS HC A19/MF A01

The effects of model scale and test technique on the jet induced of a twin turbofan V/STOL aircraft were evaluated. The smallest mode was 2.1% as large as the full scale model. It is found that the two most important items to be modeled are fuselage shape and the coannular nature of a typical turbofan exhaust. Lift enhancing strakes are effective in enhancing the ground cushion and eliminating a possible source of scale effect. E.A.K.

N82-23168# Vereinigte Flugtechnische Werke G.m.b.H., Bremen (West Germany).
JET EFFECTS ON FORCES AND MOMENTS OF A VSTOL FIGHTER TYPE AIRCRAFT
B. HAFTMANN *In* AGARD Fluid Dyn. of Jets with Appl. to V/STOL 13 p (SEE N82-23150 14-01) Jan. 1982 refs
Avail: NTIS HC A19/MF A01

Results of jet effects on forces and moments of the VAK-191 B were compiled. The jet induced effects were investigated during the Vertical/Short Take-Off and Landing (VSTOL) mode in and out of ground effect, in yawed flight, during hover and transition right up to aerodynamic flight. The flight test results were compared with wind tunnel measurements performed during the VAK-191 B development phase and used for preparation of simulation and automatic flight control system development. Trends and deviations between aircraft and model test results are verified. The adequacy of wind tunnel data preparation are questioned. The practicability of wind tunnel data for the assessment of VSTOL aircraft design and determination of flight characteristics and performances are discussed. Recommendations for the measurements of jet induced forces and moments on VSTOL aircraft are outlined. E.A.K.

N82-23169# Aeronautical Research Associates of Princeton, Inc., N. J.
THRUST AUGMENTING EJECTORS: A REVIEW OF THE APPLICATION OF JET MECHANICS TO V/STOL AIRCRAFT PROPULSION
B. QUINN *In* AGARD Fluid Dyn. of Jets with Appl. to V/STOL 14 p (SEE N82-23150 14-01) Jan. 1982 refs
Avail: NTIS HC A19/MF A01

The fundamental role played by the fluid dynamics of jets within thrust augmenting ejectors that are designed as propulsive units for V/STOL aircraft were reviewed. Energy transfer efficiency and its impact on the production of thrust is discussed. It is explained why propellor like devices more effectively convert available energy to thrust and that overall ejector performance is very sensitive to losses sustained by individual components. The most important loss mechanism is incomplete mixing between the ejector's primary and entrained streams. An experimental data base that provides insight into interactions between turbulent mixing and other factors and improving mixing and ejector performance are reviewed. Free mixing and mixing in a confined environment are contrasted and it is concluded that the development of theoretical methods that successfully predict the performance of V/STOL ejectors must await the results of new experiments that measure turbulence intensities and Reynolds stresses in confined regions. E.A.K.

N82-23170# Centre d'Etudes et de Recherches, Toulouse (France). Dept. of Aerothermodynamique.
THEORETICAL OPTIMISATION AND EXPERIMENTAL VERIFICATION OF AN INJECTOR
A. MIGNOSI *In* AGARD Fluid Dyn. of Jets with Appl. to V/STOL 12 p (SEE N82-23150 14-01) Jan. 1982 refs In FRENCH; ENGLISH summary
Avail: NTIS HC A19/MF A01

A modelization of induction systems, which could be used for thrust augmentation or more generally constitute a fluid drive system, is proposed for the steady regime case. A simple scheme in which a rapid mixing of the flows is assumed, allows to solve the basic equations and express the main parameters influence. Its verification is effected, using a set of experimental data obtained during the study of an induction driven wind-tunnel. Various parameters (are ratio between injected and driven flows, Mach number, pressure and temperature ratios) are studied. The injector

configuration also appears to be very important, in particular as to pressure fluctuations produced at injection and the corresponding aerodynamic noise in the wind tunnel. Author

N82-23171# West Virginia Univ., Morgantown. Coll. of Engineering.
UNSTEADY EJECTORS
H. VIETS *In* AGARD Fluid Dyn. of Jets with Appl. to V/STOL 12 p (SEE N82-23150 14-01) Jan. 1982 refs
(Contract AF-AFOSR-0025-81)
Avail: NTIS HC A19/MF A01

Ejectors are examined by introducing a time dependency into the flow to increase the mixing rate and hence improve the performance of very short devices. Past studies of unsteady flows related to ejectors are reviewed and a device is proposed which has the potential to increase the mixing by means of both an unsteady flow and also acoustic interaction between the frequencies generated by the jet and the ejector shroud. Standing acoustic waves are identified in the ejector and, it is found that the short unsteady ejector performance is superior to that of a slot jet geometry. E.A.K.

N82-23172# Universite Scientifique et Medicale de Grenoble (France). Inst. de Mechanique.
IMPROVEMENT OF EJECTOR THRUST AUGMENTATION BY PULSATING OR FLAPPING JETS
G. BINDER and H. DIDELLE *In* AGARD Fluid Dyn. of Jets with Appl. to V/STOL 11 p (SEE N82-23150 14-01) Jan. 1982 refs Sponsored in part by Minstere de la Defense
Avail: NTIS HC A19/MF A01

The influence of pulsating or flapping motions forced on the primary jet on the performance of thrust augmenting ejectors was investigated. The effect of the frequency and the amplitude of the forced perturbations was determined for various mixing duct lengths and diffusor geometries. In constant area ejectors the improvement in thrust augmentation ratio over the performance obtained with a steady jet in the same geometry increases with decreasing duct length. Thrust augmentation further improved by the gain in diffusor pressure recovery produced by the unsteady jets. Maximum augmentations of 1.9 and 1.65 were obtained with pulsating and flapping jets respectively as compared to 1.35 and 1.5 in the steady case. These improvements in ejector performance are mainly due to the faster mixing produced by these jets. E.A.K.

N82-23173# Societe Bertin et Cie, Plaisir (France).
EXPERIMENTAL STUDY OF A JET DEFLECTOR [ETUDE EXPERIMENTALE D'UN DEVIATEUR DE JET]
M. LEPRETRE and C. PORTIER *In* AGARD Fluid Dyn. of Jets with Appl. to V/STOL 20 p (SEE N82-23150 14-01) Jan. 1982 refs In FRENCH; ENGLISH summary Sponsored in part by Delegation Generale pour l'Armement
Avail: NTIS HC A19/MF A01

A provisional model of an aerodynamic device for orienting the thrust vector of a jet engine was set up by exploiting the reattachment properties of a sonic or slightly supersonic jet on a flat or curved deflector conveniently positioned downwards from the nozzle outlet. A parametric study shows that it would be possible to obtain important reverse rates without a drastic loss of the resultant thrust. Such a device can be of benefit in improving controllability during combat or in designing a STOL. The arrangement defined is characterized by great simplicity, the jet reattachment is spontaneous over all the explored area, and no extra systems are required for blowing or suction.
Transl. by A.R.H.

N82-23174# Alfa Romeo S.p.A., Naples (Italy).
TURBOPROP AND TURBOJET EJECTOR OPTIMISATION
V. P. RIVIELLO, A. MUROLO, and G. TORELLA (Italian Air Force Academy) *In* AGARD Fluid Dyn. of Jets with Appl. to V/STOL 13 p (SEE N82-23150 14-01) Jan. 1982 refs
Avail: NTIS HC A19/MF A01

The off design performance of turboprop and turbojet engine with ejector exhaust ducts was investigated during the AR 318 turboprop engine development and certification program. The optimization of the matching between angle and exhaust duct system is developed. A theoretical approach is used by a synthesis program the appropriate numerical simulation of the ejector, both in the case of subsonic condition at the engine exhaust station and in a sonic station, with supersonic development of the flow through the ejector. To study the supersonic flow through the ejector a set of available experimental results is examinated to evaluate the reliability of theoretical methods for the secondary flow and for conditions. Hot condition experimental tests were performed and was compared with theoretical calculations. The next step concerns the installation of a suitable ejector system on the AR 180.10 turbojet engine, which is a derived version of the AR 318 turboprop. E.A.K.

N82-23175# Aeronautical Research Associates of Princeton, Inc., N. J.
ON THE INCLUSION OF INFORMATION ON EDDY STRUCTURE IN SECOND-ORDER-CLOSURE MODELS OF TURBULENT FLOWS
C. D. DONALDSON and G. SANDRI *In* AGARD Fluid Dyn. of Jets with Appl. to V/STOL 14 p (SEE N82-23150 14-01) Jan. 1982 refs
(Contract F44620-76-C-0048)
Avail: NTIS HC A19/MF A01

The difficulties inherent in second order closure modeling are reviewed. The impropriety of using universal single scale equations in closing the equations is discussed. Defining a simple tensor scale and deriving equations for its component from a moment expansion of the two point correlation tensor equation is outlined. The results are compared with experimental data from nearly homogeneous shearing flows. E.A.K.

N82-23176# Tennessee Univ., Knoxville. Dept. of Engineering and Mechanics.
A THREE-DIMENSIONAL FINITE ELEMENT ALGORITHM FOR PREDICTION OF V/STOL JET-INDUCED FLOWFIELDS
A. J. BAKER, P. D. MANHARDT, J. A. ORZXECHOWSKI, and K. T. YEN (Naval Air Development Center, Warmister, Pa.) *In* AGARD Fluid Dyn. of Jets with Appl. to V/STOL 8 p (SEE N82-23150 14-01) Jan. 1982 refs Prepared in cooperation with Computational Mechanics Consultants, Inc.
Avail: NTIS HC A19/MF A01

A three dimensional mathematical model of the basic V/STOL jet, and the flow in the associated near field using a formal order of magnitude analysis was constructed. This produces a parabolized approximation to the steady, time averaged, three dimensional Navier-Stokes equations for a turbulent subsonic flow. A continuity constraint finite element numerical solution algorithm is identified, which independently enforces ordered phenomena for solution of the equation system including transport equations for turbulence kinetic energy and dissipation parameters. The numerical solution of the established equation system yields prediction of core vortex roll up, far field deflection of the cross flow, near field entrainment of the cross flow into the jet, and wake flow reversal with additional entrainment into the jet core. The primary causal mechanism is computationally assessed to be the turbulence interaction on the upstream face of the jet, as verified by results from a range of computational experiments.
E.A.K.

N82-23177# Naval Air Development Center, Warminster, Pa. Aircraft and Crew Systems Technology Directorate.
PREDICTION OF PROPULSION INDUCED EFFECTS IN TRANSITION USING A MODIFIED JET WAKE MODEL
M. M. WALTERS and K. T. YEN *In* AGARD Fluid Dyn. of Jets with Appl. to V/STOL 8 p (SEE N82-23150 14-01) Jan. 1982 refs
Avail: NTIS HC A19/MF A01

Improvement of the prediction of the induced surface pressures in the wake area without altering the existing accuracy for the area head of the jet was studied. Two short lived, low strength vortices were incorporated into the wake area of the existing Wooler jet model, and the location and strength were determined. The prediction of the induced surface pressure on a flat plate resulting from the modified Wooler model improved the accuracy of the existing model for a range of velocity ratios. The modified model resulted in significant improvement in the prediction of the induced lift on a complete V/STOL configuration. E.A.K.

N82-23178# Bochum Observatory (West Germany).
EFFECTS OF BUOYANCY AND ENTRAINMENT ON HOT FREE JETS AND WALL JETS
K. GERSTEN, F. V. SCHULZ-HAUSMANN, and S. SCHILAWA *In* AGARD Fluid Dyn. of Jets with Appl. to V/STOL 9 p (SEE N82-23150 14-01) Jan. 1982 refs
Avail: NTIS HC A19/MF A01

Two dimensional hot free jets and wall jets including buoyancy and entrainment effects were investigated. The flows of hot exhaust gas jets are strongly influenced by buoyancy forces as well as by entrainment effects which in turn depend on the location of the jets with respect to the ground or other geometrical boundaries. When the hot jets impinge the ground, hot wall jets develop along the ground, again under the influence of buoyancy and entrainment effects. E.A.K.

N82-23179*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
V/STOL AIRCRAFT AND FLUID DYNAMIC
L. ROBERTS (Stanford Univ.) and S. B. ANDERSON *In* AGARD Fluid Dyn. of Jets with Appl. to V/STOL 5 p (SEE N82-23150 14-01) Jan. 1982 refs
Avail: NTIS HC A19/MF A01 CSCL 01A

The impact of military applications on rotorcraft and V/STOL aircraft design with respect to fixed wing aircraft is discussed. The influence of the mission needs on the configurational design of V/STOL aircraft, the implications regarding some problems in fluid dynamics relating to propulsive flows, and their interaction with the aircraft and the ground plane, are summarized. E.A.K.

N82-23180# Technische Hochschule, Aachen (West Germany). Inst. Aerodynamisches.
INVESTIGATION OF WALL JETS
E. KRAUSE, D. HAENEL, and N. I. I. NEWEDY *In* AGARD Fluid Dyn. of Jets with Appl. to V/STOL 5 p (SEE N82-23150 14-01) Jan. 1982 refs
Avail: NTIS HC A19/MF A01

The interaction between wall jets and the main flow is studied by means of experimental and numerical investigations. The following jet configurations are considered: tangential injection of a jet through a slot in a forward facing step into a boundary layer, which is tripped at the leading edge, and tangential and slightly inclined injection of a jet through a slot in a rearward facing step. S.L.

N82-23181# Kingston Polytechnic, Kingston-Upon-Thames (England). School of Mechanical, Aeronautical and Production Engineering.
THE CALCULATION OF JET INTERFERENCE PRESSURE DISTRIBUTION USING INTEGRAL AND NUMERICAL METHODS BASED ON ACTUAL MEASUREMENTS OF ENTRAINMENT
P. E. C. RANSOM and J. H. BARNES *In* AGARD Fluid Dyn. of Jets with Appl. to V/STOL 8 p (SEE N82-23150 14-01) Jan. 1982 refs
Avail: NTIS HC A19/MF A01

Factors influencing interference effects on aerodynamic surfaces surrounding jets are discussed. A tracer gas method is used for the measurement of jet entrainment. This technique is applied to the study of axisymmetric free jets. A numerical method is developed which employs measured values of entrainment to compute the interference pressure distribution over a flat surface surrounding the jet. Comparisons are made with theory to show that computational inaccuracies may be reduced to required values. S.L.

N82-23182# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
GUIDANCE AND CONTROL TECHNOLOGY FOR HIGHLY INTEGRATED SYSTEMS
Feb. 1982 179 p refs In ENGLISH and FRENCH The 33rd Symp. held in Athens, 13-16 Oct. 1981
(AGARD-CP-314; AD-A113) Avail: NTIS HC A09/MF A01

The guidance and control implications and realizations for systems functioning within highly integrated environments are addressed. Particular attention is given to the coupling of weapons delivery to flight control systems, terrain following guidance, command and control, and target identification and tracking. For individual titles, see N82-23183 through N82-23189.

N82-23183# Vereinigte Flugtechnische Werke-Fokker G.m.b.H., Bremen (West Germany).
INTEGRATED NAVIGATION-TF/TA-SYSTEM BASED ON STORED TERRAIN DATA PROCESSING
H. D. LERCHE *In* AGARD Guidance and Control Technol. for Highly Integrated Systems 13 p (SEE N82-23182 14-01) Feb. 1982
Avail: NTIS HC A09/MF A01

A method to improve the reliability and optimization of terrain following flight is discussed. The terrain parameter comparison (TERPAC) system is described in which the main source of information is a terrain data base aboard the aircraft. The comparison is done in the position-fix-mode by matching the measured terrain signatures against terrain reference signatures stored in the mass memory. A hardware and software design of the combined navigation and terrain following/avoidance flight control system was developed and adapted to a modern avionic system architecture. M.G.

N82-23184# Societe d'Applications Generales d'Electricite et de Mecanique, Paris (France).
OPTIMAL INERTIAL NAVIGATION USING TERRAIN CORRELATION: AN ATTRACTIVE SOLUTION TO THE GROUND ATTACK AIRCRAFT NAVIGATION PROBLEM
L. CAMBERLEIN, M. DECREMIERS, and D. CHERMETTE *In* AGARD Guidance and Control Technol. for Highly Integrated Systems 15 p (SEE N82-23182 14-01) Feb. 1982 In FRENCH; ENGLISH summary
Avail: NTIS HC A09/MF A01

The use of terrain correlation for all-weather penetration and ground attack aircraft is discussed. Positioning by terrain correlation is briefly reviewed. For the ground attack aircraft application special algorithms allow large heading freedom over the updating area. The parameter sensitivity of the updating accuracy is analysed. This includes the terrain characteristics, the cartography accuracy, and the altitude measurement accuracy. The main operational features for ground attack aircraft are summarized: tri-dimensional updating; high accuracy facilitated by low altitude flight; self-contained, secure, jam-resistant, automated operation; a low level of heading constraint to and over the updating area; savings in weight, volume, electrical power and cost using sensors already needed on the aircraft. The principle of inertial system optimal updating is also briefly discussed. Temporal carryover from position and velocity updates can be crucial for accurate horizontal terrain following and weapon delivery initialization and in-flight alignment of tactical missiles. The possibility of integrating correlation and optimal filtering in the inertial unit is shown. A typical all weather ground attack mission scenario is described. This includes the extensive mission preparation, the nominal flight plan and possible alternatives, update area selection using ground based equipment and map data bases, and the data assembly and cassette loading. A possible operational systems architecture is described with the necessary equipment. M.G.

N82-23185# McDonnell Aircraft Co., St. Louis, Mo.
INTEGRATED FLIGHT AND FIRE CONTROL DEMONSTRATION ON AN F-15B AIRCRAFT: SYSTEM DEVELOPMENT AND GROUND TEST RESULTS
R. J. LANDY, C. A. SCOLATTI, and J. E. HUNTER (AFWAL) *In* AGARD Guidance and Control Technol. for Highly Integrated Systems 17 p (SEE N82-23182 14-01) Feb. 1982 refs
Avail: NTIS HC A09/MF A01

An integrated flight and fire control (IFFC) system is described which utilizes an automatic coupler and modified flight control system to steer out tracking errors calculated by a director fire control system using information from an ATLIS 2 electro-optical tracker. The F-15B aircraft is the test bed aircraft. Simulation and analysis results indicate that the IFFC system has excellent air-to-air gunnery accuracy with decreased pilot workload. These results also indicate that attacker survivability in air-to-ground gunnery and bombing encounters can be increased by using maneuvering approaches without compromising air-to-ground weapon delivery accuracy. Extensive ground testing of IFFC hardware and software is described. Details of the flight test program plan are presented. M.G.

N82-23186# Singer Co., Wayne, N. J.
THE INTEGRATION OF MULTIPLE AVIONIC SENSORS AND TECHNOLOGIES FOR FUTURE MILITARY HELICOPTERS
A. J. SHAPIRO *In* AGARD Guidance and Control Technol. for Highly Integrated Systems 21 p (SEE N82-23182 14-01) Feb. 1982 refs
Avail: NTIS HC A09/MF A01

Multi-sensor navigation systems already available and in use in helicopters are discussed followed by a review of the system trade-offs and considerations leading to new systems that use more advanced digital electronic techniques to achieve the goals of reduced pilot workload, improved performance at minimum size, weight, and cost. The beneficial impact of ongoing technological advances in improving the operating capabilities of future avionics systems is indicated. R.J.F.

N82-23187# Aeronautical Systems Div., Wright-Patterson AFB, Ohio. Plans and Management Information Dept.
PRODUCTION VERIFICATION TESTING (PVT) OF GUIDANCE AND CONTROL SYSTEMS FOR HIGH RELIABILITY
P. J. LOGUS *In* AGARD Guidance and Control Technol. for Highly Integrated Systems 11 p (SEE N82-23182 14-01) Feb. 1982 refs
Avail: NTIS HC A09/MF A01

The testing of equipment for highly integrated guidance and control systems is addressed. A departure to the usual acceptance testing is discussed by examining in some detail a technique called production verification testing (PVT). Some of the recent literature and experience is reviewed. Computer simulation are used to examine various facets of PVT. Particular emphasis is directed toward the implementation of 100% testing of all systems prior to delivery through the use of N sequential failure-free cycles. Finally, conclusions drawn from computer simulations are presented. The number of N sequential failure free cycles that may be necessary is suggested, providing insight into interpreting the results. Simulation results suggest a means for determining not only expected operational reliability but also process control problems during manufacturing. R.J.F.

N82-23188# Raytheon Co., Bedford, Mass. Missile Systems Div.
HARDWARE-SOFTWARE TRADE-OFFS FOR DIGITAL FLIGHT CONTROL OF GUIDED MISSILES
F. W. NESLINE and P. ZARCHAN *In* AGARD Guidance and Control Technol. for Highly Integrated Systems 25 p (SEE N82-23182 14-01) Feb. 1982 refs
Avail: NTIS HC A09/MF A01

Hardware and software requirements are compared for guided missile flight control systems. The utility and application of three main analog flight control systems are discussed - the open loop system, the rate gyro controlled system, and the accelerometer controlled system. For each of these analog systems, digital requirements are derived and comparisons of the requirements and performance of each system are made. The discussions point out hardware and software trade-off issues that occur in the design process. B.W.

N82-23189# Systems Control, Inc., Palo Alto, Calif.
ANALYSIS OF COMPUTING SYSTEM CONFIGURATIONS FOR HIGHLY INTEGRATED GUIDANCE AND CONTROL SYSTEMS
J. E. JONES, J. S. KARMARKAR, and R. E. FLEMING *In* AGARD Guidance and Control Technol. for Highly Integrated Systems 9 p (SEE N82-23182 14-01) Feb. 1982 refs
Avail: NTIS HC A09/MF A01

The importance of early and sustained validation of architectures for highly integrated systems is discussed. Two early validation tools are presented. A description of the two tools, (1) generalized reliability and maintainability program (GRAMP), and (2) functional emulation, is presented, along with a discussion of their utility in the development of highly integrated guidance and control systems. B.W.

N83-17470# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
PREDICTION OF AERODYNAMIC LOADS ON ROTORCRAFT
Sep. 1982 305 p refs In ENGLISH and FRENCH Meeting held in London, 17-18 May 1982
(AGARD-CP-334; ISBN-92-835-0320-1) Avail: NTIS HC A14/MF A01

Advances in rotor airloads prediction methods, including the evolution to the present state of the art, the capabilities and limitations of the current methodology, and the specific areas that need further effort are discussed. Primary emphasis is on the prediction and experimental verification of the steady and unsteady aerodynamic forces on the rotor blades of modern helicopters and related devices, such as wind turbines. For individual titles, see N83-17471 through N83-17489.

N83-17471# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). Aerodynamics Dept.
THE ROLE OF ANALYSIS IN THE AERODYNAMIC DESIGN OF ADVANCED ROTORS
L. DADONE *In* AGARD Prediction of Aerodyn. Loads on Rotorcraft 12 p (SEE N83-17470 08-01) Sep. 1982 refs
Avail: NTIS HC A14/MF A01

The extent to which flow analysis influences rotor design is reviewed from a manufacturer's point of view. An interim method is suggested for defining tip geometries for high speed flight until rotor blades can be modeled more rigorously. The potential value of new computational methods in improving the aerodynamic efficiency of helicopter rotors is addressed. A.R.H.

N83-17472# Westland Aircraft Ltd., Hayes (England).
REPRESENTATION OF AIRFOIL BEHAVIOUR
T. S. BEDDOES *In* AGARD Prediction of Aerodyn. Loads on Rotorcraft 11 p (SEE N83-17470 08-01) Sep. 1982 refs
Avail: NTIS HC A14/MF A01

A time delay model for dynamic stall, generated several years ago, is discussed with regard to current applications in rotor analysis programs. The shortcomings of the model are highlighted to illustrate the objectives for an improved approach. A formulation is presented for a second generation model for unsteady airfoil behavior. This involves the identification and representation of, trailing edge and leading edge or shock induced separation together with vortex shedding, where appropriate, all within the constraints imposed by computational requirements. The overall model is structured around the solution for time dependant fully attached flow. For a sampled solution which follows from the azimuth stepping procedure of the rotor calculation, the most appropriate form is the indicial response function for which standard solutions are available. A.R.H.

N83-17473# Office National d'Etudes et de Recherches Aerospatiales, Paris (France).
STUDIES OF AEROFOILS AND BLADE TIPS FOR HELICOPTERS
J. J. THIBERT and J. J. PHILIPPE *In* AGARD Prediction of Aerodyn. Loads on Rotorcraft 14 p (SEE N83-17470 08-01) Sep. 1982 refs In FRENCH; ENGLISH summary
Avail: NTIS HC A14/MF A01

The design methodology of a family of airfoils is presented and the performances of these airfoils deduced from wind tunnel tests are compared with those of other known airfoils and with the theoretical predictions. Theoretical and experimental studies of the flow around several blade tips are presented. Emphasis is put on the design of new blade tips in order to improve the advancing blade behavior and so the total rotor performances. A.R.H.

N83-17474# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (West Germany).
CALCULATION OF 3D UNSTEADY TRANSONIC FLOW AROUND ROTOR BLADES
H. STAHL *In* AGARD Prediction of Aerodyn. Loads on Rotorcraft 13 p (SEE N83-17470 08-01) Sep. 1982 refs
Avail: NTIS HC A14/MF A01

By applying and adapting classical wing methods to the special requirements of rotor blade tip flow the limitations of the current methods, such as large computational times can be overcome. The unsteady calculation is carried out by a finite difference method

for the 2-D case considering both the angle of attack and the Mach number variation. The 3-D calculation is based on a finite element model for fixed wings, which is adapted for the rotor blade application by a linearly varying velocity distribution over the blade radius. Only the outer 25% of the radius is considered. The final lift and moment distributions on the blade are determined by superposition of 3-D steady and 2-D unsteady results. By adapting these semi-empirical results in rotor models, their applicability can be improved especially for the advancing blade, as well as over the whole azimuth angle region. A.R.H.

N83-17475# Technische Hogeschool, Delft (Netherlands). Dept. of Aerospace Engineering.

AERODYNAMIC RESEARCH ON TIPVANE WINDTURBINES

G. J. W. VANBUSSEL, T. VANHOLTEN, and G. A. M. VANKUIK *In* AGARD Prediction of Aerodyn. Loads on Rotorcraft 13 p (SEE N83-17470 08-01) Sep. 1982 refs

Avail: NTIS HC A14/MF A01

Tipvanes are small auxiliary wings mounted at the tips of windturbine blades in such a way that a diffuser effect is generated, resulting in a mass flow augmentation through the turbine disc. For predicting aerodynamic loads on the tipvane wind turbine, the acceleration potential is used and an expansion method is applied. In its simplest form, this method can essentially be classified as a lifting line approach, however, with a proper choice of the basis load distributions of the lifting line, the numerical integration of the pressurefield becomes one dimensional. the integration of the other variable can be performed analytically. The complete analytical expression for the pressure field consists of two series of basic pressure fields. One series is related to the basic load distributions over the turbineblade, and the other series to the basic load distribution over the tipvane. A.R.H.

N83-17476# Aeritalia S.p.A., Torino (Italy). Energy Sector.

AERODYNAMIC LOAD CALCULATION OF HORIZONTAL AXIS WIND TURBINE IN NON-UNIFORM FLOW

E. LUPO *In* AGARD Prediction of Aerodyn. Loads on Rotorcraft 10 p (SEE N83-17470 08-01) Sep. 1982 refs

Avail: NTIS HC A14/MF A01

An aerodynamic computer program, applicable to upwind rotors, was developed to calculate variable loads on rotor blades due to nonuniform flow. This program takes into account the atmospheric boundary layer, the variation in wind direction, and tower reflection. The aerodynamic analysis is based on a combination of momentum and blade element equations. The aerodynamic conditions and the airloads are for 36 azimuth positions of a rigid blade during its rotation. The inputs of the program are the geometric characteristics of the rotor and blades, the aerodynamic characteristic of the airfoil sections, the wind shear expression, the yaw and tilt angle with wind direction and the rotor-tower diameter ratio for cylindrical towers. A.R.H.

N83-17477# Institut de Mecanique des Fluides de Toulouse (France). Inst. de Mecanique.

PREDICTION AND EXPERIMENTAL VERIFICATION OF THE VELOCITY FIELDS OF A ROTOR DURING HOVERING [PREDICTION ET VERIFICATION EXPERIMENTALE DU CHAMP DES VITESSES D'UN ROTOR EN VOL STATIONNAIRE]

C. MARESCA, M. N. MBA, and D. FAVIER *In* AGARD Prediction of Aerodyn. Loads on Rotorcraft 18 p (SEE N83-17470 08-01) Sep. 1982 refs In FRENCH

Avail: NTIS HC A14/MF A01

The hypotheses and confidence limits of a computer program relating to the performance of a helicopter rotor during hovering are tested. This computation, which is based on the principle of putting into partial equilibrium an initially prescribed wake using empirical laws, permits the instantaneous determination of the velocity fields and associated performances. Three components of the velocity vector were measured with the aid of crossed hot-wire and laser anemometers. The swirling lines of the tip were determined by visualization and crossed hot-wire anemometer. Total forces (traction and coupled) were likewise measured. The comparison of computation with experiment involved large scale variations of parameters: number of blades, general passage, twisting action (linear and nonlinear), and tip geometry. Results show satisfactory calculation for certain configurations. For other configurations, results remain to be seen. The consideration of a better modeled far wake and of a evolving structure of a turbulent hub prove indispensable in the computation model.

Transl. by A.R.H.

N83-17478# Bell Helicopter Co., Fort Worth, Tex. Aerodynamics Technology Dept.

VELOCITY COUPLING. A NEW CONCEPT FOR HOVER AND AXIAL FLOW WAKE ANALYSIS AND DESIGN

J. D. KOCUREK and L. F. BERKOWITZ *In* AGARD Prediction of Aerodyn. Loads on Rotorcraft 13 p (SEE N83-17470 08-01) Sep. 1982 refs

Avail: NTIS HC A14/MF A01

The history and development of the distorted prescribed wake method is reviewed as introduction to velocity coupling, a approach which defines the key parameters of the wake in hover and axial translation. This technique is formulated from the concept of principal wake induced velocities which are calculated iteratively as simple functions of loading and key geometric characteristics of the near wake tip vortex spirals. This velocity coupled wake model predicts the hovering rotor's wake geometry in greater detail as compared to earlier methods. Also, correlation with a rotor in axial climb demonstrates the successful application of the method to this regime. These examples illustrate how the velocity formulation isolates the major interactions of the wake elements, by not only clarifying experimentally observed characteristics, but also providing a physical basis for systematic refinement of the prescribed wake method. A.R.H.

N83-17479# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (West Germany).

STUDIES ON BLADE-TO-BLADE AND ROTOR-FUSELAGE-TAIL INTERFERENCES

H. HUBER and G. POLZ *In* AGARD Prediction of Aerodyn. Loads on Rotorcraft 16 p (SEE N83-17470 08-01) Sep. 1982 refs

Avail: NTIS HC A14/MF A01

Analytical modeling techniques, including prescribed-contracted-wake analysis, and free-wake-models are described for the blade-blade vortex interaction phenomenon, where the unsteady pressure fluctuations, due to the vortices impact, result in highly impulsive blade loadings, excessive dynamic hub forces/moments, and impulsive noise signatures. Experimental results obtained from in-flight blade modal bending measurements are presented. The interactional aerodynamic flow from the fuselage to the rotor blades is treated. A singularity model is used for the flow calculation around the fuselage body. Parametric influences of the rotor-fuselage separation distance are shown. Interference flow effects between the rotor head and fuselage to the tail area are investigated. For the analytical representation of the steady interference flow a model, containing separated flow calculation, is used. Steady pressure contours and dynamic pressure and flow angle fluctuations at the empennage/tail rotor area are shown including WT-model and full-scale flight test results. A.R.H.

N83-17480# Pisa Univ. (Italy). Istituto di Macchine.

ROTOR-FUSELAGE INTERFERENCE ON ENGINE INTERNAL AERODYNAMICS IN MANEUVERING HIGH-SPEED ROTORCRAFT

D. DINI *In* AGARD Prediction of Aerodyn. Loads on Rotorcraft 14 p (SEE N83-17470 08-01) Sep. 1982 refs

Avail: NTIS HC A14/MF A01

Because of the rotor-fuselage integration, aeroelastic instabilities must be predicted for a reliable engine control design. Fatigue limits imposed on helicopter engines are more severe than in other automotive application, because of the vibration level induced in the engine core. Periodic aerodynamic and inertial blade loadings may have serious consequences with respect to the shafts and the discs to which these blades are attached. Flutter, with either random or uniform phasing between adjacent blades, may exert oscillatory root reactions that integrate for the entire disc and excite a shaft resonance. Unsteady loads resulting from rotor blades vortex interactions and aerodynamic interference effects with the fuselage in high flight speed rotorcraft are considered from the point of view of the influence on engine internal aerodynamics. Author

N83-17481# Royal Aircraft Establishment, Farnborough (England). Structures Dept.

DEVELOPMENT OF THE VORTEX RING WAKE MODEL AND ITS INFLUENCE ON THE PREDICTION OF ROTOR LOADS

C. YOUNG *In* AGARD Prediction of Aerodyn. Loads on Rotorcraft 13 p (SEE N83-17470 08-01) Sep. 1982 refs

Avail: NTIS HC A14/MF A01

The wake trailed by helicopter rotor blades which is important in the determination of loads and vibrational forces transmitted to the fuselage was examined. The vortex ring wake model is widely used in the prediction of helicopter rotor loads. The evolution of the model is traced from the original form developed over 10 years ago to the current version which includes the distortion due to the aircraft fuselage and an interactive near wake. The effects of improvements in the model are illutrated at each stage with comparisons between flight test data obtained with the Puma helicopter. The predicted and measured hub forces and moments for the Lynx helicoper are compared. E.A.K.

N83-17482# Office National d'Etudes et de Recherches Aerospatiales, Paris (France).

AEROELASTIC EQUILIBRIUM OF AN HELICOPTER ROTOR WITH NONLINEAR AERODYNAMIC FORCES

J. J. COSTES *In* AGARD Prediction of Aerodyn. Loads on Rotorcraft 21 p (SEE N83-17470 08-01) Sep. 1982 refs In FRENCH; ENGLISH summary

Avail: NTIS HC A14/MF A01

A computer code which includes aeroelastic couplings for stalled flight cases is presented. The modification of the classical linear aerodynamics to include stall is examined. The nonlinear forces are given by mathematical models and a single nonlinear system of equations, written in a form suitable for a step by step resolution is obtained. Examples and a few comparisons between theory and experiment are given. E.A.K.

N83-17483# Costruzioni Aeronautiche Giovanni Agusta S.p.A., Varese (Italy). Dynamics Engineering Dept.

FIRST RESULTS FOR THE DEFINITION OF A GENERAL ROTORCRAFT DYNAMIC PROGRAM

A. RUSSO and A. CERIOTTI *In* AGARD Prediction of Aerodyn. Loads on Rotorcraft 14 p (SEE N83-17470 08-01) Sep. 1982 refs

Avail: NTIS HC A14/MF A01

A computer program able to solve the large number of problems related to the dynamic behavior of a rotor or a complete helicopter is described. The analytical model is described by a technique similar to the finite element analysis, the equations of motion are obtained by general equation of dynamics, in its standard matrix form. The operations are the linearization, around the actual position of dynamic equilibrium, of the equations of motion and constraint equations. Forcing functions can be either forces or imposed displacements depending on time as well as on any kinematic value of other elements or their own kinematic value. The steady aerodynamic coefficients are computed from the local incidence deduced by means of kinematic, gust, and induced velocities of the rotor wakes introduced into the model. Particular attention is paid to the input data both for a rational description of the model and not to cause format troubles to the user. E.A.K.

N83-17484# Sikorsky Aircraft, Stratford, Conn. Aeromechanics Dept.

REVIEW OF ROTOR LOADS PREDICTION METHODS

P. J. ARCIDIACONO and R. SOPHER *In* AGARD Prediction of Aerodyn. Loads on Rotorcraft 18 p (SEE N83-17470 08-01) Sep. 1982 refs

Avail: NTIS HC A14/MF A01

Recent progress made in predicting rotor loads is reviewed. The development of improved loads analysis is reviewed. Technical areas recommended for priority attention in the future and the perception of technology opportunities are identified. The aerodynamic aspects of rotor loads analyses generally have not changed greatly since 1974. Progress was made in addressing the fundamental aerodynamic areas, this progress is not always integrated into the load programs. The structural aspects of the loads programs have advanced, particularly with respect to consistent formulation of equations and the ability to efficiently assemble the desired dynamic elements for problems of varying degrees of complexity. E.A.K.

N83-17485# Army Research and Technology Labs., Moffett Field, Calif.

THE DEVELOPMENT OF A SYSTEM FOR INTERDISCIPLINARY ANALYSIS OF ROTORCRAFT FLIGHT CHARACTERISTICS

A. W. KERR and W. B. STEPHENS (Army Aeromechanics Labs.) *In* AGARD Prediction of Aerodyn. Loads on Rotorcraft 14 p (SEE N83-17470 08-01) Sep. 1982 refs

Avail: NTIS HC A14/MF A01

A comprehensive, interdisciplinary analysis system was developed to predict the technical characteristics of a wide variety of rotary wing configurations. The approach used in the development of the system is reviewed and the software methodology used to support the development is described. The mathematical basis for the system and the top level analysis and architectural design of the system are presented. The potential ability of the system to predict rotor loads is discussed. E.A.K.

N83-17486# Societe Nationale Industrielle Aerospatiale, Marseille (France).

METHODS USED AT AEROSPATIALE FOR CALCULATING THE LOADS ON A ROTOR AND EXPERIMENTAL CROSS CHECKS [METHODES DE CALCUL DES CHARGES SUR ROTOR UTILISEES A L'AEROSPATIALE ET RECOUPEMENTS EXPERIMENTAUX]

B. MASURE and VUILLET *In* AGARD Prediction of Aerodyn. Loads on Rotorcraft 13 p (SEE N83-17470 08-01) Sep. 1982 refs In FRENCH

Avail: NTIS HC A14/MF A01

The modal method, the method of azimuths, and a simplified method for calculating static loads are presented. The simplifying hypotheses held, common to all three methods, are reviewed as well as the condensed form of the basic equations established. The principal characteristics of the methods are described. The quality of these prediction methods is then analyzed using cross checks with flight tests on the prototype Gazelle 3492 and on the Super Puma AS332. For the former, the comparison concerns only dynamic forces; for the latter, dynamic and static forces. The only flights considered are stabilized flights with or without the load factor. Agreement is generally satisfactory but certain anomalies sometimes appear for static loads at the base of the blade as well as for torsion moments. For the latter case, the poor quality of the cross checks should be attributable to the fact that unsteady aerodynamic phenomena, not modeled in the present numerical application, play a role that cannot be neglected.

Transl. by A.R.H.

N83-17487# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick (West Germany). Inst. fuer Flugmechanik.

COMPARISON OF ROTOR ANALYSIS RESULTS WITH AERODYNAMIC WINDTUNNEL DATA

H. J. LANGER, W. V. GRUENHAGEN, and B. JUNKER *In* AGARD Prediction of Aerodyn. Loads on Rotorcraft 13 p (SEE N83-17470 08-01) Sep. 1982 refs

Avail: NTIS HC A14/MF A01

Measurements for hub moments and blade stresses are presented. Downwash velocities are recorded under the retreating and advancing side of the rotor. The windtunnel measuring data are compared with calculations and computer programs were built up to calculate downwash as well as rotor and blade forces and moments. Different procedures are compared with windtunnel measurements. The results of the calculation of the hub loads, blade loads, and downwash vary considerably, so that the accuracy of the different calculation methods can be checked. E.A.K.

N83-17488# Royal Aircraft Establishment, Bedford (England). Flight Systems Dept.

AN APPRAISAL OF ROTOR BLADE-TIP VORTEX INTERACTION AND WAKE GEOMETRY FROM FLIGHT MEASUREMENTS

P. BROTHERHOOD *In* AGARD Prediction of Aerodyn. Loads on Rotorcraft 14 p (SEE N83-17470 08-01) Sep. 1982 refs

Avail: NTIS HC A14/MF A01

The close radial spacing of leading edge pressure transducers used as incidence and loading indicators on a Puma helicopter blade produces a global picture of the effects of blade tip vortex interaction. Features of the wake geometry are compared with prediction and the loading action of the tip vortex on the following blade is assessed. E.A.K.

N83-17489# Army Research and Technology Labs., Fort Eustis, Va. Applied Technology Lab.
DATAMAP AND ITS IMPACT ON PREDICTION PROGRAMS
D. J. MERKLEY and A. E. RAGOSTA *In* AGARD Prediction of Aerodyn. Loads on Rotorcraft 13 p (SEE N83-17470 08-01) Sep. 1982 refs
Avail: NTIS HC A14/MF A01

The DATAMAP (data from aeromechanics' test and analytics--management and analysis package), a computer software system that provides direct access to large time history data bases, performs analyses and derivations, and displays the data in various formats, interactively or through batch processing is described. The ability of directly comparing analytical, model and full scale test results is emphasized; the care which must be taken when utilizing DATAMAP; and its effect on the plans for the second generation comprehensive helicopter analysis system is emphasized (2GCHAS). The operational loads survey (OLS) data base is described and the development of DATAMAP is discussed. The DATAMAP's versatility is shown and its ability to access any time history data base and its modular concept whereby any appropriate analysis or derivation can be added to the existing capabilities as the need arises are emphasized. Plots which show various formats that are available to the user are presented.
E.A.K.

N83-17490# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
HUMAN FACTORS ASPECTS OF AIRCRAFT ACCIDENTS
Oct 1982 141 p refs In ENGLISH and FRENCH Lectures held in Lisbon, 4-5 Nov 1982, in Ankara, 8-9 Nov. 1982 and in Athens, 11-12 Nov 1982
(AGARD-LS-125, ISBN-92-835-0319-7) Avail: NTIS HC A07/MF A01

Human factors engineering and aircraft accidents are discussed. For individual titles, see N83-17491 through N83-17500.

N83-17491# School of Aerospace Medicine, Brooks AFB, Tex.
AN OVERVIEW OF HUMAN FACTORS IN AIRCRAFT ACCIDENTS AND INVESTIGATIVE TECHNIQUES
B. O. HARTMAN *In* AGARD Human Factors Aspects of Aircraft Accidents 4 p (SEE N83-17490 08-01) Oct. 1982 refs
Avail: NTIS HC A07/MF A01

Human factors in aircraft accidents and investigative techniques are reviewed.
N.W.

N83-17492# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
HUMAN FACTORS IN AIRCRAFT ACCIDENTS: PRESENT STATUS AND SIGNIFICANT CONCERNS [ASPECTS DES FACTEURS HUMAINS DANS LES ACCIDENTS D'AVIATION: STATUT ACTUEL ET SOUCIS SIGNIFICATIFS]
M. VIGIER *In its* Human Factors Aspects of Aircraft Accidents 20 p (SEE N83-17490 08-01) Oct. 1982 In FRENCH
Avail: NTIS HC A07/MF A01

Inquiry is frequently led to consider the human factor in the classical chain of elements which produce an aircraft accident. When assembling the particular characteristics which are more or less favorable to aviation safety in the European context, it is interesting to examine some statistical aspects and to attempt to evaluate the importance of this factor by relating it to the group of causal factors held. This percentage shows little variation in the course of years and remains the same no matter what category of aeronautical activity is involved. The human factor very probably exceeds the 60% rate. It is not easy to correctly apprise this factor which covers an immense field. Certain principles of research are outlined for two indicators: ground personnel and flying personnel. Nevertheless, if the inquirer can generally evidence the implications of human error in the unfolding of the accident, the deep seated reasons often escape and merit the attentions of specialists.
A.R.H.

N83-17493*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
THE INFLUENCE OF HANDLING QUALITIES, CRASHWORTHINESS AND OTHER ENGINEERING FACTORS ON AIRCRAFT SAFETY
S. B. ANDERSON *In* AGARD Human Factors Aspects of Aircraft Accidents 11 p (SEE N83-17490 08-01) Oct. 1982 refs
Avail: NTIS HC A07/MF A01 CSCL 01C

The relationship of handling qualities to safety, crashworthiness, and survivability are examined.
Author

N83-17494# Canadian Forces Air Command, Winnipeg (Manitoba).
A BRIEF REVIEW OF SELECTED AREAS OF AVIATION MEDICINE AND PHYSIOLOGY
W. C. HARTZELL *In* AGARD Human Factors Aspects of Aircraft Accidents 21 p (SEE N83-17490 08-01) Oct. 1982 refs
Avail: NTIS HC A07/MF A01

Aviation medicine and physiology are reviewed with specific focus on those aspects which relate to safety and accidents. Specific emphasis is given to the aeromedical aspects of the effects of altitude, the acceleration environment, disorientation stresses and visual function and problems in flight, as these areas are felt to have most significant potential impact on flight safety. The presentation is concluded with a brief discussion of the common acute causes for grounding and sudden incapacitation which are of concern in military aviation.
Author

N83-17495# Air Force Inst. of Aviation Medicine, Fuerstenfeldbruck (West Germany).
HUMAN FACTORS
G. O. SPOHD *In* AGARD Human Factors Aspects of Aircraft Accidents 18 p (SEE N83-17490 08-01) Oct. 1982 refs
Avail: NTIS HC A07/MF A01

The complex relations of factors causing man to fail in military aviation are reduced to a simple model. Basic connections between the several components of a controller, computer and decision maker are drawn and applied step by step to the aviator's conditions. Man's abilities and qualifications for the perception of cues are discussed, their importance in the field of aviation indicated. The importance of human engineering, display and control design including information presentation is related to aviation; basic principles for the development of future design are listed. Physiological factors and their importance on pilots' performance capabilities as well as psychological factors like alterations in attention, arousal and motivation, and the aviator's need for decision making are discussed. Problems of aircrew selection, crew monitoring, crew training and performance supervision, in combination with suggestions for improvement, and an accident zone model, based on a recent study within the GAF, are included.
Author

N83-17496# Edinburgh Univ. (Scotland). Dept. of Forensic Medicine.
PATHOLOGY ASPECTS OF THE HUMAN FACTORS INVESTIGATION
J. K. MASON *In* AGARD Human Factors Aspects of Aircraft Accidents 5 p (SEE N83-17490 08-01) Oct. 1982 refs
Avail: NTIS HC A07/MF A01

The principles of aviation pathology are outlined, with particular emphasis on utilizing autopsy examination in search of the twin objectives of establishing the cause of the accident or assessing the reason for fatalities occurring. The prevention of fatal accidents is illustrated by the use of pathology in the development of the ejection seat and by a study of light aircraft accidents resulting in fatal head injuries. In accidents involving large aircraft, the importance of establishing a pattern of injuries so as to indicate the type of the accident is enlarged upon. Pathology is regarded as an essential part of the investigation of an aircraft accident but, like any other discipline, it only functions at its best in the context of a 'group system'.
Author

01 AERONAUTICS (GENERAL)

N83-17497*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
THE ENGINEERING INVESTIGATION OF AIRCRAFT ACCIDENTS
S. B. ANDERSON *In* AGARD Human Factors Aspects of Aircraft Accidents 8 p (SEE N83-17490 08-01) Oct. 1982 refs
Avail: NTIS HC A07/MF A01 CSCL 01C

The organization and plan for an investigation, procedures used at the scene of the accident, engineering aspects covered in the main investigation, use of special analytical techniques and simulation tools, and use of flight recorder data are discussed. Examples of investigations are used to illustrate the processes used. Author

N83-17498# Royal Air Force Inst. of Aviation Medicine, Farnborough (England).
LIFE SUPPORT, RESTRAINT AND EJECTION SYSTEMS INVESTIGATION
D. J. ANTON *In* AGARD Human Factors Aspects of Aircraft Accidents 7 p (SEE N83-17490 08-01) Oct. 1982 refs
Avail: NTIS HC A07/MF A01

The examination of life support, restraint and ejection systems is an integral part of the investigation of any aircraft accident. It is important that it should be conducted in a thorough manner and particular care should be taken in the field phase of the investigation as much of that evidence is, by its nature, ephemeral. Author

N83-17499# Air Force Hospital, England AFB, La.
AIRCRAFT ACCIDENT INVESTIGATION AND THE FLIGHT SURGEON
R. B. RAYMAN *In* AGARD Human Factors Aspects of Aircraft Accidents 8 p (SEE N83-17490 08-01) Oct. 1982 refs
Avail: NTIS HC A07/MF A01

The essentials of aircraft accident investigation are described. The flight surgeon's role is to determine the cause of injury/death, to decide if egress/life support equipment functioned properly during the escape, survival, and rescue sequence, and to ascertain if there were medical or human factors which contributed to the accident. How the flight surgeon fulfills this role is discussed. Author

N83-17500# Edinburgh Univ. (Scotland). Dept. of Forensic Medicine.
MEDICO LEGAL ASPECTS OF THE PATHOLOGICAL INVESTIGATION
J. K. MASON *In* AGARD Human Factors Aspects of Aircraft Accidents 5 p (SEE N83-17490 08-01) Oct. 1982 refs
Avail: NTIS HC A07/MF A01

The medico legal aspects of aircraft accidents are described from the viewpoint of a major international airline disaster as it is in such a situation that the problems are maximized. The importance of identification of cadavers both in the legal field and in accident investigation is stressed. Insurance problems in passengers are discussed and mention made of the very specific problem of aviation simultaneous death. The investigation for criminal activity is outlined, particular emphasis being placed on radiology. In view of the importance to individual families of many of these questions, a plea is made for standardization of techniques throughout the world. Author

02

AERODYNAMICS

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

N80-17991*# National Aeronautics and Space Administration, Washington, D. C.
COMPARISON OF AERODYNAMIC COEFFICIENTS OBTAINED FROM THEORETICAL CALCULATIONS WIND TUNNEL TESTS AND FLIGHT TESTS DATA REDUCTION FOR THE ALPHA JET AIRCRAFT
R. GUIOT and H. WUNNENBERG Feb. 1980 31 p refs
Transl. into ENGLISH of "Comparison des Coefficients Aerodynamiques Issues des Calculs Theoretiques, Essais en Soufflerie et Depouillements d'Essais en vol Effectues sur l'Alpha Jet", Rept. AGARD-CP-187 AGARD Presented at the 46th Meeting of the Flight Mech. Panel, Valloire, France, 9-13 Jun. 1975 p 19-1 - 19-15 Original language document was announced as N76-25295 Transl. by Kanner (Leo) Associates Redwood City, Calif. Original language document prepared by Avions Marcel Dassault-Breguet Aviation, Saint-Cloud, France and Dornier-Werke G.m.b.H., Friedrichshafen, West Germany
(Contract NASW-3199)
(NASA-TM-75237; AGARD-CP-187) Avail: NTIS HC A03/MF A01 CSCL 01A

The methods by which aerodynamic coefficients are determined and discussed. These include: calculations, wind tunnel experiments and experiments in flight for various prototypes of the Alpha Jet. A comparison of obtained results shows good correlation between expectations and in-flight test results. J.M.S.

N80-31354# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
A CRITICAL COMMENTARY ON MEAN FLOW DATA FOR TWO-DIMENSIONAL COMPRESSIBLE TURBULENT BOUNDARY LAYERS
H. H. FERNHOLZ May 1980 229 p refs
(AGARD-AG-253; AGARDOGRAPH-253; ISBN-92-835-1362-2; AD-A087704) Avail: NTIS HC A11/MF A01

A discussion of mean flow profile data for compressible boundary layers is presented. The commentary includes discussion of the theoretical basis for interpretation of measurements, concepts from low speed studies, and interpretation of mean flow data with and without pressure gradient. The causes of normal pressure gradients are described, so as to allow an estimation of their magnitude and their influence on boundary layer scale lengths. E.D.K.

N80-33363# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
SPECIAL COURSE ON UNSTEADY AERODYNAMICS
Jun. 1980 236 p refs Course held in Rhode-Saint-Genese, Belgium, 10-14 Mar. 1980; sponsored by Fluid Dyn. Panel, von Karman Inst., and the Consultant and Exchange Program of AGARD
(AGARD-R-679; ISBN-92-835-1364-9; AD-A089114) Avail: NTIS HC A11/MF A01

A wide range of related unsteady flow phenomena relevant to aeronautical applications are addressed. Aircraft response, aircraft loads, vibration environments, and flight systems analysis are emphasized. For individual titles, see N80-33364 through N80-33380.

N80-33364# Queen Mary Coll., London (England). Dept. of Aeronautical Engineering.
SOME INTODUCTORY CONCEPTS BASED ON THE UNSTEADY FLOW ABOUT CIRCULAR CYLINDERS
G. J. HANCOCK *In* AGARD Spec. Course on Unsteady Aerodyn. 15 p (SEE N80-33363 24-02) Jun. 1980 refs
Avail: NTIS HC A11/MF A01

The various categories of unsteady flows which are of current interest in an aircraft context are briefly outlined. The wide range of areas of interest in unsteady aerodynamics are considered with respect to the following: (1) attached flow in subsonic and

supersonic streams; (2) attached flow at transonic speeds; (3) separated flows; and (4) self induced unsteady flows. R.C.T.

N80-33365# Virginia Polytechnic Inst. and State Univ., Blacksburg.
INTRODUCTION TO UNSTEADY BOUNDARY LAYERS
D. P. TELIONIS *In* AGARD Spec. Course on Unsteady Aerodyn. 6 p (SEE N80-33363 24-02) Jun. 1980 refs
Avail: NTIS HC A11/MF A01

The basic characteristics of transient and oscillatory boundary layers are demonstrated in terms of elementary solutions of the Navier-Stokes equations for idealized flow situations. A qualitative description is given of the physics of unsteady boundary layers, briefly describing the response of skin friction, velocity profiles, the effects of nonlinearity on velocity and temperature fields, etc. The extension of turbulence models to unsteady flow is briefly discussed. Reversing boundary layers and unsteady separation are also briefly described. R.C.T.

N80-33366# Westland Helicopters Ltd., Yeovil (England). Aeromechanics Dept.
A QUALITATIVE DISCUSSION OF DYNAMIC STALL
T. S. BEDDOES *In* AGARD Spec. Course on Unsteady Aerodyn. 6 p (SEE N80-33363 24-02) Jun. 1980 refs
Avail: NTIS HC A11/MF A01

The factors which contribute to the onset of stall are considered with respect to the design of flight vehicles. It is shown that in a dynamic environment, (i.e., guests and manuevering flight) the statically determined loads are likely to be exceeded. An attempt is made to quantify the increase and define percisely the significance of related parameters. R.C.T.

N80-33367# Queen Mary Coll., London (England). Dept. of Aeronautical Engineering.
SOME FEATURES OF LINEAR COMPRESSIBILITY
G. J. HANCOCK *In* AGARD Spec. Course on Unsteady Aerodyn. 9 p (SEE N80-33363 24-02) Jun. 1980
Avail: NTIS HC A11/MF A01

Some of the characteristic features of linear wave propagation in air at rest are described. Several theoretical prediction methods for inviscid flows are presented in the form of linearized equations to demonstrate the small disturbances on a uniform stream. R.C.T.

N80-33368# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Goettingen (West Germany). Inst. fuer Aeroelastik.
METHOD FOR INVISCID SUBSONIC FLOWS ABOUT AIRCRAFT CONFIGURATIONS
W. GEISSLER *In* AGARD Spec. Course on Unsteady Aerodyn. 21 p (SEE N80-33363 24-02) Jun. 1980 refs
Avail: NTIS HC A11/MF A01

A variety of theoretical as well as experimental methods were used to determined unsteady airloads about complex aircraft configurations. Emphasis was also placed on the derivation of the final integral relations serving as the initial equations for special numerical approaches. R.C.T.

N80-33369# Cambridge Univ. (England). Dept. of Engineering.
UNSTEADY AERODYNAMICS IN TURBOMACHINERY
D. S. WHITEHEAD *In* AGARD Spec. Course on Unsteady Aerodyn. 11 p (SEE N80-33363 24-02) Jun. 1980 refs
Avail: NTIS HC A11/MF A01

Unsteady flow phenomena in turbomachines, blade flutter, and methods for unsteady cascades are discussed. The phenomena of inlet maldistribution, rotating stall, surge, blade vibration, and sound generation are described. The types of blade flutter and the modes in which it occurs are then examined and a theoretical method of flutter prediction is discussed. The effects of mechanical damping and mistuning are evaluated. A theory of linearized two dimensional unsteady flow in cascades is outlined for both subsonic and supersonic flow. The importance of the two different kinds of acoustic resonance which occur is then discussed. R.C.T.

N80-33370# Westland Helicopters Ltd., Yeovil (England). Aeromechanics Dept.
UNSTEADY FLOWS ASSOCIATED WITH HELICOPTER ROTORS
T. S. BEDDOES *In* AGARD Spec. Course on Unsteady Aerodyn. 8 p (SEE N80-33363 24-02) Jun. 1980 refs
Avail: NTIS HC A11/MF A01

The analytical treatment of helicopter performance and structural loading are addressed with respect to the spacial and temporal variation of the local flow, relative velocity, and angularity. Quasisteady aerodynamics in conjunction with simplified models of rotor inflow and structural characteristics were used to identify many of the fundamental problems which were encountered in the development of a practical vehicle. R.C.T.

N80-33371# Queen Mary Coll., London (England). Dept. of Aeromechanical Engineering.
ROLE OF UNSTEADY AERODYNAMICS IN AIRCRAFT RESPONSE
G. J. HANCOCK *In* AGARD Spec. Course on Unsteady Aerodyn. 14 p (SEE N80-33363 24-02) Jun. 1980 refs
Avail: NTIS HC A11/MF A01

Some of the main dynamic situations which arise in aircraft response are illustrated. Major emphasis is placed on overall aircraft performance and structural response. R.C.T.

N80-33372# Westland Helicopters Ltd., Yeovil (England). Aeromechanics Dept.
APPLICATION OF IDENTICAL AERODYNAMIC FUNCTIONS
T. S. BEDDOES *In* AGARD Spec. Course on Unsteady Aerodyn. 8 p (SEE N80-33363 24-02) Jun. 1980 refs
Avail: NTIS HC A11/MF A01

Relatively simple means for applying the theoretical results for idealized forcing to routine calculations of airloads and structural response are demonstrated. In this context nonlinear system characteristics may be simulated and complex or arbitrary forcing may be included. Initially the aerodynamics are assumed to be more or less linear, that is, the flow is assumed to remain attached but the procedure is intended to provide the parameters required to define the onset of separation. E.D.K.

N80-33373# Royal Aircraft Establishment, Bedford (England). Structures Dept.
EXPERIMENTAL TECHNIQUES IN UNSTEADY AERODYNAMICS
N. C. LAMBOURNE *In* AGARD Spec. Course on Unsteady Aerodyn. 26 p (SEE N80-33363 24-02) Jun. 1980 refs
Avail: NTIS HC A11/MF A01

The role of experiments in the field of unsteady aerodynamics and the methods of simulating unsteady conditions with models in wind tunnels, or other facilities, are outlined. The techniques of measuring unsteady quantities such as aerodynamic force and pressure are described, attention being given to the part played by computers in the acquisition, processing, and presentation of measured data. The choices facing the experimenter and some of the phenomena that may be encountered are discussed. Finally, specific examples of test rigs and test procedures are briefly described. E.D.K.

N80-33374# Virginia Polytechnic Inst. and State Univ., Blacksburg.
EXPERIMENTAL TECHNIQUES FOR UNSTEADY BOUNDARY LAYERS
D. P. TELIONIS *In* AGARD Spec. Course on Unsteady Aerodyn. 12 p (SEE N80-33363 24-02) Jun. 1980 refs
Avail: NTIS HC A11/MF A01

Methods of measuring velocity distribution in unsteady viscous flows and techniques for analyzing and presenting the data are discussed. Both hot wires and laser doppler velocimeters were successfully used to investigate unsteady boundary layers. A variety of flow visualization methods ranging from smoke and tuft observation in air to hydrogen bubbles and solid particles in water, were successfully used in the study of complex unsteady flows, as for example the formation and development of large scale vortices. Recently it was attempted to obtain simultaneously velocity measurements at a point and instantaneous flow visualization. Both laminar and turbulent flows with or without pressure gradients were investigated. Such flows, especially turbulent flows and separating

flows require special averaging techniques to disclose their basic characteristics. Typical data from flat plate flows with adverse pressure gradients, separating flows, and flows over oscillating airfoils are presented. E.D.K.

N80-33375# Queen Mary Coll., London (England). Dept. of Aeronautical Engineering.
METHODS FOR INVISCID SUBSONIC FLOWS ABOUT UNSTEADY AEROFOILS
G. J. HANCOCK (British Aerospace Aircraft Group, Bristol, England) and R. DOE *In* AGARD Spec. Course on Unsteady Aerodyn. 10 p (SEE N80-33363 24-02) Jun. 1980 refs
Avail: NTIS HC A11/MF A01

Some of the numerical approaches developed for subsonic flows about two dimensional airfoils are cataloged. Such solutions are useful in their own right, for airfoil results are often used in strip theory approaches in early design stages, but primarily these methods lay down the language and framework for applications in three dimensions. In this paper the flow is assumed to be attached and the boundary layer effects are neglected so the inviscid equations are taken. Although the distinction is artificial, if not misleading, the case of incompressible fluid flow is treated and then secondly the effects of compressibility are introduced. E.D.K.

N80-33376# Virginia Polytechnic Inst. and State Univ., Blacksburg.
ANALYTICAL METHODS FOR PREDICTION OF UNSTEADY LAMINAR BOUNDARY LAYERS
D. P. TELIONIS *In* AGARD Spec. Course on Unsteady Aerodyn. 13 p (SEE N80-33363 24-02) Jun. 1980 refs
Avail: NTIS HC A11/MF A01

Oscillatory boundary layers were investigated at first via asymptotic expansions in terms of small parameters like the amplitude or the frequency of oscillation. The pioneering work of Lighthill, Moore, Lin, and others is reviewed and subsequent more sophisticated expansions are described. In the last decade a large number of numerical investigations have appeared. Explicit, implicit methods as well as the well known box-method are described and their relative performance is evaluated. Typical examples are compared with classical experimental data. The definition of unsteady separation and criteria for its prediction have generated a lot of interest in the last decade. Analytical methods are discussed for the prediction of unsteady separation. There is still some disagreement on this point with respect to the appearance of the separation singularity. The arguments of both points of view are presented. E.D.K.

N80-33377# Virginia Polytechnic Inst. and State Univ., Blacksburg.
ANALYTICAL METHODS FOR PREDICTION OF UNSTEADY TURBULENT BOUNDARY LAYERS
D. P. TELIONIS *In* AGARD Spec. Course on Unsteady Aerodyn. 10 p (SEE N80-33363 24-02) Jun. 1980 refs
Avail: NTIS HC A11/MF A01

Almost all of the models for the closure of the turbulent boundary layer equations were extended for the calculation of unsteady flows. The advantages of introducing more governing equations and, therefore, more arbitrary functions and constants are discussed. Algebraic models prove to be quite successful and very attractive since they involve the most simple procedures for the calculation of turbulent flows. One equation and two equation models were extensively used with a variety of generalizations to account for the unsteadiness of the outer flow. Depending on the specific closure assumption, the character of the equation becomes either parabolic or hyperbolic. Numerical schemes for the solution of such equations were introduced and are referenced. E.D.K.

N80-33378# Westland Helicopters Ltd., Yeovil (England). Aeromechanics Dept.
PREDICTION METHODS FOR UNSTEADY SEPARATED FLOWS
T. S. BEDDOES *In* AGARD Spec. Course of Unsteady Aerodyn. 11 p (SEE N80-33363 24-02) Jun. 1980 refs
Avail: NTIS HC A11/MF A01

Experimental investigations have provided an understanding of the phenomena associated with separated flows, both unsteady and quasi-steady. The development of quantitative analytical methods which enable the importance of geometric and flow parameters to be evaluated was required to apply this understanding to engineering problems. Unfortunately, the potentially more rigourous theories require very considerable computational effort, and to compliement their usefulness for airfoil applications, methods for the simulation of synthesis of experimentally derived characteristics were developed for routine use. These methods are discussed. E.D.K.

N80-33379*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
NUMERICAL SOLUTION TECHNIQUES FOR UNSTEADY TRANSONIC AERODYNAMICS PROBLEMS
W. F. BALLHAUS and J. O. BRIDGEMAN *In* AGARD Spec. Course on Unsteady Aerodyn. 24 p (SEE N80-33363 24-02) Jun. 1980 refs
Avail: NTIS HC A11/MF A01 CSCL 01A

Basic concepts of finite difference solution techniques for unsteady transonic flows are presented. The hierarchy of mathematical forumulations that approximate the Navier-Stokes equations are reviewed. The basic concepts involved in constructing numerical algorthms to solve these formulations are given. Semi-implicit and implicit schemes are constructed and analyzed. The discussion focuses primarily on techniques for solving the low frequency transonic small disturbance equation. This is the simplest formulation that contains the essence of inviscid unsteady transonic flow physics. The low frequency formulation is emphasized here because codes based on this theory can be run in minutes of processor time on currently available computers. Furthermore, numerical techniques involved in solving this simple formulation also apply to the more complicated formulations. Extensions to these formulations are briefly described. An indication of the present capability for solving unsteady transonic flows is provided. Important areas of future research for the advancement of computational unsteady transonic aerodynamics are described. E.D.K.

N80-33380# British Aerospace Aircraft Group, Bristol (England).
LINEARISED METHODS IN SUPERSONIC FLOW
R. H. DOE *In* AGARD Spec. Course on Unsteady Aerodyn. 19 p (SEE N80-33363 24-02) Jun. 1980 refs
Avail: NTIS HC A11/MF A01

Following a brief statement of the linearized equations for supersonic potential flow, the essential differences between subsonic and supersonic flow and the concept of the supersonic source are examined. Specializing the time dependence to oscillatory flow, the generalized Green's Theorem for such flows is presented through which the integral equations forming the basis of the numerical methods are developed. The second part of the paper outlines the numerical solution of the integral equations for lifting surfaces. Consideration is also given to the development of panel methods applicable to general configurations of wings and bodies. E.D.K.

N81-11018# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
THREE DIMENSIONAL INTERACTIONS AND VORTICAL FLOWS WITH EMPHASIS ON HIGH SPEEDS
D. J. PEAKE, M. TOBAK, and R. H. KORKEGI, ed. Jul. 1980 226 p refs
(AGARD-AG-252; AD-A089865) Avail: NTIS HC A11/MF A01

Diverse kinds of three dimensional regions of separation in laminar and turbulent boundary layers are discussed that exist on lifting aerodynamic configurations immersed in flows from subsonic to hypersonic speeds. In all cases of three dimensional flow separation, the assumption of continuous vector fields of skin-friction lines and external flow streamlines, coupled with topology laws, provides a flow grammar of nodes, foci and saddles. Sequences of plausible flow structures are created, mean flow characteristics deduced and flow mechanics exposed. S.F.

N81-11019# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
COMPARISON OF UNSTEADY PRESSURE FIELDS COMPUTED AND MEASURED ON THE ZKP MODEL
M. COUSTON, J. J. ANGELINI, and J. P. MEURZEC Aug. 1980 21 p refs In FRENCH; ENGLISH summary Presented at the 50th Conf. of the Commission on Structures and Materials, Athens, Apr. 198 Structures and Materials, Athens, Apr. 1980
(AGARD-R-688; ISBN-92-835-2107-2; AD-A090309) Avail: NTIS HC A02/MF A01

The unsteady pressure fields prediction for a supercritical wing is considered from a bidimensional nonlinear method corrected for tridimensional interactions between strips using an asymptotic approximation. This approximation is derived for a wing with large aspect ratio and low sweep angle. An application of this method to a real case is described. Oscillation of the control surface on a rigid model in a transonic wind tunnel is considered. M.G.

N81-13018*# National Aeronautics and Space Administration, Washington, D. C.
UNSTEADY EFFECTS OF A CONTROL SURFACE IN TWO DIMENSIONAL SUBSONIC AND TRANSONIC FLOW
R. GRENON (ONERA), A. DESOPPER (ONERA), and J. SIDES (ONERA) Jun. 1980 45 p refs Transl. into ENGLISH of "Effects Instationaires d'une Governe en Ecoulement Bidimensionnel Subsonique et Transonique" Rept. AGARD-CP-262 Transl. by Kanner (Leo) Associates, Redwood City, Calif.
(Contract NASW-3199)
(NASA-TM-75775; AGARD-CP-262) Avail: NTIS HC A03/MF A01 CSCL 01A

The experimental results of steady and unsteady pressure measurements, carried out in subsonic and transonic flow on a 16 percent relative thickness supercritical aerofoil, equipped with a trailing edge flap involving 25 percent of the chord, in a sinusoidal motion are given. These experimental results are compared with those obtained by various methods of steady and unsteady inviscid flow calculations. Some calculation results in which viscous effects have been taken into account, for both steady and unsteady flows, are also presented. M.G.

N81-15991# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
SUBSONIC/TRANSONIC CONFIGURATION AERODYNAMICS
Sep. 1980 447 p refs In ENGLISH partly in FRENCH Presented at the Fluid Dyn. Panel Symp., Munich, 5-7 May 1980
(AGARD-CP-285; ISBN-92-835-0276-0; AD-A094086) Avail: NTIS HC A19/MF A01

A mixture of theoretical and experimental papers, many providing test theory comparisons, are presented. Subject matter ranges from simple wing fuselage interference for both fighter and airlift configurations to those involving additional components such as nacelle and pylons, powered jets, winglets, and most importantly stores and weapons. For individual titles, see N81-15992 through N81-16019.

N81-15992# Flow Research, Inc., Kent, Wash.
APPLICATION OF TRANSONIC POTENTIAL CALCULATIONS TO AIRCRAFT AND WIND TUNNEL CONFIGURATIONS
J. E. MERCER and E. M. MURMAN *In* AGARD Subsonic/Transonic Configuration Aerodyn. 15 p (SEE N81-15991 07-02) Sep. 1980 refs
(Contract N00014-78-C-0079; F4D600-79-C-0001)
Avail: NTIS HC A19/MF A01

The computation of inviscid transonic flow modeled by the full potential equation is presented for two geometrical configurations. The Jameson-Caughey finite volume method is used to solve the governing equations in conservative form. The development of suitable computational meshes together with computed results are presented for a swept wing in a wind tunnel and for a wing body configuration. Author

N81-15993# Societe Nationale Industrielle Aerospatiale, Toulouse (France).
A VARIATIONAL FINITE ELEMENT METHOD FOR SOLVING THREE DIMENSIONAL TRANSONIC FLOWS [UNE METHODE VARIATIONNELLE D'ELEMENTS FINIS POUR LA RESOLUTION D'ECOULEMENTS TRANSSONIQUES TRIDEMENSIONNELS]
Y. VIGNERON, O. BROCARD (ONERA), J. BOUSQUET, and T. LEJAL *In* AGARD Subsonic/Transonic Configuration Aerodyn. 16 p (SEE N81-15991 07-02) Sep. 1980 refs In FRENCH
Avail: NTIS HC A19/MF A01

A finite element method was developed at Aerospatiale to simulate inviscid steady transonic flows around complex geometries such as wing fuselage configurations. In this method, aerodynamic flow is described by the general potential equation based on an extension of Bateman's variational principle for the transonic case. This formula reduces the number of iterations needed to obtain a solution. The unity of the solution is assured by the use of artificial viscosity under the form of 'delayed' density. The discretization of the problem is effected by trilinear isoparametric approximation on hexahedral elements. In the case of bearing flows, the Kutta-Joukowski condition is realized due to associated circulatory solutions. Practical results are presented to verify the method. They are compared to experimental results and to results from other numerical methods. Transl. by A.R.H.

N81-15994# Avions Marcel Dassault, Saint-Cloud (France). Dept. des Etudes Theoriques Aerodyn.
FINITE ELEMENT METHOD STUDY OF WING-FUSELAGE-NACELLE INTERACTIONS OF A FALCON 20 TYPE AIRCRAFT AT MACH = 0.79 [ETUDE PAR LA METHODE DES ELEMENTS FINIS DES INTERACTIONS VOILURE FUSELAGE-NACELLE D'UN AVION DU TYPE FALCON A MACH = 0,79]
G. HECKMANN *In* AGARD Subsonic/Transonic Configuration Aerodyn. 11 p (SEE N81-15991 07-02) Sep. 1980 refs In FRENCH
Avail: NTIS HC A19/MF A01

Adaptation of the Garrett ATF3-6 engine on the twin engine Falcon 20, equipped in series with a General Electric CF 700 engine, revealed an important and predicted growth of drag in transonic flow. Wind tunnel tests of the new configuration showed shocks on the front of the engine nacelle and on the back of the wing at the top face of the socket at Mach = 0.79. Air flow between the wing and the nacelle was locally supersonic. The shape and position of the nacelle and mast were modified. This complex fuselage wing mast nacelle configuration should be studied in supercritical flow while considering the flow from the engine. The finite element method permits calculation in three dimensional and transonic flow with shock waves in a geometric domain under conditions of the required limits. It is shown that the matrix from a transonic calculation method provides solutions to aerodynamic problems previously detectable only by flight and wind tunnel tests. Mathematical tools are described and results obtained on the original nacelle and on the definitive nacelle with modified shape and position are discussed. Transl. by A.R.H.

N81-15995# British Aerospace Aircraft Group, Brough (England). Kingston-Brough Div.
INCREASING THE VALUE OF AIRFORCES BY IMPROVING EXTERNAL STORE CONFIGURATION
C. L. BORE *In* AGARD Subsonic/Transonic Configuration Aerodyn. 6 p (SEE N81-15991 07-02) Sep. 1980 refs
Avail: NTIS HC A19/MF A01

The value of improvements to the external stores configuration, such as reduced drag (with consequent improvements of performance), and reduced release disturbances to the trajectory are surveyed. It is shown that the effectiveness/cost ratio of a fighter G.A. airforce could be improved greatly by refining the aerodynamics of external store carriage, and that the payoff in value should be over 100 times the cost of re-equipment. E.D.K.

N81-15996# Aircraft Research Association Ltd., Bedford (England).
PROSPECTS FOR EXPLOITING FAVOURABLE AND MINIMIZING ADVERSE AERODYNAMIC INTERFERENCE IN EXTERNAL STORE INSTALLATIONS
A. B. HAINES *In* AGARD Subsonic/Transonic Configuration Aerodyn. 25 p (SEE N81-15991 07-02) Sep. 1980 refs
Avail: NTIS HC A19/MF A01

External store installations are frequently a source of considerable adverse aerodynamic interference giving large increases in drag, reductions in usable lift, and poor store release characteristics. Research has shown how this adverse interference can be greatly alleviated or even transformed into favorable interference. Some of the available evidence for a wide variety of arrangements are reviewed. The nature of the interference, both adverse and favorable, is described, particular emphasis being placed on the major adverse interference in standard multiple carriers and in some underwing installations. The possible benefits of wing tip carriage and carefully arranged underfuselage arrays are noted. The fact that dramatic improvements might be possible by adopting a radical approach to store carriage is stressed.
E.D.K.

N81-15997# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (West Germany).
EVALUATION OF AIRCRAFT INTERFERENCE EFFECTS ON EXTERNAL STORES AT SUBSONIC AND TRANSONIC SPEEDS
R. DESLANDES *In* AGARD Subsonic/Transonic Configuration Aerodyn. 11 p (SEE N81-15991 07-02) Sep. 1980 refs
Avail: NTIS HC A19/MF A01

In order to analyse the separation behavior of external stores from a combat aircraft, the store loads must be evaluated at all times after release. The resulting forces and moments are highly unsteady and depend upon the nonuniform flow field around the aircraft and the store motion itself. The exact evaluation of unsteady aerodynamics of such complicated configurations is nearly impossible, due to the required computer capacity and cost effectiveness. Simplificating assumptions leads to the quasilinearization of the time dependence to omit unsteady calculations and to the use of the flow angularity technique to minimize computational time. The MBB store separation program system is presented as a possible solution. The mixed experimental analytical approach is not restricted by compressibility effects, but is mainly described at subsonic flows. However, the transonic and supersonic extensions are mentioned, as well as the application of the program system to realistic combat aircraft missions under realistic conditions, such as jettison at high g maneuver, multiple jettison, and rail and drop launch of missiles.
E.D.K.

N81-15998# Nielsen Engineering and Research, Inc., Mountain View, Calif.
STUDY OF TRANSONIC FLOW FIELDS ABOUT AIRCRAFT: APPLICATION TO EXTERNAL STORES
S. S. STAHARA *In* AGARD Subsonic/Transonic Configuration Aerodyn. 18 p (SEE N81-15991 07-02) Sep. 1980 refs
(Contract F44620-75-C-0047)
Avail: NTIS HC A19/MF A01

A review is presented of an extensive experimental/theoretical program directed toward establishing a predictive method for determining (1) three dimensional transonic flow fields about parent aircraft and (2) loading distributions on external stores located in these nonuniform flow fields. The work represents several stages in the systematic development of a theoretical capability for enabling aircraft/store compatibility studies at transonic speeds with applications to aircraft/store design optimization and store certification programs. The objectives are two fold: (1) to describe the extensive companion experimental program and present highlights of those results, which include detailed measurements of both flow fields and surface pressures (parent and external store), taken in a systematic component buildup; and (3) to discuss the development of the associated theoretical method, describe its application to a class of idealized fighter bomber configurations, and display comparisons with data from the parallel experimental programs, including both flow field and store loading distribution results.
E.D.K.

N81-15999# Dornier-Werke G.m.b.H., Friedrichshafen (West Germany). Theoretical Aerodynamics Dept.
AERODYNAMIC SUBSONIC/TRANSONIC AIRCRAFT DESIGN STUDIES BY NUMERICAL METHODS
W. SCHMIDT *In* AGARD Subsonic/Transonic Configuration Aerodyn. 26 p (SEE N81-15991 07-02) Sep. 1980 refs
Avail: NTIS HC A19/MF A01

The need and use of computational aerodynamics in the design of aircraft and missile configurations in steady flow conditions is explored through several examples. These include aircraft and missile synthesis programs for predesign and evaluation work of aircraft and missile weapon systems, subsonic and transonic airfoil and high lift design, subsonic and transonic inviscid and viscous wing and aircraft design including leading edge vortex flows, aircraft engine integration, and three dimensional flows with separation. Use of these numerical and semiempirical methods can substantially increase airplane performance capabilities while reducing risk, flow time, and testing requirements and thus total cost. The capabilities of current aerodynamic methods are demonstrated by comparison with windtunnel results and by case studies.
Author

N81-16000# Institut fuer Theoretische Stroemungsmechanik, Goettingen (West Germany).
DESIGN OF ADVANCED TECHNOLOGY TRANSONIC AIRFOILS AND WINGS
H. SOBIECZKY *In* AGARD Subsonic/Transonic Configuration Aerodyn. 13 p (SEE N81-15991 07-02) Sep. 1980 refs
Avail: NTIS HC A19/MF A01

A systematic method to design supercritical shock free 2D and 3D configurations is described. Simplified examples were chosen from airfoils and wings which are used in advanced technology aerodynamic concepts. With the outlined methods theoretical tools are presented to extend essentially subsonic design aerodynamic into the transonic regime.
T.M.

N81-16001# British Aerospace Aircraft Group, Hertfordshire (England). Fluid Dynamics Dept.
INTERFERENCE ASPECTS OF THE A310 HIGH SPEED WING CONFIGURATION
J. A. JUPP *In* AGARD Subsonic/Transonic Configuration Aerodyn. 16 p (SEE N81-15991 07-02) Sep. 1980 refs
Avail: NTIS HC A19/MF A01

The effect of the fuselage representation on the inboard wing transonic design and the influence of the tailplane in the optimization of the wing twist for minimium drag are discussed. Highlights from the wind tunnel testing program are presented and include the development of the wing root leading edge fillet to improve wing/fuselage viscous interference, and the optimization of the flap support fairings for the minimum high speed interference.
T.M.

N81-16002# Vereinigte Flugtechnische Werke G.m.b.H., Bremen (West Germany).
TRANSONIC WING TECHNOLOGY FOR TRANSPORT AIRCRAFT
G. KRENZ and B. EWALD *In* AGARD Subsonic/Transonic Configuration Aerodyn. p 12 (SEE N81-15991 07-02) Sep. 1980 refs
Avail: NTIS HC A19/MF A01

The Aircraft Energy Efficiency Program is described. Results from the program are presented which describe the standard transonic wing aerodynamics, taking into account impacts on structure and aeroelastics. The main objectives of the program are the development of high aspect ration wings, better wing engine integration, and the development of active control with movable wing parts.
T.M.

N81-16003# Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, Brunswick (West Germany). Inst. fuer Entwurfsaerodynamik.

DESIGN AND EXPERIMENTAL VERIFICATION OF A TRANSONIC WING FOR A TRANSONIC AIRCRAFT

G. REDEKER, N. SCHMIDT, and R. MUELLER *In* AGARD Subsonic/Transonic Configuration Aerodyn. p 14 (SEE N81-15991 07-02) Sep. 1980 refs

Avail: NTIS HC A19/MF A01

Force, moment, and wing surface pressure measurements were made on a half scale model of a wing fuselage configuration. Drag reduction was the major design concept and thus the basis for all modifications to the slender wing. Modifications include: increasing average wing thickness from 10.5% to 12.5%; reducing the leading edge sweep angle from 30 deg to 27 deg; and increasing the cruising lift coefficient to c sub L = 0.5. T.M.

N81-16004# National Research Council of Canada, Ottawa (Ontario).

THE TALE OF TWO WINGS

E. ATRAGHJI, L. THORNQUIST (Saab-Scania), and L. TORNGREN (Aeronautical Res. Inst. of Sweden) *In* AGARD Subsonic/Transonic Configuration Aerodyn. p 10 (SEE N81-15991 07-02) Sep. 1980 refs

Avail: NTIS HC A19/MF A01

Two design philosophies for a wing for an attack aircraft were investigated experimentally. In the first case, the wing was equipped with a leading edge that could be deflected mechanically to cope with leading and maneuvering cases without suffering extensive drag. In the second case, the wing leading edge profile is permanently set as a compromise for all flight conditions. Results indicate that, using the second concept, a carefully tailored wing can be generated which need not suffer a drag penalty or a reduction in maneuver capability. Such a wing has the advantage of simplicity and lighter weight also. T.M.

N81-16005# British Aerospace Aircraft Group, Brough (England). Aerodynamics Dept.

SOME PARTICULAR CONFIGURATION EFFECTS ON A THIN SUPERCRITICAL VARIABLE CAMBER WING

D. R. HOLT and B. PROBERT *In* AGARD Subsonic/Transonic Configuration Aerodyn. p 18 (SEE N81-15991 07-02) Sep. 1980 refs

Avail: NTIS HC A19/MF A01

Variable camber devices were shown to represent a powerful means of matching a variety of disparate transonic points for a thin wing if designed into the wing from the outset. In particular, trailing edge devices allow for the provision of good high lift performance without degrading the sea level dash capability. Strakes were designed with only a small drag penalty by matching the strake to the wing streamlines at particular incidences. T.M.

N81-16006# National Aerospace Lab., Amsterdam (Netherlands). Theoretical Aerodynamics Dept.

A CONSTRAINED INVERSE METHOD FOR THE AERODYNAMIC DESIGN OF THICK WINGS WITH GIVEN PRESSURE DISTRIBUTION IN SUBSONIC FLOW

J. M. J. FRAY and J. W. SLOOFF *In* AGARD Subsonic/Transonic Configuration Aerodyn. p 9 (SEE N81-15991 07-02) Sep. 1980 refs

Avail: NTIS HC A19/MF A01

The method combines well established linear techniques for the analysis of thick wing configurations, and for the design of asymptotically thin wings. These techniques are used in an iterative way. The design codes were constructed in such a way that constraints on the spanwise distributions of thickness, twist, leading edge radius, and trailing edge angle can be taken into account. In this way the designer may execute control over the geometry at the cost of a penalty in the pressure distribution. Examples of application to a swept wing and a wing body configuration are presented. T.M.

N81-16007# British Aerospace Aircraft Group, Warton (England).

JET WING INTERACTION TO GIVE IMPROVED COMBAT PERFORMANCE

A. VINT *In* AGARD Subsonic/Transonic Configuration Aerodyn. p 12 (SEE N81-15991 07-02) Sep. 1980 refs

Avail: NTIS HC A19/MF A01

Prediction techniques showed that a conventional propulsive jet at the wing trailing edge gives a significant improvement in the high lift characteristics of the wing providing deflections of up to 30 deg can be provided. Application of the predicted effects to a projected aircraft showed that the best configuration would be the canard, to provide beneficial trim effects of the deflected thrust, and that large improvements in sustained turn rate at low speed and in peak attained turn rate at low level would be obtained. Weight penalties associated with the required deflecting nozzles are presented. T.M.

N81-16008# Salford Univ. (England).

JET WING INTERFERENCE FOR AN OVERWING ENGINE CONFIGURATION

R. A. SAWYER and M. P. METCALFE (British Aerospace, Manchester, England) *In* AGARD Subsonic/Transonic Configuration Aerodyn. p 10 (SEE N81-15991 07-02) Sep. 1980 refs

Avail: NTIS HC A19/MF A01

Detailed pressure distributions over the wing are presented for jet to free stream velocity ratios of 2:1, 3:1, and 5:1, over a range of incidence. The configuration of the jet nozzle, wing section, and the relative positions of the engine and the wing, correspond to a moderate by-pass ratio engine mounted over the wing of a low wing feeder liner aircraft. Entrainment rates into the jet and the path of the jet relative to the wing were established by flow measurement and flow visualization. Theoretical considerations showed that it is the bound vorticity associated with jet curvature which produces the pressure increments on the wing surface. T.M.

N81-16009# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (West Germany).

INTERFERENCE EFFECTS OF CONCENTRATED BLOWING AND VORTICES ON A TYPICAL FIGHTER CONFIGURATION

W. STAUDACHER *In* AGARD Subsonic/Transonic Configuration Aerodyn. p 13 (SEE N81-15991 07-02) Sep. 1980 refs

Avail: NTIS HC A19/MF A01

Generation and/or stabilization and control of these vortex systems was obtained by planform variation (such as strakes, short coupled canards); modifications of wing section (shape and camber of leading edges and leading edge flaps); and concentrated spanwise blowing for arbitrary planforms. Specific and combined results of these modifications are presented. Optimum jet positions, in respect of various criteria applied, were derived. The effects of strakes and/or spanwise blowing on performance, stability and control, dynamic characteristics, and flow distributions are discussed. T.M.

N81-16010# Office National d'Etudes et de Recherches Aerospatiales, Paris (France).

EXPERIMENTAL STUDY OF THE INTERACTION BETWEEN THE WING OF A SUBSONIC AIRCRAFT AND A NACELLE OF A HIGH BY-PASS RATIO ENGINE [ETUDE EXPERIMENTALE DE L'INTERACTION ENTRE UNE VOILURE L'AVION SUBSONIQUE RAPIDE ET UNE NACELLE DE MOTEUR A HAUT TAUX DE DILUTION]

P. LEVART *In* AGARD Subsonic/Transonic Configuration Aerodyn. 11 p (SEE N81-15991 07-02) Sep. 1980 refs In FRENCH; ENGLISH summary

Avail: NTIS HC A19/MF A01

The oncoming of a new generation of subsonic transport aircraft (with supercritical wing and high by-pass ratio turbofans) has led to an experimental study of wing nacelle jet pylon interference in transonic flow. To this end, a test set-up was developed at the ONERA S3Ch wind tunnel. The nacelle models represent a turbofan by means of two compressed air jets. The scale is 1/18,5. The nacelles are fixed on a thrust balance measuring afterbody thrust and discharge coefficients. The wing is located between the sidewalls of the test section. Pressures are measured through 456 holes located on 8 airfoils. Drag coefficient of the wing is

obtained by wake survey. The following parameters can vary: (1) wing/nacelle position; (2) upstream Mach number (from 0.3 to 0.8); (3) jet pressure ratio; (4) with/without pylon; and (5) type of nacelle. Wing nacelle interference can be studied by means of total thrust drag analysis, as a function of the various parameters. The test set-up is described, and examples of results are presented illustrating the possibilities of this set-up. Author

N81-16011# Air Force Wright Aeronautical Labs., Wright-Patterson AFB, Ohio. Flight Dynamics Lab.

A WIND TUNNEL INVESTIGATION OF THE AERODYNAMIC CHARACTERISTICS OF FORWARD SWEPT WINGS

T. M. WEEKS, G. C. UHUAD, and R. LARGE *In* AGARD Subsonic/Transonic Configuration Aerodyn. 15 p (SEE N81-15991 07-02) Sep. 1980

Avail: NTIS HC A19/MF A01

An experimental investigation of a forward swept wing and a state of the art equivalent aft swept wing was conducted to compare the relative performance of both wings at identical transonic maneuver design conditions and to determine any associated drag penalty of the forward swept wing for a high supersonic cruise condition. At the transonic maneuver design condition, the results indicate a significant reduction in the profile drag of the forward swept wing relative to the aft swept wing. The forward swept wing drag exhibited extreme sensitivity to wing root height and incidence variations. A relocation of the FSW root from a mid to high body position and an increase in incidence of 0.8 degrees resulted in a two hundred count drag reduction at C sub L = 0.9. A drag penalty was recorded at M = 2.0 for the forward swept 'cruise wing' which had the same sweep and 'box geometry' as the transonic maneuver wing but with reduced camber and twist accomplished by flap deflection. The drag penalty decreased at lower supersonic Mach numbers. The results indicate that aft swept wing transonic aerodynamic design methods can be used to design and analyze forward swept wings with only minor modifications. Author

N81-16012# Aeronautical Research Inst. of Sweden, Bromma. Aerodynamics Dept.

AN INVESTIGATION OF A SWEPT WING-BODY CONFIGURATION WITH DROOPED LEADING EDGE AT LOW AND TRANSONIC SPEEDS

G. DROUGGE *In* AGARD Subsonic/Transonic Configuration Aerodyn. 10 p (SEE N81-15991 07-02) Sep. 1980 refs

Avail: NTIS HC A19/MF A01

A basic, non-drooped wing was designed (using an inverse transonic small disturbance method) to have a critical Mach Number of around M = 0.85 at C sub L = 0.2. The sweep angle is 25 deg, the aspect ratio 4 and the taper ratio 0.4. Several drooped leading edges, about 15 percent of the local chord and also including spanwise variation, were designed and tested. Numerical calculations were done for the low speed high lift case using a vortex lattice panel method and for the transonic speed case, first using a small disturbance method, later a full potential equation method (Jameson's FLO22) and finally also a full Euler equations method (Rizzi). The experimental investigations were performed at low speeds at FFA (Re approximately 3 x 10 to the 6th power) at transonic speeds at FFA (Re approximately 1.5 to 4 x 10 to the 6th power) and at NAE, Canada (Re approximately 12 to 18 x 10 to the 6th power). These are mainly balance measurements but also some pressure distribution measurements have been obtained. The results indicate that it is possible to design a wing which has no transonic cruise drag penalty but which has a higher maximum coefficient of left and also better maneuver performance than the wing without droop. Author

N81-16013# Office National d'Etudes et de Recherches Aerospatiales, Paris (France).

AERODYNAMIC INTERACTION BETWEEN A CLOSE-COUPLED CANARD AND A SWEPTBACK WING IN TRANSONIC FLOW [INTERACTION AERODYNAMIQUE ENTRE UN CANARD PROCHE ET UNE AILE EN FLECHE EN ECOULEMENT TRANSSONIQUE]

Y. BROCARD and V. SCHMITT *In* AGARD Subsonic/Transonic Configuration Aerodyn. 23 p (SEE N81-15991 07-02) Sep. 1980 refs In FRENCH

Avail: NTIS HC A19/MF A01

A swept wing model was tested with and without a canard in the transonic wind tunnel S2MA to study the effects of a closed coupled canard on the flow around the main wing. The most significant results in terms of force and pressure measurements on the main wing and wall flow visualizations are presented. The compressibility effect analysis for the wing alone configuration shows that the Mach number has a marked effect on the lift gradient at low incidence and on the vortex onset angle of attack. In transonic flow, the canard changes the flow field on the wing in a similar way as it does in incompressible flow: a decrease in the lift gradient and a delay in the vortex development. But the vortex lift decay is delayed so that the maximum lift is about the same with or without canard. The canard attenuates the discontinuity due to the vortex breakdown migration but increases two other discontinuities which occur at higher angles of attack and which are connected with the formation and the bursting of a quite strong secondary vortex. A.R.H.

N81-16014# Royal Aircraft Establishment, Farnborough (England).

SOME AERODYNAMIC INTERFERENCE EFFECTS THAT INFLUENCE THE TRANSONIC PERFORMANCE OF COMBAT AIRCRAFT

D. TREADGOLD and K. H. WILSON *In* AGARD Subsonic/Transonic Configuration Aerodyn. 17 p (SEE N81-15991 07-02) Sep. 1980 refs

Avail: NTIS HC A19/MF A01

The magnitude of the effects of viscous interactions, aeroelasticity and the aerodynamic interaction between the wing and fuselage are discussed in the context of a swept wing planform typical of some designs of combat aircraft. Illustrations drawn from experimental measurements and theoretical calculations show the significant influence of these factors on the form of the supercritical flow development at high subsonic speeds. Some experimental measurements are given which indicate how small changes to the contour of the fuselage can produce significant changes in the drag measured at high subsonic speeds. The example shows that fuselage shaping can contribute to the development of a desirable form of supercritical flow on the wing with consequential benefit in drag levels at these speeds. Author

N81-16015# Royal Netherlands Aircraft Factories Fokker, Schiphol-Oost. Aerodynamics Dept.

DESIGN STUDY FOR THE INNER WING OF A TRANSONIC WING-BODY COMBINATION OF ASPECT RATIO 8

N. VOOGT and J. T. V. D. KOLK *In* AGARD Subsonic/Transonic Configuration Aerodyn. 11 p (SEE N81-15991 07-02) Sep. 1980 refs

Avail: NTIS HC A19/MF A01

A transonic design procedure for wing body combinations combines direct and inverse panel type computations and is based on the relationship between the exact transonic solution and an equivalent subsonic pressure distribution. The latter can be obtained by applying the subsonic panel method at the design condition for a shock free airfoil designed by hodograph theory. Several problems arise in the design of the inner wing because of the three dimensional character of the flow, which prevents a unique determination of the equivalent subsonic pressure distribution. Two essentially different approaches were followed by prescribing either a subcritical or a supercritical flow condition at the wing root. It is shown that the subcritical flow condition at the wing root can be achieved for a range of wing geometries with leading edge extensions on the inner wing or alternatively, by applying extensive body contouring to a wing originally designed to have supercritical flow at the root. A.R.H.

N81-16016*# Grumman Aerospace Corp., Bethpage, N.Y.
COMPLEX CONFIGURATION ANALYSIS AT TRANSONIC SPEEDS
C. W. BOPPE and P. V. AIDALA *In* AGARD Subsonic/Transonic Configuration Aerodyn. 13 p (SEE N81-15991 07-02) Sep. 1980 refs
(Contract NAS1-14732; F33615-78-C-3014)
Avail: NTIS HC A19/MF A01 CSCL 01A

Advanced performance requirements of new combat and transport aircraft together with design time constraints intensify the development and application of three dimensional computational analyses. A computational method which was developed for the specific purpose of providing an engineering analysis of complex aircraft configurations at transonic speeds. Particular attention is given to the recently incorporated wing viscous interaction and canard capabilities. The treatment of fuselage fairings, nacelles, and pylons is reviewed. The means for keeping computing resources at reasonable levels are identified. Three configurations were selected for correlations with experimental data. Taken together, the comparisons illustrate the full extent of current analysis capabilities. The configurations include: (1) a wing fuselage canard fighter; (2) a transport with fuselage fairings, four nacelles, four pylons; and (3) a space vehicle which includes an external fuel tank and rocket boosters (transonic launch configuration). A.R.H.

N81-16017*# Boeing Military Airplane Development, Seattle, Wash. Advanced Airplane Branch.
THEORETICAL AND EXPERIMENTAL STUDIES OF AERODYNAMIC INTERFERENCE EFFECTS
I. H. RETTIE *In* AGARD Subsonic/Transonic Configuration Aerodyn. 19 p (SEE N81-15991 07-02) Sep. 1980 refs Supported in part by NASA and USAF
Avail: NTIS HC A19/MF A01 CSCL 01A

Theoretical studies of aerodynamic forces on winglets shed considerable light on the mechanism by which these devices can reduce drag at constant total lift and on the necessity for proper alignment and cambering to achieve optimum favorable interference. Results of engineering studies, wind tunnel tests and performance predictions are reviewed for installations proposed for the AMST YC-14 and the KC-135 airplanes. The other major area of aerodynamic interference discussed is that of engine nacelle installations. Slipper and overwing nacelles have received much attention because of their potential for noise reduction, propulsive lift and improved ground clearance. A major challenge is the integration of such nacelles with the supercritical flow on the upper surface of a swept wing in cruise at high subsonic speeds. A.R.H.

N81-16018*# Nielsen Engineering and Research, Inc., Mountain View, Calif.
DATA BASE FOR THE PREDICTION OF INLET EXTERNAL DRAG
O. J. MCMILLAN, E. W. PERKINS, and S. C. PERKINS, JR. *In* AGARD Subsonic/Transonic Configuration Aerodyn. 23 p (SEE N81-15991 07-02) Sep. 1980 refs
(Contract NAS2-8874; NAS2-9513)
Avail: NTIS HC A19/MF A01 CSCL 01A

Results are presented from a study to define and evaluate the data base for predicting an airframe/propulsion system interference effect shown to be of considerable importance, inlet external drag. The study is focused on supersonic tactical aircraft with highly integrated jet propulsion systems, although some information is included for supersonic strategic aircraft and for transport aircraft designed for high subsonic or low supersonic cruise. The data base for inlet external drag is considered to consist of the theoretical and empirical prediction methods as well as the experimental data identified in an extensive literature search. The state of the art in the subsonic and transonic speed regimes is evaluated. The experimental data base is organized and presented in a series of tables in which the test article, the quantities measured and the ranges of test conditions covered are described for each set of data; in this way, the breadth of coverage and gaps in the existing experimental data are evident. Prediction methods are categorized by method of solution, type of inlet and speed range to which they apply, major features are given, and their accuracy is assessed by means of comparison to experimental data.
Author

N81-16019# Vereinigte Flugtechnische Werke G m b H , Bremen (West Germany).
PHILOSOPHY AND RESULTS OF STEADY AND UNSTEADY TEST TECHNIQUES ON A LARGE SCALE TRANSPORT AIRCRAFT MODEL IN THE ONERA TRANSONIC TUNNEL S1 MA. PART 1: PHILOSOPHY AND RESULTS OF STEADY TESTS. PART 2: INTEREST OF LARGE MODELS IN UNSTEADY AERODYNAMICS
G. ANDERS, A. GIACCHETTO (ONERA, Modane, France), and A. GRAVELLE (ONERA, Paris) *In* AGARD Subsonic/Transonic Configuration Aerodyn. 25 p (SEE N81-15991 07-02) Sep. 1980 refs Partly in ENGLISH and FRENCH
Avail: NTIS HC A19/MF A01

Steady and unsteady wind tunnel tests with a large scale half model performed in the large ONERA transonic wind tunnel S1 MA within the German technology program ZKP and the development phase of the A 310 Airbus are considered. ious test techniques are introduced, their advantages and p. ns are discussed. The test arrangement concept is describe typical results for each of the investigated items are presented. Test results are compared with those on a complete model at lower Reynolds numbers. Stationary measurements are described and discussed. Characteristic results from unsteady tests are also presented and correlations are shown. A.R.H.

N81-23044# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
BOUNDARY LAYER EFFECTS ON UNSTEADY AIRLOADS
Feb. 1981 175 p refs In ENGLISH and FRENCH Proceedings of the 15th Meeting, Aix-en-Provence, France, 14-19 Sep. 1980 (AGARD-CP-296; ISBN-92-835-0281-7; AD-A098057) Avail: NTIS HC A08/MF A01

Recent progress in the theoretical and experimental analysis of unsteady flow is reported. Topics include boundary layer separation and boundary layer control, wing oscillations and vibratory loads, the scale effect on airfoils at transonic and subsonic speeds, and means of coupling inviscid and viscous flow. Several flow models were developed as possible tools for the introduction of viscous effects in classical aeroelastic applications.

N81-23045# Vereinigte Flugtechnische Werke-Fokker G.m.b.H., Bremen (West Germany).
INTRODUCTORY REMARKS ON BOUNDARY LAYER EFFECTS ON UNSTEADY AIRLOADS
H. ZIMMERMANN *In* AGARD Boundary Layer Effects on Unsteady Airloads 4 p (SEE N81-23044 14-02) Feb. 1981
Avail: NTIS HC A08/MF A01

Unsteady aerodynamic coefficients are discussed as a function of reduced frequency in subcritical flow. The strong interaction between steady and unsteady pressure in the transonic range is discussed. This unsteady pressure distribution, apart from its Mach dependence, depends on the profile of the wing, its mean incidence, and its mean flap angle. T.M.

N81-23046*# Princeton Univ., N. J.
AN ASSESSMENT OF THEORETICAL MODELS FOR VISCOUS AND TRANSONIC FLOW
E. H. DOWELL, M. H. WILLIAMS, and M. R. CHI (G.E. Co., Evendale, Ohio) *In* AGARD Boundary Layer Effects on Unsteady Airloads 28 p (SEE N81-23044 14-02) Feb. 1981 refs Sponsored jointly by NASA Ames, NASA Langley, NASA Lewis, and the Pratt and Whitney Group
Avail: NTIS HC A08/MF A01 CSCL 01A

Topics discussed include shear flow models, simplified models for treating separation, classical linear theory, a local linearization theory, a transonic linear theory, a transonic nonlinear theory, the experiment of Davis, and the experiment of Tijdeman. It is concluded that shear flow models, which have proven very accurate in taking into account boundary layer effects for panel flutter, are likely to be less so for lifting surface flutter. For many applications in transonic flow, transonic linear theory will be adequate T.M.

N81-23047# Boeing Military Airplane Development, Seattle, Wash.

OSCILLATING SUPERCRITICAL AIRFOILS IN THE TRANSONIC REGIME WITH VISCOUS INTERACTIONS

D. P. RIZZETTA and H. YOSHIHARA *In* AGARD Boundary Layer Effects on Unsteady Airloads 7 p (SEE N81-23044 14-02) Feb. 1981 refs

Avail: NTIS HC A08/MF A01

A method is presented for computing the unsteady transonic flowfield about thick supercritical airfoils in the small disturbance limit. In order to compensate for the limitations of the small disturbance assumption and also to account for the aft decambering effect of viscous displacement, the airfoil geometry is modified such that the steady mean experimental pressure distribution is recovered. In addition, effects of the unsteady shock-boundary layer interaction were simulated by placing a moving wedge-nosed ramp at the base of the shock to produce quasi-statically the reduced shock pressure rise which is observed experimentally in the steady case. T.M.

N81-23048# Centre d'Etudes et de Recherches, Toulouse (France). Dept. d'Aerothermodynamique.

METHODS FOR CALCULATING UNSTEADY TURBULENT BOUNDARY LAYERS [METHODES DE CALCUL DES COUCHES LIMITES INSTATIONNAIRES]

J. COUSTEIX, R. HOUDEVILLE, and J. JAVELLE *In* AGARD Boundary Layer Effects on Unsteady Airloads 16 p (SEE N81-23044 14-02) Feb. 1981 refs In FRENCH; ENGLISH summary

Avail: NTIS HC A08/MF A01

Several unsteady turbulent boundary layer prediction methods were studied by using various levels of closure. The most complex methods are constituted by a set of transport equations for the components of the turbulent kinetic energy, its dissipation rate, and the turbulent shear stress. The simplest methods consist in solving the global boundary layer equations. For certain applications, a linearized version of this latter method was developed. The application of these techniques and their limitations are discussed through comparisons with experimental data. T.M.

N81-23049# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Goettingen (West Germany). Inst. fuer Aeroelastik.

VISCOUS EFFECTS ON UNSTEADY AIRLOADS OF OSCILLATING CONFIGURATIONS

W. GEISSLER *In* AGARD Boundary Layer Effects on Unsteady Airloads 11 p (SEE N81-23044 14-02) Feb. 1981 refs

Avail: NTIS HC A08/MF A01

The steady and unsteady Kutta- Joukowsky condition, boundary layer displacement effects, gap flows on wings with oscillating controls and vortex formations on rotor blade tips, on wings with highly swept leading edges and on bodies at incidence severely influence the unsteady pressure distributions and overall forces. Numerical calculations of unsteady airloads based on a sophisticated potential theory were compared with carefully measured experimental data to obtain detailed information of the viscous effects involved. T.M.

N81-23050# National Aerospace Lab., Amsterdam (Netherlands).

SOME REMARKS ON BOUNDARY LAYER EFFECTS ON UNSTEADY AIRLOADS

R. HOUWINK *In* AGARD Boundary Layer Effects on Unsteady Airloads 7 p (SEE N81-23044 14-02) Feb. 1981 refs

Avail: NTIS HC A08/MF A01

Steady, quasi-steady and unsteady boundary layer effects on oscillating airfoils are discussed. The discussion is illustrated by experimental and theoretical data for wing sections with oscillating flap. Results of current investigations at NLR to obtain insight in boundary layer effects are presented, and prediction methods for unsteady airloads are included T.M.

N81-23051# Office National d'Etudes et de Recherches Aerospatiales, Paris (France).

INTRODUCTION OF UNSTEADY BOUNDARY LAYER EFFECTS IN TWO DIMENSIONAL TRANSONIC CALCULATION

M. COUSTON, J. J. ANGELINI, J. C. LEBALLEUR, and P. GIRODROUX-LAVIGNE *In* AGARD Boundary Layer Effects on Unsteady Airloads 16 p (SEE N81-23044 14-02) Feb. 1981 refs In FRENCH; ENGLISH summary

Avail: NTIS HC A08/MF A01

A computation of viscous unsteady flows over wing profiles was researched using two methods elaborated at ONERA, on one hand for the inviscid flow, within a transonic small disturbance approach, on the other hand for the calculation and coupling of viscous layer, within a strong interaction analysis. The difference between the viscous and inviscid solutions, calculated by an integral method, determines the inviscid normal velocity at the wall. The two problems, solved by implicit methods, are linked through a strong coupling, guarantee of validity for the viscous model and of regularity for separated flows solutions. The coupling was applied numerically only to nonseparated flows configurations, namely for profiles with trailing edge flap. T.M.

N81-23052# Royal Aircraft Establishment, Farnborough (England). Structures Dept.

EXPERIMENTAL FLUTTER AT HIGH SUBSONIC SPEEDS AND ITS THEORETICAL PREDICTION, TAKING INTO ACCOUNT WING THICKNESS AND REYNOLDS NUMBER

H. C. GARNER and B. W. PAYNE (British Aerospace Aircraft Group, Weybridge, England) *In* AGARD Boundary Layer Effects on Unsteady Airloads 21 p (SEE N81-23044 14-02) Feb. 1981 refs

Avail: NTIS HC A08/MF A01

Half model flutter tests of a symmetrical high aspect ratio wing at stream Mach numbers M sub infinity between 0.75 and 0.90 are described. Equivalent air speeds at flutter, calculated with aerodynamics from subsonic lifting surface theory, are in fairly good agreement with the measured values up to M sub infinity = 0.86 In the range 0.86 M sub infinity 0.89 the measured flutter speed increases rapidly until the flow is stable, contrary to the predictions with the linear theoretical aerodynamics. However, the use of approximate theories compatible with steady and quasi-steady aerodynamics flow transonic small perturbation (TSP) theory leads to the correct qualitative behavior of flutter speed. With inviscid TSP aerodynamics the rapid rise in flutter speed is anticipated by about 0.02 in M sub infinity, but allowance for the boundary layers is shown to halve this discrepancy. T.M.

N81-23053*# Scientific Research Associates, Inc., Glastonbury, Conn.

ANALYSIS OF TURBULENT FLOW ABOUT AN ISOLATED AIRFOIL USING A TIME DEPENDENT NAVIER-STOKES PROCEDURE

S. J. SHAMROTH and H. J. GIBELING *In* AGARD Boundary Layer Effects on Unsteady Airfoils 14 p (SEE N81-23044 14-02) Feb. 1981 refs Sponsored in cooperation with Army Research and Technology Lab.

(Contract NAS1-15214)

Avail: NTIS HC A08/MF A01 CSCL 01A

The procedure solves the Navier-Stokes equations by the consistently split linearized block implicit method of Briley and McDonald in a body fitted coordinate system. The procedure is described and results are presented for flow about an airfoil whose incidence changes from 6 degrees to 19 degrees at a Reynolds number of one million and Mach number of 0.2. In addition, the unsteady flow about an airfoil held at a constant 19 degree incidence is examined and compared to data T.M.

N81-23054*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

EXPERIMENTAL STUDIES OF SCALE EFFECTS ON OSCILLATING AIRFOILS AT TRANSONIC SPEEDS

S. S. DAVIS *In* AGARD Boundary Layer Effects on Unsteady Airfoils 13 p (SEE N81-23044 14-02) Feb. 1981 refs

Avail: NTIS HC A08/MF A01 CSCL 01A

Scale effects are discussed with reference to a conventional airfoil (NACA 64A010) and a supercritical airfoil (NLR 7301) at mean flow conditions that support both weak and strong shock waves. During the experiment the Reynolds number was varied

from 3 x 10 to the sixth power at time history data are presented over the range of reduced frequencies that are important in aeroelastic applications. The experimental data show that viscous effects are important in the case of the supercritical airfoil at all flow conditions and in the case of the conventional airfoil under strong shock wave conditions. Some frequency dependent viscous effects were also observed. T.M.

N81-23055# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Goettingen (West Germany). Inst. fuer Aeroelastik.

SOME REMARKS ON THE UNSTEADY AIRLOADS ON OSCILLATING CONTROL SURFACES IN SUBSONIC FLOW

H. FOERSCHING *In* AGARD Boundary Layer Effects on Unsteady Airloads 8 p (SEE N81-23044 14-02) Feb. 1981 refs
Avail: NTIS HC A08/MF A01

Parameters which are neglected within the framework of linearized potential flow theory, but which are highly influential in the development of unsteady airloads on oscillating control surfaces in subsonic flow are discussed. Based on theoretical and experimental results the effects of gap width and slot geometry, finite thickness, flow viscosity, and incidence of both wing and control surface are explained. Some topics for further research work with regard to active control applications are indicated.
Author

N81-23056# Royal Aircraft Establishment, Bedford (England). Structures Dept.

OSCILLATORY FLOWS FROM SHOCK INDUCED SEPARATIONS ON BICONVEX AEROFOILS OF VARYING THICKNESS IN VENTILATED WIND TUNNELS

D. G. MABEY *In* AGARD Boundary Layer Effects on Unsteady Airfoils 14 p (SEE N81-23044 14-02) Feb. 1981 refs
Avail: NTIS HC A08/MF A01

The flow instability boundaries on a series of biconvex airfoils with thickness/chord ratios varying from 10 to 20%, set at zero incidence, were measured in a small transonic tunnel. The region of flow instability with laminar boundary layer/shock wave interactions was a little wider than the corresponding region with turbulent boundary layer/shock wave interactions. A criterion for the occurrence of the instability was developed from the measurements. Some interesting examples of dynamic wall interference effects were observed in the slotted working sections with hard slats, which were greatly reduced in the alternative slotted working sections with slats made from sound absorbing laminates. Interesting examples of dynamic interference were also observed in special comparative tests in closed working sections formed by hard or laminate walls. T.M.

N81-23057# Politecnico di Milano (Italy). Ist. di Ingegneria Aerospaziale.

EXPERIMENTS ON A TURBULENT UNSTEADY BOUNDARY LAYER WITH SEPARATION

S. DEPONTE and A. BARON *In* AGARD Boundary Layer Effects on Unsteady Airfoils 6 p (SEE N81-23044 14-02) Feb. 1981 refs Sponsored in part by the Italian Research Council
Avail: NTIS HC A08/MF A01

Turbulent separation is an unsteady phenomenon in itself, even in steady external conditions. In this experiment a cyclic variation is produced in the outstream of a typical boundary layer wind tunnel with variable pressure gradient. Due to this cyclic variation, the point of separation is quasi-steady conditions is shifted in the stream wise direction approximately one third of the boundary layer length. A hot wire analysis of the velocity profiles, made by a sampling technique, shows no significant change in profile behavior, except a lag in separation and reattachment. This result seems to be important in explaining some features of dynamic stall. T.M.

N81-33161# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).

INVESTIGATION OF UNSTEADY AIRLOADS ON WINGS WITH OSCILLATING CONTROL FOR ACTIVE CONTROL PURPOSES

W. GEISSLER (DFVLR, Goettingen, West Germany) Jul. 1981 16 p refs Presented at 52nd Meeting of the AGARD Structures and Mater. Panel, Cesme, Turkey, 5-10 Apr. 1981
(AGARD-R-699; ISBN-92-835-1392-2; AD-A103949) Avail: NTIS HC A02/MF A01

Intensive experimental investigations were carried out on a wing section with oscillating control including a streamlined gap between both wing parts. Steady as well as unsteady pressure distributions were measured outside and inside the gap region for various incidences, flap angles, and frequencies. In addition to the experimental investigations, a calculation procedure was developed taking into account the real boundaries of the configuration including the gap region and assuming the fixed wing part and the oscillating control as two lifting systems with two Kutta conditions and correspondingly two wakes behind wing and control. Comparisons between theory and experiment are discussed in detail and the major influences and effects of viscosity are pointed out. The results lead to special conclusions for the applicability of lifting systems for active conrol purposes. J.M.S.

N82-10020# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).

AIRCRAFT EXCRESCENCE DRAG

A. D. YOUNG, J. H. PATERSON, and J. L. JONES, ed. Jul. 1981 172 p refs
(AGARD-AG-264; ISBN-92-835-1392-4; AD-A106030) Avail: NTIS HC A08/MF A01

A review was undertaken of the available data on the subject of the drag of excrescences on aircraft surfaces. Information from this review is summarized and presented in a way that is readily usable for prediction and design purposes. The basic characteristics of boundary layers are discussed and, where possible, the drag of excrescences is relatd to those characteristics. In particular, because the size of many types of surface imperfection is small in comparison with boundary layer thicknesses, the drag of such imperfections can be correlated in terms of the properties of inner regions of the boundary layer. Several previously published analyses of this type are highlighted and, where possible, extensions to other data sources or other types of excrescence are presented. The practical problems of applying these data in the varying velocity gradients existing on aircraft surface are treated and one section is devoted to the drag of auxiliary air inlet and exit openings. Gaps in existing data which offer opportunities for research effort are pointed out. J.M.S.

N82-27232*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

AGARD THREE-DIMENSIONAL AEROELASTIC CONFIGURATIONS

S. R. BLAND Mar. 1982 17 p refs Prepared in cooperation with AGARD, Neuilly-Sur-Seine, France
(NASA-TM-84708; NAS 1.15:84708; AGARD-AR-167; AD-A115045) Avail: NTIS HC A02/MF A01 CSCL 01A

The calculation of unsteady aerodynamic forces in the critical transonic speed regime is investigated. The development of such methods is be enhanced by the availability of a limited number of test cases for the comparison of competing methods. Test cases for five clean, isolated wings are presented. Wing geometric descriptions, airfoil coordinates, and suggested aerodynamic conditions for each are included. S.L.

N83-14064# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).

APPLIED COMPUTATIONAL TRANSONIC AERODYNAMICS

Aug. 1982 108 p refs
(AGARD-AG-266, ISBN-92-835-1431-9) Avail: NTIS HC A06/MF A01

A review of state of the art computational fluid dynamics as applied to the transonic computational design of combat and airlift aircraft is given. The theoretical fluid dynamics bases on which computer programs are based are discussed. Viscous interactions, computational procedures used in aerodynamic design, and advanced concepts are discussed. R.J.F.

N83-14065# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
COMPENDIUM OF UNSTEADY AERODYNAMIC MEASUREMENTS
Aug. 1982 192 p refs
(AGARD-R-702; ISBN-92-835-1430-0) Avail: NTIS HC A09/MF A01

A compendium intended to assist the development of improved methods of predicting transonic unsteady aerodynamics and aeroelastic response by collecting the known unsteady aerodynamic experimental data for two dimensional and three dimensional aeroelastic configurations is given. R.J.F.

N83-18683# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
HIGH ANGLE-OF-ATTACK AERODYNAMICS
London Dec. 1982 411 p refs Lectures held in Langley, Va., 10-11 Mar. 1982 and in Goettingen, West Germany, 22-23 Mar. 1982
(AGARD-LS-121; ISBN-92-835-0322-8) Avail: NTIS HC A18/MF A01

Three dimensional flows on simple components including separation and reattachment are reviewed. Vortex breakdown, vortex control, and the effect of compressibility on these three dimensional flows are discussed. For individual titles, see N83-18684 through N83-18696.

N83-18684*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
THREE-DIMENSIONAL SEPARATION AND REATTACHMENT
D. J. PEAKE and M. TOBAK *In* AGARD High Angle-of-Attack Aerodyn. 14 p (SEE N83-18683 09-02) Dec. 1982 refs Original document was announced as N82-24167
Avail: NTIS HC A18/MF A01 CSCL 01A

The separation of three dimensional turbulent boundary layers from the lee of flight vehicles at high angles of attack is investigated. The separation results in dominant, large scale, coiled vortex motions that pass along the body in the general direction of the free stream. In all cases of three dimensional flow separation and reattachment, the assumption of continuous vector fields of skin friction lines and external flow streamlines, coupled with simple laws of topology, provides a flow grammar whose elemental constituents are the singular points: the nodes, spiral nodes (foci), and saddles. The phenomenon of three dimensional separation may be constrained as either a local or a global event, depending on whether the skin friction line that becomes a line of separation originates at a node or a saddle point. B.W.

N83-18685*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
THREE-DIMENSIONAL FLOWS ABOUT SIMPLE COMPONENTS AT ANGLE OF ATTACK
D. J. PEAKE and M. TOBAK *In* AGARD High Angle-of-Attack Aerodyn. 56 p (SEE N83-18683 09-02) Dec. 1982 refs Original document was announced as N82-27222
Avail: NTIS HC A18/MF A01 CSCL 01A

The structures of three dimensional separated flow about some chosen aerodynamic components at angle of attack are synthesized, holding strictly to the notion that streamlines in the external flow (viscous plus inviscid) and skin friction lines on the body surface may be considered as trajectories having properties consistent with those of continuous vector fields. Singular points in the fields are of limited number and are classified as simple nodes and saddles. Analogous flow structures at high angles of attack about blunt and pointed bodies, straight and swept wings, etc., are discussed, highlighting the formation of spiral nodes (foci) in the pattern of the skin friction lines. How local and global three dimensional separation lines originate and form is addressed, and the characteristics of both symmetric and asymmetric leeward wakes are described. Author

N83-18686# Office National d'Etudes et de Recherches Aerospatiales, Leclerc (France).
FLOW VISUALIZATION TECHNIQUES FOR THE STUDY OF HIGH INCIDENCE AERODYNAMICS
H. WERTE *In* AGARD High Angle-of-Attack Aerodyn. 36 p (SEE N83-18683 09-02) Dec. 1982 refs In FRENCH and ENGLISH Original language document was announced as A82-34493
Avail: NTIS HC A18/MF A01

Descriptions are given of the use of solid, liquid or gas tracers in water and wind tunnels for the visualization of aerodynamic flows, with emphasis on the methods employed by the experimental facilities of ONERA. The range of visualization techniques covered reveal flow patterns with all their parietal singularities, as well as the evolution of such patterns as a function of such aerodynamic parameters as incidence, yaw angle and Reynolds number. Visualization methods also reveal the separation phenomena which characterize high incidence angle aerodynamics, and they precisely define vortical, transitional and unsteady flow regimes. The aerodynamic surfaces tested by visualization methods include airfoil profiles, sweptback wings, slender bodies, inlets, and entire aircraft configurations. Attention is given to the layout of ONERA and other water tunnel facilities. O.C.(IAA)

N83-18687# Northrop Corp., Hawthorne, Calif. Aerodynamics Research Dept.
MODERN FIGHTER AIRCRAFT DESIGN FOR HIGH-ANGLE-OF-ATTACK MANEUVERING
A. M. SKOW and G. E. ERICKSON *In* AGARD High Angle-of-Attack Aerodyn. 59 p (SEE N83-18683 09-02) Dec. 1982 refs
Avail: NTIS HC A18/MF A01

Design methodologies for fighter aircraft that operate at high AOA are discussed. Basic wing design features and the effects of high-lift devices on high-AOA characteristics are presented. Forebody design considerations for high-AOA stability are developed, as are the effects of forebody shape on radar performance. The interaction of the vortex system emanating from the forebody with other vortex systems downstream, such as from a leading edge extension (LEX) or canard or from a highly swept main wing panel, are shown to be significant. Control surface placement relative to the wing flowfield and to the vortex flowfield downstream of a highly swept LEX is shown to be important for both stability and controllability. A criterion for high-AOA pitch controllability including the effects of kinematic and inertial coupling is presented. Inlet design considerations regarding placement relative to the body and wing and the effects of duct geometry on engine compressor face distortion at high AOA are discussed. Author

N83-18688# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (West Germany). Dynamics Div.
MODERN MISSILE DESIGN FOR HIGH ANGLE-OF-ATTACK
G. GREGORIOU *In* AGARD High Angle-of-Attack Aerodyn. 23 p (SEE N83-18683 09-02) Dec. 1982 refs
Avail: NTIS HC A18/MF A01

Aerodynamic problems associated with the design of modern missiles for high angles of attack are addressed. The design considerations that have to be given by the aerodynamicist to develop the external configuration are exemplified. It is shown how the information available from existing literature on in-plane and out-of-plane forces and moments of the single missile components wing, body, tail or of complete configurations is of influence on the aerodynamicist's decisions during the design process. In addition the effect of the mostly rather complex aerodynamic characteristics on other missile components (i.e., propulsion or control system, etc.) is mentioned. Finally methods for the theoretical and experimental determination of aerodynamic coefficients are discussed and critically assessed. Author

N83-18689# *British Aerospace Aircraft Group, Preston (England).* Aerodynamics Dept.
THE ROLE OF COMPUTATIONAL FLUID DYNAMICS IN HIGH ANGLE-OF-ATTACK AERODYNAMICS
B. HUNT *In* AGARD High Angle-of-Attack Aerodyn. 28 p (SEE N83-18683 09-02) Dec. 1982 refs
Avail: NTIS HC A18/MF A01

Following a discussion of the overall design task for a modern military aircraft and the position of aerodynamic excellence in the hierarchy of design objectives. The prospects of high alpha aerodynamic prediction via theoretical methods are discussed; with particular emphasis on panel methods (including rolling and coning motions), discrete vortex dynamics calculations for the incompressible Euler and Navier-Stokes equations, and the new generation of field methods for the compressible Euler equations. Author

N83-18690# Von Karman Inst. for Fluid Dynamics, Rhode-Saint-Genese (Belgium).
COMPRESSIBILITY EFFECTS ON FLOWS AROUND SIMPLE COMPONENTS
J. F. WENDT *In* AGARD High Angle-of-Attack Aerodyn. 20 p (SEE N83-18683 09-02) Dec. 1982 refs
Avail: NTIS HC A18/MF A01

The effects of compressibility are considered on the flow fields and overall aerodynamic characteristics of low aspect ratio, sharp-edged planforms - rectangular, trapezoidal, and delta - and long ogive-cylinders at high incidence. Emphasis is placed on the leeside vortex-dominated flow structure, including vortex bursting. Both subsonic and supersonic regimes are included; unsteady effects are not considered. Author

N83-18691# National Aeronautical Establishment, Ottawa (Ontario). Unsteady Aerodynamics Lab.
UNSTEADY AERODYNAMICS AND DYNAMIC STABILITY AT HIGH ANGLES OF ATTACK
K. J. ORLIK-RUECKEMANN *In* AGARD High Angle-of-Attack Aerodyn. 18 p (SEE N83-18683 09-02) Dec. 1982 refs
Avail: NTIS HC A18/MF A01

A review of some of the fluid dynamics phenomena that are associated with the oscillatory flight at high angles of attack, with particular emphasis on asymmetric shedding of forebody vortices, asymmetric breakdown of leading edge vortices, the oscillatory motion of such vortices, and the time lag between the motion of the vortices and that of the aircraft are discussed. These phenomena cause a number of important effects on the dynamic stability parameters at high angles of attack (high a), such as strong non-linearities with a, significant static and dynamic aerodynamic cross-coupling, large time-dependent effects and a strong configuration dependence. The importance of these effects on the prediction capabilities of aircraft behavior at high angles of attack is discussed and some of the new wind tunnel testing techniques required to determine these effects are briefly described. R.J.F.

N83-18692# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Hamburg (West Germany).
VORTEX BREAKDOWN
E. WEDEMEYER *In* AGARD High Angle-of-Attack Aerodyn. 17 p (SEE N83-18683 09-02) Dec. 1982 refs
Avail: NTIS HC A18/MF A01

The different forms of vortex breakdown are considered. Experimental results, theoretical explanations, and predictions are discussed with emphasis on vortex breakdown over wings with highly swept leading edges. Author

N83-18693*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
CONTROL OF THE FOREBODY VORTEX ORIENTATION BY ASYMMETRIC AIR INJECTION. PART A: APPLICATION TO ENHANCE DEPARTURE/SPIN RECOVERY OF FIGHTER AIRCRAFT. PART B: DETAILS OF THE FLOW STRUCTURE
A. M. SKOW and D. J. PENKE *In* AGARD High Angle-of-Attack Aerodyn. 22 p (SEE N83-18683 09-02) Dec. 1982 refs Prepared in cooperation with Northrop Corp., Hawthorne, Calif.
Avail: NTIS HC A18/MF A01 CSCL 01A

A novel concept which was developed to provide powerful directional control effectiveness for a fighter aircraft at high angles of attack, where more traditional controls have very limited capability is discussed. The concept utilizes the energy concentrated in the strong forebody vortices (which form on slender bodies at high relative incidence) by controlling the lateral orientation of the vortices with respect to the body. The present concept seeks to utilize the inherent sensitivity of the vortex positioning and its bistable nature to an advantage allowing control of the forces which are developed. As it turns out, the direction or sense of the asymmetric vortex pair is much easier to control than to attenuate. The work which was done to develop the concept for application to an aircraft is described and is directed toward the effects of the concept on aircraft forces and moments and on the flight mechanics of the aircraft during maneuvering at high angles of attack. The objective was to utilize the side force associated with asymmetric vortices, in a controlled manner, to enhance the ability of the fighter to recover from a departure from controlled flight. The results from these water tunnel and wind tunnel experiments show that a small amount of tangential blowing along the forebody near the apex can effectively alter the forebody vortex system and generate large restoring yawing moments. R.J.F.

N83-18694# Dornier-Werke G.m.b.H., Friedrichshafen (West Germany).
INFLUENCE OF CONFIGURATION COMPONENTS OF STATICALLY UNSTABLE COMBAT AIRCRAFT ON THE AERODYNAMIC DESIGN FOR HIGH ANGLE-OF-ATTACK
G. WEDEKIND *In* AGARD High Angle-of-Attack Aerodyn. 33 p (SEE N83-18683 09-02) Dec. 1982 refs
Avail: NTIS HC A18/MF A01

The influence of some aircraft components on the design of statically unstable aircraft will be shown in order to give an insight into the basic problems of such aircraft. All tendencies related to aerodynamics are derived from wind-tunnel tests. Special problems at high angles of attack that occur when the upper limit of the maneuver range is shifted to angles of attack that are far beyond the angle for maximum lift are discussed. R.J.F.

N83-18695# British Aerospace Dynamics Group, Bristol (England). Aerodynamics Research Dept.
MISSILE BODY VORTICES AND THEIR INTERACTION WITH LIFTING SURFACES
J. R. DEANE *In* AGARD High Angle-of-Attack Aerodyn. 40 p (SEE N83-18683 09-02) Dec. 1982 refs
Avail: NTIS HC A18/MF A01

It is shown that existing empirical prediction methods for vortex characteristics can yield reasonable estimates of overall circulation contained in the symmetric body vortex wake and that core positions are similarly well predicted. However, it is also shown that the concept of modeling the vortex wake as a single pair of contra-rotating potential line vortices will not adequately represent the true distributed nature of the vorticity. At the very least, a viscous core and feeding sheet should be added to the flow model. When flow around wing-body combinations is considered, the importance of considering the vortices as diffuse rather than concentrated entities is emphasized. Comparison of results for spanwise loading distributions for the predicted and experimental cases shows that, even using a viscous core and feeding sheet model, satisfactory results are not likely to be achieved at high angles of incidence with the panel rolled into the leeside. It is speculated that this follows from the action of the wing panel and is dispersing the previously well-defined body vortex core at some point adjacent to the wing panels. Evidence of flow visualization tests in water and wind tunnels indicated that significant changes of trajectory and drastic changes of structure are possible in such areas. R.J.F.

N83-18696# Von Karman Inst. for Fluid Dynamics, Rhode-Saint-Genese (Belgium).
STRAKE-WING-BODY COMBINATIONS
L. VIGEVANO *In* AGARD High Angle-of-Attack Aerodyn. 19 p (SEE N83-18683 09-02) Dec. 1982 refs
Avail: NTIS HC A18/MF A01

The complex flow fields occurring around a typical strake-wing-body missile configuration at high angle of attack are considered at subsonic and transonic speeds. Force and surface pressure measurements, together with water tunnel visualizations up to 33 degrees incidence were carried out on flat plate trapezoidal

wings and strake-wing combinations as well as complete missile configurations to provide a detailed description of the relative flow fields. Emphasis is placed on the improvement in the normal force characteristics due to the addition of the strake, and on the body-wing and wing-body interference mechanism. Compressibility effects are considered. Author

N83-23276# Advisory Group for Aerospace Research and Development, Paris (France). Fluid Dynamics Panel.
WIND TUNNEL FLOW QUALITY AND DATA ACCURACY REQUIREMENTS
F. STEINLE (NASA), E. STANEWSKY (DFVLR-AVA), and R. O. DIETZ, ed. Nov. 1982 35 p refs
(AGARD-AR-184; ISBN-92-835-1440-8) Avail: NTIS HC A03/MF A01

Flow quality and data accuracy requirements for wind tunnel testing are discussed. The emphasis is on transonic test conditions. The current level of testing technology, the requirements for the future, and what needs to be done were considered. To aid in understanding the impact of flow quality and data accuracy, a detailed examination of their contributions to the test results of a transport-type configuration is included. The approach can be adapted to other types. The results of this effort correlate well with what is generally accepted. The result of this effort brought focus on the need to document the flow quality in each facility and that the measurements should include a standard set of both instrumentation and data reduction methods. Aside from the already well known need to improve angle of attack measuring capability, the need to understand the role of aeronoise on Reynolds number effects was highlighted. S.L.

03

AIR TRANSPORTATION AND SAFETY

Includes passenger and cargo air transport operations; and aircraft accidents.

N81-17000# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
AIRCREW SAFETY AND SURVIVABILITY (LIMITED TO COMBAT AIRCRAFT)
R. AUFFRET, ed. (Centre d'Essais en Vol, Bretigny-Air, France) Oct. 1980 162 p refs In ENGLISH and FRENCH Proc. of conf. held in Bodo, Norway, 20-23 May 1980
(AGARD-CP-286; ISBN-92-835-0279-5; AD-A094965) Avail: NTIS HC A08/MF A01

Protection against cold, emergency ejection accidents, survivability equipment, and crew performance during difficult missions are discussed. Recommendations include improvements to equipment to improve the chance of survival, the adoption of some standard method of evaluating anti-exposure suits and, not least, radiographic screening of the spine during training to, inter alia, exclude those with conditions incompatible with flight. For individual titles, see N81-17001 through N81-17021.

N81-17001# School of Aerospace Medicine, Brooks AFB, Tex.
PREDICTION OF IMMERSION HYPOTHERMIA IN MEN WEARING ANTI-EXPOSURE SUITS AND/OR USING LIFE RAFTS
S. A. NUNNELEY and E. H. WISSLER (Texas Univ., Austin) *In* AGARD Aircrew Safety and Survivability (Ltd. to Combat Aircraft) 8 p (SEE N81-17000 08-03) Oct. 1980 refs
Avail: NTIS HC A08/MF A01

A computer model of human thermoregulation was developed in an effort to improve operational guidance while minimizing the need for further human experimentation. The model is subdivided into 15 cylindrical elements representing the head, thorax, abdomen, and limbs, which are coupled through the circulatory system. Within each element, radial layers simulate tissues with appropriate physical and physiological properties; time dependent temperatures are computed at 15 radial locations. Various garments can be simulated by adding layers. Validation of the model against several experimental studies involving water temperatures of 5 to 18 C and subjects who were nude, lightly clothed, or used ventile suits and/or life rafts is described. The model is used to produce preliminary graphs and tables for operational use. Other possible model applications include: (1) evaluation of new or modified protective ensembles; (2) development of tables showing minimal clothing compatible with given environmental conditions and duration of exposure; and (3) prediction of survival times for search and rescue operations. E.D.K.

N81-17002# Centre d'Essais en Vol, Bretigny-Air (France). Laboratoire de Medecine Aerospatiale.
METHODS USED IN MILITARY AERONAUTICS FOR EVALUATING ACCIDENTAL IMMERSION PROTECTIVE EQUIPMENT [METHODE D'EVALUATION DES EQUIPMENTS DE PROTECTION CONTRE LES IMMERSIONS ACCIDENTELLES UTILISES EN AERONAUTIQUE MILITAIRE]
C. BOUTELIER *In* AGARD Aircrew Safety and Survivability (Ltd. to Combat Aircraft) 5 p (SEE N81-17000 08-03) Oct. 1981 refs In FRENCH
Avail: NTIS HC A08/MF A01

Equipments for protection against immersion must possess a certain number of qualities: they must be sufficiently tight to assure good thermal protection both in the water and in the ambient cold air; they must be compatible with the wearing of other equipment; they must not inflict too important a thermal restraint on the crew nor restrain freedom of movement during flight; and they must have a certain resistance to wear and tear. Methods for evaluating such equipment rarely take into account all these factors and, with the exception of that concerning immersions of human subjects in water (ASCC Air STD 61/12, Nov. 1, 1978), they are not standardized. The evaluation methods used in France are described by defining the principle for interpreting results, particularly those concerning thermal protection, and the estimation of tolerance time as a function of water temperature.
Transl. by A.R.H.

N81-17003# Defence and Civil Inst. of Environmental Medicine, Downsview (Ontario).
RADIO-TEMPERATURE TRANSDUCERS FOR MEASUREMENT OF THERMAL STRESS IN COLD WATER IMMERSION SUIT RESEARCH AND DEVELOPMENT
L. A. KUEHN *In* AGARD Aircrew Safety and Survivability (Ltd. to Combat Aircraft) 9 p (SEE N81-17000 08-03) Oct. 1980 refs
Avail: NTIS HC A08/MF A01

The skin temperature tab is glued to the skin at appropriate sites to measure localized skin or micro-clothing temperatures. This transducer contains a miniature radiofrequency near field transmitter circuit which emits a radio signal that varies with the temperature of a critical temperature sensitive element of the circuit. It is used in conjunction with a separate hand held radio receiver unit which decodes the emitted signal from the transducer and displays its temperature value in analogue or digital form. The evaluation and use of this wireless technology for studies of personnel immersion/cold weather protection is reviewed. Special reference is made to the appraisal of an immersion protection jacket known as the thermal immersion protection system (TIPS) jacket which has a buoyancy bladder for self righting flotation. Use of the aforementioned technology enabled the immersion protection period of this jacket in still 4 C water or turbulent 20 C water to be assessed at two hours before hypothermic danger to survival became of paramount concern. This jacket was found to be of use only for protection of personnel in short term cold water environments, such as that of the man overboard situation.
E.D.K

N81-17004# Institute of Aviation Medicine, Farnborough (England).
LABORATORY STUDIES ON COOLING IN SINGLE SEAT DINGHIES
D. J. ANTON *In* AGARD Aircrew Safety and Survivability (Ltd. to Combat Aircraft) 7 p (SEE N81-17000 08-03) Oct. 1980 refs
Avail: NTIS HC A08/MF A01

Preliminary experiments failed to demonstrate any difference in cooling rates when expressed in terms of mean esophageal or mean rectal temperature. After the initial temperature rise, rectal temperature fell consistently below esophageal temperature and in two subjects failed to stabilize in the experimental runs where

the inner coverall was omitted. This failure to stabilize rectal temperature occurred in the presence of normal esophageal temperatures and raises doubts as to the validity of rectal temperature as an indicant of deep body temperature under these experimental conditions. In view of the low rectal temperature recorded, no attempt has been made to derive a body temperature. Foot temperatures suggest that non-freezing cold injury should be expected in survivors who have a protected period at sea under similar environmental conditions and is a possibility after as short a period as four hours thirty minutes. No subject exhibited serious signs of hypothermia in either condition in exposures up to six hours. E.D.K.

N81-17005# Danish Defence Command, Copenhagen. Aeromedical Services.
CENTRAL REWARMING TECHNIQUE IN THE TREATMENT OF PROFOUND ACCIDENTAL HYPOTHERMIA
K. JESSEN *In* AGARD Aircrew Safety and Survivability (Ltd. to Combat Aircraft) 4 p (SEE N81-17000 08-03) Oct. 1980
Avail: NTIS HC A08/MF A01

Accidental hypothermia is an unintended decrease of the body core temperature due to heat loss to cold and in particular wet surroundings. During the treatment an after-drop in core temperature leading to a rewarming collapse and a development of hypopotassaemia must be avoided. Rapid, central rewarming is recommended as the treatment of choice. Among various modalities peritoneal dialysis was a very efficient method. It is a simple routine procedure in many hospitals, it has few contraindications and almost no complications. During transportation to the definitive treatment the patient should be kept cold as the developed hypothermia by itself protects against anoxic tissue damage as the oxygen consumption is decreased to 50% of normal at 30 C and to 20% of normal at 20 C. This is also the reason why normal criteria of death are not valid for patients suffering from profound accidental hypothermia. Author

N81-17006# Institute of Aviation Medicine, Oslo (Norway).
PRINCIPLES OF TEACHING WINTER SURVIVAL TO AIR CREW
H. T. ANDERSEN *In* AGARD Aircrew Safety and Survivability (Ltd. to Combat Aircraft) 3 p (SEE N81-17000 08-03) Oct. 1980
Avail: NTIS HC A08/MF A01

A training program is described which provides aircrews with principles of arctic survival. The problems of the lone fighter pilot having ejected successfully into mountainous terrain high above sea level are addressed. Mental preparedness as well as practical exercises are emphasized. Trends in the development and testing of personal flying equipment are discussed. R.C.T.

N81-17007# Army Research Inst. of Environmental Medicine, Natick, Mass. Military Ergonomics Div.
IMMERSION SURVIVAL: THE KEY FACTORS
R. F. GOLDMAN *In* AGARD Aircrew Safety and Survivability (Ltd. to Combat Aircraft) 11 p (SEE N81-17000 08-03) Oct. 1980 refs
Avail: NTIS HC A08/MF A01

Several factors significant to the sustenance of body temperature while submerged in cold water were investigated. Particular attention was given to examining man's ability to sustain elevated heat production through continued body motion. Results indicate that without adequate insulation, increasing heat production by body motion can increase heat loss to such an extent that there is actually a net loss of body heat; generally unclothed individuals with less than 40 kg of body weight per square meter of surface should remain as still as possible during immersion. It is further indicated that even with the best available protective clothing, tolerance is limited without auxiliary heating of the extremities during immersion in less than 12 C water. R.C.T.

N81-17008# Institute of Aviation Medicine, Farnborough (England).
SURVIVAL AFTER EJECTION, 1968 - 1979
D. J. ANTON *In* AGARD Aircrew Safety and Survivability (Ltd. to Combat Aircraft) 4 p (SEE N81-17000 08-03) Oct. 1980
Avail: NTIS HC A08/MF A01

Several problems encountered in post ejection situations were examined. Particular attention was placed on identifying deficiencies in equipment and drills and determining the difference between pilot preference and laboratory theory as well as their effect on overall survivability. R.C.T.

N81-17009# Naval Safety Center, Norfolk, Va.
SELECTED AEROMEDICAL FACTORS IN US NAVY COMBAT-TYPE AIRCRAFT MISHAPS
V. M. VOGE and A. MILLER *In* AGARD Aircrew Safety and Survivability (Ltd. to Combat Aircraft) 5 p (SEE N81-17000 08-03) Oct. 1980
Avail: NTIS HC A08/MF A01

Some of the major aeromedical problem areas in fighter/attack jet aircraft communities are outlined. The following are emphasized: the ejection sequence; flail injuries; helmet injuries, ejection survival rates; fatalities due to out of the seat envelope ejection; delay of ejection; drowning; and other injuries caused by the ejection sequence. Some of the proposed methods of resolving these problems are discussed. Helicopter combat type aircraft have similar problem areas involving escape from the aircraft and survival until rescue. Various needs are discussed relative to these areas, with possible methods of resolution. The most common psychophysiological factors reported in a 6 year period on mishaps occurring to 2 major combat type aircraft were reviewed, and general conclusions drawn. Two recognized aeromedical problem areas discussed are: (1) the Emergency Deployment Syndrome, where the mishap rate increases because of a general disregard for rules and regulations at a time of national crisis; and (2) increased susceptibility to disorientation secondary to the ingestion of quinine water. R.C.T.

N81-17010# North Atlantic Treaty Organization, Bodo (Norway).
SEAT PACK FOR FIGHTER AIRCRAFT OPERATING ON THE NATO NORTHERN FLANK
T. M. ARESTOL *In* AGARD Aircrew Safety and Survivability (Ltd. to Combat Aircraft) 3 p (SEE N81-17000 08-03) Oct. 1980
Avail: NTIS HC A08/MF A01

The survival seatpack for fighter aircraft is discussed. The seatpack is suited for arctic survival in winter as well as in summer and can sustain life for weeks when used effectively. The kit contains signaling and protective equipment, survival tools, and rations. M.G.

N81-17011# Centre d'Essais en Vol, Bretigny-Air (France). Lab. de Medecine Aerospatiale.
ERGONOMETRIC STUDY OF EJECTION THROUGH A BREAKABLE CANOPY [ETUDE ERGONOMIQUE L'EJECTION A TRAVERS VERRIERE FRAGILISEE]
B. VETTES *In* AGARD Aircrew Safety and Survivability (Ltd. to Combat Aircraft) 9 p (SEE N81-17000 08-03) Oct. 1980 In FRENCH
Avail: NTIS HC A08/MF A01

In order to do away with the delay necessary for ejecting the canopy before seat separation in classic systems, tests of passage directly through the canopy have been conducted at the Brittany Flight Test Center's Aerospace Medicine Laboratory since 1962. Although it presents some risks such as acceleration, deterioration of equipment, and impact on the pilot, this method of evacuation can be seen as being of value for canopies whose thickness does not exceed 9 mm. The systemization of a means for preliminary breakage can be considered. Some static and dynamic tests (between 0 and 600 kt) performed on Mirage F 1 and Delta 2000 dummies gave satisfactory results. However, the application of the system to aircraft with freely falling canopies involves a certain number of difficulties. Aerodynamic forces are such that some pieces of plexiglass fall back on the pilot, which creates important risks. To overcome these inconveniences, a number of breakage devices were tested. Those giving the greatest satisfaction involve a two cycle breaking. In the first cycle, a pyrotechnic decoupling of the dome above the pilot takes place; in the second cycle, the rest breaks away from the canopy just before the knees pass.
Transl. by A.R.H.

N81-17012# Milan Univ. (Italy). Inst. of Neurosurgery.
NEUROTRAMATOLOGICAL ASPECTS IN EJECTED PILOTS
V. A. SIRONI, P. M. RAMPINI, E. GUERRISI (Italian Air Force, Milan), and U. VITALE (Italian Air Force, Milan) *In* AGARD Aircrew Safety and Survivability (Ltd. to Combat Aircraft) 7 p (SEE N81-17000 08-03) Oct. 1980 refs
Avail: NTIS HC A08/MF A01

Neurological and neurosurgical aspects in injured jet pilots after ejection are considered. Observations were carried out on 108 military and civil jet pilots, that from 1958 to 1978 performed a total of 110 ejections (80 from R84, and G91 and 30 from F104). The injuries were classified into none, minor, major, and fatal. The analysis of results shows that 42.% had no injuries, 19% had minor injuries, 25.5% had major injuries, and 12.8% had fatal injuries. In 24 cases (21.8%) vertebral injuries were present: in 16 cases vertebral fractures (62.% in dorso-lumbar tract and 25% in dorsal tract), in 2 cases dislocations and in 10 cases sprains and strains. Neurological signs were present in 12 cases: spinal cord injuries in 5 cases, head trauma in 6 cases, and peripheral nerve injuries in 3 cases. The importance of the correct diagnosis and treatment, the follow-up of these cases in relation to the pathogenetic mechanisms and the prevention of the permanent neurological deficits are presented and discussed. M.G.

N81-17013# Aerospace Medical Research Labs., Wright-Patterson AFB, Ohio.
TRAUMATIC LESIONS OF THE CERVICAL SPINE 1971 - 1979: INCIDENCE-SEVERITY AND CLASSIFICATION
L. E. KAXZARIAN, W. F. BELK (Air Force Inspection and Safety Center, Norton AFB, Calif.), and H. P. HOFFMAN (Aeronautical Systems Div., Wright-Patterson AFB, Ohio) *In* AGARD Aircrew Safety and Survivability (Ltd. to Combat Aircraft) 13 p (SEE N81-17000 08-03) Oct. 1980 refs
(AMRL-TR-80-53) Avail: NTIS HC A01/MF A01

The biodynamic pathogentic mechanisms of cervical spinal trauma associated with the open ejection seat are analyzed through a retrospective investigation. A change appears to have occurred in the frequency of severe neck injury over the eight years. Specifically the incidence of indirect neck injuries associated with fatality have increased. It was found that the type and mechanics of injuries to the upper cervical spine are much different when compared to injuries seen in the lower cervical spine. Injuries to the upper cervical spine seem to be related more frequently to fatalities, where injuries to the lower cervical spine result in major trauma and in a single case quadraplegia. A standardized classification system is proposed based on anatomical criteria discussed in radiographs of the head and neck. A classification scheme that considers the primary injury site and direction of the applied load is discussed. The injury types observed in this limited population are discussed. It is clear that the primary loading factors (inertial or aerodynamic) responsible for the aforementioned cervical injuries are the results of head loads that produce bending or twisting of the neck relative to the torso. M.G.

N81-17014# Naval Air Test Center, Patuxent River, Md.
AN OPINION FOR ENHANCED AIRCREW SURVIVABILITY
H. GREGOIRE *In* AGARD Aircrew Safety and Survivability (Ltd. to Combat Aircraft) 6 p (SEE N81-17000 08-03) Oct. 1980
Avail: NTIS HC A08/MF A01

The capabilities of ram-air parachute canopies in comparison to present canopy designs used in emergency egress systems are discussed. An estimate of potential ram-air parachute advantages in reducing injuries, fatalities, and capture within the limitations of southeast Asia combat escape experience is documented. Experiments in training requirements and recent developments in ram-air parachute reliability are described as applicable to utilization in present inventory combat aircraft. The enhancement of noncombat as well as combat survivability from a medical perspective is discussed, particulary as involves trauma and drowning during the parachute landing phase of an in-flight egress occurence. M.G.

N81-17015# Department of the Air Force, Wright-Patterson AFB, Ohio. Life Support System Program Office.
A SURVIVAL AVIONICS SYSTEM FOR THE 1980'S
D. E. ROOT and F. W. AHEARN *In* AGARD Aircrew Safety and Survivability (Ltd. to Combat Aircraft) 2 p (SEE N81-17000 08-03) Oct. 1980
Avail: NTIS HC A08/MF A01

A survival avionics system (SAS) is described that combines airborne avionics with an advanced survival radio and transponder, in a system designed to overcome past deficiencies. Derived from technology proven in the U.S. space program, SAS provides the search and rescue aircraft with precise range and direction data on up to six downed survivors simultaneously. The system is covert and operates over ranges up to 100 nautical miles. R.C.T.

N81-17016# Institute of Aviation Medicine, Farnborough (England).
THE EVOLUTION OF THE HELICOPTER SEAT PAN MOUNTED PERSONAL SURVIVAL PACK (PSP)
A. STEELE-PERKINS *In* AGARD Aircrew Safety and Survivability (Ltd. to Combat Aircraft) 3 p (SEE N81-17000 08-03) Oct. 1980 refs
Avail: NTIS HC A08/MF A01

A seat pan mounted personal survival pack of glass reinforced fiber construction was developed for use in all military helicopters. This offers much improved crashworthiness and increased comfort. These improvements are discussed, as well as the evolution of the survival pack through experience and application of ergonomics. R.C.T.

N81-17017# Army Aviation Research and Development Command, Fort Eustis, Va. Applied Technology Lab.
TEST AND EVALUATION OF IMPROVED AIRCREW RESTRAINT SYSTEMS FOR COMBAT HELICOPERS
G. T. SINGLEY, III *In* AGARD Aircrew Safety and Survivability (Ltd. to Combat Aircraft) 16 p (SEE N81-17000 08-03) Oct. 1980 refs
Avail: NTIS HC A08/MF A01

US Army aviation accident data shows that a majority of all injuries in attack helicopters could have been avoided if these aircraft had been equipped with crashworthy seat and restraint systems. The compactness of the cockpit and the close proximity of mission equipment to the crew in attack and scout helicopters pose serious crash impact hazards. Although not desirable from a crashworthiness standpoint, operational considerations may dictate that mission equipment and structure be located within the occupant's crash impact motion envelope. Given this situation, it is critical to the occupant's crach impact survival chances that he be provided with a restraint system that minimizes his crash impact motion envelope, particularly for his head. The cockpit can be delethalized further when the improved restraint is complemented by padding potential strike surfaces in the cockpit, making contact surface frangible, and providing weapon system sights with frangibility, telescoping, and/or swing-away features. T.M.

N81-17018# Institute of Aviation Medicine, Fuerstenfeldbruck (West Germany).
INFLUENCE OF THE WORKLOAD OF FLIGHT MISSIONS ON THE PERFORMANCE OF THE VISUAL SYSTEM OF AIRCREW
D. HARMS, E. PACHALE, R. HABERSETZER, and G. KOEHLER *In* AGARD Aircrew Safety and Survivability (Ltd. to Combat Aircraft) 6 p (SEE N81-17000 08-03) Oct. 1980 refs
Avail: NTIS HC A08/MF A01

The importance of saccades (rapid eye movements from one target to another) for perception of visual environment and measure of mental fatigue is demonstrated. Pilots and aircrews' latencies of saccadic eye movements were measured with the EOG-technique pre and post-flight. F-104G pilots showed a significant increase in latencies after air-to-air gunnery training missions. Anti-tank helicopter crews showed a different but overall-remarkable increase in reaction time in the evening after a full day s job combined with restricted sleep. This effect cumulated from day to day and was completely abolished after a full night of undisturbed sleep. F-4F crews showed only an insignificant prolongation of saccadic latencies after air-to-air or air-to-ground missions. The results are discussed and compared with pertinent literature. T.M.

N81-17019# Institute of Aviation Medicine, Manching (West Germany).

TO THE FUNDAMENTALS OF THE ISOMETRIC MUSCLE TRAINING AS A PHYSICAL COUNTERACTION OF THE JET PILOT AGAINTS G-LOADS

A. RIECK *In* AGARD Aircrew Safety and Survivability (Ltd. to Combat Aircraft) 6 p (SEE N81-17000 08-03) Oct. 1981
Avail: NTIS HC A08/MF A01

In spite of technical aids (anti-g-suit) increasing physical demands are made on the g-strength of the jet combat pilot as a result of the continuous advancement of aircraft. During g-loads this requires in addition to special breathing techniques the ability to contract certain muscle regions rapidly and effectively and to maintain this isometric tension for a certain period of time as strong as possible. Using an ELAG dynamometer the flexor and extensor muscle groups of the forearm as well as the extensor groups of the lower leg were trained in a defined sitting posture. The duration of the maximum arbitrary tension during the training phase was 6 sec each time and in the control phase 1 sec, while the interval between the onset of contractions was 1 minute. The number of contractions was varied for the different experimental set-ups. The recordings were continuously made using a line recorder. For the evaluation the maximum strength achieved was used. T.M.

N81-17020# Army Aeromedical Research Lab., Fort Rucker, Ala.

AVIATOR PERFORMANCE IN WEEK-LONG EXTENDED FLIGHT OPERATIONS IN A HELICOPTER SIMULATOR

G. P. KRUEGER, R. N. ARMSTRONG, and R. R. CISCO *In* AGARD Aircrew Safety and Survivability (Ltd. to Combat Aircraft) 14 p (SEE N81-17000 08-03) Oct. 1980 refs
Avail: NTIS HC A08/MF A01

Three 2 man crews of rotary wing aviators performed 14 hours of precision instrument flight in a simulator on each of five successive work days. Missions included repetitions of routine 2 hour standardized day and night instrument flight profiles which were occasionally interrupted by simulated flight emergency situations. Aviator flight performance was measured. Parameters assessed included: meeting airspeed, altitude, headings, turn rates, navigation ability, etc. In addition, measures of fatigue, stress and bodily state were collected throughout the study. These latter measures included physiological (cardiovascular monitoring and body temperature), psychological (behavioral, short term memory, oculomotor performance and subjective ratings), and biochemical (urine and isoprene) parameters. When not flying, pilots participated in laboratory tests of pursuit rotary tracking skill and visual search strategies. They were also examined by flight surgeons daily. The pilots ate three regularly scheduled meals and slept approximately four hours each night. Baseline data were collected prior to, and recovery data after the extended flight schedule. T.M.

N81-17021# British Aerospace Aircraft Group, Preston (England).

HUMAN FACTORS IN HIGH PERFORMANCE AIRCRAFT OPERATING IN DESERT AREA

M. F. HAEKINS *In* AGARD Aircrew Safetly and Survivability (Ltd. to Combat Aircraft) 4 p (SEE N81-17000 08-03) Oct. 1980
Avail: NTIS HC A08/MF A01

A desert is defined as an area with a mean annual rainfall of less than 10 inches. The factors discussed are typical of a Middle Eastern desert with winter mean daily maximum temperatures of about 21 C but summer figures of about 43 C. The physiological responses to heat by aircraft pilots was examined. Pilot visibility over desert terrain was investigated. During sand storms it was found that pilots are likely to commit themselves to visual flight with consequent loss of orientation. The desert terrain was found to produce an empty visual field, similar to that of flying over the sea. T.M.

N82-29279# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).

AIRCRAFT FIRE SAFETY

May 1982 174 p refs Presented at AGARD Lecture Series, Oslo, 7-8 Jun 1982 and London, 10-11 Jun. 1982 and Washington, 15-16 Jun. 1982
(AGARD-LS-123; ISBN-92-835-1424-6; AD-A116380) Avail: NTIS HC A09/MF A01

Progress in aerospace science and technology, especially pertaining to aircraft safety was reported. The goals of the international organization are to: strengthen common defense posture, improve international cooperation in research and development, provide scientific and technical advance to NATO in aerospace R&D, increase scientific and technical potential and recommend effective use of R&D capabilities. The following topics are discussed: aircraft fire mishap experience/crash fire scenario quantitation; human response to fire; aviation fuels, future outlook and impact on aircraft fire threat; fuel system protection methods; fireworthiness of transport aircraft interior systems; the development and application of a full scale wide body test article to study the behavior of interior materials during a postcrash fuel fire; aircraft postcrash fire reduction/survivability enhancement from a manufacturer's viewpoint; and aircraft postcrash fire fighting/rescue. For individual titles, see N82-29280 through N82-29287.

N82-29280# Federal Aviation Administration, Washington, D.C. Engineering Analysis Branch.

AIRCRAFT FIRE MISHAP EXPERIENCE/CRASH FIRE SCENARIO QUANTITATION

T. G. HOREFF *In* AGARD Aircraft Fire Safety 6 p (SEE N82-29279 20-03) May 1982 refs
Avail: NTIS HC A09/MF A01

Civil and military turbine aircraft accidents were reviewed. It was confirmed that the major postcrash fire hazard was caused by ignition of fuel released from wing separation failured during impact survivable accidents. General scenarios for postcrash fire hazards are described and heat flux levels and cabin airflow rates based on fuselage postcrash fire tests are suggested. Fire fatalities to fire tests are suggested. Fire fatalities to fire scenarios and fire experience data base through 1979 are related. It is concluded that the reduction of postcrash fire gives the greatest potential for improved crashworthiness and increased occupant survivability. E.A.K.

N82-29281# Army Aeromedical Research Lab., Fort Rucker, Ala.

HUMAN RESPONSE TO FIRE

S. C. KNAPP and F. S. KNOX, III *In* AGARD Aircraft Fire Safety 19 p (SEE N82-29279 20-03) May 1982
Avail: NTIS HC A09/MF A01

Human survival in aircraft fire was investigated. Aircraft fires and human survival in thermophysical dimensions and aircraft fire properties, chemical and toxic nature of fibres, the concept of worst credible environment, and survival time dimension derived from ground and airborne fire suppression are discussed. The epidemiology of human fire morbidity and mortality are divided into: (1) no personal protection, no prevention of fire; (2) inadequate protection, no prevention of fire; and (3) prevention of fire and good protection. Assessment techniques to select fabric for protective clothing are examined. Physical and biomedical bases to formulated strategies for the development of aircraft fire prevention and personal protection which leads to increased human survival is constructed. E.A.K.

N82-29282# Air Force Wright Aeronautical Labs., Wright-Patterson AFB, Ohio. Aero Propulsion Lab

AVIATION FUELS-FUTURE OUTLOOK AND IMPACT ON AIRCRAFT FIRE THREAT

A. V. CHURCHILL *In* AGARD Aircraft Fire Safety 17 p (SEE N82-29279 20-03) May 1982 refs
Avail: NTIS HC A09/MF A01

The properties of aviation turbine fuels with respect to aircraft fire safety are described. It is indicated that projections of the availability of petroleum crudes specifications for aviation turbine fuels may have to be modified to use fuels produced from shale oil, heavy oils and coal. Projections of the chemical and physical properties of future aviation fuels produced from these alternative

sources are discussed and compared with present fuels. Progress on programs to develop fire safe fuels through the use of antimisting additives is also described. E.A.K.

N82-29283# Royal Aircraft Establishment, Farnborough (England). Engineering Physics Dept.
FUEL SYSTEM PROTECTION METHODS
H. W. G. WYETH *In* AGARD Aircraft Fire Safety 16 p (SEE N82-29279 20-03) May 1982 refs
Avail: NTIS HC A09/MF A01

A fuel system protection equipment for military aircraft and helicopters, to reduce fires and explosions which occur under combat conditions was developed. Equipments are available for fitment to civil transport for survivability enhancement. It is recommended that aircraft fire safety and crash resistance in the initial design and appropriate safety precautions taken to minimize the risk of fire and explosion both in flight and on the ground should be considered. It is concluded that fuel containment systems and antimisting fuels can reduce dynamic fuel spillage and improve occupant survivability in postcrash fire. E.A.K.

N82-29284*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
FIREWORTHINESS OF TRANSPORT AIRCRAFT INTERIOR SYSTEMS
J. A. PARKER and D. A. KOURTIDES *In* AGARD Aircraft Fire Safety 17 p (SEE N82-29279 20-03) May 1982 refs
Avail: NTIS HC A09/MF A01

The fire worthiness of air transport interiors was evaluated. The effect of interior systems on the survival of passengers and crew in an uncontrolled transport aircraft fire is addressed. Modification of aircraft interior subsystem components which provide improvements in aircraft fire safety are examined. Three specific subsystem components, interior panels, seats and windows, offer the most immediate and highest payoff by modifying interior materials of existing aircrafts. It is shown that the new materials modifications reduce the fire hazards because of significant reduction in their characteristic flame spread, heat release, and smoke and toxic gas emissions. E.A.K.

N82-29285# Federal Aviation Administration, Atlantic City, N.J. Fire Safety Branch.
THE DEVELOPMENT AND APPLICATIONS OF A FULL-SCALE WIDE BODY TEST ARTICLE TO STUDY THE BEHAVIOR OF INTERIOR MATERIALS DURING A POSTCRASH FUEL FIRE
C. P. SARKOS, R. G. HILL, and W. D. HOWELL *In* AGARD Aircraft Fire Safety 21 p (SEE N82-29279 20-03) May 1982 refs
Avail: NTIS HC A09/MF A01

The full scale, wide body test article was developed to study postcrash cabin fires. Applications of the C-133 article are described as follows: (1) capabilities and instrumentation; (2) derivation of fuel fire test conditions based on physical modeling and fire tests; (3) characterization of cabin fire hazards which result from exposure of wide body interior materials to external fuel fire, and (5) evaluation of effectiveness of urethane seat cushion fire blocking layers and improved cushioning materials. It is shown that cabin hazards and parameters associated with postcrash fire can be realized by use of improved materials. E.A.K.

N82-29286# British Aerospace Aircraft Group, Bristol (England). Fire Precautions Engineering Dept.
AIRCRAFT POST CRASH FIRE REDUCTION/SURVIVABILITY ENHANCEMENT FROM A MANUFACTURER'S VIEWPOINT
T. MADGWICK *In* AGARD Aircraft Fire Safety 23 p (SEE N82-29279 20-03) May 1982 refs
Avail: NTIS HC A09/MF A01

The importance of achieving a balanced level of overall safety for flight and crash situations are outlined. Research and development in the area of external fire effects and occupant escape is evaluated. The crashworthiness requirements developed for the SST and the means of compliance are outlined. Cabin interior material combustion hazards are discussed. Visibility tests in a smoke filled cabin and the relative importance of toxicity effects in hindering escape are assessed. E.A.K.

N82-29287# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Cologne (West Germany). Inst. fuer Antriebstechnik.
AIRCRAFT POST-CRASH FIRE FIGHTING/RESCUE
R. FIALA *In* AGARD Aircraft Fire Safety 27 p (SEE N82-29279 20-03) May 1982 refs
Avail: NTIS HC A09/MF A01

The correlation between specific extinguishing time and the size of the burning fuel area was calculated. The influence of fuel properties, the boiling temperature and viscosity on extinguishing efficiency of foams is described. An extinguishing technique which considers the dependence of extinguishing efficiency on the foam properties is presented. The requirements for foam monitors are shown. The break up of foam jets, produced by foam monitors is discussed. The extinguishing efficiency with the combined application of dry powder halon and foam and the advantages of a combined use when there is only a pool fire are outlined. E.A.K.

04

AIRCRAFT COMMUNICATIONS AND NAVIGATION

Includes digital and voice communication with aircraft; air navigation systems (satellite and ground based); and air traffic control.

N80-23294# 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 2D: SPECIFIC STUDY NO. 4, GYRO ACCURACY REQUIREMENTS IN A STRAP DOWN INERTIAL NAVIGATION SYSTEM WITH GPS AIDING FOR RPV MISSIONS
K. HURRASS, ed. (Inst. fuer Flugfuehrung, Flughafen, Germany) and H. WINTER, ed. (Inst. fuer Flugfuehrung, Flughafen, Germany) Feb. 1980 15 p
(AGARD-AR-147-VOL-2D; AD-A082957) Avail: NTIS HC A02/MF A01

The influence of the NAVSTAR Global Positioning System aiding of a strap-down system on the accuracy requirements for the gyros was investigated for a remotely piloted vehicle. R.E.S.

N80-26291# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
TECHNICAL EVALUATION REPORT ON THE 29TH GUIDANCE AND CONTROL PANEL SYMPOSIUM ON AIR TRAFFIC MANAGEMENT. CIVIL/MILITARY SYSTEMS AND TECHNOLOGIES
C. DEBRUYN (Liege Univ., Belgium) Mar. 1980 20 p Symp. held at Copenhagen, 9-12 Oct. 1979
(AGARD-AR-149; ISBN-92-835-1356-8; AD-A085461) Avail: NTIS HC A02/MF A01

Air traffic control is considered as a joint civil/military system with emphasis on the caom compatibility, the coordination, and the complementary aspects of the civil and military components. The adequacy of those ATC concepts in current use is discussed and recent advances in technology are reviewed. J.M.S.

N80-27324# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
AIR TRAFFIC MANAGEMENT: CIVIL/MILITARY SYSTEM AND TECHNOLOGIES
Feb. 1980 300 p refs Presented at the Guidance and Control Panel Symp., Copenhagen, 9-12 Oct. 1979
(AGARD-CP-273; ISBN-92-835-1347-9; AD-A087018) Avail: NTIS HC A13/MF A01

Various aspects of air traffic on control in civil and military systems and technologies are presented. The specific areas discussed are: (1) operational scene and requirements; (2) civil/military cooperation; (3) aspects of air traffic management philosophy (criteria and human factors; communications and separation); (4) air traffic management in hostile environment; (5) flight management in terminal area; (6) subsystem technology; and (7) advanced systems.

N80-27325# Board of Trade, London (England).
AIR TRAFFIC IN NATO EUROPE: ITS CHARACTERISTICS AND ITS NEEDS
I. M. PEDDER *In* AGARD Air Traffic Management: Civil/Mil. Systems and Technol. 3 p (SEE N80-27324 18-04) Feb. 1980
Avail: NTIS HC A13/MF A01

The needs and characteristics of air traffic in NATO Europe are reviewed. The divergent requirements and particular problems of airspace users are described and it is concluded that efficient use of the airspace can only be achieved through cooperation between the civil and military authorities. Areas where research and development would be fruitful are listed. Author

N80-27326# Army Avionics Research and Development Activity, Fort Monmouth, N. J. Air Traffic Management Systems Div.
HELICOPTER AIR TRAFFIC MANAGEMENT SYSTEMS WITH CIVIL/MILITARY INTEROPERABILITY
J. T. SAGANOWICH *In* AGARD Air Traffic Management: Civil/Mil. Systems and Technol. 16 p (SEE N80-27324 18-04) Feb. 1980 refs
Avail: NTIS HC A13/MF A01

In order to achieve significant near-term improvement in the Army's air traffic management capability, several configurations of 'very lightweight air traffic management equipment' (VLATME) were developed. Based upon totally compatible use of today's common civil/military system ATCRBS (air traffic control radar beacon system). Concurrently with the VLATME development, helicopter instrument landing technology work over the past few years has revealed that the key to solving this problem lies in the ability to perform deceleration of the aircraft on instruments, along the approach path, so as to bring the aircraft to a hover a few feet above the intended landing point. The decelerated instrument approach means that helicopter spacings will have to be much smaller than those encountered in fixed wing practice if reasonable flow rates are to be realized. Because of the potential garbling problem in conventional ATCRBS with closely spaced aircraft, a system which integrates the ground and airborne equipments of a scanning beam microwave landing system with the airborne transponder while preserving interoperability was also developed and successfully tested. R.E.S.

N80-27327# Selenia S.p.A., Rome (Italy).
A STUDY FOR DEVELOPMENT OF METHODS FOR AIR TRAFFIC MANAGEMENT
R. PETRIOLI, S. PARDINI, G. BERTONI (Bologna Univ.), and C. BONIVENTO (Bologna Univ.) *In* AGARD Air Traffic Management: Civil/Mil. Systems and Technol. 14 p (SEE N80-27324 18-04) Feb. 1980 refs
Avail: NTIS HC A13/MF A01

Models and methods for optimal air traffic management were studied as part of the multi-year project 'Navigation aids and air traffic control' funded by the Italian National Research Council (CNR). The scope of the study on the context of CNR project is reviewed. The software structure, its main characteristics and possible utilizations in the planning and management of air traffic system is discussed. Finally, a description is given of more relevant used models and algorithms. R.E.S.

N80-27328# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (West Germany). Human Engineering Dept.
SYSTEM, AIRSPACE, AND CAPACITY REQUIREMENTS FOR FUTURE ATC-SYSTEMS
R. SEIFERT and G. OCH *In* AGARD Air Traffic Management: Civil/Mil. Systems and Technol. 15 p (SEE N80-27324 18-04) Feb. 1980 refs
Avail: NTIS HC A13/MF A01

Based on control capacity measurements of various air traffic control (ATC) systems, a theory of control capacity was developed. The theory of control capacity allows comprehensive knowledge to be gained concerning the relationship and interdependence of the following: (1) The airspace configuration (including the present separation requirements), the traffic structure and the resulting conflict probability. (2) The airspace capacity, the control capacity of the ATC control positions (functional units) and their dependence on air traffic structure and the technical ATC system features and capabilities. Using the theory of control capacity, systems of different technical structure were then assessed. Outdated, present day's, and future ATC systems are compared, showing the effect certain technical components and/or system functions have on system capacity. R.E.S.

N80-27329# Civil Aeromedical Inst., Oklahoma City, Okla. Aviation Psychology Lab.
AIR TRAFFIC CONTROL AUTOMATION: ITS IMPACT AND USE IN THE SELECTION AND SCREENING OF AIR TRAFFIC CONTROLLERS
J. O. BOONE *In* AGARD Air Traffic Management: Civil/Mil. Systems and Technol. 7 p (SEE N80-27324 18-04) Feb. 1980 refs
Avail: NTIS HC A13/MF A01

The impact of automation in air traffic control on personnel screening is discussed. The mathematical and technical aspects as they are currently being developed are focused upon. R.E.S.

N80-27330# Eurocontrol Agency, Brussels (Belgium).
DATA LINK: THE KEY TO IMPROVEMENTS IN CIVIL/MILITARY AIR TRAFFIC MANAGEMENT?
M. E. COX *In* AGARD Air Traffic Management: Civl/Mil. Systems and Technol. 20 p (SEE N80-27324 18-04) Feb. 1980 refs
Avail: NTIS HC A13/MF A01

Experimental work which is being undertaken both to explore how an air/ground data link might be exploited for future air traffic control purposes and to determine its possible capacity requirements is described. Details of the form and functions of experimental equipment built to investigate what is believed to be the major problem area influencing communications improvements, the pilot/link interface, are given. Details are also given of studies investigating the possible use of the link in transferring aircraft, derived data both to yield improvements in the precision of meteorological forecast data and to enhance the performance of radar-based tracking and conflict-alerting systems. Capacity requirements and the feasibility of realizing a link for these purposes within the next two decades are discussed. R.E.S.

N80-27331# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick (West Germany).
MIDAIR CONFLICTS AND THEIR POTENTIAL AVOIDANCE BY PROGRESSIVE IMPLEMENTATION OF AUTOMATION
O. WEBER *In* AGARD Air Traffic Management: Civil/Mil. Systems and Technol. 16 p (SEE N80-27324 18-04) Feb. 1980 refs
Avail: NTIS HC A13/MF A01

Actual midair conflicts between civil and military aircraft in German airspace where at least one of the airplanes involved was flying under visual flight rules were analyzed. Operational, environmental and human factors, which contributed to the accidents, and the limits of the 'see and avoid' concept for collision avoidance are discussed. Some shortcomings of the present air traffic control system are mentioned. Taking the actual midair conflicts and some simulated three dimensional flights as examples, the improvement of collision avoidance by progressive implementation of advanced techniques is discussed. The lead time to the potential conflict or to a circular zone of protection, the distance at the closest approach and some other thresholds, estimated by means of a ground-based radar system or an airborne electronic collision avoidance system, are used as main criteria for an automatic conflict alert. Potential advantages of a data link to detect sudden manoeuvres in time are mentioned. R.E.S.

N80-27332# National Aerospace Lab., Amsterdam (Netherlands).
DETERMINATION OF THE SAFETY IN A NORTH ATLANTIC ORGANIZED TRACK SYSTEM WITH REDUCED LATERAL SEPARATION
G. MOEK and C. R. TRAAS *In* AGARD Air Traffic Management: Civil/Mil. Systems and Technol. 7 p (SEE N80-27324 18-04) Feb. 1980 refs
Avail: NTIS HC A13/MF A01

Collision risk modelling as related to the reduction of lateral separation from 120 NM to 60 NM at any fixed level in the North Atlantic Organized Track System is considered. Requirements on the navigation performance are described which aircraft must be able to meet if this reduction would be implemented. Two statistical tests are derived which can be applied to the measured number of navigation errors to determine whether the actual navigation performance is such that the system with 60 NM lateral separation meets a target level of safety. The first test which belongs to the

standard equipment of the NAT/SPG for judging the safety of the track system is based on one random model for all navigation errors. The second test is applicable for the case different types of navigation errors can be distinguished and modelled separately. The different contribution of each type of error to the total risk is taken into account by the use of weighting factors. This test, however, is still in discussion in the North Atlantic Systems Planning Group. A.R.H.

N80-27333# Army Air Traffic Control Office, APO New York, N.Y. 09056.

US ARMY USERS OUTLOOK ON AIR TRAFFIC MANAGEMENT

W. H. MALONEY and L. P. KREPS *In* AGARD Air Traffic Management: Civil/Mil. Systems and Technol. 5 p (SEE N80-27324 18-04) Feb. 1980

Avail: NTIS HC A13/MF A01

The need for air traffic control, not only in support of its fixed base peace-time mission, but also its tactical mission is recognized by the U.S. Army. Air traffic management as it existed during the Vietnam era of the 1960's and as it evolved during the 1970's is described. The European scenario literally dictates doctrine for hostile operations in a mid-intensity environment. What is happening and planned from an ATC viewpoint in support of U.S. Army/Europe (USAREUR) is discussed including the future potential of a global positioning system. A.R.H.

N80-27334# Army Avionics Research and Development Activity, Fort Monmouth, N. J. Advanced Avionics Systems Div.

THE DEVELOPMENT AND TEST OF A TACTICAL SELF-CONTAINED LANDING SYSTEM

N. K. SHUPE *In* AGARD Air Traffic Management: Civil/Mil. Systems and Technol. 25 p (SEE N80-27324 18-04) Feb. 1980 refs

Avail: NTIS HC A13/MF A01

The existence of a digital symbol generator (DSG) whose basic function is to compute and display the augmenting symbolic data necessary to operate a helicopter in the NOE environment via a FLIR presentation of the contact world, and a digitally-generated topographic map display (DMG) is sufficient justification to consider adaptation of the DSG and DMG equipments to the reversionary function of providing IMC terrain-following and tactical landing capabilities. The control/display architecture necessary to use a radar altimeter to control the elevation flight path of the aircraft and a Doppler radar to control the deceleration of the aircraft is presented. The assumed precision navigation system provides the Northing/Easting aircraft position: (1) to permit the aircraft to be steered along the prescribed ground track to the landing zone; (2) to provide a starting point for interrogation of the DMG terrain elevation data for purposes of generating anticipation for the TF system; and (3) to act in concert with the velocity output of the Doppler radar for purposes of following a preprogrammed deceleration profile to the landing zone. A multi-phase simulation and flight-test program to assess the performance of the complete system in the NOE environment are described. A.R.H.

N80-27335# Bendix Corp., Detroit, Mich. Communications Div.

VERY LIGHTWEIGHT AIR TRAFFIC MANAGEMENT SYSTEM USING AN ELECTRONIC SCAN ANTENNA

P. J. WOODALL and J. L. SHAGENA, JR. *In* AGARD Air Traffic Management: Civil/Mil. Systems and Technol. 12 p (SEE N80-27324 18-04) Feb. 1980

Avail: NTIS HC A13/MF A01

An electronically scanned antenna with all solid-state interrogator, complemented by a multi-microprocessor driver tactical interactive display, provides a full alphanumeric PPI air traffic management system. This system utilizes the standard Mark X/XII ACTRBS/IFF airborne transponder to provide position information on all targets (up to 100) and tracked range, azimuth, and altitude (via mode C) on up to 13 targets. The two key features of this system are the electronically steered matrix-fed cylindrical array and the microprocessor based intelligent controller. The controller performs search and active track, minimizing interrogator PRF (64-198.5/Sec) and electromagnetic interference. The antenna and R/T are physically integrated into a single assembly to minimize set-up time and maximize reliability. A.R.H.

N80-27336# Elektronik-System G.m.b.H., Munich (West Germany).

TECHNICAL AND OPERATIONAL FACTORS CONCERNING THE LICENSING AND INTRODUCTION OF A NEW MICROWAVE LANDING SYSTEM FOR CATEGORY 2

K. G. BRAMMER and K. D. KRICKE *In* AGARD Air Traffic Management: Civil/Mil. Systems and Technol. 12 p (SEE N80-27324 18-04) Feb. 1980 refs

Avail: NTIS HC A13/MF A01

For the new aircraft Tornado and Alpha-Jet, the landing system SETAC is now being prepared for category 2 service at the assigned air bases in Germany. As soon as this system's technical capabilities are to be exploited to the full extent for operational use, all relevant rules and regulations applicable for ILS category 2 operations must be exhaustively expanded and supplemented. This concerns concepts for infrastructural measures, such as extension of obstacle clearance limits to the whole area of coverage, calibration and testing of the total radio field, modifications of the approach light pattern, additional training and licensing of ATC staff and pilots etc. In order to reduce this extensive task to a short-term solution, a stagewise procedure of system introduction is outlined. The concept is to utilize SETAC equipment with all the corresponding advantages regarding installation, but to retain in the first stage as closely as possible all regulations, flight procedures and instrumentation pertaining to ILS approach and landing. A.R.H.

N80-27337# Systems Control, Inc., West Palm Beach, Fla.

THE INTEGRATION OF AREA NAVIGATION AND THE MICROWAVE LANDING SYSTEM

D. W. RICHARDSON and P. M. RICH (FAA, Washington, D.C.) *In* AGARD Air Traffic Management: Civil/Mil. Systems and Technol. 17 p (SEE N80-27324 18-04) Feb. 1980 Sponsored by FAA

Avail: NTIS HC A13/MF A01

The RNAV and MILS are non-competitive complementary navigation/landing systems that, working together, can markedly enhance the safety and efficiency of terminal area operation while at the same time impacting the overall concept of terminal airspace management. Primarily, these systems afford the opportunity, which has been debated so vigorously for many years, of converting to a distributed management philosophy of ATC system design and operation in which much of the navigation function is transferred from the radar vectors issued by the ground controller to the flight crew, aided by increasingly available, low cost, multifunction avionics systems. Some activities on the part of the United States Federal Aviation Administration to develop and integrate these complementary capabilities into the terminal area airspace system are examined. A.R.H.

N80-27338# Thomson-CSF, Arcueil (France).

SINTAC-C TMA: APPLICATION OF SINTAC-C IN THE TERMINAL AREA, DURING LANDING AND GROUND TAXIING

L. MILOSEVIC and J. HETYEI *In* AGARD Air Traffic Management: Civil/Mil. Systems and Technol. 20 p (SEE N80-27324 18-04) Feb. 1980

Avail: NTIS HC A13/MF A01

An integrated navigation, traffic control, collision avoidance and communication system is described which can control between 200 and 1000 aircraft according to the number of runways (or airports) included in terminal area. During final approach and landing, the system controls 16 aircraft, the maximum which can be considered in the MLS beam, with a 30 second landing rate. According to the required control capacity, the system uses one, two or three time-shared nets for all the functions and for all the in flight and ground phases. The navigation transmission rates are very high (32-16 Hz) thus ensuring a practically continuous navigation function. The surveillance and synchronization frequency depend on the area: a maximum of 4 seconds in the terminal area and a 1 second maximum at landing time. Three types of SINTAC ground stations are considered: (1) SINTAC-TMA: 100-150 km range covering the TMA area with three or four stations; (2) SINTAC-landing: located at the far-end of the runway (precision DME), range and antenna beam aperture same as MLS; and (3) SINTAC-ground taxiing: airport area coverage by three stations: station range: 5 to 10 km. A.R.H.

N80-27339# Singer-Kearfott, Wayne, N. J.
EVOLUTION AND TRANSITION OF TODAY'S MILITARY LANDING SYSTEM TO COMPATIBILITY WITH PRESENT AND FUTURE CIVIL MILITARY SYSTEMS
A. J. SHAPIRO *In* AGARD Air Traffic Management: Civil/Mil. Systems and Technol. 13 p (SEE N80-27324 18-04) Feb. 1980
Avail: NTIS HC A13/MF A01

The operational need for a single avionics system to operate with the present instrument landing system, the future ICAO approved microwave landing system and the Marine remote area approach landing system (MRAALS), is discussed. The operational solution developed in response to a U.S. Navy/Marine requirement is a multimode receiver that is capable of operating with any of the systems mentioned above. The evolutionary process involved in progressing from a single to a multiple mode system capability is reviewed with emphasis on the technological advances leading to a most cost and volume effective solution. Author

N80-27340# Hollandse Signaalapparaten N. V., Hengelo (Netherlands).
INTRODUCTION ON LORADS AND ASDE
E. C. PRIEBEE *In* AGARD Air Traffic Management: Civil/Mil. Systems and Technol. 18 p (SEE N80-27324 18-04) Feb. 1980
Avail: NTIS HC A13/MF A01

A long range radar and display system (LORADS) and airport surface detection equipment (ASDE) are described. A panoramic view of both systems, its functional and operational requirements, and the system architecture of both the hardware and software are given. M.G.

N80-27341# Ferranti Ltd., Bracknell (England). Computer Systems.
APPLICATIONS OF MICROPROCESSORS IN AIR TRAFFIC
D. L. STODDART *In* AGARD Air Traffic Management: Civil/Mil. Systems and Technol. 10 p (SEE N80-27324 18-04) Feb. 1980 refs
Avail: NTIS HC A13/MF A01

The use of microprocessors in air traffic control (ATC) systems is examined. The characteristics of microprocessors are compared with those of mini and main frame computers to identify the most suitable role of the microprocessor in ATC Systems. The application of microprocessors for system functions such as Data Link Management, Display Console Management and Format Converters is discussed. To emphasize the impact of microprocessors on system design a conventional display system is compared with one using microprocessors where this device is built into the overall design of the display system with consequent saving in display generation hardware. The design is extended so that the display microprocessor becomes the central element in display console management. The F100L microprocessor is described in some detail and used as model to define the capability of a microprocessor. M.G.

N80-27342# Royal Signals and Radar Establishment, Malvern (England). Ground Radar and ATC Dept.
PRECISION NAVIGATION FOR AIR TRAFFIC MANAGEMENT
S. RATCLIFFE *In* AGARD Air Traffic Management: Civil/Mil. Systems and Technol. 5 p (SEE N80-27324 18-04) Feb. 1980 refs
Avail: NTIS HC A13/MF A01

The problems that would arise if airspace users had the use of NAVSTAR or some other much better position-fixing aid than at present, and the uses that air traffic control (ATC) could or could not make of this capability are examined. There would be formidable transitional problems in the vertical plane, because NAVSTAR measures height from the Earth's center whereas current altimeters measure atmosphere pressure. In either vertical or horizontal planes much work would be necessary to prove that the separation standards can be reduced at all. The changes that might be possible in the ATC system should appreciable reductions in separation standards prove possible are discussed. NAVSTAR might form the basis of a collision avoidance system based on either the broadcast coordinates of each aircraft or on a time frequency basis using NAVSTAR as the time reference. The latter scheme would offer protection of a fully equipped aircraft against threat that could not afford the expense of a NAVSTAR fit. M.G.

N80-27343# Mitre Corp., Bedford, Mass.
JTIDS: AN INTEGRATED COMMUNICATIONS NAVIGATION AND IDENTIFICATION SYSTEM, AND ITS POTENTIAL FOR AIR TRAFFIC MANAGEMENT
D. D. NEUMAN *In* AGARD Air Traffic Management: Civil/Mil. Systems and Technol. 13 p (SEE N80-27324 18-04) Feb. 1980 refs
Avail: NTIS HC A13/MF A01

The integrated data communications, voice communications, navigation, and identification features of the Joint Tactical Information Distribution System (JTIDS) are described with emphasis on those features applicable to air traffic management. The JTIDS system architecture simultaneously provides data at the ground centers and in the cockpit. Airspace control and advisory data are made available to all aircraft to permit subscribers to be aware of, and comment upon, directions provided to others. Network control techniques are discussed which support civil air traffic management applications. These techniques provide for the apportionment of capacity among subscribers in such a manner as to allow all subscribers access to all data in their area of interest without real time network management. The potential exists for a substantial reduction in the avionics boxes aboard aircraft. A JTIDS like system can simultaneously provide the data for airspace management and control, collision avoidance, area navigation, air-to-air coordination, cooperative surveillance, cockpit situation display, airport surface traffic control, and possibly instrument landing. The transition from the existing air traffic management system to a JTIDS like system is also addressed. Austere terminal designs appear to be possible at a cost that is affordable for general aviation. M.G.

N80-27344# Federal Aviation Administration, Washington, D.C. Systems Research and Development Service.
DISCRETE ADDRESS BEACON SYSTEM
P. D. HOGKINS *In* AGARD Air Traffic Management: Civil/Mil. Systems and Technol. 10 p (SEE N80-27324 18-04) Feb. 1980 refs
Avail: NTIS HC A13/MF A01

A discrete address beacon system (DABS) to provide upgraded air traffic control radar beacon system (ATCRBS) surveillance is discussed. The DABS concept provide improved air traffic control automation service and ground based automatic traffic advisory and resolution service through its integral high capacity digital air ground data link. The compatibility of DABS with ATCRBS, interrogation concepts, and the computer processing subsystem are specifically discussed and current testing and evaluations of the system are reviewed. M.G.

N80-27345# Royal Signals and Radar Establishment, Malvern (England).
ADSEL: SELECTIVE ADDRESS SSR, PERFORMANCE OF THE EVALUATION STATION
R. C. BOWES, T. B. NICHOLS, and J. M. BONNY *In* AGARD Air Traffic Management: Civil/MIL. Systems and Technol. 8 p (SEE N80-27324 18-04) Feb. 1980 refs
Avail: NTIS HC A13/MF A01

A selectively addressed radar system (ADSEL) designed to overcome the 'garble' problem of the current secondary surveillance radar (SSR) system and provide a data link facility is discussed. The system requires aircraft to carry a transponder which includes the selective address mode of operation and a ground station with monopulse direction finding system plus data processing facilities. In particular the evaluation trials that have been carried out are reviewed and the results of a large number of aircraft flights are given. The main aim of the trials is to assess the accuracy with which the position of an aircraft can be measured, the performance of the communication links, and to optimise the operating rules. A detailed analysis is given of the performance of the SSR and ADSEL system when monitoring two aircraft flying close together such that their transponder replies were 'garbling'. M.G.

N80-27346# Lincoln Lab., Mass. Inst. of Tech., Lexington.
SURVEILLANCE PERFORMANCE MEASUREMENTS OF THE SSR MODE OF THE DISCRETE ADDRESS BEACON SYSTEM
V. A. ORLANDO and P. R. DROUILHET *In* AGARD Air Traffic Management: Civil/Mil. Systems and Technol. 11 p (SEE N80-27324 18-04) Feb. 1980 refs Sponsored by FAA
Avail: NTIS HC A13/MF A01

The field measurements, taken to evaluate the surveillance performance of the Discrete Address Beacon System (DABS), are described. Simultaneous measurements made by transportable measurements facilities and the existing ground stations provided the opportunity for a side-by-side comparison of DABS off-boresite monopulse and conventional surveillance measurement performance. The results indicate that both range and azimuth accuracies of the DABS design are four times better than those provided by current terminal secondary surveillance radar (SSR) equipment. Blip/scan ratio for monopulse SSR is 98% or better, and remains high in crossing track situations where the performance of existing equipment is observed to degrade. Significantly, this improvement in SSR performance was accomplished with 1/4 the pulse repetition frequency of the present equipments. M.G.

N80-27347*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
EFFECTIVENESS OF ADVANCED FUEL-CONSERVATIVE PROCEDURES IN THE TRANSITIONAL ATC ENVIRONMENT
L. TOBIAS and P. J. OBRIEN (National Aviation Facilities Experimental Center, Atlantic City, N.J.) *In* AGARD Air Traffic Management: Civil/Mil. Systems and Technol. 14 p (SEE N80-27324 18-04) Feb. 1980 refs
Avail: NTIS HC A13/MF A01 CSCL 17G

The real time simulation (involving both the pilot and the air traffic controller) of fuel conservative approaches, profile descents, and four dimensional area navigation to assess the effectiveness of the procedures is discussed. Generally, results indicate some difficulties with the procedures tested in a mixed traffic environment and point to the need for computer assistance for effective implementation of candidate procedures. M.G.

N81-26091# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
PRECISION POSITIONING AND INERTIAL GUIDANCE SENSORS: TECHNOLOGY AND OPERATIONAL ASPECTS
Mar. 1981 370 p refs In ENGLISH; partly in FRENCH Symp. held at London, 14-17 Oct. 1980
(AGARD-CP-298; ISBN-92-835-0287-6; AD-A101019) Avail: NTIS HC A16/MF A01

Inertial sensors and systems technology, development and status of positioning systems, and evaluation methods and results are discussed. Other topics include filtering and estimate, fault tolerance design and redundancy techniques, and systems requirements and applications. For individual titles, see N81-26092 through N81-26113.

N81-26092# Air Force Systems Command, Wright-Patterson AFB, Ohio.
INVESTIGATION OF A STRAPDOWN ATTITUDE AND HEADING REFERENCE SYSTEM UTILIZING RING LASER GYROS
G. M. SIOURIS *In* AGARD Precision Positioning and Inertial Guidance Sensors 14 p (SEE N81-26091 17-04) Mar. 1981 refs
Avail: NTIS HC A16/MF A01

The potential benefits of utilizing ring laser gyro technology in a strapdown attitude and heading reference system configuration for rotary and fixed wing aircraft are assessed. The ring laser gyro has demonstrated highly acceptable performance with the promise of even better results and greater design margins to enhance the low cost goals. System performance is evaluated using a strapdown covariance error analysis simulation. The covariance matrix represents the standard deviations of the errors in the system at any point in time of the trajectory or mission. Coupled with a transition matrix that propagates the covariance matrix forward along the route, the errors along the entire route can be computed. E.D.K.

N81-26093# British Aerospace Precision Products Group, Stevenage (England).
SMART INERTIAL MEASUREMENT UNITS AND THE COMPENSATION OF DYNAMICALLY TUNED GYROS FOR STRAPDOWN INERTIAL SYSTEMS
C. S. EDWARDS and R. J. CHAPLIN *In* AGARD Precision Positioning and Inertial Guidance Sensors 19 p (SEE N81-26091 17-04) Mar. 1981 refs
Avail: NTIS HC A16/MF A01

The growth of low cost strapdown inertial guidance systems that has occurred in recent years is considerd. For the majority of current applications the only gyroscopes that are sufficiently mature for such systems are the rate integrating gyro and the dynamically tuned gyro. It is often thought that the error models of these two gyroscopes are very different and that it is more difficult to use the dynamically tuned gyroscope. It is shown that such impressions are misconceived and that both types of gyroscope are being offered in packages complete with digital compensation of the error terms. E.D.K.

N81-26094# Honeywell, Inc., St. Petersburg, Fla. Avionics Div.
ESG INERTIAL TECHNOLOGY: AN APPROACH TO SELF-CONTAINED PRECISION NAVIGATION AND POSITIONING ON AND OVER THE BATTLEFIELD
M. J. HADFIELD *In* AGARD Precision Positioning and Inertial Guidance Sensors 18 p (SEE N81-26091 17-04) Mar. 1981 refs
Avail: NTIS HC A16/MF A01

Special topics such as the hybrid operation of high precision electrically suspended gyroscopes (ESG) systems are described and discussed. The relatively low reliance of ESG inertial systems on other navigation aids is considered. The importance of this feature in the adverse electromagnetic radiation environment of the battlefield is evaluated. The importance of effective Kalman filtering to hybrid system operation is reviewed. The hardware developments which led to the emergence of ESG inertial technology are summarized and interrelated with software developments. Critical parameters such as accelerometer and gyro stability in the battlefield environment are addressed and supporting test data provided for the error budget values. Other hardwares, such as the fault tolerance benefits of design centering as well as built in fault detection and isolation are described in terms of the SPN/GEANS and GEO-SPIN equipments. E.D.K.

N81-26095# Standard Elektrik Lorenz A.G., Stuttgart (West Germany).
THE POTENTIAL OF A MULTIFUNCTION INFORMATION DISTRIBUTION SYSTEM (MIDS) FOR POSITION LOCATION
G. HOEFGEN *In* AGARD Precision Positioning and Inertial Guidance Sensors (Mar. 1981) 13 p (SEE N81-26091 17-04) Mar. 1981 refs
Avail: NTIS HC A16/MF A01

The multifunction information distribution system (MIDS) offers a great potential for position location and navigation. The position location is accomplished by multiranging based on time of arrival measurements. Besides this preferred passive mode an active method providing range and time measurements most accurately and independently from each other is feasible. The achievable accuracy depends on the operational and physical environment and on the performance of the equipment used. For the stationary case, which is characterized by fixed or very slowly moving participants, the main parameters determining accuracy are source time and position qualities, propagation time measurement accuracy, short term clock stability, geometric dilution of precision, and propagation anomalies. In the dynamic case characterized by fast moving users the accuracy is further degraded by the user dynamics, the P-message rate, the filter performance, and the dead reckoner performance. E.D.K

N81-26096# ITT Avionics, Nutley, N.J.
JTIDS DISTRIBUTED TDMA (DTDMA) TERMINAL DEVELOPMENT RESULTS WITH EMPHASIS ON RELATIVE NAVIGATION PERFORMANCE
J. RUBIN and S. WELT *In* AGARD Precision Positioning and Inertial Guidance Sensors 14 p (SEE N81-26091 17-04) Mar. 1981 refs
(Contract N66269-76-C-0105)
Avail: NTIS HC A16/MF A01

Extensive testing of the command and tactical terminals were performed utilizing the joint tactical information distribution system environment simulator (JES) to simulate highly dynamic and diverse RF environments. System performance limits were obtained with barrage and optimum jamming for active and passive net entry as well as for each communication function individually and various mixes of com/nav functions. Multinet, multifunction tests were performed utilizing time division multiple access (TDMA), distributed TDMA, and TACAN waveforms simultaneously. Communication and navigation system function design, integration, dynamic laboratory verification, and transition to field test tasks were aided by using the dynamic real time simulation and evaluation capabilities of the JES. The computer controlled JES furnished an effective method of bridging the gap and provided a smooth transition between system integration and field test phase of the program. E.D.K.

N81-26097# Singer-Kearfott, Wayne, N. J.
JTIDS DUAL GRID NAVIGATION USING TIME SYNCHRONIZED DATA LINKS
R. C. STOW and J. D. REISS *In* AGARD Precision Positioning and Inertial Guidance Sensors 17 p (SEE N81-26091 17-04) Mar. 1981 refs
Avail: NTIS HC A16/MF A01

A comprehensive survey is presented of the fundamental theory, principal design considerations, and expected operational performance capabilities of relative navigation utilizing the JTIDS data link. The design of the relative navigation estimation algorithm is presented beginning with a description of the basic methodology of dual grid hybrid navigation, with special emphasis on modelling considerations within the relative navigation Kalman filter and the observation screening algorithm. These considerations include requirements for global navigation, communities composed of mixed types of dead reckoning units, and efficient usage of available data provided the JTIDS data link. Specific requirements for integration of the basic software design in a robust configuration are discussed and expected performance levels within various community structures are presented. The application of this capability to operational problems in targetting and weapon delivery are emphasized. E.D.K.

N81-26098# Thomson-CSF, Bagneux (France).
SINTAC AND ITS POSITIONING PERFORMANCES [LE SINTAC ET SES PERFORMANCES EN LOCALISATION]
C. MILOSEVIC, J. C. CHARAVIT, and M. RONSIN *In* AGARD Precision Positioning and Inertial Guidance Sensors 38 p (SEE N81-26091 17-04) Mar. 1981 refs In FRENCH
Avail: NTIS HC A16/MF A01

A short review of the SINTAC program is presented and the information processing when the terminal is used in the navigation mode is described. The receiver of the SINTAC terminal provides a series of distance information. It is shown that the major hardware errors are related with the terminal master oscillator and the interval between synchronization. The navigation processor includes a Kalman filter which smoothes these data and reduces them using the craft bearing and the air data. Using the hardware limitation and the Kalmann algorithm, the results of the simulation program are given. The navigation errors are in accordance with the forecasts. They are within 20 meters when the distance measurements occur with an average of 1 second. E.D.K.

N81-26099# Air Force Systems Command, Norton AFB, Calif.
NAVSTAR GPS PROGRAMME REVIEW
H. CORIAT *In* AGARD Precision Positioning and Inertial Guidance Sensors 10 p (SEE N81-26091 17-04) Mar. 1981 refs
Avail: NTIS HC A16/MF A01

The origins of the Navstar Global Positioning System are traced. The activities and results of the first formal phase of the program which set out to validate the GPS concept are reviewed. The current activities which are focused on the full scale engineering development of the system are disucussed, as well as the system's operational deployment. E.D.K.

N81-26100# Air Force Space Div., Los Angeles, Calif.
NAVSTAR FIELD TEST RESULTS
R. L. PETERSON *In* AGARD Precision Positioning and Inertial Guidance Sensors 7 p (SEE N81-26091 17-04) Mar. 1981
Avail: NTIS HC A16/MF A01

The most significant user equipment tests conducted during the concept validation phase of the Navstar Global Positioning System are described. These tests demonstrated that a 10 to 20 meter accuracy is achievable and a very precise navigation capability has a wide range of military applications. E.D.K.

N81-26101# Bodenseewerk Geraetetechnik G.m.b.H., Ueberlingen (West Germany).
ESTIMATION OF STRAPDOWN SENSOR PARAMETERS FOR INERTIAL SYSTEM ERROR-COMPENSATION
D. K. JOOS and U. K. KROGMANN *In* AGARD Precision Positioning and Inertial Guidance Sensors 25 p (SEE N81-26091 17-04) Mar. 1981 refs
Avail: NTIS HC A16/MF A01

Laboratory test procedures to determine static and dynamic parameters of the gyro and accelerometer measurement model are determined. It is shown that a proper rate test and a multiposition test with respect to Earth rate and gravity vector are well suited to ascertain static parameters with sufficient accuracy. Optimal parameter values are retrieved from measured test-data applying regression analysis techniques. It is further shown how uncertainities in parameter estimates can be determined from actual measurement residues. The verification of major dynamic performance parameters of interest (i.e., anisoinertia torque, angular acceleration term) by appropriate test procedures utilizing a 3-axes testtable is illustrated. Applicability and feasibility of the proposed test procedures is demonstrated utilizing the modular strapdown system (MSS). Test configuration and sequence as well as processing of test data including collection and reduction are described. Significant MSS error parameters are extracted and evaluated applying iterative linear regression techniques. The corresponding software-structure is also described. The results obtained confirm the usefullness of the developed test-procedures and software for calibrating a strapdown system with sufficient accuracy. It is further indicated that the software package exceeds its pure calibration function. R.C.T.

N81-26102# Centre d'Essais en Vol, Bretigny-sur-Orge (France).
EVALUATION OF A HYBRID NAVIGATION SYSTEM WITH LASER GYROSCOPES: SEXTAN [EVALUATION D'UN SYSTEME DE NAVIGATION HYBRIDE A GYROLASERS SEXTAN]
D. REGNAULT, J. LECLERC (Crouzet Aerospace and Systems), B. DESALABERRY (Societe Francais d'Equipment pour la Navigation Aerienne, Velizy Villacoublay, France), and J. P. PRADOUX (Societe Francais d'Equipment pour la Navigation Aerienne, Boulogne, France) *In* AGARD Precision Positioning and Inertial Guidance Sensors 20 p (SEE N81-26091 17-04) Mar. 1981 In FRENCH
Avail: NTIS HC A16/MF A01

The program SEXTAN was designed for low flying military helicopters. The design considerations included cost reduction as a major factor in order to comply to the European economic markets and military needs. Major components of the system include: three laser gyroscopes, three accelerometers, an on-board computer, Doppler radar, and a control terminal that utilizes computer graphics for visual presentation of flight control data. Transl. by T.M.

N81-26103# Naval Air Development Center, Warminster, Pa. Communication Navigation Technology Directorate
FLIGHT TEST RESULTS OF AN ADVANCED DEVELOPMENT MODEL RING LASER GYRO NAVIGATOR (RLGN)
K. L. BACHMAN *In* AGARD Precision Positioning and Inertial Guidance Sensors 9 p (SEE N81-26091 17-04) Mar. 1981 refs
Avail: NTIS HC A16/MF A01

The requirements leading to the formulation of an advanced development program for the RLGN are addressed. The functional description of the RLGN including key hardware and software

design features are described. Particular emphasis is given to a discussion of the flight test program in an A-7E and P-3C aircraft, and the resultant navigation and reliability performance. Effects of high latitude on system alignment and navigation is also discussed. The proposed follow on full scale development of a second generation carrier aircraft inertial navigation system (CAINS-II) applicable to all Navy carrier aircraft is given. R.C.T.

N81-26104# Naval Air Development Center, Warminster, Pa. Communication and Navigation Technology Directorate.
JTIDS RELATIVE NAVIGATION TEST AND EVALUATION
L. NEWMAN and P. J. FINNEGAN *In* AGARD Precision Positioning and Inertial Guidance Sensors 9 p (SEE N81-26091 17-04) Mar. 1981
Avail: NTIS HC A16/MF A01

An extensive test program was conducted to measure the performance of the advanced development model of the joint tactical information distribution system. The test program, flight scenarios, data analysis and general results of this effort are described. R.C.T.

N81-26105# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick (West Germany). Inst. fuer Flugfuehrung.
INTEGRATED NAVIGATION SYSTEMS BASED ON MULTIPLE DME
U. BROKOF and K. HURRASS *In* AGARD Precision Positioning and Inertial Guidance Sensors 10 p (SEE N81-26091 17-04) Mar. 1981 refs
Avail: NTIS HC A16/MF A01

Two integrated navigation systems are described which consist of a self contained dead reckoning system which is constantly aided by distance measurements down to different distance measuring equipment (DME) ground stations. The first dead reckoning system is based on the true air speed as well as the heading of the aircraft. The second one is an inertial navigation system. The integration of the dead reckoning systems and the DME system was carried out by means of a Kalman filter. The DME interrogator was constantly switched over to frequencies of five different ground stations. Both integrated systems were tested during test flights made by the jet aircraft HFB 320. A tracking radar was used for determining reference trajectories in order to check the self diagnosis of the Kalman filter. A comparison between the two systems shows that extremely high navigation accuracies can be obtained, too, by the dead reckoning system which is less expensive. R.C.T.

N81-26106# Canadian Marconi Co., Montreal (Quebec).
DYNAMIC PERFORMANCE ANALYSIS OF NAVSTAR/GPS NAVIGATION FILTERS
M. J. DYMENT and D. F. LIAN (Defence Research Establishment, Ottawa) *In* AGARD Precision Positioning and Inertial Guidance Sensors 19 p (SEE N81-26091 17-04) Mar. 1981 refs
Avail: NTIS HC A16/MF A01

Real time performance capabilities of a Navstar Global Positioning System Receiver equipped with a Kalman navigation filter are addressed. The results presented are derived from detailed simulation. The root-sum-square position and velocity error performance is examined in light of required processing power. R.C.T.

N81-26107# Naval Air Development Center, Warminster, Pa.
RAPID ALIGNMENT OF AIRCRAFT STRAPDOWN INERTIAL NAVIGATION SYSTEMS USING NAVSTAR GLOBAL POSITIONING SYSTEM (GPS)
R. W. TAFEL, JR. and D. KRASNJANSKI *In* AGARD Precision Positioning and Inertial Guidance Sensors 20 p (SEE N81-26091 17-04) Mar. 1981 refs
Avail: NTIS HC A16/MF A01

The use of the GPS navigation satellite system as a reference for the in air alignment of a strapdown inertial navigation system (INS) was investigated. A Kalman filter covariance simulation program was used to determine the optimal alignment performance which can be achieved with a hybrid INS/GPS configuration. The sensitivity of in air alignment to reset interval and choice of observable was examined. The impact of various flight profiles upon the effectiveness of the alignment mechanism was evaluated. The alignment sensitivities determined in the optimal study were then used to develop a suboptimal alignment filter suitable for mechanization in an airborne computer. The trade off between filter size and alignment speed and accuracy was determined. The recommended filter was compared to the optimal filter over a range of alignment conditions in order to demonstrate its effectiveness. R.C.T.

N81-26108# Naval Air Development Center, Warminster, Pa.
NEW NAVY PROGRAMS FOR DEVELOPMENT OF INTEGRATED INERTIAL SENSORS
C. R. ABRAMS and R. J. SKOYLES *In* AGARD Precision Positioning and Inertial Guidance Sensors 14 p (SEE N81-26091 17-04) Mar. 1981 refs
Avail: NTIS HC A16/MF A01

Concepts in sensor redundancy and subsystem integration are described for navigation/flight control functions and other using subsystems. The major emphasis is on a reduction in the number of required sensors, by the use of skewed configurations and functional integration. Substantial improvements in reliability and maintainability are anticipated from both the reduction in sensor complement and the introduction of ring laser gyros. Survivabilty is enhanced by the dispersion of redundant units. The data management software for skewed rate sensors and accelerometers that were developed, validated in the laboratory, and verified in flight tests are discussed. Status of planned system hardware, software, and flight testing for an advanced development model of an integrated inertial sensor assembly to supply inertial data for flight control, weapon delivery and navigation are also presented. R.C.T.

N81-26109*# Draper (Charles Stark) Lab., Inc., Cambridge, Mass. Control and Flight Dynamics Div.
F-8 DIGITAL FLY-BY-WIRE AIRCRAFT ANALYTIC REDUNDANCY MANAGEMENT FLIGHT TEST EXPERIENCE
J. C. DECKERT *In* AGARD Precision Positioning and Inertial Guidance Sensors 11 p (SEE N81-26091 17-04) Mar. 1981 refs
(Contract NAS4-2675)
Avail: NTIS HC A16/MF A01 CSCL 17G

The formulation and flight test results of an algorithm to detect and isolate the first failure of any one of twelve duplex control sensors being monitored are described. The technique uses like sensor output differences for fault detection while relying upon analytic redundancy relationships among unlike quantities to isolate the faulty sensor. The fault isolation logic utilizes the modified sequential probability ratio test, which explicitly accommodates the inevitable irreducible low frequency errors present in the analytic redundancy residuals. In addition, the algorithm uses sensor output selftest, which takes advantage of the duplex sensor structure by immediately removing a highly erratic sensor from control calculations and analytic redundancy relationships while awaiting a definitive fault isolation decision via analytic redundancy. R.C.T.

N81-26110# Lowell Univ., Mass.
ENHANCING POSITION RELIABILITY BY FULLY INTEGRATING JTIDS AND GPS
H. J. ROME, R. A. REILLY (ITT Avionics, Nutley, N.J.), and C. R. WARD (ITT Avionics, Nutley, N.J.) *In* AGARD Precision Positioning and Inertial Guidance Sensors 16 p (SEE N81-26091 17-04) Mar. 1981 refs
Avail: NTIS HC A16/MF A01

The key functional design features of a fully integrated JTIDS/GPS receiver are described. It is shown that by fully integrating the signal processing of both systems, and by appropriate source selection algorithms, the control and slewing of the GPS tracking loops make it possible to dramatically enhance the positional reliability of the two systems. Functional block diagrams of the integrated design approach are described. In addition, the rationale for key elements of the design approach is outlined. A performance estimate is made showing the increase in the tolerable jammer to signal ratio made possible through integrating the systems. R.C.T.

N81-26111# Magnavox Co., Torrance, Calif. Advanced Products and Systems.

NAVSTAR GPS RECEIVER FOR SATELLITE APPLICATIONS

R. THORENSEN, K. M. JOSEPH, J. J. WINTERHALTER, and J. R. CHAMPION (APL, Laurel, Md.) *In* AGARD Precision Positioning and Inertial Guidance Sensors 21 p (SEE N81-26091 17-04) Mar. 1981 refs

Avail: NTIS HC A16/MF A01

A GPS navigation receiver/processor and ancillary units which combined constitute a spaceborne GPS Navigator (GPSPAC) are described. This navigator is intended for use on low altitude satellite host vehicles, i.e., LANDSAT D. The GPSPAC provides highly accurate three dimensional position and velocity of the host vehicle together with precision time determination using signals from NAVSTAR/GPS constellation of navigation development satellites. The GPSPAC system architecture and design are described, functional and operational characteristics discussed as well as principal hardware, software and navigation features. A description of test support equipment, test methods and test results is presented. R.C.T.

N81-26112# Litton Systems, Inc., Woodland Hills, Calif. Guidance and Control Systems Div.

JTIDS STRAPDOWN INERTIAL MIDCOURSE GUIDANCE PERFORMANCE ANALYSIS

S. C. BOSE *In* AGARD Precision Positioning and Inertial Guidance Sensors 13 p (SEE N81-26091 17-04) Mar. 1981 refs

Avail: NTIS HC A16/MF A01

Midcourse guidance performance of ship launched missiles against over the horizon airborne targets is investigated. The strapdown inertial guidance system of the missile was augmented by JTIDS passive ranging from two airborne early warning aircraft situated between the launching ship and the target. The purpose of midcourse guidance was to place the missile in an acquisition basket sufficiently small to permit target sighting by the seeker within the constraints of its field of view and acquisition range. The terminal seeker pointing angle errors of the missile to target line of sight was selected as the performance index. Seeker pointing angle errors at acquisition time were functions of missile navigation position and attitude rors. Missile navigation errors were obtained as a function of different inertial instrument errors and JTIDS errors. Different shipboard alignment techniques and inertial instrument error budgets were included in the performance analysis. A typical relative range updating scheme in accordance with the timing structure of JTIDS was used in a Kalman filter to augment the strapdown inertial navigation system of the missile. The major error sources affecting midcourse guidance were identified and the results obtained give seeker pointing angle errors as a function of shipboard alignment technique, quality of the inertial instruments, seeker acquisition range and JTIDS relative range updating. R.C.T.

N81-26113# Systems Control, Inc., Palo Alto, Calif.

INTEGRATION OF POSITIONING AND NAVIGATION INTO THE C-(3)I STRUCTURE

R. DENARO, F. KARKALIK, and S. W. GILBERT (Office of the Secretary of Defense) *In* AGARD Precision Positioning and Inertial Guidance Sensors 11 p (SEE N81-26091 17-04) Mar. 1981 refs

Avail: NTIS HC A16/MF A01

The role of positioning and navigation information in the C(3)I structure is defined. A candidate methodology to assure its integration in C(3)I design and mission analysis is presented. All levels of conflict, from strategic to tactical are considered, since positioning and navigation play an important role at any level. An example mission is described in terms of the potential of deep pos. nav integration for benefiting the C(3)I process. R.C.T.

N81-31172# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France)

ADVANCES IN INERTIAL NAVIGATION SYSTEMS AND COMPONENTS

H. W. SORG, ed. Apr. 1981 140 p refs

(AGARD-AG-254, ISBN-92-835-1383-5, AD-A101446) Avail: NTIS HC A07/MF A01

Three major developments of the last decade are covered. These are: the dry tuned gyro, the laser gyro, and the strapdown technology, taking into consideration cost reduction and higher reliability.

N81-31173# Anschuetz and Co. G.m.b.H., Kiel (West Germany).

TUNED GYRO COST REDUCTION THROUGH A NOVEL HINGE DESIGN

R. HABERLAND and H. KARNICK *In* AGARD Advances in Inertial Navigation Systems and Components 13 p (SEE N81-31172 22-04) Apr. 1981 refs

Avail: NTIS HC A07/MF A01

The gyro hinge design described combines producibility with high performance capability due to optimal flexure contour and utilization of design space. Its indirect effect on the design and the effort for manufacturing and calibrating dtg's was shown with respect to strapdown gyros in the size ranging from 12 to 23 mm rotor radius. The following cost-reducing consequences on gyro design and calibration can be noted: (1) no need for multi-gimbal design even in the inertial quality domain with day to day repeatability down to 0.01 deg/h; (2) no need for gimbal balancing in the same domain; (3) no tuning treatment what ever for gyros of day to day repeatability of more than 0.1 deg/h to 1 deg/h, dependent on size and pickoff stability; (4) reduction of tuning treatment to suspension pre-tuning for most inertial grade gyros; and (5) reduced influence of elastic modulus variations. Consequent utilization of this potential renders gyro concepts of specific simplicity and cost effectiveness in each application range from low performance to inertial quality. E.D.K.

N81-31174# Air Force Office of Scientific Research, Bolling AFB, Washington, D.C.

OPTICAL ROTATION RATE SENSORS

G. E. KNAUSENBERGER *In* AGARD Advances in Inertial Navigation Systems and Components 40 p (SEE N81-31172 22-04) Apr. 1981 refs

Avail: NTIS HC A07/MF A01

The measurement of inertial rotation using optical methods are based on two principles: one on the Sagnac effect, leading to the rightlasers (RLG) and its derivatives and two other based on the spin of the nuclei leading to the nuclear magnetic resonance gyro (NMRG or MRG). In the case of the RLG the inertial reference quantity is the velocity of light since it is independent of the platform motion. In the case of the MRG, one attempts to derive the inertial reference from the spin vector of a conglomerate of oriented atomic nuclei. Successful approaches are so far limited to inertial angular velocity measurement via comparison with a magnetic field induced Larmor precession of the nuclei. Both methods rely on optical operating and readout means. Justification for pursuing both approaches derives from the fact that the RLG requires a certain size and mechanical precision in construction while the MRG has the potential for greater miniaturization. On the other hand, recent RLG work indicates possibilities for significant sensitivity increase and optimum adaptability to specific environments and missions. E.D.K.

N81-31175# Litton Systems, Inc., Woodland Hills, Calif. Guidance and Control Systems Div.

A NUCLEAR MAGNETIC RESONANCE GYRO USING NOBLE GAS ISOTOPES

E. KANEGSBERG *In* AGARD Advances in Inertial Navigation Systems and Components 5 p (SEE N81-31172 22-04) Apr. 1981

Avail: NTIS HC A07/MF A01

A nuclear Magnetic Resonance (NMR) Gyro is an inertial angle sensor in which the inertial properties are derived from an intrinsic angular momentum and magnetic moment associated with the nuclei of certain atomic isotopes. Such magnetic moments precess in a magnetic field. A measurement of the shift in precession phase angle is used to obtain the gyro rotation information. The general requirements of NMR gyro operation include the existence of a measurable magnetic moment, the ability to make a continuous high precision measurement of the precession phase of such moments, and a means of distinguishing between rotation effects and magnetic field effects. An approach which satisfies these requirements utilizes two isotopes of the noble gases as the inertial sensors and uses an optically pumped rubidium magnetometer as the readout mechanism. A breadboard NMR gyro utilizing this aproach was tested and is characterized by a high signal to noise ratio and a low random bias drift. E.D.K.

N81-31176# Hamilton Standard, Farmington, Conn.
HAMILTON STANDARD SUPERJET SOLID STATE FLUIDIC RATE SENSOR
R. E. SWARTS, R. J. SLABINSKI, and M. T. LOPICCOLO *In* AGARD Advances in Inertial Navigation Systems and Components 16 p (SEE N81-31172 22-04) Apr. 1981 refs
Avail: NTIS HC A07/MF A01

The sensor is a solid state fluidic rate sensor replacing conventional inertia wheel gyroscopes in applicatons where high shock loading, rapid turn on, and long storage life are important. Applied angular rates are measured by means of the Coriolis acceleration generated deflection of a recirculated gas jet flow. This gas jet flow is used to differentially cool a precision temperature sensitive wire pair located downstream in the jet flow. The instrument contains no rotating or mating sliding parts. The sensors is a small, lightweight, low power consumption device which is capable of extreme over ranging without degradation of performance upon recovery. A description of the Superjet (TM) sensor and its associated supporting electronics is presented. Discussions of the theory of operation, design implementation, and test results substantiating the performance capability of the unit are included. Data are presented which demonstrate capabilities of 0.3 deg/sec null offset over temperature, 0.02 deg/sec resolution, and 1.0 % scale factor linearity for rates up to 150 deg/sec. E.D.K.

N81-31177# Office National d'Etudes et de Recherches Aeronautiques, Paris (France).
THE CACTUS ACCELEROMETER
A. BERNARD, M. GAY, and R. JUILLERAT *In* AGARD Advances in Inertial Navigation Systems and Components 10 p (SEE N81-31172 22-04) Apr. 1981 refs
Avail: NTIS HC A07/MF A01

The functioning of Cactus (ultra-sensitive, three axis, capacitive accelerometric transducer) is based on the measurement of the force necessary to maintain a reference or proof mass within a cage without any material contact. This force is the resultant of three orthogonal electrostatic attraction forces. Each of them is generated by an electronic circuit fed with the measure of the relative position of the proof mass within the cage. Each of these circuits thus ensures a servo-positioning function of the proof mass. The whole apparatus being mounted on board a spacecraft, the forces that can create a relative movement of the proof mass within the cage are on the one hand, the surface forces acting on the spacecraft, and on the other hand, the inertial forces resulting from the spacecraft movement about its center of mass. The forces of the first kind are due to radiation pressure and to the drag resulting from the impact of gas molecules on the spacecraft surfaces. Those of the second kind can be minimized by a thorough centering and a sufficiently small amplitude of the spacecraft movement. The apparatus permits the measurement of the resultant of these surface forces, this resultant being measured in terms of force per unit mass, or accelerations. E.D.K.

N81-31178# Honeywell Systems and Research Center, Minneapolis, Minn
INERTIAL SYSTEM ALIGNMENT AND CALIBRATION ON A MOVING BASE
M. B. IGNAGNI *In* AGARD Advances in Inertial Navigation Systems and Components 13 p (SEE N81-31172 22-04) Apr. 1981 refs
Avail: NTIS HC A07/MF A01

The problem of optimally aligning and calibrating an inertial navigation system on a moving base is addressed. A comprehensive solution to this class of problems is given and shown to be optimal, subject only to structural constraint normally imposed by practical implementation limitations. E.D.K.

N81-31179# Bodenseewerk Geraetetechnik G.m.b.H., Ueberlingen (West Germany).
IDENTIFICATION AND DETERMINATION OF STRAPDOWN ERROR-PARAMETERS BY LABORATORY TESTING
D. K. JOOS and U. K. KROGMANN *In* AGARD Advances in Inertial Navigation Systems and components 37 p (SEE N81-31172 22-04) Apr. 1981 refs
Avail: NTIS HC A07/MF A01

The performance of an inertial navigation system (INS) is largely affected by a number of important error sources, where most of which are related to the instruments used. This particularly applies to strapdown systems. Laboratory test procedures are described which determine static and dynamic parameters of the gyro and accelerometer measurement model. It is shown that a proper rate test and a multiposition test with respect to Earth rate and gravity vector are well suited to ascertain static parameters with sufficient accuracy. Optimal parameter values are retrieved from measured test data applying regression analysis techniques. It is shown how uncertainties in parameter estimates can be determined from actual measurement residues. The verification of major dynamic performance parameters of interest by appropriate test procedures utilizing a three axes test table is shown. Applicability and feasibility of the proposed test procedures are demonstrated utilizing the modular strapdown system. E.D.K.

N82-29293# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
HUMAN FACTORS IN AIR TRAFFIC CONTROL
V. D. HOPKIN (Royal Air Force Inst. of Aviation Medicine) Apr. 1982 187 p refs
(AGARD-AG-275; ISBN-92-835-1421-1; AD-A116394) Avail: NTIS HC A09/MF A01

Human factors are related to air traffic control, air traffic control systems, the physical surroundings, equipment, and operation of the system, and the selection, development, training and evaluation of air traffic controllers. For individual titles, see N82-29294 through N82-29310.

N82-29294# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
THE AIR TRAFFIC CONTROL SYSTEM
In its Human Factors in Air Traffic Control p 3-9 (SEE N82-29293 20-04) Apr. 1982
Avail: NTIS HC A09/MF A01

Principles and practices of air traffic control are described. The information influencing the air traffic control system and the information available to the controller are summarized and defined. The users of air traffic control, whether commercial, military, or general aviation traffic is considered, are categorized, and their responsibilities discussed. Interactions between air traffic control and the pilot are considered. National and regional variations in the problems and practices of air traffic control are described. J.D.

N82-29295# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
HUMAN FACTORS CONTRIBUTIONS TO AIR TRAFFIC CONTROL SYSTEMS
In its Human Factors in Air Traffic Control p 10-21 (SEE N82-29293 20-04) Apr. 1982
Avail: NTIS HC A09/MF A01

The role of the human factors specialist in air traffic control systems operations and planning is analyzed. Man-machine interactions; the contribution of human factors engineering to system design, the implementation and testing of air traffic control systems and tasks, and the evolution of air traffic control systems; and the educational role of human factors specialists as applied to air traffic control are considered. J.D.

N82-29296# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
MAN AS A SYSTEM COMPONENT
In its Human Factors in Air Traffic Control p 22-30 (SEE N82-29293 20-04) Apr. 1982
Avail: NTIS HC A09/MF A01

The air traffic controller is considered as a component of a man-machine system. Limitations of this approach are considered. The allocation of functions, the effects of automation and computer

assistance, the man-machine interface, and human reliability are discussed. J.D.

N82-29297# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
HUMAN CAPABILITIES AND LIMITATIONS IN SYSTEMS
In its Human Factors in Air Traffic Control p 31-46 (SEE N82-29293 20-04) Apr. 1982
Avail: NTIS HC A09/MF A01

Human capabilities and limitations which restrict the development of air traffic control systems are discussed. Sensory factors, perception, learning, memory, capacity for attention, information processing, understanding, problem solving, decision making, and motivation are considered. Common mismatches of system requirements with human capabilities are described. J.D.

N82-29298# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
JOBS AND TASKS IN AIR TRAFFIC CONTROL
In its Human Factors in Air Traffic Control p 47-52 (SEE N82-29293 20-04) Apr. 1982
Avail: NTIS HC A09/MF A01

Jobs and tasks are discussed. The required content of job descriptions and their application to allocation of jobs is considered. Task analysis and task synthesis, task grouping, interactions between tasks, and workloads are described. J.D.

N82-29299# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
THE WORK ENVIRONMENT
In its Human Factors in Air Traffic Control p 53-62 (SEE N82-29293 20-04) Apr. 1982
Avail: NTIS HC A09/MF A01

The work environment for all traffic control tasks is considered. Principles of workspace design are discussed. The physical environment, suites and consoles, air traffic control centers and control rooms, and air traffic control towers are described. J.D.

N82-29300# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
DISPLAYS
In its Human Factors in Air Traffic Control p 63-78 (SEE N82-29293 20-04) Apr. 1982
Avail: NTIS HC A09/MF A01

Factors affecting interactions between visual displays and their users are discussed. The physical dimensions of the display, the layout of the display and of information within the display, the information content of the display, visual codings and color codings, the legibility and readability of displays, the relation between displays, and the quality of displayed information are considered. New display technology is summarized. J.D.

N82-29301# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
CONTROLS
In its Human Factors in Air Traffic Control p 79-84 (SEE N82-29293 20-04) Apr. 1982
Avail: NTIS HC A09/MF A01

The location, type, sensitivity, and interactions of the controls used by the human to convey information to the air traffic control system are discussed. The relationships between controls and visual displays are considered. J.D.

N82-29302# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
COMMUNICATIONS
In its Human Factors in Air Traffic Control p 85-93 (SEE N82-29293 20-04) Apr. 1982
Avail: NTIS HC A09/MF A01

The human factor terms of communication in air traffic control are examined. The effects of known specified variables in communications on controller performance or system efficiency were measured. The importance of speech and the use of computers in the man machine systems as a means of dialogue and information transmission is emphasized. The following topics are discussed: transmission of information between air and ground; speech as a medium of communication; qualitative attributes of speech; automated speech recognition and automated speech synthesis; coordination and liaison; language and terminology of air traffic control; air traffic phrasing and message formats; information quantification and redundancy in air traffic control messages. E.A.K.

N82-29303# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
THE SELECTION OF CONTROLLERS
In its Human Factors in Air Traffic Control p 94-100 (SEE N82-29293 20-04) Apr. 1982
Avail: NTIS HC A09/MF A01

The process of selection of air traffic controllers is examined. Two fundamental issues are the relationship between selection and training, and attributes unrelated to air traffic control. The issues discussed are: supply and demand; identification of relevant attributes; psychological tests; the role of air traffic control tasks and knowledge; validity and reliability of selection procedures; and adapting selection procedures to changing needs. E.A.K.

N82-29304# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France)
THE TRAINING OF CONTROLLERS
In its Human Factors in Air Traffic Control p 101-109 (SEE N82-29293 20-04) Apr. 1982
Avail: NTIS HC A09/MF A01

The standardization of training of air traffic controllers to produce fully qualified, safe, and efficient controllers by the most cost effective training methods was examined. Topics discussed are: training objectives; content of training courses; the role of simulation in training; assessments of progress during training; reliability and validity of training procedures; training for new tasks; retraining; and automation in training. E.A.K.

N82-29305# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
HUMAN FACTORS IMPLICATIONS OF CONDITIONS OF EMPLOYMENT
In its Human Factors in Air Traffic Control p 110-118 (SEE N82-29293 20-04) Apr. 1982
Avail: NTIS HC A09/MF A01

The managerial direction of air traffic controllers is reviewed. Performance, attitude, management controller relations, and successfully developed collaboration techniques are examined. The following topics are discussed: management of controllers; consultation with controllers; needs of controllers at work; career structure; work rest cycles; occupational health; and retirement. E.A.K.

N82-29306# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
INFLUENCES ON THE INDIVIDUAL CONTROLLER
In its Human Factors in Air Traffic Control p 119-125 (SEE N82-29293 20-04) Apr. 1982
Avail: NTIS HC A09/MF A01

Experiences of and influences on individual air traffic controllers are analyzed. Different parameters which interfere with the daily workload are outlined. The following influences that interfere with performance efficiency are considered: experience, age, stress, boredom, personality, attitudesm trust and job satisfaction. E.A.K.

N82-29307# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
THE MEASUREMENT OF THE AIR TRAFFIC CONTROLLER
In its Human Factors in Air Traffic Control p 126-140 (SEE N82-29293 20-04) Apr. 1982
Avail: NTIS HC A09/MF A01

The standardization of measurements for air traffic controller performance are discussed. The purpose for measuring the controllers is outlined and factors measured by task performance are presented. Issues related to the measurements are as follows: system performance, task performance, error, delays, omissions and nonconsistencies; physiological and biological indices; modelling and allied techniques; subjective assessments; social factors; qualitative factors; tests and other measures; and interactions between measures. E.A.K.

N82-29308# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
HUMAN FACTORS IN AIR TRAFFIC CONTROL RESEARCH AND DEVELOPMENT
In its Human Factors in Air Traffic Control p 141-149 (SEE N82-29293 20-04) Apr. 1982
Avail: NTIS HC A09/MF A01

Research and development in human factors in air traffic control is examined. Topics discussed are: contribution of human factors; human factors applications to air traffic control evaluations; real time and fast time simulation; alternative techniques; identification of relevant measures and variables; reliability and validity of evidence; and interpretation and dissemination of findings.
E.A.K.

N82-29309# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
ADDITIONAL FUNCTIONS WITHIN THE AIR TRAFFIC CONTROL SYSTEM
In its Human Factors in Air Traffic Control p 150-153 (SEE N82-29293 20-04) Apr. 1982
Avail: NTIS HC A09/MF A01

The application of human factors engineering to other job functions existing within the air traffic control system is discussed. Personnel involved in data gathering, maintenance of system integrity, fault finding, supervision, and traffic control assistance are considered.
J.D.

N82-29310# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
FUTURE TRENDS AND PROBLEMS
In its Human Factors in Air Traffic Control p 154-155 (SEE N82-29293 20-04) Apr. 1982
Avail: NTIS HC A09/MF A01

Anticipated developments and problems occurring in the application of human factors engineering to air traffic control systems, particularly in the light of technological advances in hardware and software, are summarized.
J.D.

05

AIRCRAFT DESIGN, TESTING AND PERFORMANCE

Includes aircraft simulation technology.

N80-22306*# National Aeronautics and Space Administration, Washington, D. C.
AERODYNAMICS OF THE NEW GENERATION OF COMBAT AIRCRAFT WITH DELTA WINGS
M. P. BOHN Mar. 1980 26 p Transl. into ENGLISH of "Aerodynamique de la Nouvelle Generation d'Avions de Combat a Aile Delta". Rept AGARD-CP-241 AGARD, Paris, Jun. 1978 p 11-1-11-13 Presented at the Multi-Panel Symp. on Fighter Aircraft Design, Florence, 3-6 Oct 1977 Translation was announced as N78-30106 Transl. by Scientific Translation Service, Santa Barbara, Calif
(Contract NASW-3198)
(NASA-TM-75793, AGARD-CP-241) Avail: NTIS HC A03/MF A01 CSCL 01C

The use of delta wing aerodynamic design for modern fighter aircraft is discussed. Various current French fighter airplanes are utilized for comparisons.
E.D.K.

N80-23303# 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 2A: SPECIFIC APPLICATION STUDY NO. 1, CLOSE AIR SUPPORT
L. J. URBAN ed. (ASD) Feb. 1980 70 p
(AGARD-AR-147-VOL-2A, ISBN-92-835-1349-5, AD-A082957)
Avail: NTIS HC A04/MF A01

The application of NAVSTAR/Global Positioning System to Close Air Support is described. A currently available 'model' was selected, namely the F-4E aircraft equipped with the ARN-101 weapon delivery system. This was selected since it represents the current state-of-the-art for externally aided (LORAN) digital avionics system integrated into a reasonably modern fighter aircraft which is currently in the operational inventory of several NATO countries.
R.E.S.

N80-25325# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
AIRCRAFT DYNAMIC RESPONSE TO DAMAGED RUNWAYS
Mar. 1980 37 p refs Presented at the 49th Meeting of the Struct. and Mater. Panel, Porz-Wahn, West Germany, Oct. 1979
(AGARD-R-685; ISBN-92-835-1354-1; AD-A085466) Avail: NTIS HC A03/MF A01

The potential problems of aircraft dynamic response to damaged and repaired runways were studied. For small aircraft with relatively simple landing gear, the operation over nominal repairs was dominated by rigid body motions of the aircraft. The prediction of those motions was possible and compared reasonably well with experimental data. For larger aircraft or aircraft with large external stores, the prediction of detailed loads in critical areas has met with limited success so far. Since landing gear equations are highly nonlinear, the prediction of aircraft dynamic response required time consuming numerical integrations. Also the behavior of large external stores can be affected by nonlinear effects (such as rigging loads), and both landing gear and external stores nonlinearities are affected by aircraft servicing precedures and by the ambient environment. For individual titles, see N80-25326 through N80-25328.

N80-25326# Air Force Engineering and Services Center, Tyndall AFB, Fla.
RUNWAY SURFACE ROUGHNESS
L. R. CALDWELL, A. G. GERARDI (AFFDL), and R. BOROWSKI (AFFTC) *In* AGARD Aircraft Dyn. Response to Damaged Runways p 1-18 (SEE N80-25325 16-05) Mar. 1980 refs
Avail: NTIS HC A03/MF A01

The techniques used for analysis of runway surface roughness on an f-4 aircraft are reported. Computer simulations and their results are discussed. These results are compared to test data measured from operation of an f-4 over simulated bomb damage repair. Surface roughness criteria to be used in repairing an airfield after an attack are presented.
E.D.K.

N80-25327# British Aerospace Aircraft Group, Weybridge (England).
UK APPROACH TO AIRCRAFT DYNAMIC RESPONSE ON DAMAGED AND REPAIRED RUNWAYS
B. W. PAYNE, A. E. DUDMAN (British Aerospace Aircraft Group, Warton, England), B. R. MORRIS, M. ORMEROD (Aeroplane and Armament Experimental Establishment), and C. BRAIN *In* AGARD Aircraft Dyn. Response to Damaged Runways p 19-24 (SEE N80-25325 16-05) Mar. 1980
Avail: NTIS HC A03/MF A01

The operation of military aircraft from damaged and repaired runways was studied. Mathematical models and associated validation trials were successfully employed to predict the dynamic response of aircraft on damaged and repaired runways and together with engineering support trials allow the operational capability of the aircraft to be defined, provided proper consideration can be given to the variability of the environment and the aircraft. Clearance problems arise from rigid aircraft response in pitch and roll giving rise to high undercarriage loads and/or unacceptable handling problems for the pilot and from flexible structure response leading to high aircraft structure loads, especially for heavy external stores. Considerable simplifications were achieved on those aircraft studied as the critical features came essentially from single degree of freedom responses.
E.D.K.

N80-25328# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (West Germany)

PARAMETERS AFFECTING AIRCRAFT PERFORMANCE ON RUNWAYS IN BAD CONDITION

A. KRAUSS, O. BARTSCH, and G. KEMPE *In* AGARD Aircraft Dyn. Response to Damaged Runways p 25-31 (SEE N80-25325 16-05) Mar. 1980 refs

Avail: NTIS HC A03/MF A01

It is postulated that calculations of dynamic response to damaged runways must account for the nonlinearities of the undercarriage. Examples taken from simulations of the F-104G running across AM2 runway repair mats serve to identify the influence of some of these nonlinearities and to discuss possibilities to improve undercarriage performance. The subsequent considerations on structural response of the airframe deal with the validity of models and with cost effective ways of determining aircraft performance on runways in bad condition. E.D.K.

N80-28348# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).

TECHNICAL EVALUATION REPORT ON THE FLIGHT MECHANICS PANEL SYMPOSIUM ON THE USE OF COMPUTERS AS A DESIGN TOOL

S. N. WAGNER (Hochschule der Bundeswehr, Munich) Mar. 1980 21 p refs Symp. presented at Munich, 3-6 Sep. 1979 (AGARD-AR-158; ISBN-92-835-1353-3; AD-A085465) Avail: NTIS HC A02/MF A01

The application of computer technology to aircraft design is considered. Specific topics covered include: specifications and assessment of requirements; computer aided design and computer graphics; computational aerodynamics and design; structural analysis and design; and propulsion and systems design. The primary conclusions are that the human being still plays a critical role during all steps of computerized aircraft design and that remarkable progress has been made in many areas related to aircraft design because of recent developments in computer hardware and software. However, there are still areas where the designer has to relay rely on wind tunnel and structural testing. The computer has reduced the routine workload of the engineer to save time for creative work, but there is still a need for faster and larger computers that will probably incorporate new architectures. J.M.S.

N81-20064# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).

APPLICATION OF A STRUCTURAL OPTIMIZATION PROCEDURE FOR ADVANCED WINGS

H. GODEL (Messerschmitt-Boelkow-Blohm GmbH, Munich West Germany) and G. SCHNEIDER (Messerschmitt-Boelkow-Blohm GmbH, Munich West Germany) Jan. 1981 20 p refs Presented at the 51st Meeting of the AGARD Struct. and Mater. Panel, Aix-en-Provence, France, 14-19 Sep. 1980

(AGARD-R-691; ISBN-92-835-1379-7) Avail: NTIS HC A02/MF A01

A computer software called ASAT exists which allows an automatic design of minimum weight structures. The application of the system to several structures is described. It is shown that a structural optimization system can be very useful in the preliminary design of an airplane, especially when it consists of several modules such as static load calculation, deformations and stress calculation by finite elements, static aeroelastics, weight calculation, unsteady aerodynamic forces, vibration calculation, flutter calculation, flutter, and strength optimization which all can be used separately and independently. E.D.K.

N81-26126# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).

HELICOPTER FATIGUE LIFE ASSESSMENT

Mar. 1981 261 p refs Partly in ENGLISH and FRENCH Proc. of 51st meeting held in Aix-en-Provence, France, 14-19 Sep. 1980

(AGARD-CP-297; ISBN-92-835-0289-2; AD-A101017) Avail: NTIS HC A12/MF A01

The substantiation of the fatigue life of civil and military helicopters is considered with emphasis on comparisons with operational experience, the development of new technologies and the advent of new concepts. Topics covered include, current procedures, damage tolerance and fail safe concepts, service experience with existing procedures; testing techniques and methodology; constant amplitude spectrum loading. For individual titles, see N81-26127 through N81-26143.

N81-26127# National Aerospace Lab., Emmeloord (Netherlands).

STATE OF THE ART AND STATISTICAL ASPECTS OF HELICOPTER FATIGUE SUBSTANTIATION PROCEDURES

R. NOBACK *In* AGARD Helicopter Fatigue Life Assessment 22 p (SEE N81-26126 17-05) Mar. 1981 refs

Avail: NTIS HC A12/MF A01

The recipe that is used to calculate safe fatigue life for helicopter components is described. Basic ingredients are flight loadspectrum, derived from measured flightloads and mission profile; a reduced S-N curve, based on statistically treated coupon and specimen test results; and a damage hypothesis. These ingredients are generally used, but many different ways of handling, especially statistically, exist and these may lead to a great variety of calculated safe fatigue lives. An example is used to illustrate the influence of various ways of handling on the end result. An attempt is made to bring together alternative statistical opinions. Author

N81-26128# Royal Aircraft Establishment, Farnborough (England). Structures Dept.

FATIGUE ASSESSMENT OF UK MILITARY AEROPLANES

J. L. M. FORSYTH *In* AGARD Helicopter Fatigue Life Assessment 6 p (SEE N81-26126 17-05) Mar. 1981

Avail: NTIS HC A12/MF A01

Fatigue assessment procedures used in the United Kingdom at all stages from the initial specification of the mission profile to the monitoring of Service use of military aircraft are described. The present thinking on fatigue assessment procedures for fiber reinforced plastic and damage tolerant structures as well as the latest work on loads measurement and in service monitoring is indicated. A.R.H.

N81-26129# Army Aviation Research and Development Command, St. Louis, Mo. Structures and Aeromechanics Div.

SYNOPSIS OF SPECIALISTS' MEETING ON HELICOPTER FATIGUE METHODOLOGY

D. C. BORGMAN and D. P. SCHRAGE *In* AGARD Helicopter Fatigue Life Assessment 10 p (SEE N81-26126 17-05) Mar. 1981 refs Also presented at the Am. Helicopter Soc. Spec. Meeting, St. Louis, 25-27 Mar. 1980

Avail: NTIS HC A12/MF A01

The principal results from the American Helicopter Society (AHS) Specialists' Meeting on Helicopter Fatigue Methodology held in St. Louis, Mo., on March 25-27, 1980 are summarized. The four essential elements of fagigue methodology usage spectrum, flight loadings, component testing, and life calculations were considered as well as the feasibility of standardization of helicopter fatigue methodology. The manufacturers' fatigue methodology based on a calculated fatigue life of a hypothetical helicopter component was presented. A.R.H.

N81-26130# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (West Germany)

APPLICATION OF DAMAGE TOLERANCE CONCEPTS FOR THE HELICOPTERS

M. V. TAPAVICZ' and F. OCH *In* AGARD Helicopter Fatigue Life Assessment 8 p (SEE N81-26126 17-05) Mar. 1981 refs

Avail: NTIS HC A12/MF A01

The more and more pronounced tendency of modern helicopters towards higher efficiency and reliability requires materials and structural designs possessing high strength and good damage tolerance behavior. The damage tolerance methodology used for helicopters of the BO 105 family as well as for the BK 117 is outlined. One example of each type of damage tolerant design realized in or developed for MBB helicopters is discussed and the design criteria for the other vital components are summarized. It is shown that only a few vital components are designed according to the safe life philosophy. A.R.H.

N81-26131# Societe Nationale Industrielle Aerospatiale, Marignane (France.) Div. Helicopters.
FATIGUE ANALYSIS OF COMPOSITE MATERIALS USING THE FAIL-SAFE CONCEPT [JUSTIFICATION EN FATIGUE DE PIECES EN MATERIAU COMPOSITE BENEFICIANT DU CONCEPT FAIL SAFE]
G. STIEVENARD *In* AGARD Helicopter Fatigue Life Assessment 5 p (SEE N81-26126 17-05) Mar. 1981 In FRENCH
Avail: NTIS HC A12/MF A01

A regulation established jointly between SNIAS and the Official French Service requires failure probability for any individual helicopter part below or equal to 10 to the minus 6th power. This demands knowledge of (1) the fatigue properties of the material; (2) the probability of onset of cracking in the component; and (3) the component crack propagation rate if the load spectrum is applied. Composite materials developed at Aerospatiale and used for rotors have a good fatigue life with evident fail/safe character (delayed start of delamination and slow rate of propagation). The method used at SNAIS to calculate the global risk of rupture is described. A.R.H.

N81-26132# Army Aviation Research and Development Command, Fort Eustis, Va. Applied Technology Lab.
COMBAT DAMAGE ASSESSMENT
C. H. CARPER, JR. *In* AGARD Helicopter Fatigue Life Assessment 20 p (SEE N81-26126 17-05) Mar. 1981 refs
Avail: NTIS HC A12/MF A01

Ballistic damage to helicopters is discussed with primary attention given to the airframe structure. A synopsis is provided of the air defense threat systems and nature of combat damage received by Army helicopters in South Vietnam versus the threat and nature of ballistic damage anticipated in today's environment. New materials, structural concepts, and other vulnerability reduction measures presently being employed on Army helicopters and promising concepts currently under development are addressed. An overview of the combat threats anticipated for the helicopter in the near future is included. A.R.H.

N81-26133# Royal Aircraft Establishment, Farnborough (England). Structures Dept.
AN EVALUATION OF FATIGUE PROCEDURES FOR UK MILITARY HELICOPTERS
R. CANSDALE *In* AGARD Helicopter Fatigue Life Assessment 5 p (SEE N81-26126 17-05) Mar. 1981
Avail: NTIS HC A12/MF A01

In many areas, the formal UK requirements concerning fatigue strength of military helicopters set out in MOD Aviation Publication 970, Volume 3, are known to be deficient, more stringent, clearance procedures stated in the Specifications against which new helicopters are procured. Current UK procedures for the fatigue substantiation of military helicopters are reviewed in the light of practical experience of testing and of service usage. The problems of demonstrating both safe lives and damage tolerance are examined. The philosophy and problems of clearing composite components are mentioned. A.R.H.

N81-26134# Civil Aviation Authority, Redhill (England). Airworthiness Div.
HELICOPTER FATIGUE: A CIVIL VIEW
H. E. LESUEUR *In* AGARD Helicopter Fatigue Life Assessment 4 p (SEE N81-26126 17-05) Mar. 1981 refs
Avail: NTIS HC A12/MF A01

The majority of catastrophic accidents to helicopters involving structure were due to fatigue of some kind, and in comparison with civil jet aircraft, the accident rate for helicopters appears to be worse by a factor of at least two. Methods currently available to reduce the number of accidents due to structural failures are described. It is suggested that some benefits should be obtained by the introduction of damage tolerant materials, the incorporation of multipath loads, and the use of vibration monitoring. A.R.H.

N81-26135# Textron Bell Helicopter, Fort Worth, Tex. Structures Technology.
HELICOPTER COMPONENT FATIGUE LIFE DETERMINATION
M. J. MCGUIGAN *In* AGARD Helicopter Fatigue Life Assessment 10 p (SEE N81-26126 17-05) Mar. 1981 refs
Avail: NTIS HC A12/MF A01

The fatigue evaluation program for helicopter components is reviewed and some of the uncertainties that can be encountered in each stage of the program are discussed in some detail. These include the fatigue test and the flight loads measurement phases. Also considered is the frequency of occurrence spectrum and the effects of changes in operational usage as well as possible solutions to the problem of the resulting changes in load spectrums. Variables in the final fatigue life calculations are discussed and some different approaches to setting component retirement time are discussed. In view of the existing uncertainties involved in the safe life determination process the fail safe approach is considered and some examples are discussed of damage tolerance testing for both metal and composite main rotor blades. Author

N81-26136# Societe Nationale Industrielle Aerospatiale, Marignane (France.)
FATIGUE TESTS ON THE TOTAL STRUCTURE OF THE GAZELLE SA 341 HELICOPTER [ESSAI DE FATIGUE D'UNE STRUCTURE COMPLETE DE LHELICOPTERE SA 341 GAZELLE]
P. PETARD and J. P. LAMBERT (Centre D'Essais Aeronautique, Toulouse) *In* AGARD Helicopter Fatigue Life Assessment 22 p (SEE N81-26126 17-05) Mar. 1981 In FRENCH
Avail: NTIS HC A12/MF A01

The Gazelle is a light, single turbine, 3-blade main rotor's aircraft whose structure combines metal assemblages and honeycomb structures. A peculiarity of the helicopter is a drift-fenestron (fan-in-fin) which replaces the classic anti-torque rotor. This design, especially at high speeds, permits reduction of necessary force on the fenestron because of the aerodynamic action of the f drift and consequently increases the force available on the main rotor. Transl. by A.R.H.

N81-26137# Sikorsky Aircraft, Stratford, Conn. Transmission Systems Design and Development.
HELICOPTER GEARBOX TESTING
R. ZINCONE and J. H. MANCINI *In* AGARD Helicopter Fatigue Life Assessment 10 p (SEE N81-26126 17-05) Mar. 1981 refs
Avail: NTIS HC A12/MF A01

Helicopter gearboxes have benefited from improved materials and from design concepts. However, in the design arena, exhaustive testing to verify that reliability, maintainability, and safety objectives achieved remains the key to a successful product. Overstress testing and the methods used to design the gearboxes to meet these overstress test requirements are the key issues. A gearbox designed for mission reliability will most likely have an unacceptably high risk of not passing an accelerated test. The types of tests use to qualify gearboxes to provide reliability in the field are discussed. Also discussed are the test approaches taken and the differences in acceptance criteria used by the various certifying agencies, the ramifications of overstress testing, and the reliability assessment used in the design of a modern helicopter gearbox. Author

N81-26138# Westland Helicopters Ltd., Yeovil (England).
FATIGUE TESTING OF HELICOPTER GEARBOXES
A. H. BAKER *In* AGARD Helicopter Fatigue Life Assessment 24 p (SEE N81-26126 17-05) Mar. 1981
Avail: NTIS HC A12/MF A01

The fatigue testing of helicopter gearboxes which covers not only the gears but the casings and shafts and other parts of the gearboxes is addressed. Testing with the required factors for fatigue scatter and extrapolation leads to difficulties with the tooth meshing and premature tooth surface damage requiring modified tooth profiles and high pressure lubricants. The principal test method has been on 'back to back' rigs, but for the future, open loop testing is planned in order to give greater flexibility and versatility. A comparison of service experience with test experience is of some value in assessing the merit of the test factors. L.F.M.

N81-26139# Hughes Helicopters, Culver City, Calif. Structural Analysis Section.

THE METHODOLOGY OF FATIGUE ANALYSIS AND TESTING: MAIN ROTOR BLADES AND HUB, HUGHES YAH-64 ADVANCED ATTACK HELICOPTER

J. M. MCDERMOTT *In* AGARD Helicopter Fatigue Life Assessment 17 p (SEE N81-26126 17-05) Mar. 1981 refs

Avail: NTIS HC A12/MF A01

The fatigue methodology applied to the structural analysis and testing of the main rotor blade, blade retention system, and main rotor hub of the Hughes YAH-64 advanced attack helicopter are presented. The basic structural concepts are described, including provision of fail-safe redundant load paths, and damage tolerance. A description of the materials used for the various structural elements is given, and the factors affecting their choice are discussed. The strap retention system, which incorporates both flapping and feathering motion, is described with emphasis on its fail-safety. The approach to fatigue testing of the main rotor elements is described. Fatigue test results are presented, including failure modes and the ability of many components with large amounts of fatigue damage to sustain full loads. A description is given of the fatigue testing of parts with ballistic damage and also of the crack propagation testing of parts with a fatigue crack already developed. The analysis of failed parts to determine failure modes, origins of crack inception and possible improvements to extend fatigue life is discussed. L.F.M.

N81-26140# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (West Germany).

FATIGUE TESTING OF COMPOSITE ROTOR BLADES

F. OCH *In* AGARD Helicopter Fatigue Life Assessment 14 p (SEE N81-26126 17-05) Mar. 1981 refs

Avail: NTIS HC A12/MF A01

Fatigue testing methodology for composite rotor blades established and proved during the last 20 year is based on nonlinear regression analysis. An equation with four material-dependent parameters is used to derive mean and working S/N curves between static strength and endurance limit. To calculate a scatter factor, the fatigue failure load for a given number of cycles is chosen as statistical variable. The fatigue testing program is comprised of testing coupons cut out of production blades to establish basic S/N curve shapes both for fiber and matrix failure. Coupon testing includes temperature/humidity preconditioning effects and the effect of test temperature as well as service usage on the fatigue strength of unidirectional glass fiber composite. It was found that the S/N curve shapes and scatter factors determined from coupon data could be applied to the full scale specimens. A reduction in interlaminar shear fatigue strength was found with coupons, after artificial environmental exposure. With coupons no degradation could be found, as it is with full scale speciments. Composite rotor blades show excellent damage tolerance characteristics, where damage will be indicated by changes in the eigenfrequencies, due to decreasing stiffnesses, long before the structural integrity will be questioned. L.F.M.

N81-26141# Royal Aircraft Establishment, Farnborough (England).

DEVELOPMENT OF STANDARDISED FATIGUE TEST LOAD HISTORIES FOR HELICOPTER ROTORS: BASIC CONSIDERATION AND DEFINITION OF HELIX AND FELIX

J. DARTS and D. SCHUETZ (Fraunhofer-Inst. fuer Betriebsfestigkeit) *In* AGARD Helicopter Fatigue Life Assessment 42 p (SEE N81-26126 17-05) Mar. 1981 refs

Avail: NTIS HC A12/MF A01

The development of two standard load histories for the fatigue evaluation of helicopter rotor materials and design details is described. The loading environment experienced by helicopter rotor components is generally around the constant amplitude fatigue limit. Realistic assessment of the fatigue performance of helicopter materials and design details by flight simulation loading therefore results in long testing times on electrohydraulic machines. The adoption of a standard loading history for such assessments should reduce the amount of testing required and greatly increase the technical value of individual test results. This is because with an agreed standard a wealth of relevant data accumulates quickly, which may negate the need for some tests and gives extensive comparative data for others. Large evaluation programs can therefore be more readily shared between different organizations and countries because the results of the program will be comparable with the organizations' own standard data and the standard data previously accumulated. L.F.M.

N81-26142# Fraunhofer-Inst. fuer Betriebsfestigkeit, Darmstadt (West Germany).

FATIGUE TEST PROGRAM AND TEST RESULTS

D. SCHUETZ, H. G. KOEBLER, W. SCHUETZ (Industrieanlagen-Betriebsgesellschaft), and M. HUECK (Industrieanlagen Betriebsgesellschaft) *In* AGARD Helicopter Fatigue Life Assessment 7 p (SEE N81-26126 17-05) Mar. 1981

Avail: NTIS HC A12/MF A01

The estimation of fatigue life of helicopter rotor parts is obtained by application of standarized load sequences where the service and standard load spectra are very similar. Test results yield data of helicopter main rotor parts in the form of fatigue life curves. L.F.M.

N81-26143# Pisa Univ. (Italy). Inst. of Aeronautics.

FATIGUE BEHAVIOR OF HELICOPTER DYNAMIC COMPONENTS UNDER CONSTANT AMPLITUDE AND SPECTRUM LOADING

G. CAVALLINI, A. LANCIOTT, G. ALDINIO (Costruzioni Aeronautiche G. Agusta), and R. ROVELLOTTI (Costruzioni Aeronautiche G. Agusta) *In* AGARD Helicopter Fatigue Life Assessment 14 p (SEE N81-26126 17-05) Mar. 1981 refs

Avail: NTIS HC A12/MF A01

A number of results obtained in a research helicopter fatigue are given. Various approaches to design for fatigue in helicopter components and; subsequently, an evaluation of improvement in this area were compared. Current methodologies used in helicopter industries are considered, as well as nominal stress approach, and advanced methods, namely methods based on local stress-strain approaches. Fatigue test constant amplitude and variable amplitude loading were carried out on typical dynamic component, the tail rotor mast of A 109A helicopter. Spectrum loading tests were performed using a sequence directly deduced from flight load survey. Such experimental data, and theoretical data from of all the methods considered, are then compared. Useful indications concerning fatigue evaluation methodolgies are given. L.F.M.

N81-27088# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). Flight Mechanics Panel.

AIRCRAFT FLIGHT TEST DATA PROCESSING: A REVIEW OF THE STATE OF THE ART

L. J. SMITH (Air Force Flight Test Center, Edwards AFB, Calif.) and N. O. MATTHEWS (Cranfield Inst. of Technol., Bedford, Engl.) Nov. 1980 63 p refs

(AGARD-AG-160-VOL-12; ISBN-92-835-1376-2; AD-A097225)

Avail: NTIS HC A04/MF A01

A general outline of methods, techniques, and problems associated with data processing is presented. Application of data processing systems to produce data in support of flight testing are described. Data sources, and the considerations required prior to data processing are reviewed. Two major components of data processing, hardware and software, and the people who make it work, are discussed. Data processing in support of flight testing is described according to processing functions and potential problem area are identified. E.A.K.

N81-31186# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).

FACTORS OF SAFETY RELATED TO STRUCTURAL INTEGRITY. A REVIEW OF DATA FROM MILITARY AIRWORTHINESS AUTHORITIES

Jun. 1981 44 p

(AGARD-R-677; ISBN-92-835-1390-8; AD-A103706) Avail: NTIS HC A03/MF A01

The numerical factors applied to insure structural safety of aircraft are presented. Documents and specifications where the factors of safety are defined are identified. The relation of design conditions to extreme operational conditions is considered. Relevant aerodynamic effects taken into account in addition to the safety factors are discussed. The application of the safety factors to rare events, loading, and to experimental aircraft is

discussed. Varying interpretations of the factors of safety are considered, and differences between the NATO countries with regard to structural safety are discussed. J.D.H.

N82-11056# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
ROTORCRAFT ICING: STATUS AND PROSPECTS
Aug. 1981 136 p refs
(AGARD-AR-166; ISBN-92-835-1397-5; AD-A106100) Avail: NTIS HC A07/MF A01

The impact of icing meteorological conditions on helicopter operations was examined, and methods for improving ice protection investigated. For individual titles, see N82-11057 through N82-11061.

N82-11057# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
OPERATIONAL ENVIRONMENT, METEOROLOGICAL CONDITIONS AND WEATHER FORECASTING
In its Rotorcraft Icing p 1-13 (SEE N82-11056 02-05) Aug. 1981 refs
Avail: NTIS HC A07/MF A01

Helicopter icing is a significant operational consideration for helicopters operating throughout Europe. Existing weather statistics demonstrate significant operational limitations during the winter months, and for as much as five percent of the time on a year-around basis. Unfortunately the existing meteorological data base is insufficient to describe the operating environment in which NATO rotorcraft must conduct flight. At present for design purposes, the United States Federal Air Regulation 25 Appendix C or the UK Icing Atmosphere are employed for determination of airworthiness release of helicopters. However, neither of these atmospheres adequately defines the operational environment. This condition is exacerbated by the fact that forecasting techniques are currently inadequate to allow unrestricted helicopter operations in icing conditions. Increased coordination among cloud physicists, forecasters, and helicopter icing specialists is needed - and ultimately a new icing atmosphere is required to better define the helicopter operational icing requirements. J.D.H.

N82-11058# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
TECHNOLOGY BASE FOR ICING INSTRUMENTATION AND MATHEMATICAL MODELLING
In its Rotorcraft Icing p 14-33 (SEE N82-11056 02-05) Aug. 1981 refs
Avail: NTIS HC A07/MF A01

The fundamental mechanisms of ice accretion and shedding from rotor airfoils are considered. It is felt that an opportunity exists to exploit a combination of two-dimensional model and three-dimensional model scale testing, measurement of ice release mechanisms, inclusion of heat transfer models, and consideration of icing simulation. These efforts should be aimed at development of analytical models verified by both laboratory and full-scale data which then can be used to better predict performance of rotors in icing conditions. Only with the above analytical basis can ice accretion and shedding characteristics become sufficiently predictable to permit the determination of what type of ice protection is necessary or, conversely, what degree of flight envelope release might be permitted with a given level of ice protection. Further improvement in research and development of operational icing sensors is recommended. J.D.H.

N82-11059# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
FACILITIES FOR DEVELOPMENT AND CLEARANCE
In its Rotorcraft Icing p 34-53 (SEE N82-11056 02-05) Aug. 1981
Avail: NTIS HC A07/MF A01

A catalog of all NATO icing test facilities was compiled. It is recommended that the Canadian National Research Council's small high speed icing tunnel is a one-of-a-kind facility that needs to be available to support analytical development recommended, and that the tunnel should be reactivated or replaced. A decision has been made to retain the Ottawa Spray Rig in operational status for the near future. Efforts underway at the NASA-Lewis Research Center regarding rehabilitation of the Icing Research Tunnel and considering a major new icing test facility are endorsed. The US Army Helicopter Icing Spray System Improvement Program is also supported by the Working Group and, as a recommendation for future discussion, the need for European airborne icing spray systems should be considered. A conclusion reached by the Working Group is that current full scale development and qualification facilities and procedures are extremely expensive and time consuming. J.D.H.

N82-11060# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
ICE PROTECTION SYSTEM TECHNOLOGY
In its Rotorcraft Icing p 54-99 (SEE N82-11056 02-05) Aug. 1981 refs
Avail: NTIS HC A07/MF A01

Deicing systems technology concepts are discussed. The conclusion is that electrothermal deicing systems are the only effective present system for broad application. However, it is noted that the cost of electrothermal deicing in terms of weight, power and expense is high, and provides an incentive for examination of alternatives. Therefore, additional work is clearly warranted on options such as ice phobics, fluid ice suppressant systems, pneumatic boots, vibratory surface systems, microwave and other hybrid systems concepts. It is recommended that the operational limitations of ice protected aircraft such as the Black Hawk and Puma, be explored with the ice protection systems deliberately turned off, so as to simulate an aircraft without (or with inoperative) ice protection. Only through such definition of the actual icing environment can a better estimation be made of the operational impact of icing conditions on helicopter flight operations. J.D.H.

N82-11061# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
PROPOSED STANDARD REQUIREMENTS AND PROCEDURES FOR ICING CLEARANCE
In its Rotorcraft Icing p 100-117 (SEE N82-11056 02-05) Aug. 1981
Avail: NTIS HC A07/MF A01

A set of proposed standard requirements and procedures for icing clearance is presented. It is felt that this clearance procedure constitutes a basis for NATO-wide icing clearance and should be adopted by the NATO military community as an interim approach. The opportunity also exists to consider this proposal for civil icing clearance. J.D.H.

N82-17160# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). Structures and Materials Panel.
DESIGN MANUAL FOR IMPACT DAMAGE TOLERANT AIRCRAFT STRUCTURE
J. G. AVERY (Boeing Military Airplane Co., Seattle) Oct. 1981 230 p refs Sponsored in part by Dept. of Defense
(AGARD-AG-238; ISBN-92-835-1403-3; AD-A109260) Avail: NTIS HC A11/MF A01

The structural design information is grouped into three major sections: description of projectile threats; analysis methods for predicting structural response to projectile impact; and design guidelines for impact tolerance. The hydrodynamic ram effect and aircraft engine disintegration are highlighted. For individual titles, see N82-17161 through N82-17170.

N82-17161# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
DESCRIPTION OF PROJECTILE THREATS
In its Design Manual for Impact Damage Tolerant Aircraft Struct. p 1-24 (SEE N82-17160 08-05) Oct. 1981 refs
Avail: NTIS HC A11/MF A01

Evaluating the degradation of aircraft structure resulting from projectile impact requires a knowledge of the threat and encounter conditions. This is necessary in understanding the failure mechanisms and structure response modes induced by the various types of threats. Projectile types, important encounter parameters, and typical terminal effects are discussed. Information that is helpful in understanding the analysis of structural response to impact and the design guidelines for impact damage tolerance is presented. T.M.

N82-17162# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
ANALYSIS METHODS FOR PREDICTING STRUCTURAL RESPONSE TO PROJECTILE IMPACT
In its Design Manual for Impact Damage Tolerant Aircraft Struct. p 27-44 (SEE N82-17160 08-05) Oct. 1981
Avail: NTIS HC A11/MF A01

Analysis methods and data available for predicting the response of metal and fiber composite structure to projectile impact are presented. The analysis methods discussed are applicable to impacts from small arms projectiles, missile warhead fragments, and the fragmentation and blast effects of high-explosive projectiles. The responses addressed include penetration capability, damage size and type, strength degradation of damaged structure, and internal load redistribution. T.M.

N82-17163# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
ANALYSIS METHODS FOR BALLISTIC DAMAGE SIZE AND TYPE
In its Design Manual for Impact Damage Tolerant Aircraft Struct. p 45-78 (SEE N82-17160 08-05) Oct. 1981
Avail: NTIS HC A11/MF A01

The parameters which influence the size and character of projectile impact damage are described. Predicting damage size is the first step is assessing the structural capability of impacted structure, since damage size determines net section strength loss, stiffness loss, and the flaw size for failure analysis. The discussion is organized according to projectile type as follows: non-exploding projectiles, high explosive projectiles; and engine debris projectiles. Within each projectile category the responses of both metallic and fiber composite structure are discussed. The effects of fluid pressure in causing damage, a phenomenon known as hydrodynamic ram, are discussed. T.M.

N82-17164# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
DAMAGE FROM HIGH EXPLOSIVE (HE) PROJECTILES
In its Design Manual for Impact Damage Tolerant Aircraft Struct. p 79-135 (SEE N82-17160 08-05) Oct. 1981 refs
Avail: NTIS HC A11/MF A01

The structural damage done by HE projectiles (20- to 30-mm, for example) is the result of multiple fragment penetrations and internal blast pressures, acting separately and in combination. The fragments are created as the metal casing surrounding the explosive bursts due to the intense pressures generated by the detonation. Fragment damage degrades structural strength and stiffness, and blast pressures added to the existing flight loads can cause excessive deformations and element failures. The nature and extent of structural damage from HE projectile fragments and blast pressure depend upon these variables: material type and thickness; projectile size and delay characteristics; striking velocity and obliquity; distance from detonation to impacted structure (standoff); and internal volume of structural cell and extent of venting. The significance of each of these variables is discussed. Qualitative descriptions of HE projectile damage in metallic and fiber composite structure are presented followed by a discussion of damage prediction analysis techniques for blast and fragments. T.M.

N82-17165# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
DAMAGE FROM ENGINE DEBRIS PROJECTILES
In its Design Manual for Impact Damage Tolerant Aircraft Struct. p 136-139 (SEE N82-17160 08-05) Oct. 1981
Avail: NTIS HC A11/MF A01

The effects of uncontained projectile emanating from an engine and subsequently striking an adjacent portion of the airframe are assessed. The effects are treated the same as for effects resulting from nonexploding military projectiles. There is an important distinction, however, in that the engine debris projectile is typically an irregular fragment (as opposed to a bullet), behaving more like a warhead fragment or the fragments generated from a high-explosive projectile. T.M.

N82-17166# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
HYDRODYNAMIC RAM DAMAGE
In its Design Manual for Impact Damage Tolerant Aircraft Struct. p 140-152 (SEE N82-17160 08-05) Oct. 1981
Avail: NTIS HC A11/MF A01

Hydrodynamic ram is a phenomenon that may cause extensive structural failure of aircraft fuel cells when they are subjected to ballistic impact. During impact and penetration of the fuel cell, intense pressure waves are generated within the liquid by the projectile. The response of the fuel cell to this pressure loading varies according to its construction. For example, the walls of an integral fuel cell are formed by the aircraft skin, which is usually constructed of high-strength metal designed to withstand normal flight loads. This type of structure can fail catastrophically in response to hydrodynamic ram pressure loading due to fracturing of the walls of the cell. Self-sealing fuel cells can also be defeated due to hydrodynamic ram by gross tearing of the material or by misalignment of the wound edges, thereby defeating the self-sealing process. Both of these effects become increasingly severe as fuel cells become smaller, or projectile kinetic energies increase. An analysis method to predict hydrodynamic ram pressures generated by small arms ammunition was developed. The analysis method is based on the conversion of projectile kinetic energy to pressure field energy and includes the effects of reflections from the tank walls. T.M.

N82-17167# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
EFFECTS OF CYCLIC LOADING ON PROJECTILE IMPACT DAMAGE
In its Design Manual for Impact Damage Tolerant Aircraft Struct. p 153-157 (SEE N82-17160 08-05) Oct. 1981
Avail: NTIS HC A11/MF A01

The cyclic loading induced during flight can influence the severity of existing impact damage by initiating fatigue cracks at the damage site, subsequent crack sharpening or blunting and crack growth. There can be significant time dependent changes in the residual strength of the structure due to these alterations in the size and character of the impact damage. Projectile produce a wide variety of damage types, including cracks, holes, tears, large determination, even totally severed structural elements. The response of the damaged structure when exposed to cyclic loads reflects this wide variety of structural damage. For example, the cyclic loading can result in immediate growth when the projectile damage is a crack. There may be, however, a time (number of cycles) devoted to crack nucleation. Several important aspects of the fatigue response of impact damaged structure are described in terms of crack initiation and extension. An approach which basically consists of assuming immediate fatigue crack initiation at the damage site, and then applying conventional crack growth analysis is suggested. T.M.

N82-17168# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
STIFFNESS DEGRADATION OF IMPACT DAMAGED STRUCTURE
In its Design Manual for Impact Damage Tolerant Aircraft Struct. p 159-160 (SEE N82-17160 08-05) Oct. 1981
Avail: NTIS HC A11/MF A01

Stiffness reduction in impact damaged structural elements can be important from two standpoints. The first is the alteration of load distribution within the structure, potentially causing overloading and failure of undamaged elements. The second area of potential concern is the residual stiffness of major structural components, since stiffness degradation may lead to instability and control inadequacy. These two topics are discussed, however, there are few verified analysis methods for predicting stiffness degradation associated with ballistic damage. Both of these stiffness degradation effects, but particularly the latter, become increasingly significant as the extent of the inflicted damage becomes larger. Stiffness degradation may well be a problem for HE projectile impacts, but it is generally insignificant with small arms. T.M.

N82-17169# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
STRENGTH DEGRADATION OF IMPACT DAMAGED STRUCTURE
In its Design Manual for Impact Damage Tolerant Aircraft Struct. p 161-194 (SEE N82-17160 08-05) Oct. 1981
Avail: NTIS HC A11/MF A01

Projectile damage destroys a portion of the load carrying capability of the structure, alters the distribution of internal loads, and introduces a flaw which may cause failure by locally disturbing the stress field. The latter effect is most significant with regard to the relatively small damage induced by small arms projectile and dispersed warhead or engine debris fragments. High explosive projectiles can often create damage of sufficient size to substantially degrade structural performance by all three effects. Estimating the residual strength of structure damaged by projectile impact is a major step in predicting structural capability. The analysis methods presented for evaluating strength capability are organized according to structural complexity: analysis of monolithic panels; analysis of multiple load path panels; and analysis of multielement structure. The application of conventional and modified fracture mechanics analysis to ballistic damaged panels is discussed. The extension of these approaches to the requirements of panels having discrete stiffening members are discussed. T.M.

N82-17170# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
ANALYSIS OF MULTIPLE LOAD PATH PANELS CONTAINING IMPACT DAMAGE
In its Design Manual for Impact Damage Tolerant Aircraft Struct. p 195-209 (SEE N82-17160 08-05) Oct. 1981
Avail: NTIS HC A11/MF A01

Many structural configurations cannot be represented as monolithic panels in assessing strength degradation from impact damage. The wings of transport aircraft, for example, often consist of skin with riveted stiffeners. The stiffeners can provide damage containment or crack assessment capability that is not considered in element residual strength analysis. Since the crack arrestment capability can significantly improve the residual strength of damaged structure, the stiffening must be included in the analysis. The response of stiffened panels to projectile damage, and available analytical techniques for residual strength prediction, are discussed. T.M.

N83-10039# Magrath (Howard A.), Dayton, Ohio.
EVALUATION REPORT: THE SPECIALISTS' MEETING ON DYNAMIC ENVIRONMENTAL QUALIFICATION TECHNIQUES
H. A. MAGRATH AGARD Jul. 1982 33 p refs Sponsored by AGARD
(AGARD-AR-183; AD-A119561) Avail: NTIS HC A03/MF A01

The blast pressures, from the muzzle of a gun from the properties of the propellant exhaust were determined. A theory which is based upon an analogy of gun blast with an explosive releasing energy at a constant rate and having strong directional effects due to the momentum of the propellant gas flow is extended. The apparent center of the explosion in the shock bottle is placed at a distance of about six gun calibers from the muzzles instead of at it. Pressure predictions based on this model agree well with experimental data for a 7.62 mm (30 caliber) rifle and a 27 mm aircraft gun. Gun blast measurements were also obtained experimentally on a surface near the gun muzzle. It was found that these can be predicted with reasonable accuracy if regular acoustic reflection occurs, but in the region of Mach reflection the agreement is poor particularly for small distances between the line of fire and the reflecting surface. Mach reflection occurs when the reflected waves tend to coalesce with the incoming waves. Under such circumstances the pressure on reflecting surfaces can be as high as four to eight times the pressure of the incident waves, instead of the usual pressure doubling on rigid surfaces that intercept acoustic waves. S.L.

N83-14104# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
OPERATIONAL LOADS MEASUREMENT AND EVALUATION
Sep. 1982 23 p refs
(AGARD-R-704; ISBN-92-835-1435-0) Avail: NTIS HC A02/MF A01

Design loads and fatigue analysis, and differing approaches to one determination of operational loads and structural stresses are characterized. Author

N83-15284# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
AIRCRAFT DYNAMIC RESPONSE TO DAMAGED AND REPAIRED RUNWAYS
London Aug. 1982 224 p refs In ENGLISH and FRENCH Meeting held in Cesme, Turkey, 5-10 Apr. 1981 and in Brussels, 4-9 Apr. 1982
(AGARD-CP-326; ISBN-92-835-0316-2; AD-A122061) Avail: NTIS HC A10/MF A01

The two purposes of the AGARD conference on aircraft dynamic response to damaged and repaired runways were to review the programs and methods for dynamic analysis and testing of taxiing aircrafts, and to encourage exchange of information on aircraft dynamic response to improve the interoperability of NATO military aircraft. Topics discussed are: (1) advanced rapid runway repair, application of semigrid pavements in rapid runway repair, repaired runway clearance environment, the have bounce program; (2) mathematical modelling of aircraft dynamic response; (3) test methods and correlation with analyses; and (4) designs and clearance. For individual titles, see N83-15285 through N83-15301.

N83-15285# Air Force Engineering and Services Center, Tyndall AFB, Fla.
MINIMUM OPERATING STRIP SELECTION PROCEDURE
W. S. STRICKLAND and L. R. CALDWELL *In* AGARD Aircraft Dyn. Response to Damaged and Repaired Runways 23 p (SEE N83-15284 06-05) Aug. 1982
Avail: NTIS HC A10/MF A01

Minimum operating strip (MOS) selection procedures for use in postattack launch and recovery operations are reported. The procedures are based on interim surface roughness guidance and are provided pending development of finalized procedures under the rapid runway repair (RRR) program. The general procedures can be applied to MOS selection for any aircraft at any particular airfield. The MOS selection criteria are to minimize the time required to repair a MOS, prevent damage to the aircraft, and optimize the flexibility in selection of a MOS. Five levels of repair quality, for AM-2 mat and crushed stone repairs, together with a repair spacing criteria for the F-4 aircraft. E.A.K.

N83-15286# Air Force Engineering and Services Center, Tyndall AFB, Fla.
PROPOSED SPECIFICATIONS FOR INTERNATIONAL INTEROPERABILITY ON REPAIRED BOMB DAMAGED RUNWAYS
L. R. CALDWELL and A. G. GERARDI *In* AGARD Aircraft Dyn. Response to Damaged and Repaired Runways 20 p (SEE N83-15284 06-05) Aug. 1982 refs Original document was announced as N79-19325
Avail: NTIS HC A10/MF A01

Definitions for data, data formats, and National responsibilities for development of war emergency airfield pavement repair specifications was suggested. The specifications are used to make repairs after an enemy attack. Minimum Operating Strip size, repair quality, repair spacing, and other parameters are specified. Exchange of the specifications between the nation operating an aircraft and the nation managing an airfield could enhance NATO interoperability. E.A.K.

N83-15287# United States Air Forces in Europe, APO New York 09012. Force Development Div.

ADVANCED RAPID RUNWAY REPAIR. A STABLE AND FLUSH REPAIRED RUNWAY SURFACE

R. J. BERGHOLZ *In* AGARD Aircraft Dyn. Response to Damaged and Repaired Runways 8 p (SEE N83-15284 06-05) Aug. 1982
Avail: NTIS HC A10/MF A01

The nature of damage to aircraft launch surfaces that may reasonably be expected to occur during a conflict was examined. The need to develop rapid large area and deep trenched runway repair is suggested, new civil engineering methods to deal with rapid repair of that damage are proposed and effects on aircraft landing gear shock absorbers are postulated. Currently ongoing field investigative efforts to adapt commercially available materials and equipment to provide flush repaired runway surfaces for this expected damage, lessening vertical and horizontal shock forces on aircraft landing gear systems are described. E.A.K.

N83-15288# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (West Germany).

EVALUATION OF THE PILOT PAPERS FROM THE SPRING 1981 SMP MEETING

A. KRAUSS *In* AGARD Aircraft Dyn. Response to Damaged and Repaired Runways 7 p (SEE N83-15284 06-05) Aug. 1982 refs
Avail: NTIS HC A10/MF A01

Two different types of runway damage, regular craters and scabs and penetrated craters are outlined. Minimum operating strip (MOS) selection procedures for use in postattack launch and recovery operations are presented. Examples are given for an F-4 aircraft, yet the general procedures can be applied to MOS selection for any aircraft at any particular airfield. The ground roughness data are supplemented and the scope to the problems to be solved in an environment where a nation managing an airfield is to accommodate other nations operating a variety of aircraft types are expanded. Data on manpower and equipment for rapid runway repair and two runway repair procedures developed and tested in Germany are described. E.A.K.

N83-15289# Centro de Mecanica e Engenharia Estruturais, Lisbon (Portugal). Thermomechanics Section.

APPLICATION OF SEMI-RIGID PAVEMENTS IN RAPID RUNWAY REPAIR

A. F. T. DELEMOS *In* AGARD Aircraft Dyn. Response to Damaged and Repaired Runways 4 p (SEE N83-15284 06-05) Aug. 1982 refs
Avail: NTIS HC A10/MF A01

The semirigid pavements are described and compared with the traditional types: the rigid pavements made of cement concrete and flexible pavements made of bituminous concrete. The design and process of application for aeronautic pavements are presented. Experience on the application of semirigid pavements in Europe and in Africa is described. It is emphasized that normally in Portugal this type of pavement is used in new runways, chiefly thresholds, but it is also used for pavement repairs, which are not due to bombs. The merits and disadvantages of the semirigid type pavements as opposed to traditional ones are discussed. E.A.K.

N83-15290# Aeroplane and Armament Experimental Establishment, Boscombe Down (England).

THE REPAIRED RUNWAY CLEARANCE ENVIRONMENT

C. BRAIN *In* AGARD Aircraft Dyn. Response to Damaged and Repaired Runways 10 p (SEE N83-15284 06-05) Aug. 1982
Avail: NTIS HC A10/MF A01

Aspects of the repaired runway operational environment which influence considerations of aircraft dynamic response are examined. These aspects include: the roughness of repaired and unrepaired operating surfaces and operational factors which cause variability of aircraft response and pilot techniques which influence the loads on undercarriages. How aircrafts are cleared to operate from repaired runways; the safety margins required for this type of operation and the need to transfer data between NATO nations on the roughness tolerance of individual aircraft types if there is to be genuine interoperability are investigated. E.A.K.

N83-15291# Aeronautical Systems Div., Wright-Patterson AFB, Ohio.

THE HAVE BOUNCE PROGRAM

J. E. HOLPP *In* AGARD Aircraft Dyn. Response to Damaged and Repaired Runways 7 p (SEE N83-15284 06-05) Aug. 1982
Avail: NTIS HC A10/MF A01

The purpose of the HAVE BOUNCE program which is to define aircraft response to runway repair in a military conflict environment is discussed. Computer programs that model the dynamic and structural response of aircraft are developed and aircraft are tested over simulated repaired runways to gather data for use in validating these computer programs. The HAVE BOUNCE has two objectives: (1) a computer program which models the dynamic response of an aircraft operating over repaired bomb damaged runways; and (2) aircraft operating limitations and guidelines for operation over these repair surfaces. E.A.K.

N83-15292# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (West Germany).

INFLUENCE OF MATHEMATIC MODELLING OF UNDERCARRIAGES ON THE PREDICTION OF AIRCRAFT LOADS DUE TO DAMAGED AND REPAIRED RUNWAYS

A. KRAUSS, O. BARTSCH, and G. KEMPF *In* AGARD Aircraft Dyn. Response to Damaged and Repaired Runways 20 p (SEE N83-15284 06-05) Aug. 1982 refs
Avail: NTIS HC A10/MF A01

The peculiarities of the response on damaged runway simulation are described and their influence on the loads assessed. The requirements of digital simulation are referred to. It is shown that simulating an oleopneumatic shock strut as a parallel combination of gas spring and hydraulic damper by far overestimates undercarriage load and hence structural response on shortwave obstacles. It is found that physically existing additional flexibility of the undercarriage in series to the oleo strut must be included in the model. E.A.K.

N83-15293# British Aerospace Aircraft Group, Weybridge (England).

DEVELOPMENT OF A COST EFFECTIVE APPROACH TO MODELLING AIRCRAFT RESPONSE TO REPAIRED RUNWAYS

B. W. PAYNE, A. E. DUDMAN, B. R. MORRIS, and M. HOCKENHULL *In* AGARD Aircraft Dyn. Response to Damaged and Repaired Runways 12 p (SEE N83-15284 06-05) Aug. 1982
Avail: NTIS HC A10/MF A01

The capability of an aircraft to operate from repaired runways which concerns aircraft dynamic response, which causes critical conditions involving aircraft loads and aircraft control is examined. Procedures involve mathematically modelling of the aircraft, which predict response and validate the theory with the test results. A cost effective approach to this problem, which gives results to the fully validated model for the important set of critical loads or accelerations is described. The simplified model may be used to carry out the operational analyses with the full matrix of variables at minimum cost and time, and use of the more accurate model restricted to the minimum necessary to confirm results. E.A.K.

N83-15294# Air Force Wright Aeronautical Labs., Wright-Patterson AFB, Ohio.

STATUS OF COMPUTER SIMULATIONS OF USAF AIRCRAFT AND AN ALTERNATIVE SIMULATION TECHNIQUE

A. G. GERARDI and L. MINNETYAN (Clarkson Coll.) *In* AGARD Aircraft Dyn. Response to Damaged and Repaired Runways 10 p (SEE N83-15284 06-05) Aug. 1982
Avail: NTIS HC A10/MF A01

The formulation of preliminary guidance and evacuation techniques for operating off of damaged runways using existing simulation methods and the status of final surface roughness criteria using the results of the USAF HAVE BOUNCE program is reported. An alternate approach in simulating aircraft response to surface roughness is discussed. The technique is to combine a conventional time history analysis using numerical methods to solve the coupled nonlinear differential equations with a frequency domain analysis to solve the linear substructure equations of motion. The nonlinear landing gear struts and linear structure are solved separately by different techniques and the solution combined to get the total aircraft response. E.A.K.

N83-15295# Avions Marcel Dassault, Saint-Cloud (France).
A METHOD FOR THE NUMERICAL SIMULATION OF AN AIRCRAFT UNDERCARRIAGE SYSTEM [METHODE DE SIMULATION NUMERIQUE DU SYSTEME AVION ATTERRISSEUR]
C. PETTAU and A. CELIER *In* AGARD Aircraft Dyn. Response to Damaged and Repaired Runways 18 p (SEE N83-15284 06-05) Aug. 1982 In FRENCH; ENGLISH summary
Avail: NTIS HC A10/MF A01

A simulation method, being developed for the dynamic calculation of landing, roll-off, taxiing, takeoff and catapulting impacts, provides the landing-gear loads and the overall structural stresses as functions of time. The calculation takes account of the dynamic response of the structure and the non-linearities of the problem: large rotations, non-linear elasticity of tyres and shock absorbers, oil shearing, dry friction, etc. The implicit integration algorithm proceeds by elimination at different levels, of the freedom degrees of both the linear and linearized parts, leading, at each time step, to the solution of a non-linear equation system relative to the degrees of freedom associated with oil film shearing and dry friction. Shock absorber sticking due to friction can be considered. As the simulation cost is very low, statistical studies can be carried out, especially as regards the simulation of taxiing and takeoff. Author

N83-15296# National Aerospace Lab., Amsterdam (Netherlands).
PREDICTED AND MEASURED LANDING GEAR LOADS FOR THE NF-5 AIRCRAFT TAXIING OVER A BUMPY RUNWAY
H. H. OTTENS *In* AGARD Aircraft Dyn. Response to Damaged and Repaired Runways 14 p (SEE N83-15284 06-05) Aug. 1982 refs
Avail: NTIS HC A10/MF A01

A mathematical model of the NF-5A aircraft was developed. The model is validated using measured results. Landing gear loads are calculated for the aircraft taxiing across a repaired runway using an AM-2 mat. The results depend strongly on the heaving and pitching motion of the aircraft when it meets the repair. E.A.K.

N83-15297# MTS Systems Corp., Minneapolis, Minn.
LABORATORY TESTING SYSTEMS FOR STRUCTURAL DYNAMIC RESPONSE TO LARGE-SCALE DISTURBANCES
J. W. PIRAINO *In* AGARD Aircraft Dyn. Response to Damaged and Repaired Runways 8 p (SEE N83-15284 06-05) Aug. 1982 refs
Avail: NTIS HC A10/MF A01

The application of servohydraulic testing systems which were employed to simulate the environment of heavy duty land vehicles, to investigate the dynamic structural response of aircraft operating in the damaged runway environment is discussed. The control technique known as RPC is described. The test method and its relationship to the computer modeling and field testing approach to the solution of the acceptable runway surface roughness definition is shown. E.A.K.

N83-15298# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
THE PROBLEM OF DESIGN CRITERIA FOR AIRCRAFT LOADS DUE TO ROUGH RUNWAY OPERATION
M. HACKLINGER (BWB-ML, Munich) *In its* Aircraft Dyn. Response to Damaged and Repaired Runways 13 p (SEE N83-15284 06-05) Aug. 1982 refs
Avail: NTIS HC A10/MF A01

Aircraft design criteria for the rough runway case with emphasis on the initial design were reviewed. The criteria are so divergent in the NATO countries that further design guidance is required to avoid excessively heavy undercarriages of new aircraft projects or shortfalls in interoperability. Nonlinearity and dynamic load cases from multiple obstacle encounter with sometimes adverse operational procedures are the two main problem areas. Groundworthiness criteria for the repaired runway which can provide a reasonable balance of normal operating and rough runway capability are proposed. E.A.K.

N83-15299# Dowty Rotol Ltd., Gloucester (England).
LANDING GEAR SHOCK ABSORBER DEVELOPMENT TO IMPROVE AIRCRAFT OPERATING PERFORMANCE ON ROUGH AND DAMAGED RUNWAYS
G. H. HAINES *In* AGARD Aircraft Dyn. Response to Damaged and Repaired Runways 19 p (SEE N83-15284 06-05) Aug. 1982
Avail: NTIS HC A10/MF A01

Aircraft landing gear shock absorber characteristics are almost entirely dictated by landing impact energy absorption and suitability to support ground maneuvering loads. To improve the performance of such systems when taxiing on rough or damaged surfaces requires further optimization of the damping level and spring stiffness. Higher damping and softer spring rate than generally used reduces aircraft response when taxiing on typically rough ground. Shock absorber hardware which are developed provides characteristics so modified and tests on single landing gears demonstrate significant taxiing improvements without degrading the landing energy absorption capability. E.A.K.

N83-15300# Lockheed-Georgia Co., Marietta.
ROUGHNESS CONSIDERATIONS FOR TRANSPORT AIRCRAFT
B. M. CRENSHAW *In* AGARD Aircraft Dyn. Response to Damaged and Repaired Runways 9 p (SEE N83-15284 06-05) Aug. 1982 refs
Avail: NTIS HC A10/MF A01

The accurate calculations of landing gear and structural loads which could occur from taxi, takeoff, and landing on repaired bomb-damaged airfields are outlined. Collection of applicable test data was accomplished for two transport aircraft. Tests of the C-141B aircraft were conducted. To date, C-5A roughness testing consists of traversing (1-cosine) shaped bumps at low speeds. Additional C-5A testing is planned for 1982 to obtain structural response near landing and takeoff speeds. Results are used to validate computer simulation predictions of loads and to assist in the development of operating techniques. E.A.K.

N83-15301# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
A FIGHTER LANDING GEAR FOR THE 1980'S
R. F. BUTTLES and R. D. RENSHAW *In its* Aircraft Dyn. Response to Damaged and Repaired Runways 13 p (SEE N83-15284 06-05) Aug. 1982
Avail: NTIS HC A10/MF A01

Design considerations for a landing gear incorporating soft field, damage/repaired runway, and increased sink speed capabilities over that of current USAF design in a present day fighter/attack aircraft are discussed. The establishment of the design criteria and constraints are discussed, and the resulting configuration is defined as applied to the Northrop F/A-18L aircraft. Shock strut weight and stroke comparisons various fighter landing gears illustrate trends and philosophy differences between land based and carrier based aircraft. The effects of oil loads, air loads, and friction are discussed as design parameter considerations. Shock strut internal geometry philosophy is discussed.

N83-19747# Vereinigte Flugtechnische Werke G m b H., Bremen (West Germany).
AIRCRAFT DYNAMIC RESPONSE TO DAMAGED AND REPAIRED RUNWAYS
K. KOENIG Nov. 1982 17 p refs AGARD/SMP Sub-Committee Meeting Held in Cologne, 1979, Cesme, Turkey, 1981, and Brussels, 1982 Sponsored by AGARD
(AGARD-AR-198; ISBN-92-835-1441-6) Avail: NTIS HC A02/MF A01

The capability of aircraft to operate on uneven runways was investigated. It was, however, found difficult to establish realistic unevenness data. Nevertheless, it is important and urgent to elaborate and agree on international ground-worthiness requirements GRA

06

AIRCRAFT INSTRUMENTATION

Includes cockpit and cabin display devices; and flight instruments.

N80-33406# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
HELICOPTER FLIGHT TEST INSTRUMENTATION
A. POOL, ed., K. C. SANDERSON, ed., and K. R. FERRELL (Army Aviation Research and Development Command, Edwards AFB, Calif.) Jul. 1980 46 p refs
(AGARD-AG-160-VOL-10; AD-A089909) Avail: NTIS HC A03/MF A01

The helicopter characteristics with which instrumentation must contend with are discussed. Typical tests that are conducted are outlined. Major aircraft components and systems which may be instrumented are listed and suggestions are made for sensors, locations, and installation. Instrumentation requirements are summarized. A sample instrumentation management technique is also presented. T.M.

N80-33407# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
PRESSURE AND FLOW MEASUREMENT
W. WUEST (DFVLR, Goettingen, W. Germany), A. POOL, ed., and K. C. SANDERSON, ed. London, Harford House Jul. 1980 137 p refs
(AGARD-AG-160-VOL-11; ISBN-92-835-1368-1; AD-A090961)
Avail: NTIS HC A07/MF A01

The evolution of flight test instrumentation systems during the last decade reflects the radical changes of electronic measuring techniques. Nevertheless the basic principles of measurement methods are essentially unchanged and the sensors for flow and pressure measurements have experienced only slight changes. The fundamentals of flow and pressure measurements are explained from the viewpoint of flight test instrumentation. An overview of modern instrumentation is given with important applications to altitude measurement, vertical and horizontal speed measurement, boundary layer, wake and engine flow measurement. The scope of this manual is to give self consistent information on the different techniques and systems and to give references for a more detailed study of special techniques. Author

N81-17063# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
ADVANCEMENT ON VISUALIZATION TECHNIQUES
W. M. HOLLISTER, ed. (MIT) Oct. 1980 217 p refs
(AGARD-AG-255; AGARDOGRAPH-255; ISBN-920-835-1371-1; AD-A094661) Avail: NTIS HC A10/MF A01

Principles, technology, and applications in the field of visualization and display in aircraft cockpits are discussed. Topics include liquid crystals, light emitting diodes, electroluminescent displays, and gas plasma panels, as well as, helmet mounted display devices and human factors engineering. For individual titles, see N81-17064 through N81-17077.

N81-17064# Cranfield Inst. of Tech., Bedfordshire (England).
THE PRESENTATION OF STATIC INFORMATION ON AIR TRAFFIC CONTROL DISPLAYS Ph.D. Thesis
R. J. G. EDWARDS *In* AGARD Advan. on Visualization Tech. 44 p (SEE N81-17063 08-06) Oct. 1980 refs
Avail: NTIS HC A10/MF A01

The physical characteristics of display consistent with human performance are defined. Eight display characteristics were selected as critically important, they are: (1) frame rate; (2) contrast ratio; (3) ambient illumination; (4) symbol characteristics; (5) resolution; (6) bandwidth; (7) registration; and (8) phosphor type. The exact priority of each characteristics and the specific result of their interrelationships is a function of the particular application and is considered with respect to an ATC display environment. E.D.K.

N81-17065# Naval Air Development Center, Warminster, Pa.
FLAT PANEL DISPLAY TECHNOLOGY REVIEW
J. BRINDLE, B. GURMAN (Army Avionics Res. Develop. Activity, Ft. Monmouth), J. REDFORD (Army Aviation Res. and Develop. Command, St. Louis), E. SCHLAM (Army Electron. Res. and Develop. Command, Ft. Monmouth), W. MULLEY, P. SOLTAN (Naval Ocean Systems Center, San Diego), G. TSAPARAS (Naval Air Systems Command, Arlington), K. B. URNETTE (AFFDL, Wright-Patterson AFB), J. COONROD (AFAL, Wright-Patterson AFB), and W. MELNICK (AFFDL, Wright-Patterson AFB) *In* AGARD Advan. on Visualization Tech. 5 p (SEE N81-17063 08-06) Oct. 1980
Avail: NTIS HC A10/MF A01

There are three display media presently receiving the most attention and which appear to be the most promising. These are: (1) electroluminescence (EL); (2) light emitting diode (LED), and (3) liquid crystal (LC). There are other technologies that also appear promising but that have not advanced in development to the point where they are receiving serious consideration for aircraft use or that have serious limitations, some of which may be eliminated in time. These include plasma, electrochromic, electrophoretic, ferroelectric, magnetic particle, and microchannel playe display technologies. In order to exploit flat panel display media, development of suitable addressing techniques is required. Three representative methods of addressing display media (silicon, thin-film transistor (TFT) and crossed electrodes) are discussed. E.D.K.

N81-17066# Royal Aircraft Establishment, Farnborough (England).
THE ELECTRO-OPTICAL DISPLAY/VISUAL SYSTEM INTERFACE: HUMAN FACTORS CONSIDERATIONS
J. LAYCOCK and R. A. CHORLEY (Aerospace & Defence Systems Co., Cheltenham, England) *In* AGRAD Advan. on Visualization Tech. 15 p (SEE N81-17063 08-06) Oct. 1980 refs
Avail: NTIS HC A10/MF A01

Display systems are currently developed by a cyclical two stage process. Equipment is developed, and there is then a period in which its suitability for use by an operator is assessed. The results of the evaluation determine the modifications to be introduced into the next cycle of the process. This paper considers the possibility of adopting a design strategy which initially asseses operator performance and then uses the result of this assessment to determine what equipment development would best meet the requirements of the operator. As the subject under consideration is visual display systems, the text considers only the visual aspects of human performance and relates these attributes to display parameters. Author

N81-17067# Ferranti Ltd., Edinburgh (Scotland). Electronics Systems Dept.
INTEGRATION OF SENSORS WITH DISPLAYS
A. C. WESLEY and I. T. B. BLACKIE *In* AGARD Advan. on Visualization Tech. 25 p (SEE N81-17063 08-06) Oct. 1980
Avail: NTIS HC A10/MF A01

The sensors commonly found on military aircraft often provide information for display. The various categories of displays available are described with their signal characteristics, cockpit location, and operational uses, together with a discussion on their particular suitability to provide integrated sensor/display systems. Author

N81-17068# Royal Signals and Radar Establishment, Malvern (England).
LIQUID CRYSTAL DISPLAYS
A. J. HUGHES *In* AGARD Advan. on Visualization Tech. 15 p (SEE N81-17063 08-06) Oct. 1980 refs
Avail: NTIS HC A10/MF A01

An introduction is given to the physical properties of liquid crystals and the electro-optic effects that may be used for display purposes. A more detailed description follows of both the twisted nematic effect, as used in the vast majority of current liquid crystal displays, and of the dyed phase-change effect, which is a likely candidate eventually to supercede the twisted nematic display. The performance and limitations of simple, directly driven displays are analyzed, and the problems and difficulties associated with more complex, matrix addressed displays are described. Finally, a brief description is given of a selection of laboratory prototypes and drive methods that demonstrate the progress of liquid crystal

research towards solving the various problems associated with high complexity displays. Author

N81-17069# Thorn-Brimar Ltd., Chadderton (England).
CATHODE RAY TUBES AND PLASMA PANELS AS DISPLAY DEVICES FOR AIRCRAFT DISPLAYS
S. WOODCOCK *In* AGARD Advan. on Visualization Tech. 8 p (SEE N81-17063 08-06) Oct. 1980 refs
Avail: NTIS HC A10/MF A01

The various types of electronic display presently being incorporated in aircraft and the displays being proposed for future use are reviewed and their technical requirements examined. These include head-up displays, helmet mounted displays, and various head-down displays which can be generated by TV techniques. The state of the art of CRT and d.c. plasma technology is described and the suitability of these two devices for the different displays is discussed, along with possible future improvements in performance. Author

N81-17070# Thomson-CSF, Paris (France). Div. Tubes Electroniques.
LARGE AREA GAS DISCHARGE DISPLAYS
J. P. MICHEL *In* AGARD Advan. on Visualization Tech. 6 p (SEE N81-17063 08-06) Oct. 1980 refs
Avail: NTIS HC A10/MF A01

Gas discharge displays or plasma displays are generally classed as a.c. displays, and d.c. displays. In d.c. displays the electrodes or resistive extension of these are immersed in the gas (ac operation would be possible but almost always discharge currents are unidirectional). In a.c. displays, a dielectric surface isolates the electrodes from the gas with which they only have an electrostatic coupling and only a.c. operation is possible. Both can be operated in a storage or nonstorage mode (storage meaning that the memory is inherent to the display device, whereas in the nonstorage or cyclic mode the memory is external to the display and the image information is transferred to the display device sequentially and refreshed frequently enough to avoid flicker). E.D.K.

N81-17071# Air Force Human Resources Lab., Wright-Patterson AFB, Ohio. Operational Training Div.
OPTICAL INFINITY LENS DEVELOPMENT FOR FLIGHT SIMULATOR VISUAL DISPLAYS
W. B. ALBERY and J. A. LARUSSA *In* AGARD Advan. on Visualization Tech. 9 p (SEE N81-17063 08-06) Oct. 1980 refs Prepared in cooperation with Farrand Optical Co., Inc., Valhalla, N.Y.
Avail: NTIS HC A10/MF A01

A very fast, large aperture magnifying optical package was developed which can present to the observer a displayed image at optical infinity. The Pancake Window, so called because of its minimal depth and relatively flat appearance, is currently being used in two Air Force flight simulator visual displays. The optical quality of this magnifier is due to the fact that it is comprised of reflective, and not refractive elements. The advantages of its configuration as an on-axis reflective system and the optical properties of its elements are presented. The latest improvement to its development, incorporation of a spherical holographic beamsplitter mirror, is discussed. This development holds promise for reducing both the cost and weight of the package. A technique for reducing unwanted optical effects by tilting the birefringent package of the window is also discussed. E.D.K.

N81-17072# Ferranti Ltd., Edinburgh (Scotland). Inertial Systems Dept.
EVOLUTION OF TACTICAL AND MAP DISPLAYS FOR HIGH PERFORMANCE AIRCRAFT
W. H. MCKINLAY *In* AGARD Advan. on Visualization Tech. 8 p (SEE N81-17063 08-06) Oct. 1980 refs
Avail: NTIS HC A10/MF A01

The operational problems which determine the display characteristics of high performance military aircraft are particularly exacting in tactical operations flown at low altitudes over land. Because these operations are related to the terrain, situation displays having map like characteristics have become important and are now being embodied in full electronic display systems for aircraft. In such aircraft, the need to conserve display area and handle sensor data in the context of the terrain has led to combined display techniques. The display requirements and the available technologies are considered. It is suggested that the optically combined display based on film storage is the most notable solution available today although several different electronic solutions are being or could be developed. Some conclusions as to the relative significance of the difference alternative solutions are given. E.D.K.

N81-17073# Aerospace Medical Research Labs., Wright-Patterson AFB, Ohio. Visual Display Systems Branch.
HELMET MOUNTED DISPLAYS: DESIGN CONSIDERATIONS
H. L. TASK, D. F. KOCIAN, and J. H. BRINDLE *In* AGARD Advan. on Visualization Tech. 13 p (SEE N81-17063 08-06) Oct. 1980 refs Prepared in cooperation with Naval Air Development Center, Warminster, Pa.
Avail: NTIS HC A10/MF A01

Several parameters that must be considered in the design of a helmet mounted display (HMD) are described. The parameters discussed include: size, weight, exit pupil, eye relief, field of view, collimation, distortion, and image quality. Detailed discussion and specific related equations are provided for many of these variables. Optical design approaches to HMD's are discussed with reference to specific systems. A summary table is included that shows the values of many HMD design parameters for six HMD's. The HMD image sources, both present and future, are presented. E.D.K.

N81-17074*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
AN ADVANCED ELECTRONIC COCKPIT INSTRUMENTATION SYSTEM: THE COORDINATED COCKPIT DISPLAY
D. BATY and M. L. WATKINS *In* AGARD Advan. on Visualization Tech. 11 p (SEE N81-17063 08-06) Oct. 1980 refs Prepared in cooperation with San Jose State University Foundation, Calif.
Avail: NTIS HC A10/MF A01 CSCL 01D

Cathode ray tube (CRT) and computer technologies have reached the stage where current flight and engine instruments can economically be replaced by computer controlled CRT displays. This provides a tremendous opportunity for flexibility to the cockpit display designer, but the use of this flexibility should stay within the realities of the flight environment. One approach to the replacement of flight instruments is described, using three separate color CRT's. Each CRT displays information pertinent to one of the three orthogonal projections of the aircraft flight situation. Three airline pilots made a preliminary assessment of this display set. Comments, rankings, and ratings show that, in general, the pilots accepted the concept of pictorial flight displays. E.D.K.

N81-17075# British Aerospace Aircraft Group, Brough (England). Kingston-Brough Div.
THE INFLUENCE OF VISUAL REQUIREMENTS ON THE DESIGN OF MILITARY COCKPITS
J. W. LYONS and G. ROE *In* AGARD Advan. on Visualization Tech. 29 p (SEE N81-17063 08-06) Oct. 1980 refs
Avail: NTIS HC A10/MF A01

The effect of visual requirements for combat aircraft is discussed with emphasis on the next generation of fighters. External vision is vital for success in air to air engagements, hence the need to define canopy lines with extreme care. The criteria for doing this are discussed in some detail. Problems of internal vision are discussed next. Cockpit display layout is considered from the point of view of moding and presentation of information as well as the more human factors problems of search. An insight into the workload aspects of cockpit assessment is included. E.D.K.

N81-17076# Grumman Aerospace Corp., Bethpage, N.Y. Guidance and Control Dept.
DISPLAY CONCEPTS FOR CONTROL CONFIGURED VEHICLES
R. W. KLEIN and W. M. HOLLISTER *In* AGARD Advan. on Visualization Tech. 13 p (SEE N81-17063 08-06) Oct. 1980 refs Prepared in cooperation with MIT, Cambridge
(Contract AF-AFOSR-3260-78)
Avail: NTIS HC A10/MF A01

The unique flight modes of a control configured vehicle (CCV) need to be taken into account in the design of displays for these craft. Several compensatory displays are suggested and evaluated using a fixed base, F-16 CCV simulation. The displays were found to enhance the improved tracking performance available when

CCV modes are used in comparison to conventional flight.
Author

N81-17077# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va. Flight Mechanics Div.
EXPERIMENTS USING ELECTRONIC DISPLAY INFORMATION IN THE NASA TERMINAL CONFIGURED VEHICLE
S. A. MORELLO *In* AGARD Advan. on Visualization Tech. 10 p (SEE N81-17063 08-06) Oct. 1980 refs
Avail: NTIS HC A10/MF A01 CSCL 01D

The results of research experiments concerning pilot display information requirements and visualization techniques for electronic display systems are presented. Topics deal with display related piloting tasks in flight controls for approach-to-landing, flight management for the descent from cruise, and flight operational procedures considering the display of surrounding air traffic. Planned research of advanced integrated display formats for primary flight control throughout the various phases of flight is also discussed. E.D.K.

N82-13140*# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
PRACTICAL ASPECTS OF INSTRUMENTATION SYSTEM INSTALLATION, VOLUME 13
R. W. BOREK, A. POOL, ed., and K. C. SANDERSON, ed. Sep. 1981 197 p refs
(NASA-TM-84067; AGARD-AG-160-VOL-13; ISBN-92-835-1399-1; AD-A107355) Avail: NTIS HC A09/MF A01 CSCL 01D

A review of factors influencing installation of aircraft flight test instrumentation is presented. Requirements, including such factors as environment, reliability, maintainability, and system safety are discussed. The assessment of the mission profile is followed by an overview of electrical and mechanical installation factors with emphasis on shock/vibraion isolation systems and standardization of the electric wiring installation, two factors often overlooked by instrumentation engineers. A discussion of installation hardware reviews the performance capabilities of wiring, connectors, fuses and circuit breakers, and a guide to proper selections is provided. The discussion of the installation is primarily concerned with the electrical wire routing, shield terminations and grounding. Also inclued are some examples of installation mistakes that could affect system accuracy. System verification procedures and special considerations such as sneak circuits, pyrotechnics, aircraft antenna patterns, and lightning strikes are discussed. M.D.K.

N82-27293# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
IMPACT OF ADVANCED AVIONICS TECHNOLOGY AND GROUND ATTACK WEAPON SYSTEMS
Feb. 1982 147 p refs Meeting held at Agheos-Andreas, Greece, 19-23 Oct. 1981
(AGARD-CP-306; ISBN-92-835-0310-4; AD-A115065) Avail: NTIS HC A07/MF A01

Autonomous operations conducted by day, night, and in adverse weather are associated with a high degree of automation, requiring sensors with high performance and a large data and signal processing capacity. The vulnerability of attack aircraft to the ground to air defense and the excessive workload of the pilot in the guidance of air to ground weapons point to the concept of a generation of fire and forget weapons. For individual titles, see N82-27294 through N82-27308.

N82-27294# Aeronautical Systems Div., Wright-Patterson AFB, Ohio. Deputy for Avionics Control.
IMPACT OF ADVANCED AVIONICS AND MUNITIONS TECHNOLOGY ON GROUND ATTACK WEAPONS SYSTEMS IN NIGHT AND ADVERSE WEATHER CONDITIONS
L. J. URBAN *In* AGARD Impact of Advan. Avionics Technol. on Ground Attack Weapon Systems 4 p (SEE N82-27293 18-06) Feb. 1982
Avail: NTIS HC A07/MF A01

Worldwide environmental conditions that may be encountered by fighter pilots are reviewed as well as the capabilities of potential adversaries. Technology efforts and systems developed to improve capability to operate at night and under unfavorable weather conditions discussed include advanced medium range air-to-air missiles, the PAVE TACK system used on the F-4 and F-111 aircraft, and the low altitude navigation and targeting infrared system for night (LANTIRN) which assists the pilot of a single seat aircraft to fly under the weather in night and helps in acquiring targets and readying weapons for launch. To complement LANTIRN, high resolution synthetic aperture tactical radar and millimeter wave radars are under development to improve target recognition, resolution, and navigation. The precision location strike system, imaging infrared Maverick, combined effects bomblets, GATOR air delivered mines, and wide area antiarmor munitions are other developments summarized. A.R.H.

N82-27295# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
AIR-GROUND ATTACK: AXES OF RESEARCH FOR AIRBORNE SYSTEMS [ATTAQUE AIR-SOL: AXES DE RECHERCHE POUR LES SYSTEMES AEROPORTES]
S. CROCE-SPINELLI *In its* Impact of Advan. Avionics Technol. on Ground Attack Weapon Systems 14 p (SEE N82-27293 18-06) Feb. 1982 In FRENCH
Avail: NTIS HC A07/MF A01

The integration of weapons systems with other airborne systems and equipment is considered from the point of view of operational aspects. Various weapons and their fire control characteristics are classed and the requirements and possibilities offered for meeting them are tabulated. Target acquisition, mission constraints, and versatility of mission are examined. Strapdown inertial guidance, radio altimeters, radar maps, electro-optics, and multiple access transmission networks are discussed. Systems for very low altitude flight and threat evaluation are described. Transl. by A.R.H.

N82-27296# British Aerospace Aircraft Group, Kingston-upon-Thames (England).
SOME POTENTIAL NOVEL APPROACHES TO THE AUTOMATIC AIRBORNE DETECTION AND IDENTIFICATION OF GROUND TARGETS
J. S. WILLIAMS *In* AGARD Impact of Advan. Avionics Technol. on Ground Attack Weapon Systems 13 p (SEE N82-27293 18-06) Feb. 1982 refs
Avail: NTIS HC A07/MF A01

Basic sensor processing functions are examined in an effort to establish the type of operation to be conducted optically. If optical techniques are to be used in target detection and identification, interfaces must be minimized in order to reduce the size of the device used, improve reliability and inspectability, and conserve signal power during processing. Topics covered include receiving optics, optical signal decomposition, image preprocessing, display prepreparation, acquisition computation, and range and bearing. Coherent transform optics, holographic methods, optical feedback, real-time processing, and optical bistable devices are discussed as processing elements. Although optical signal processing has considerable potential in airborne target recognition, considerable research is needed in this capability is to be realized. There is a need to support this activity with adequate modelling of the perception capability of the human visual system if information is to properly displayed and then utilized. A.R.H.

N82-27297# National Aerospace Lab., Amsterdam (Netherlands).
A PLANNING SYSTEM FOR F-16 AIR-TO-SURFACE MISSIONS
P. J. M. URLINGS, W. LOEVE, and J. BATENBURG (Royal Netherlands Air Force, Zeist) *In* AGARD Impact of Advan. Avionics Technol. on Ground Attack Weapon Systems 6 p (SEE N82-27293 18-06) Feb. 1982 refs
Avail: NTIS HC A07/MF A01

Recently introduced into the Royal Netherlands Air Force, the F-16 aircraft is to be employed in both air-to-air and air-to-surface operations. Successful air-to-surface mission accomplishment is highly dependent on the avionics system capabilities as navigation, target acquisition, fire control, and weapons delivery. To make use of the full avionic potential, the set-up of its systems requires careful planning and preflight preparation. Checklists must also be prepared for navigation and in-flight system operation. A concept for a mission planning system is presented to provide the F-16 pilot with a tool for performing adequate preparation. Specific F-16 avionic demands on mission planning are summarized and two systems related to this planning are described. The assembling of F-16 in-flight essentials into a combat mission folder is described. A.R.H.

N82-27298# Hughes Aircraft Co., El Segundo, Calif. Advanced Programs Lab.
PAVE MOVER AIDED INTEGRATED STRIKE AVIONICS SYSTEM
A. J. MENDEZ, T. A. DUPUIS (AFWAL), and J. BOAZ *In* AGARD Impact of Advan. Avionics Technol. on Ground Attack Weapon Systems 6 p (SEE N82-27293 18-06) Feb. 1982 refs
Avail: NTIS HC A07/MF A01

Methods were developed for specifying targeting sensor performance based on tactics and weapons characteristics alone. Targeting sensor specifications (demand curves) developed in this manner indicate that, for quick reaction, short range attack with precision-guided munitions, single sensors do not generate sufficient confidence (supply curves) to satisfy the required timeliness. This problem is alleviated by treating all sensors as an integrated set - the ISAS concept. New tactics produce sudden encounters which do not always yield a favorable attack geometry, even if the ISAS is able to distinguish the high priority targets in its field of regard. This situation is greatly improved by real-time targeting data from a stand off target acquisition/control system such as Pave Mover. Maximum benefit from the new tactics and weapon delivery concepts is accrued by pairing the complementary capabilities of ISAS and Pave Mover. This combination optimizes the strike effectiveness and survivability of ground attack aircraft which must penetrate to the battlefield and deep interdiction regions. A.R.H.

N82-27299# AEG-Telefunken, Ulm (West Germany).
ADAPTIVE MULTIFUNCTION SENSOR CONCEPT FOR AIR-GROUND MISSIONS
R. P. MILLS-GOODLET, D. J. R. STOCK, E. G. WOELFLE, and C. HAMILTON *In* AGARD Impact of Advan. Avionics Technol. on Ground Attack Weapon Systems 13 p (SEE N82-27293 18-06) Feb. 1982 refs
Avail: NTIS HC A07/MF A01

The requirements imposed on a radar system it is to be installed in aircraft flying low-level interdiction missions are discussed. A typical low low-level air-ground attack scenario is described together with the various radar techniques and modes that must be employed. Particular attention is given to the nose radar, its antenna, and its integration with other aircraft sensors to form an adaptive multisensor system. The ways in which such a multisensor system can reduce pilot workload are examined. A.R.H.

N82-27300# Naval Air Systems Command, Washington, D. C.
ATTACK AND EN ROUTE AVIONICS FOR IN-WEATHER OPERATIONS
E. B. BEGGS, W. F. BALL (Naval Weapons Center, China Lake, Calif.), and N. J. SCHNEIDER (Naval Weapons Center, China Lake, Calif.) *In* AGARD Impact of Advan. Avionics Technol. on Ground Attack Weapon Systems 11 p (SEE N82-27293 18-06) Feb. 1982
Avail: NTIS HC A07/MF A01

An increasingly sophisticated and lethal ground threat environment must be countered in large part by technological advances in the avionics of naval attack aircraft. Critical deficiencies exist in the areas of standoff targeting and weapon delivery, defense suppression, equipment reliability, and crew loading. To reduce pilot workload, automated procedures and decision aids must be developed. Technology must be made available for precise navigation, integration of weapon delivery and flight control systems, automatic target recognition, detection avoidance, automatic flight path routing, and secure communications. The ingress and egress phases of naval air missions are discussed as well as the attack phase and defense suppression Author

N82-27301# Electronique Marcel Dassault, St Cloud (France).
WEAPON SYSTEM OF A FUTURE ATTACK AIRCRAFT [SYSTEME D'ARME D'UN AVION D'ATTAQUE FUTUR]
B. E. BORTOMB *In* AGARD Impact of Advan. Avionics Technol. on Ground Attack Weapon Systems 11 p (SEE N82-27293 18-06) Feb. 1982 refs In FRENCH
Avail: NTIS HC A07/MF A01

A hypothetical all-weather air-to-surface weapon system is presented which is adaptable to a single seat aircraft whose weight without armor would be on the order of 4 tons. It would appear that this system requires a precise predesignation of objectives, so that it can then fulfill its mission with good chances of success by day as well as by night, through diverse fogs and relatively important precipitation, conditions which cover 99% of the cases in which it is used. Transl. by A.R.H.

N82-27302# British Aerospace Public Ltd. Co., Preston (England).
ADVANCED TECHNOLOGY AND FIGHTER COCKPIT DESIGN: WHICH DRIVES WHICH?
I. E. SCHOFIELD *In* AGARD Impact of Advan. Avionics Technol. on Ground Attack Weapon Systems 10 p (SEE N82-27293 18-06) Feb. 1982
Avail: NTIS HC A07/MF A01

Problems experienced by the ground attack fighter pilot are reviewed, and the design of an acceptable man machine interface in the cockpit in order to ensure maximum head up operation for low level flying is discussed. The present use of automation and CRT displays is reviewed. Problems in the employment of increased automation, direct voice input, and synthetic speech, and their integration into the avionics system are considered. The use of multifunction displays and controls, keyboards, and the more traditional switchery is discussed. J.D.

N82-27303# Army Armament Research and Development Command, Dover, N. J.
DIGITAL IMAGE PROCESSING FOR ACQUISITION, TRACKING, HAND OFF AND RANGING
R. R. MARINELLIE and J. V. SPANGLER *In* AGARD Impact of Advan. Avionics Technol. on Ground Attack Weapon Systems 12 p (SEE N82-27293 18-06) Feb. 1982 refs
Avail: NTIS HC A07/MF A01

The design, application, and preliminary analysis of flight test results of the AUTO-Q digital image processor for the automatic recognition of targets in reconnaissance images are discussed. The problems of information extraction from and bandwidth reduction in raw sensor data and the way they lead to the evolution of a common preprocessing approach are considered. The image processing tasks involved in target acquisition, tracking, and handoff are described. The basic concepts and algorithms in AUTO-Q are presented, and the volution of three generations of digital hardware described. A description of the electrical and mechanical characteristics of the latest system is presented. J.D.

N82-27304# Marconi Avionics Ltd., Rochester (England). Airborne Display Div.
WIDE ANGLE RASTER HEAD UP DISPLAY DESIGN AND APPLICATION TO FUTURE SINGLE SEAT FIGHTERS
D. W. HUSSEY *In* AGARD Impact of Advan. Avionics Technol. on Ground Attack Weapon Systems 8 p (SEE N82-27293 18-06) Feb. 1982 refs
Avail: NTIS HC A07/MF A01

Unconventional optical design capable of the largest practical field of view, around 20 degrees by 30 degrees for the majority of existing fighter cockpits are described. Some auxiliary advantages implicit in the designs are also outlined. Head up displays of this type are currently in development for the USAF LANTIRN program to be flown in the F-16 and A-10. They are also compatible with a wide range of other fighter aircraft. J.D.

N82-27305# Army Night Vision Lab., Fort Belvoir, Va.
ADVANCED TARGET ACQUISITION AND TRACKING CONCEPTS FOR REAL TIME APPLICATIONS
J. T. HALL *In* AGARD Impact of Advan. Avionics Technol. on Ground Attack Weapon Systems 7 p (SEE N82-27293 18-06) Feb. 1982 refs
Avail: NTIS HC A07/MF A01

The basic functional requirements for the target acquisition mission based on the sensor input, preprocessing, image segmentation, feature extraction, target detection, and target classification operations are presented. The impact on designing real time tracking algorithms to follow targets through clutter is considered. An advanced tracking concept considering the coupling of the target detection/classification algorithm with the multimode track is discussed. The thrust for multisensor systems is considered from the synergistic target acquisition point of view. The implementation of smart sensor target acquisition functions is presently limited by hardware capabilities. The advancement in the very high speed dedicated integrated circuit technology will make present advanced algorithms realizable in integrated circuit

hardware. The projected needs for real time target acquisition and tracking are considered for the autonomous vehicle. Several approaches are considered for realization of the truly real time target acquisition system in the next decade. J.D.

N82-27306# Rome Air Development Center, Griffiss AFB, N.Y.
TACTICAL SYSTEMS APPROACH TO INTERDICTION OF 2ND ECHELON MOVING TARGETS USING REAL TIME SENSORS
M. J. BLANCALANA and H. J. MANCINI (GE, Utica, N.Y.) *In* AGARD Impact of Advan. Avionics Technol. on Ground Attack Weapon Systems 9 p (SEE N82-27293 18-06) Feb. 1982 refs
Avail: NTIS HC A07/MF A01

An integrated system architecture for the effective interdiction of second echelon ground forces which are advancing under the cover of intense EW and air defense protection is described. The proposed architecture is based on principles derived from control theory and present practice, and includes the use of advanced air to surface and surface to surface quasi-autonomous attack elements operating in a complementary manner with stand off target acquisition and track sensors. All of the necessary elements of such an advanced architecture are in fact in various stages of development today. Author

N82-27307# Fraunhofer-Inst. fuer Informations- und Datenverarbeitung, Karlsruhe (West Germany)
A CONTRIBUTION TO AUTONOMOUS VEHICLE DETECTION BY A MOVING SENSOR
R. KORIES *In* AGARD Impact of Advan. Avionics Technol. on Ground Attack Weapon Systems 9 p (SEE N82-27293 18-06) Feb. 1982 refs
Avail: NTIS HC A07/MF A01

An algorithm capable of detecting autonomously moving vehicles seen by a moving sensor is presented. The detection is based on the analysis of the motion vector field within the field of view. Examples are given as the algorithm determines the motion vector field for translation, rotation, and focal length changes. The use for the autonomous cueing of a moving tank in a landscape environment is described. J.D.

N82-27308# Air Force Wright Aeronautical Labs., Wright-Patterson AFB, Ohio. Avionics Lab.
MULTISENSOR AND MULTIMODE INTEGRATION: A PERSPECTIVE
H. M. PASKIN *In* AGARD Impact of Advan. Avionics Technol. on Ground Attack Weapon Systems 6 p (SEE N82-27293 18-06) Feb. 1982 refs
Avail: NTIS HC A07/MF A01

The development of targeting and fire control sensors (radar, television, forward infrared, carbon dioxide lasers, and millimeter wave sensors) is reviewed and their application to weapons systems design discussed. The questions of the number and type of sensor to be used, their physical and functional integration, and the evaluation of system effectiveness are considered. A simple probabilistic approach for examining some of the factors which bear on the questions is presented and a prognosis of the prospects for achieving satisfactory answers is made. Analyses and simulations of various multisensor and multimode options for air to surface missions indicate the potential for significantly reduced operator workload and increased mission effectiveness, especially in diverse weather and countermeasure conditions. These improvements result from systematic and synergistic integration of various sensors and modes, with emphasis on automatic target recognition and information fusion. J.D.

07 AIRCRAFT PROPULSION AND POWER

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.

N80-26306# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
ADVANCED CONTROL SYSTEMS FOR AIRCRAFT POWERPLANTS
Feb. 1980 226 p refs Partly in ENGLISH and FRENCH Presented at the 54th Propulsion and Energetics Panel Specialist's Meeting, Cologne, 1-2 Oct. 1979
(AGARD-CP-274; ISBN-92-835-0258-2) Avail: NTIS HC A11/MF A01

Control systems for aircraft power units are discussed. Areas of consideration are: development experience; control implementation; optimum control strategies; and digital control concepts. For individual titles, see N80-26307 through N80-26325.

N80-26307*# National Aeronautics and Space Administration Marshall Space Flight Center, Huntsville, Ala.
SPACE SHUTTLE MAIN ENGINE DIGITAL CONTROLLER
W. T. MITCHELL *In* AGARD Advan. Control Systems for Aircraft Powerplants 11 p (SEE N80-26306 17-07) Feb. 1980
Avail: NTIS HC A11/MF A01 CSCL 21E

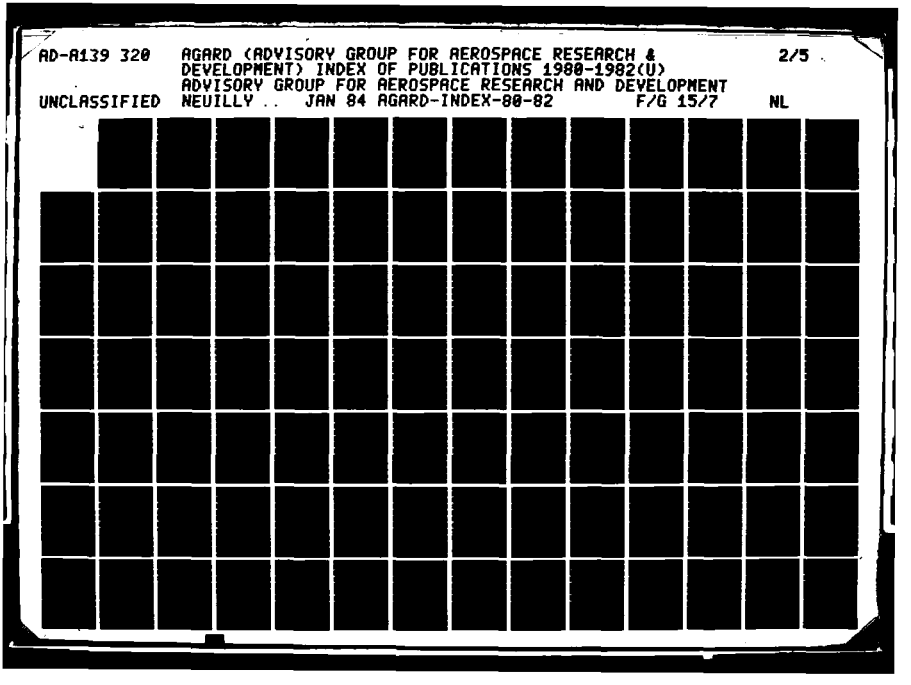
The controller provides responsive control of engine thrust and mixture ratio through the digital computer in the controller, updating the instructions to the engine control elements 50 times per second (every 20 milliseconds). Additionally, precise engine performance is achieved through closed loop control, utilizing 16 bit computation, 10 bit input/output resolution, and self calibrating analog-to-digital conversion. Engine reliability is enhanced by a dual redundant control system that allows normal operation after the first failure and a fail-safe shutdown after a second failure. The digital computer is programmable, allowing modification of engine control equations and constants by change of the stored program (software). The controller is packaged in a sealed, pressurized chassis with cooling provided by convection heat transfer through pin fins as part of the main chassis. The electronics are distributed on functional modules having special provisions for thermal and vibrational protection. R.C.T.

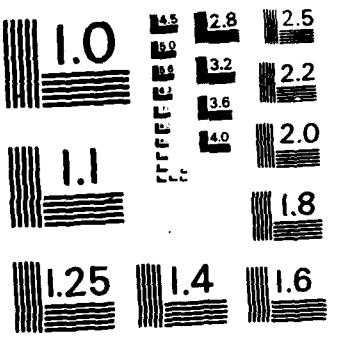
N80-26308# Rolls-Royce Ltd., Bristol (England).
EXPERIMENTAL FULL-AUTHORITY DIGITAL ENGINE CONTROL ON CONCORDE
J. MCNAMARA, C. G. LEGGE, and E. ROBERTS (Sperry Gyroscope Co., Great Neck, N.Y.) *In* AGARD Advan. Control Systems for Aircraft Powerplants 17 p (SEE N80-26306 17-07) Feb. 1980
Avail: NTIS HC A11/MF A01

The first ever flight standard full-authority digital engine controller is described. As well as the existing dry engine control and monitoring functions, the controller incorporated reheat control, fault recording and ground-check, and fitted into the same volume as the existing analogue dry engine controller. Particular emphasis is given to computer monitoring techniques and the production of high-integrity software. R.C.T.

N80-26309# VDO-Luftfahrtgeraete Werk Adolf Schindling G.m.b.H., Frankfurt (West Germany)
THE SECONDARY POWER SYSTEM CONTROL UNIT, AND ELECTRONIC SUBSYSTEM IN THE PANAVIA TORNADO
W. BENDER *In* AGARD Advan. Control Systems for Aircraft Powerplants 8 p (SEE N80-26306 17-07) Feb. 1980
Avail: NTIS HC A11/MF A01

The Secondary Power System [illegible] emphasis on system configuration. [illegible] of the APU operation of the [illegible] well defined specifications [illegible] starting phase of the aircraft engines [illegible]


AD-A139 320 AGARD (ADVISORY GROUP FOR AEROSPACE RESEARCH & DEVELOPMENT) INDEX OF PUBLICATIONS 1980-1982(U) ADVISORY GROUP FOR AEROSPACE RESEARCH AND DEVELOPMENT
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MICROCOPY RESOLUTION TEST CHART
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N80-26310# Bendix Corp., South Bend, Ind. Electronic Controls Div.

CONCURRENT DEVELOPMENT AND TEST OF A DIGITAL ELECTRONIC CONTROLLER WITH AN ADVANCED VARIABLE CYCLE ENGINE

R. W. CORDING and F. J. OKEEFE *In* AGARD Advan. Control Systems for Aircraft Powerplants 10 p (SEE N80-26306 17-07) Feb. 1980 Prepared in cooperation with Detroit Diesel Allison, Indianapolis, Ind.

Avail: NTIS HC A11/MF A01

The need for high performance systems with wide operating envelopes is discussed with respect to the design of advanced technology variable cycle engines. A program is described in which full authority digital electronic controller is used as a tool in the development of an advanced technology variable cycle engine. The problems and advantages associated with an advanced variable cycle engine are highlighted in a discussion of the control system development. R.C.T.

N80-26311# Societe Microturbo, Toulouse (France).

A NEW FUEL SUPPLY CONTROL SYSTEM FOR SMALL TURBOMACHINES [NOUVEAU SYSTEME DE COMMANDE DE DEBIT DE CARBURANT POUR PETITES TURBOMACHINES]

F. ARNAUD, J. GONZALES, and B. SECHER *In* AGARD Advan. Control Systems for Aircraft Powerplants 13 p (SEE N80-26306 17-07) Feb. 1980 In FRENCH

Avail: NTIS HC A11/MF A01

Small turbomachines used as starting systems or as autonomous power groups require specific devices for controlling fuel flow. The constraints proper to these turbomachines and the different solutions possible are reviewed. The underlying principle and operations are described for an original system which is composed of an electropump whose speed can be varied by an electronic device and a simplified pressure differential regulator. The main problems encountered in two particular applications are discussed. Transl. by A.R.H.

N80-26312# Plessey Aerospace Ltd., Titchfield (England).

TRANSDUCERS FOR ENGINE CONTROL SYSTEMS

G. E. DAVIES *In* AGARD Advan. Control Systems for Aircraft Powerplants 12 p (SEE N80-26306 17-07) Feb. 1980

Avail: NTIS HC A11/MF A01

Some active fluidic transducers which measure the fundamental nondimensional quantities required for engine control systems are described. The use of these transducers offers a true nondimensional measurement of engine performance and allows the system designer a freer choice of control parameters. R.C.T.

N80-26313# Pierburg Luftfahrtgeraete Union G.m.b.H., Neuss (West Germany).

A COMBINED PARALLEL-DIGITAL AND PULSE-DURATION MODULATED FUEL METERING SYSTEM

H. HOLZEM *In* AGARD Advan. Control Systems for Aircraft Powerplants 6 p (SEE N80-26306 17-07) Feb. 1980 refs

Avail: NTIS HC A11/MF A01

A fuel metering system is presented which is controlled parallel-digitally by a computer. This system is preferably suited for small and medium size engines. High accuracy requirements coupled with both robust and simple construction are met. The design and functional description is supplemented by the laboratory test results so far achieved. R.C.T.

N80-26314# Societe Nationale d'Etude et de Construction de Moteurs d'Aviation, Suresnes (France).

THE APPLICATION OF MICROPROCESSORS TO THE REGULATION OF MILITARY AIRCRAFT ENGINES: THE DESIGN OF ELECTRONIC REGULATORS [APPLICATION DES MICROPROCESSEURS A LA REGULATION DES MOTEURS D'AVIONS MILITAIRES. CONCEPTION DES REGULATEURS ELECTRONIQUES]

J. M. COLLIN and B. GAJ *In* AGARD Advan. Control Systems for Aircraft Powerplants 16 p (SEE N80-26306 17-07) Feb. 1980 refs In FRENCH

Avail: NTIS HC A11/MF A01

The availability of highly integrated circuits offers the designer new possibilities for rationally defining automatons numerically integrated in the engine regulating system. The architecture of these automatons is defined by simultaneously taking into consideration functional specifications, operational specifications which have an important bearing on the reliability and security of missions, and the technological constraints imposed by an aggressive environment. The possibilities offered by microprocessors are illustrated with a summary description of three types: a minicomputer type regulator, a multimicroprocessor system, and a regulator with a data processor. Transl. by A.R.H.

N80-26315# Hawker Siddeley Dynamics Ltd., Hatfield (England).

THE DESIGN CONCEPT AND EXPERIMENTAL RESULTS USING THE INTEL 8080/8085 MICROPROCESSOR

N. A. JUSTICE *In* AGARD Advan. Control Systems for Aircraft Powerplants 9 p (SEE N80-26306 17-07) Feb. 1980

Avail: NTIS HC A11/MF A01

Prototype flight equipment was built using the 8080A and is flying with full authority in a twin engine helicopter. Isochronous load sharing on torque with simultaneous data logging output of transducer inputs and control functions was provided for monitoring purposes. This detailed background provided valuable insight to the true flexibility of a microprocessor controller and also illustrated any shortcomings that the later generation devices will need to overcome. R.C.T.

N80-26316*# Air Force Aero Propulsion Lab., Wright-Patterson AFB, Ohio.

DESIGN, EVALUATION AND TEST OF AN ELECTRONIC, MULTIVARIABLE CONTROL FOR THE F100 TURBOFAN ENGINE

C. A. SKIRA (Systems Control, Inc., Palo Alto, Calif.), R. L. DEHOFF, and W. E. HALL, JR. (Systems Control, Inc., Palo Alto, Calif.) *In* AGARD Advan. Control Systems for Aircraft Powerplants 21 p (SEE N80-26306 17-07) Feb. 1980 refs Sponsored in part by NASA

Avail: NTIS HC A11/MF A01 CSCL 21E

A digital, multivariable control design procedure for the F100 turbofan engine is described. The controller is based on locally linear synthesis techniques using linear, quadratic regulator design methods. The control structure uses an explicit model reference form with proportional and integral feedback near a nominal trajectory. Modeling issues, design procedures for the control law and the estimation of poorly measured variables are presented. R.C.T.

N80-26317# Pisa Univ. (Italy).

ENGINE INTAKE CONTROL DESIGN FOR ADVANCED FIGHTER AIRCRAFT

D. DINI and R. LAZZERETTI *In* AGARD Advan. Control Systems for Aircraft Powerplants 11 p (SEE N80-26306 17-07) Feb. 1980 refs

Avail: NTIS HC A11/MF A01

The factors influencing variable geometry intake design for fighter aircraft over their flight velocity profile are reviewed. Separate operating performance ranges, depending on the positions of the changeover valves, ramps and doors, are analyzed for an acceptable design compromise. A criterion for prediction of airframe integration effects on inlet stability with application to advanced fighter aircraft is presented and discussed. To accomodate desired flow changes through the engine as flight speed, altitude, and climatic conditions, change, the control of intake is studied and designed, taking into account mutual interferences between propulsion units and controlled elements. Airframe/propulsion integration in fighter aircraft is considered in the design of intake control. M.G.

N80-26318# Centre d'Etudes et de Recherches, Toulouse (France). Dept. d'Automatique.

DETERMINING THE OPTIMAL CONTROL LAWS FOR SETTING THE RPM'S OF A TURBOJET ENGINE [DETERMINATION DE LOIS OPTIMALES DE MONTEE EN REGIME D'UN TURBOREACTEUR]

C. BARROUIL *In* AGARD Advan. Control Systems for Aircraft Powerplants 4 p (SEE N80-26306 17-07) Feb. 1980 refs In FRENCH

Avail: NTIS HC A11/MF A01

Two operational modes can be distinguished for a simple body turbojet engine without afterburning: changing the limits and regulating the limits. A rapid change of limits is desirable but a

suitable margin of safety must be assured during the transition and the engine must be left in a practically stabilized state after the transition. The engine controls are the fuel flow and the tail pipe section. They are released by actuators which are themselves controlled by a digital or analog computer or electromechanically. The control laws are not sought for the actuators directly, but for the fuel flow and the optimal tail pipe section. The laws determined are those displayed on the actuators. Transl. by A.R.H.

N80-26319# Motoren- und Turbinen-Union Muenchen G.m.b.H. (West Germany).

MODE CONTROL: A FLEXIBLE CONTROL CONCEPT FOR MILITARY AIRCRAFT ENGINES

K. BAUERFEIND *In* AGARD Advan. Control Systems for Aircraft Powerplants 9 p (SEE N80-26306 17-07) Feb. 1980

Avail: NTIS HC A11/MF A01

An engine control concept (mode control) which will minimize the aircraft performance penalties due to normal engine matching to severe handling requirements is described. In mode control these penalties are reduced by matching the engine closer to the optimum steady state performance of the aircraft. Extreme flight conditions are registered and signalled to an electronic control system. This control system then trims and overrides the normal control laws in order to provide the necessary margins required for safe operation so long as the extreme condition prevails. In order to implement mode control successfully the response rates of the engine variables or trims must be compatible with the requirements, i.e., the respective rates at which a certain problem can develop. Because of the type of computing required a digital control system is more suitable for this task than an analogue one. The example of a military three spool by-pass engine equipped with an afterburner is presented. M.G.

N80-26320# Smiths Industries Ltd., Basingstoke (England). Aviation Div.

REDUNDANCY CONCEPTS IN FULL AUTHORITY ELECTRONIC ENGINE CONTROL, PARTICULARLY DUAL REDUNDANCY

E. S. ECCLES, E. D. SIMONS (Dowty and Systems, Cheltenham, England), and J. F. O. EVANS *In* AGARD Advan. Control Systems for Aircraft Powerplants 14 p (SEE N80-26306 17-07) Feb. 1980

Avail: NTIS HC A11/MF A01

The available methods of redundancy in full authority electronic engine controls and the reasons for their selection in particular applications are surveyed with particular reference to the effects of the electro-hydromechanical interface. Various 'dual' redundant arrangement, Adour and Pegasus engine controls, and helicopter controls are specifically addressed. System safety and the variety of failure survival strategies which can be employed are considered. In general, ease of analysis is accompanied by simple failure survival strategies. More complex strategies may result in higher system availabilities and there is therefore a trade-off to conduct between non-recurring design cost and system availability in service. The impact of more flexible system architectures due to microprocessors and military requirements are discussed and the direction of future development is indicated. M.G.

N80-26321# Societe Nationale Industrielle Aerospatiale, Toulouse (France). Bureau d'Etudes Installation Motrice.

CONTROL OF THE ENGINES FOR THE NEW AIRBUS FAMILY [CONDUITE DES MOTEURS DE LA NOUVELLE FAMILLE AIRBUS]

J. C. TCHAVDAROV *In* AGARD Advan. Control Systems for Aircraft Powerplants 14 p (SEE N80-26306 17-07) Feb. 1980 refs

Avail: NTIS HC A11/MF A01

The general problem of engine performance is considered including the objectives to be satisfied and the basic principles to be retained. The operation of the A-300 aircraft is described with emphasis on gas control, hydromechanical regulation, principal instrumentation, motors, the theory and choice of performance parameters, associated automatic systems, and operational procedures. Solutions currently envisioned for future AIRBUS A-310 are presented, particularly the introduction of partially electronic regulation. Transl. by A.R.H.

N80-26322# National Research Center for Energetics and Propulsion, Milan (Italy).

CONTROL OF ALTERNATIVE ENGINES BY MICROCOMPUTER SYSTEMS

C. CASCI, F. M. MONTEVECCHI, and B. ABBIATI *In* AGARD Advan. Control Systems for Aircraft Powerplants 9 p (SEE N80-26306 17-07) Feb. 1980 refs

Avail: NTIS HC A11/MF A01

Development in microcomputer controlled fuel systems for internal combustion engines are discussed. Three cars - Fiat 127, Ford Fiesta and Alfa Romeo Alfasud - were provided with a microcomputer to control mixture ratio by means of floating chamber pressure regulation in the carburetor. A complex feedback control loop adjusts pressure level depending upon exhaust gases oxygen contents. Experimental testing of the device evidentiated the dependence of control system time delay upon rpm along with sensitivity to manifold geometry, sensor positioning, and related engine design details. Implemented control has taken into account rpm in relation with the forecast map of the specific engine. Tests were carried out on both at constant rev. speed and in emission tests. Engine design parameters and sensor location showed a strong influence on control system performance. Results indicated inherent limitations in control loop efficiency related to the use of exhaust sensors. The closed loop approach looks potentially capable of controlling automotive engines in the demanding future operational requisites. Progress is dependent upon improvement in air-fuel mixing techniques and in combustion sensors. M.G.

N80-26323# Lucas Aerospace Ltd., Birmingham (England).

A UNIFIED DIGITAL APPROACH TO THE CONTROL OF A DIVERSE RANGE OF ENGINES

M. J. JOBY and R. D. POWELL *In* AGARD Advan. Control Systems for Aircraft Powerplants 12 p (SEE N80-26306 17-07) Feb. 1980 refs

Avail: NTIS HC A11/MF A01

Digital control systems for gas turbine engines are examined in the light of the commonality of hardware and software requirements between diverse applications. Alternative control configurations for a main gas turbine engine are examined including: (1) a full hydromechanical, (2) hydromechanical with a supervisory electronic trim, (3) a full electronic with a hydromechanical backup, and (4) a full electronic with a further electronic backup. Through a consideration of the digital control unit structure for the different configurations, the commonality in hardware requirements is demonstrated. In addition, by having modules for each input and output a standard 'pack of cards' can be created from which a selection can be made for any application. Self monitoring and testing capabilities in digital systems are examined and examples from different applications are discussed, including helicopters, civil transport engines, industrial gas turbines, and military power plants. M.G.

N80-26324# Bodenseewerk Geraetetechnik G.m.b.H., Ueberlingen (West Germany).

ADVANTAGES OF THE DIGITAL TECHNOLOGY FOR THE REALIZATION OF ENGINE CONTROL SYSTEMS

G. DAHL and H. DRTIL *In* AGARD Advan. Control Systems for Aircraft Powerplants 8 p (SEE N80-26306 17-07) Feb. 1980

Avail: NTIS HC A11/MF A01

Requirements to be met by the digital control units and the advantages resulting therefrom are discussed. It is shown that with respect to their capacity future digital engine control units have essential advantages (integrated engine-flight control, functions, reliability, adjustments) compared to hydromechanical and analog electronical systems. Digital control units have a higher efficiency but will probably be of the same volume than actual control units. A considerable reduction of the interface and its volume will only be possible if the environment of the digital computer is digitalized as well, that means if sensors are provided with a digital pick-up, and if a direct digital control of the actuators and the displays is available. M.G.

N80-26325# Rolls-Royce Ltd., Leavesden (England). Aero Div.
THE DIGITAL CONTROL SYSTEM AS PART OF AN INTEGRATED ACCESSORY FIT FOR FUTURE ENGINES
M. P. PERKS and T. G. MORTON *In* AGARD Advan. Control Systems for Aircraft Powerplants 11 p (SEE N80-26306 17-07) Feb. 1980 refs
Avail: NTIS HC A11/MF A01

The development of digital control systems for gas turbine engines is discussed. It is suggested that the traditional approach of designing the control system in isolation from the other accessories on a gas turbine engine may not provide the most cost effective total solution for an engine having a digital control system. It is considered that the integrity of the digital control can be maintained while providing additional functions not associated with its prime control task. This could allow the development of advanced monitoring systems to minimize life cycle costs and achieve maximum aircraft utilization. The application of these principles to helicopter engines is discussed and an arrangement proposed which could provide substantial benefits both to the helicopter pilot and to the ground crew. Pilot work-load would be substantially reduced by advising him of engine or aircraft management factors on a 'need to know' basis. Operators would benefit from regular information on the operational status of the engines. M.G.

N80-26326# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
TECHNICAL EVALUATION REPORT ON THE 54TH(B) PROPULSION AND ENERGETICS PANEL MEETING ON COMBUSTOR MODELLING
D. DRYBURGH (Rolls Royce, Darby, England) and R. B. EDELMAN (Science Applications, Inc., Canoga Pk., Calif.) Mar. 1980 20 p Meeting held at Cologne, 3-5 Oct. 1979
(AGARD-AR-153; ISBN-92-835-1355-X; AD-A085463) Avail: NTIS HC A02/MF A01

After a short introduction, the meeting papers are classified into categories concerning model elements, dimensionality, survey type, application and theoretical development. The first evaluation follows this classification, while other evaluations are related to the manufacturer's and the researcher's point of view. Conclusions and recommendations for future treatment of combustor modelling are presented. Author

N80-27371# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
COMBUSTOR MODELLING
Feb. 1980 377 p refs In ENGLISH and FRENCH Meeting held in Cologne, 3-5 Oct. 1979
(AGARD-CP-275; ISBN-92-835-0260-4; AD-A085463) Avail: NTIS HC A17/MF A01

Twenty-four papers addressing the different models and methods used in turbine engine research are presented. Four general areas are discussed: basic phenomena, transient phenomena and instabilities, furnaces and boilers, and gas turbine combustors and R/H systems. For individual titles, see N80-27372 through N80-27395.

N80-27372# Societe Nationale d'Etudes et de Construction de Moteurs d'Aviation, Moissy-Cramayel (France). Dept. du Combustion.
MODELING THE COMBUSTION CHAMBER OF A GAS TURBINE: A MECHANICS VIEWPOINT [MODELISATION DES FOYERS DE TURBOREACTEURS: POINT DE VUE D'UN MOTORISTE]
P. GASTEBOIS *In* AGARD Combustor Modelling 7 p (SEE N80-27371 18-07) Feb. 1980 refs In FRENCH
Avail: NTIS HC A17/MF A01

Two objectives must be met when modeling combustion chambers for gas turbines. The optimization of combustion chambers presently directed towards the reduction of pollutant emissions, but which can be directed towards performance, stability, and relighting, must take into consideration the characteristics of the injection system, the primary zone, and the dilution. In addition, the prediction of combustion chamber performances should also permit the prediction of the characteristics of the outlet temperature, the wall temperature, and of the polluting emissions. To fill these two objectives, the mechanical engineer wants two types of models: a simplified one for performance estimation, and a more thorough model for optimizing the architecture of the combustion chamber. In both cases, a better knowledge of the physical phenomena (radiation, transfer, and reaction kinetics) obtained from improved measurements is indispensable. Transl. by A.R.H.

N80-27373# Sheffield Univ. (England). Dept. of Chemical Engineering and Fuel Technology.
FUNDAMENTAL MODELLING OF MIXING, EVAPORATION AND KINETICS IN GAS TURBINE COMBUSTORS
J. SWITHENBANK, A. TURAN (Science Applications, Inc., Woodland Hills, Calif.), P. G. FELTON, and D. B. SPALDING (Imperial Coll. of Science and Technology) *In* AGARD Combustor Modelling 21 p (SEE N80-27371 18-07) Feb. 1980 refs
Avail: NTIS HC A17/MF A01

Past achievements current status and future prospects of combustor modeling are discussed. The past achievements largely consist of detailed studies of idealized flames which have given an understanding of the relevant fundamental processes. However, gas turbine combustor computations must include the simultaneous interacting processes of three dimensional two-phase turbulent flow, evaporating droplets, mixing, radiation and chemical kinetics. At the present time numerical prediction algorithms are becoming available which can model all these processes to compute the hydrodynamic, thermodynamic and chemical quantities throughout a three dimensional field. Complementary stirred reactor network algorithms permit the prediction of minor consistuents (pollutants), again including such effects as droplet evaporation and unmixedness. Experimental verification of these various predictions reveals remarkably good agreement between measured and predicted values of all parameters in spite of the physical and mathematical assumptions currently used. Future problems include: more accurate modeling of turbulence/kinetic interactions, numerical procedure optimization and detailed measurements of residence time distribution and two-phase parameters in real, hot combustors. R.E.S.

N80-27374# Imperial Coll. of Science and Technology, London (England). Dept. of Chemical Engineering and Chemical Technology.
MATHEMATICAL MODELLING OF GAS-TURBINE COMBUSTION CHAMBERS
W. P. JONES and J. J. MCGUIRK *In* AGARD Combustor Modelling 11 p (SEE N80-27371 18-07) Feb. 1980 refs Sponsored by Rolls-Royce Ltd.
Avail: NTIS HC A17/MF A01

A mathematical model for predicting the performance of gas turbine combustion chambers is described. The model is based on the finite difference solution of the averaged forms of the governing partial differential conservation equations and turbulent transport is approximated via a variable density form of the k-epsilon turbulence model. The reactions associated with heat release are assumed sufficiently fast for chemical equilibrium to prevail on an instantaneous basis; and the influence of local turbulent fluctuations in mixture strength accounted for by a beta-probability density function. Liquid fuel sprays are represented by a transport equation for the probability density function describing the variation of droplet mass fraction with droplet radius. Computations of 2-d axisymmetric and 3-d flows are compared with experimental results and an assessment made of the adequacy of the various submodels embodied in the prediction procedure. Author

N80-27375# Von Karman Inst. for Fluid Dynamics, Rhode-Saint-Genese (Belgium).
A PREDICTION MODEL FOR TURBULENT DIFFUSION FLAMES INCLUDING NO-FORMATION
J. JANICKA (RWTH, Aachen, West Germany) and W. KOLLMANN *In* AGARD Combustor Modelling 17 p (SEE N80-27371 18-07) Feb. 1980 refs
Avail: NTIS HC A17/MF A01

A prediction model for turbulent diffusion flames burning gaseous fuels was developed and applied to H2-air flames. In the (simplified) system of chemical reactions the fast reactions are assumed in equilibrium. equilibrium whereas three-body recombinations are treated in non-equilibrium. For the H2-air flames this assumption leads to a description of the reacting system with only two variables f and r. Two methods of treating such a system in a turbulent flow are discussed: (1) modeling and solving transport equations for first and second order moments of these variables and prescribing the form of the pdf of f and r as a function of the

selected moments, or (2) modeling and solving the equation for the pdf of f and r. Both sets of equations are complemented with a modified version of the k-epsilon turbulence model. The NO-formation in such flames can be calculated using the non-equilibrium values (mean values and covariances) of the O and H radicals. The results obtained with both models are compared with experiment and show good agreement. R.E.S.

N80-27376# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Cologne (West Germany). Inst. fuer Antriebstechnik.

TURBULENT REACTION AND TRANSPORT PHENOMENA IN JET FLAMES

H. EICKHOFF, K. GRETHE (Karlsruhe Univ.), and F. THIELE (Technische Univ., Berlin, West Germany) *In* AGARD Combustion Modelling 11 p (SEE N80-27371 18-07) Feb. 1980 refs

Avail: NTIS HC A17/MF A01

A new reaction model accounting for intermediate species was applied in connection with the k-epsilon model to predict different free and enclosed turbulent natural gas flames. The reaction model is based on the assumption of a quasilaminar flame substructure of a turbulent diffusion flame and a probability density distribution of fuel-atom-concentration. It is assumed, that the quasilaminar flames are in local chemical equilibrium within zones of finite thickness. The influence of variable density on the mixing process was studied for different jets and jet flames. In the parabolic flow cases it was found necessary to account for variable density which was done by a mixing length relation. Different numerical procedures were applied for the parabolic and elliptic flow fields. Author

N80-27377# Karlsruhe Univ. (West Germany). Inst. fuer Thermische Stroemungsmaschinen.

ON THE PREDICTION OF TEMPERATURE PROFILES AT THE EXIT OF ANNULAR COMBUSTORS

O. M. F. ELBAHAR and S. L. K. WITTIG *In* AGARD Combustor Modelling 9 p (SEE N80-27371 18-07) Feb. 1980 refs

Avail: NTIS HC A17/MF A01

Despite their inherent limitations, two dimensional prediction procedures based on solving the basic equations and incorporating the k-epsilon model of turbulence are shown to be effective tools in designing annular combustors. In comparing the results it was found that predictions from available jet mixing correlation data within certain limitations represent measurements from single row injection more accurately. Detailed calculations, however, are more effective in predicting opposite wall cooling air injection, multiple row jet mixing, heat transfer, film cooling and the effects of converging combustor exit. R.E.S.

N80-27378# Aeronautical Research Associates of Princeton, Inc., N. J.

SECOND-ORDER CLOSURE MODELING OF TURBULENT MIXING AND REACTING FLOWS

A. K. VARMA, G. SANDRI, and C. D. DONALDSON *In* AGARD Combustor Modelling 13 p (SEE N80-27371 18-07) Feb. 1980 refs

(Contract N00014-75-C-1143; N00014-79-C-0335; F44620-76-C-0048; PROJ. SQUID)

Avail: NTIS HC A17/MF A01

Models for the scalar probability density function (PDF) have to be developed to achieve closure of turbulent transport equations for mixing and reacting flows. A delta function typical eddy model was developed for the joint PDF of the scalar variables. It was demonstrated that delta functions are a necessary part of PFTs in order to attain the extremums of the statistical constraints on the moments. The statistical bounds on a number of moments of interest for two and three species flows were derived. It was proven that a rational PDF composed of a set of delta functions alone can always be constructed at any point within the statistically valid moment space. The model provides a good representation of actual PDFs in two species, variable density, mixing flows. The model was directly compared to experimental PDF measurements and good agreement for higher order moments was demonstrated. It can be shown that the delta function PDF model is significantly simpler than other proposed PDF models and is more than adequate for the closure of the transport equations. E.D.K.

N80-27379*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

COMBUSTOR MODELLING FOR SCRAMJET ENGINES

J. P. DRUMMOND, R. C. ROGERS, and J. S. EVANS *In* AGARD Combustor Modelling 30 p (SEE N80-27371 18-07) Feb. 1980 refs

Avail: NTIS HC A17/MF A01

A system of computer programs being developed to model complex combustor flow fields is discussed. Each code solves a system of equations compatible with the type of flow being analyzed in any particular part of the combustor. For flows that remain supersonic throughout, a parabolic Navier-Stokes solver is used successfully. An extension of this computer program, to partially introduce elliptic character into the analysis by accounting for a full three dimensional pressure field, is being tested. This partially elliptic scheme accounts for the effects of streamwise pressure feedback present in the subsonic flow, thereby allowing the detection and calculation of embedded subsonic regions known to be present in the combustor. Although the partially elliptic procedure can handle mixed subsonic-supersonic flows, it still requires that a predominant flow direction exists; for recirculating flows, the fully elliptic Navier-Stokes equations are required. Since recirculating flow does exist in regions near points of fuel injection from struts in the engine, work is currently underway to begin development of a three dimensional elliptic Navier-Stokes solver. Initial work includes development of a two dimensional elliptic code for the analysis of slot fuel injectors. E.D.K.

N80-27380# International Flame Research Foundation, Ijmuiden (Netherlands).

DEVELOPMENT AND VERIFICATION OF RADIATION MODELS

H. BARTELDS (Organization for Applied Scientific Research, TNO, Apeldoorn, Netherlands) *In* AGARD Combustor Modelling 20 p (SEE N80-27371 18-07) Feb. 1980 refs

Avail: NTIS HC A17/MF A01

The prediction of radiative heat transfer from a flame may be divided into three categories: (1) the evaluation of temperature distribution and radiating species concentrations; (2) the evaluation of the absorption, emission, and scattering characteristics of the species at the prevailing temperatures; and (3) the evaluation of the radiation exchange. All three categories are discussed with respect to experiments and mathematical models. Emphasis is placed on models falling into categories two and three. The models were verified by comparison with measured radiation intensities and measured radiative heat fluxes from relatively large gas flames. Measured temperatures and species concentrations were used as input to the models. However, the models are well suited to be combined with each other and with prediction procedures for fluid flow and combustion. E.D.K.

N80-27381# Imperial Coll. of Science and Technology, London (England). Dept. of Mechanical Engineering.

ASSESSMENT OF AN APPROACH TO THE CALCULATION OF THE FLOW PROPERTIES OF SPRAY-FLAMES

Y. E. BANHAWY and J. H. WHITELAW *In* AGARD Combustor Modelling 11 p (SEE N80-27371 18-07) Feb. 1980 refs Sponsored by the Minister of Defence

Avail: NTIS HC A17/MF A01

A method for the calculation of the local properties of spray flames is described and its capabilities and limitations appraised by comparing calculated results with measurements. The method solves elliptic differential equations representing the conservation of mass, momentum, enthalpy, and species concentrations in finite difference form. In addition, Lagrangian equations for the droplet motion and thermal balance are solved for the finite ranges of droplet size. A two equation turbulence model, a combustion model based on mean mass fraction equations for fuel and oxidant, and a four flux radiation model are used. The droplet model assumes that the evaporating droplets act as distributed point sources of fuel vapor. The merits of the method are quantified by comparison with measurements obtained for three different spray flame geometries. The assumption of representing the spray by a finite number of size ranges was also examined and the results indicate that the importance of this number is related to the spray type and the aerodynamic features of the flow close to the spray. E.D.K.

N80-27382# Science Applications, Inc., Woodland Hills, Calif. Combustion Dynamics and Propulsion Technology Div.
FUNDAMENTAL CHARACTERIZATION OF ALTERNATIVE FUEL EFFECTS IN CONTINUOUS COMBUSTION SYSTEMS
R. B. EDELMAN, A. TURAN, P. T. HARSHA, E. WONG, and W. S. BLAZOWSKI (Exxon Research and Engineering Co., Linden, N.J.) *In* AGARD Combustor Modelling 14 p (SEE N80-27371 18-07) Feb. 1980 refs
Avail: NTIS HC A17/MF A01

The problem of net soot generation which is aggravated by the reduced hydrogen content characteristic of syncrudes that have been identified as probable alternate fuel sources for use in gas turbines is addressed. The kinetics of the process are modeled using the quasi-global concept while experimental data are developed primarily from a laboratory jet stirred combustor. Results are presented showing that soot emissions can be characterized in terms of major species and that soot oxidation must be included in the prediction of net soot generation. In addition, the techniques being employed for coupling the chemical and aerodynamic processes are outlined. E.D.K.

N80-27383# Princeton Univ., N. J. Dept. of Mechanical and Aerospace Engineering.
CHEMICAL KINETIC MODELLING FOR COMBUSTION APPLICATION
F. L. DRYER and C. K. WESTBROOK (California Univ., Livermore, Lawrence Livermore Lab.) *In* AGARD Combustor Modelling 17 p (SEE N80-27371 18-07) Feb. 1980 refs
(Contract W-7405-ENG-48; EC-77-S-02-4272)
Avail: NTIS HC A17/MF A01

A systematic study of kinetic oxidation models for practical fuels is described. The construction of detailed reaction mechanisms for the oxidation of typical hydrocarbon fuels and the validation of these mechanisms through careful comparisons between computer and experimental data are discussed. These mechanisms are strongly hierarchical with reactions for complex fuels containing subsets which describe the combustion of chemically simpler fuels. Progress to date includes relatively complete descriptions of carbon monoxide, hydrogen, methane, and methanol oxidation. In the development and verification of these reaction mechanisms, data from a variety of experimental sources including slow reactor techniques at intermediate temperatures and shock tube results at high temperatures were used. In addition, ranges in fuel-air equivalence ratio between very lean through stoichiometric to very rich were also considered. E.D.K.

N80-27384# Massachusetts Inst. of Tech., Cambridge. Dept. of Mechanical Engineering and Applied Mechanics.
COALESCENCE/DISPERSION MODELLING OF GAS TURBINE COMBUSTORS
D. T. PRATT *In* AGARD Combustor Modelling 13 p (SEE N80-27371 18-07) Feb. 1980 refs Presented at the Proj. SQUID Workshop on Gas Turbine Combust., Princeton, N.J., 31 May - 1 Jun. 1978 Sponsored in part by Utah Univ. and AVCO-Lycoming Corp.
(Contract NSF ENG-76-84533)
Avail: NTIS HC A17/MF A01

Finite rate micromixing may be introduced into both the perfectly stirred reactor (PSR) and plug flow reactor (PFR) models due to recent advances in computation of stochastic or Monte Carlo methods together with improved algorithms for calculating equilibrium and nonequilibrium chemistry. In the PSR this improvement allows assessment of the effects of primary zone inhomogeneities due to fuel-air ratio, temperature, and age or degree of reactedness within fluid elements. In the PFR regions finite rate mixing of secondary air admission into the post primary stream may be described, leading eventually to prediction of mixing inhomogeneities on pattern factors. E.D.K.

N80-27385# Office National d'Etudes et de Recherches Aeronautiques, Paris (France).
COMBUSTION ZONE MODELING IN UNSTEADY REGIME
F. HIRSINGER and H. TICHTINSKY *In* AGARD Combustor Modelling 12 p (SEE N80-27371 18-07) Feb. 1980 refs In FRENCH; ENGLISH summary
Avail: NTIS HC A17/MF A01

A modeling of the flows was undertaken reveal characteristic behaviors rather than to represent the whole set of phenomena taking place in actual, geometrically complicated combustion zones. The modeling technique consists of writing the equations of unsteady aerothermochemical budgets, taking into account the gas dynamics of the laminar or turbulent diffusion and the chemical kinetics for a series of cells representing the domain under study. These budget equations are treated in an integral manner in space and a differential manner in time. This method makes it possible to exactly follow the actual unsteady phenomena or to have a faster access to steady regimes through virtual unsteady evolutions. The applications presented correspond to a two dimensional flow in a duct partially choked by a plate representing a flame holder and to a three dimensional flow in a domain representing a section of flame tube fed by lateral orifices. This method permits the simulation of the establishment of the cold flow from rest, then an ignition initiated in a small zone at high temperature and the resulting oscillations, as well as the onset of a permanent flame. E.D.K.

N80-27386# California Inst. of Tech., Pasadena.
ANALYSIS OF LOW-FREQUENCY DISTURBANCES IN AFTERBURNERS
F. E. MARBLE, M. V. SUBBAIAH, and S. M. CANDEL *In* AGARD Combustor Modelling 11 p (SEE N80-27371 18-07) Feb. 1980 refs
Avail: NTIS HC A17/MF A01

The behavior of stabilized flame zones were examined when they were situated in an afterburner. The turbine discharge and the nozzle inlet planes were represented by appropriate admittance functions for low frequencies. The distances which separate turbine discharge, flame holders, and nozzle throat, as well as the number of flame holders, were parameters in the problem. The results show that small disturbances which originate in combustion roughness, may be amplified to serious amplitudes and the amplitude level is a strong function of the geometric parameters of the flame-afterburner arrangement. In some instances instability may result. R.E.S.

N80-27387# International Flame Research Foundation, Ijmuiden (Netherlands).
SURVEY ON PREDICTION PROCEDURES FOR THE CALCULATION OF FURNACE PERFORMANCE
J. B. MICHEL, S. MICHELFELDER, and R. PAYNE *In* AGARD Combustor Modelling 16 p (SEE N80-27371 18-07) Feb. 1980 refs
Avail: NTIS HC A17/MF A01

The numerous published mathematical models for the prediction of furnace heat transfer were classified into three categories. The degree of subdivision chosen for the heat transfer calculations (dimensionality) was used as the main criterion. It is shown that the flow pattern and the desired accuracy determine the required degree of subdivision, which can be zero dimensional (model type 1), one dimensional (model type 2) or multidimensional (model type 3). The survey on models and some applications show also that all model types have their justification and their specific range of application. Models of the type 1 and 2 are generally considered to be especially suitable for practical furnace calculations and parameter studies. In principle these calculations can also be performed with models of the type 3 although their applicability is as yet confined to special cases which can be handled computationally and where the greater effort and expense is justified. For typical 3D geometries and if pollution emission data are to be predicted, which depend heavily on local properties, the use of type 3 models is indispensable. A.R.H.

N80-27388# Politecnico di Milano (Italy).
NUMERICAL ANALYSIS AND EXPERIMENTAL DATA IN A CONTINUOUS FLOW COMBUSTION CHAMBER: A COMPARISON
F. GAMMA, C. CASCI, A. COGNE, and U. GHEZZI *In* AGARD Combustor Modelling 15 p (SEE N80-27371 18-07) Feb. 1980 refs
Avail: NTIS HC A17/MF A01

Measured and computed temperature distribution, axial velocity, and swirl velocity results obtained in an experimental furnace using methane as the fuel are presented and compared. The finite difference solution was obtained to the equations controlling combustion in the combustion chamber which was essentially a cylinder of inner 200 mm diameter with a test length of 1.000 mm. The fuel nozzle was placed axially in the injection head and the oxidizer was fed by two different lines. Primary air flowed through a tube surrounding the fuel nozzle, and the dilution air entered at the periphery of the injection head. In general, the agreement between theory and experiments can be considered as acceptable. A.R.H.

N80-27389# Centre de Recherche Claude-Delorme de l'Air Liquide, Jouy-en-Josas (France).
MODELING FURNACES FED WITH OXYGEN-ENRICHED AIR [MODELISATION DES FOURS ALIMENTES A L'AIR ENRICHI EN OXYGENE]
R. GUENOT, A. IVERNEL, F. C. LOCKWOOD, and A. P. SALOOJA *In* AGARD Combustor Modelling 12 p (SEE N80-27371 18-07) Feb. 1980 refs In FRENCH Prepared in cooperation with Imperial Coll. of science and Technology, London, England
Avail: NTIS HC A17/MF A01

The numerical modeling of combustion chambers with furnaces fed with oxygenated air presents particular problems related partly to the thermal dissociation produced by high temperatures, and partly to the increased role played by radiative transfer. A model is presented for including these phenomena in existing calculations. The method is in the process of verification by means of measurements obtained on an experimental 300 kW furnace designed to operate with high intensity boilers fed by natural gas and oxygenated air or pure oxygen. The first experimental results are in good agreement with predictions made using the model.
Transl. by A.R.H.

N80-27390# Technische Hogeschool, Delft (Netherlands). Thermal Power Engineering Lab.
AN EFFECTIVE PROBABILISTIC SIMULATION OF THE TURBULENT FLOW AND COMBUSTION IN AXISYMMETRIC FURNACES
T. T. A. PAAUW, A. J. STROO, and C. W. J. VANIOPPEN *In* AGARD Combustor Modelling 22 p (SEE N80-27371 18-07) Feb. 1980 refs
Avail: NTIS HC A17/MF A01

The conservation equations governing the flow field and the combustion process in isothermal and in diffusion controlled combusting confined flows are solved using a numerical finite difference technique; the results are compared with measurements. The combustion process of the hydrocarbon fuel was modeled by using instant reaction with fluctuations in the mixture fracture, and with three different assumptions for the chemical conditions: frozen chemistry, equilibrium chemistry and partial equilibrium chemistry. Attention is paid to the formation of nitrogen oxides, and it is shown that in hydrocarbon diffusion flames a substantial amount of the NO formed is due to prompt NO formation. An effective model is presented for this process. Author

N80-27391# Institut Francais du Petrole, Rueil-Malmaison.
MATHEMATICAL MODELING OF BOILER OPERATIONS [MODELISATION MATHEMATIQUE DU FONCTIONNEMENT DES CHAUDIERES DE CHAUFFAGE]
E. PERTHUIS *In* AGARD Combustor Modelling 24 p (SEE N80-27371 18-07) Feb. 1980 refs In FRENCH
Avail: NTIS HC A17/MF A01

During a cooperative study of small boilers for domestic heating, a mathematical model was developed which describes the phenomena regulating the boiler operations and studies their evolution as a function of practical parameters. The operations of a given apparatus can be simulated in continuous or discontinuous regime. The influences on the boiler of such a parameters as heat insulation, load factor, boiler control, and control of the differential of the aquastat can be estimated. The order of magnitude of heat maintenance can also be predicted, something which is difficult to determine on a test bed. Transl. by A.R.H.

N80-27392# Motoren- und Turbinen-Union Muenchen G.m.b.H. (West Germany).
A CHEMICAL REACTOR MODEL AND ITS APPLICATION TO A PRACTICAL COMBUSTOR
W. KROCKOW, B. SIMON, and E. C. PARNELL (Rolls-Royce Ltd., Bristol, England) *In* AGARD Combustor Modelling 19 p (SEE N80-27371 18-07) Feb. 1980 refs Sponsored in part by Bundesministerium der Verteidigung
Avail: NTIS HC A17/MF A01

A computer model of a combustion chamber is presented, which in its approach is based on chemical reactors. The reactive flow field of the combustor primary zone is divided into elements (vortices) with different mixture ratios and residence times. The variations in concentration in each element are calculated by means of a detailed kinetic reaction mechanism, in which the decomposition of the fuel to carbon monoxide and hydrogen is described by a one-step-quasi-global reaction rate. Each element born in the primary zone of the combustor reacts according to its residence time and is subsequently followed on its way through the remaining zones of the combustor by the computer, with discrete amounts of air being added corresponding to the boundary conditions in the combustor. Idealization of the model (normal distribution) is supported by measurement of the gas concentration at the outlet from the primary zone of a vaporiser-annular combustion chamber. Comparison between the calculated primary zone and outlet concentrations of nitric oxide, CO and unburned hydrocarbons and the measurements show very good agreement.
Author

N80-27393# Purdue Univ., Lafayette, Ind. School of Mechanical Engineering.
SEMI-EMPIRICAL CORRELATIONS FOR GAS TURBINE EMISSIONS, IGNITION, AND FLAME STABILIZATION
A. M. MELLOR *In* AGARD Combustor Modelling 13 p (SEE N80-27371 18-07) Feb. 1980 refs
(Contract F33615-77-C-2069)
Avail: NTIS HC A17/MF A01

For operating conditions where the fuel evaporation rate is fast compared to the fuel vapor/air mixing rate, a characteristic time model has been formulated to predict gaseous emissions and efficiency in terms of combustor inlet conditions and geometry. The model, which involves kinetic and fluid mechanic times, has been used to design low metric oxide burners, and study of several different conventional engine combustors suggests that the correlation may be universal. A related model, which includes a fuel droplet evaporation time, is being validated with data from laboratory combustors for spark ignition and lean flame stabilization. The preliminary application of this latter model to engine situations is described. Author

N80-27394# Universite Laval (Quebec).
COMBUSTION MODELLING WITHIN GAS TURBINE ENGINES, SOME APPLICATIONS AND LIMITATIONS
J. ODGERS *In* AGARD Combustor Modelling 14 p (SEE N80-27371 18-07) Feb. 1980 refs
Avail: NTIS HC A17/MF A01

Some of the more pertinent models postulated to describe the performance of gas turbine combustors are reviewed. Six different design/development stages are considered: (1) the initial sizing of a combustor; (2) the initial development testing; (3) primary zone modelling; (4) secondary zone modelling; (5) dilution zone modelling; and (6) changes due to the alteration of ambient conditions. The models are assessed in scope 1 plausibility, experimentally, and in terms of time and economic justification. For (1) it is suggested that a zero-dimensional model suffice, as also for (2). Item (3) will probably require a three dimensional model; (4) and (5) with probably suffice with A zone or two dimensional model. For item (6) a zero-order model might well be satisfactory. If it can be produced with sufficient accuracy, a single complex (probably three dimensional) model could adequately describe all items, (1) to (6). The need of future data, the type of models which may be used currently, and those which are likely to be used in the future are discussed. A.R.H.

N80-27395# Office National d'Etudes et de Recherches Aeronautiques, Paris (France).
AERODYNAMIC STUDY OF A COMBUSTION CHAMBER WITH A VIEW TO ITS SEMI-EMPIRICAL MODELLING
P. HEBRARD and P. MAGRE *In* AGARD Combustor Modelling 18 p (SEE N80-27371 18-07) Feb. 1980 refs In FRENCH; ENGLISH summary
Avail: NTIS HC A17/MF A01

The prediction of combustion performance and of polluting species formation in turbomachine combustors requires a calculation method that takes into account all phenomena taking place in various parts of the combustion chamber. Among these, aerodynamic effects, often very poorly known, must be introduced to justify modelling methods based on a combination of elementary combustors; these methods rest on a correct description of their features and their relationships: location, nature, volume, flowrate and distribution, connexions. To this end, experiments were carried out on a combustor model, both without and with combustion, with a view to: (1) characterize the combustor aerodynamics, by visualizations in the water tunnel and velocity measurements on an aerodynamic model; (2) measure residence times in a flame tube by thermodilution (aerodynamics) and particle dynamics (water tunnel); and (3) determine the combustion efficiency and the polluting species production for each regime. Using these results for the development of a one dimensional model of elementary combustors makes it possible to calculate the distribution function of residence time in all elmentary reactors, especially in the primary zone. The overall performance of the combustor can also be predicted. The agreement between calculated and experimental results is satisfactory if the simplicity of the assumptions on which the model is based is considered. A.R.H.

N80-29342# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
CERAMICS FOR TURBINE ENGINE APPLICATIONS
Mar. 1980 353 p refs In ENGLISH; partly in FRENCH Presented at the 49th Meeting of the AGARD Struct. and Mater. Panel, Cologne, 8-10 Oct. 1979
(AGARD-CP-276; ISBN-92-835-0261-2; AD-A087594) Avail: NTIS HC A16/MF A01

Advances in high temperature materials technology and/or the design and fabrication approaches to use them to increase the performance or durability, or to reduce the cost of turbine engines are assessed. One specific approach investigated involves high temperature ceramics and the associated design technology for using brittle materials in automobile engines and electric power generators. The design, fabrication, and testing of actual components are reported and the results are evaluated for aerospace applications. For individual titles, see N80-29343 through N80-29366.

N80-29343# General Electric Co., Lynn, Mass. Aircraft Engine Group.
BENEFITS OF CERAMICS TO GAS TURBINES
A. BROOKS and A. I. BELLIN *In* AGARD Ceram. for Turbine Eng. Appl. 25 p (SEE N80-29342 20-07) Mar. 1980 refs
Avail: NTIS HC A16/MF A01

The potential areas of benefit of structural ceramics in advanced propulsion engines for manned and short-life, unmanned aircraft applications are addressed. Ceramic characteristics such as rupture strength, creep, oxidation and corrosion are viewed in the perspective of advanced metal alloys. For various engine elements, operating regimes are indicated in which ceramics are anticipated to have benefits over metal parts. Considerations of cooling requirements, contours and tolerances, clearances and contacts, inspection and proof tests are discussed and their impact on engine performance, durability, and cost are assessed. For parts such as turbine blades and vances, bearings, combustors and flame-holders, establishment of benefit for ceramics is dependent upon the engine size. An example is presented for a ceramic turbine blade which shows that for conventional scaling, the probability of part survival decreases as engine size increases due to the brittle, statistical, volume dependent characteristics of the material In general, as engine size increases, the design approaches and the degree of benefit for various ceramic parts will be modified and/or a size limit will be reached. Within the ceramic payoff regime, low cost relative to metal parts is anticipated to be a significant benefit. J.M.S.

N80-29344# Army Materials and Mechanics Research Center, Watertown, Mass.
CERAMICS FOR SMALL AIRBORNE ENGINE APPLICATIONS
R. N. KATZ and E. M. LENOE *In* AGARD Ceram. for Turbine Eng. Appl. 13 p (SEE N80-29342 20-07) Mar. 1980 refs
Avail: NTIS HC A16/MF A01

The likelihood for successful application of ceramics to several classes of airborne engines with different duty cycles is assessed. The general design criteria and associated key materials and requirements for generic engines for limited, APU, and man-rate helicopter use are addressed. Materials, processes, design approaches, and reliability considerations appropriate to each generic engine category are briefly discussed. A scenario for a least risk strategy for the introduction of ceramics into airborne engines will presented. Key issues in materials research and development are identified. J.M.S.

N80-29345# Noel Penny Turbines Ltd., Toll Bar End (England). Engineering Analysis Dept.
REQUIREMENTS FOR MATERIALS FOR LAND VEHICLE GAS TURBINES
D. F. MOSS *In* AGARD Ceram. for Turbine Eng. Appl. 11 p (SEE N80-29342 20-07) Mar. 1980 refs
Avail: NTIS HC A16/MF A01

The requirements for land-vehicle power plants are discussed. It is shown how engine concepts and working cycles are being developed, and how improvements in materials will contribute to making the gas turbine a major competitor in this field. J.M.S.

N80-29346# Office National d'Etudes et de Recherches Aerospatiales, Paris (France).
TECHNOLOGIES FOR USE OF CERAMICS IN TURBOENGINES
S. BOUNDIGUES and G. FRATACCI (Direction des Recherches, Etude et Techniques, Paris) *In* AGARD Ceram. for Turbine Eng. Appl. 13 p (SEE N80-29342 20-07) Mar. 1980 In FRENCH; ENGLISH summary
Avail: NTIS HC A16/MF A01

The problems raised by the introduction of ceramics in aircraft engines are discussed from two view points, adaptation of technological solutions used for metals, and concept of aerodynamics and turbine technology adapted to ceramic materials. After an aerothermodynamic justification of the contrarotative solutions proposed, several formulas of turbines integrated in a complete engine are presented. The aerodynamic loads, temperature, stresses, batch fabrication, and fixation on the disc circumference are determined for the blades. The stress level, the possibility of fretting with fibers, and the thermal insulation are determined for the discs. Ideas on the adaptation of the classical formulas to ceramics are presented along with, in particular, a technique reducing pressure losses upstream and downstream of a ceramics heat exchanger. J.M.S.

N80-29347# AiResearch Mfg. Co., Phoenix, Ariz.
SILICON NITRIDE TURBINE BLADE DEVELOPMENT
F. B. WALLACE, J. E. HARPER, C. R. DINS, D. W. RICHERSON, and H. L. KINGTON *In* AGARD Ceram. for Turbine Eng. Appl. 12 p (SEE N80-29342 20-07) Mar. 1980
Avail: NTIS HC A16/MF A01

Hot-pressed silicon nitride (HPSN) rotor blades were developed as part of a two stage turbine. Program activities are described including design optimization to minimize steady-state and vibratory stress, material characterization, attachment tests, manufacturing process development, inspection, proof tests, turbine-rig development, and engine tests. This program demonstrates for the first time that ceramics can withstand the severe environment imposed on gas turbine rotating components, and that the potential for engines with increased efficiency and decreased use of strategic materials can be realized. J.M.S.

N80-29348# Ford Motor Co., Dearborn, Mich. Engineer and Research Staff.
DUO-DENSITY CERAMIC TURBINE ROTOR: CONCEPTS, MATERIALS PROCESSES AND TEST RESULTS
R. R. BAKER and A. F. MCLEAN *In* AGARD Ceram. for Turbine Eng. Appl. 19 p (SEE N80-29342 20-07) Mar. 1980 refs Sponsored in part by DARPA, DOE and Army Materials and Mechanics Research Center
Avail: NTIS HC A16/MF A01

The duo-density ceramic turbine rotor concept utilizes the high strength of hot pressed silicon nitride in the simple-shaped hub and adequately high strength of reaction bonded silicon nitride for the complex-shaped blades which can be readily formed by injection molding or slip casting. Design concepts, materials and fabrication process for making duo-density rotors are presented including recent developments in Ford's hot press/press bonding process. Background and status of the Ford/DARPA rotor testing program is presented including cold spin test and hot spin test results on duo-density rotors. Recommendations are presented for follow-on work. Author

N80-29349# Pratt and Whitney Aircraft, West Palm Beach, Fla. Government Products Div.
DEVELOPMENT OF AN INTEGRAL CERAMIC BLADE-METAL DISK WITH CIRCUMFERENTIAL BLADE ATTACHMENT
S. A. MCLEOD, B. H. WALKER, and M. I. MENDELSON *In* AGARD Ceram. for Turbine Eng. Appl. 10 p (SEE N80-29342 20-07) Mar. 1980 refs Sponsored by DARPA
Avail: NTIS HC A16/MF A01

The development of a hydrid turbine rotor by attaching hot-pressed Si3N4 airfoils to a wrought AF2-1DA superalloy disk using the GATORIZING forging process is summarized. An approach for fabricating low cost ceramic airfoils (platformless blades) is discussed. The ceramic blade rotors were hot spin tested at 750 rev/s (45,000 rpm) and 1505 K blade temperature, which were representative of small gas turbine engine conditions. J.M.S.

N80-29350# Daimler-Benz A. G., Stuttgart (West Germany).
INVESTIGATIONS OF A HOT-PRESSED SILICON NITRIDE TURBINE ROTOR
E. TIEFENBACHER *In* AGARD Ceram. for Turbine Eng. Appl. 9 p (SEE N80-29342 20-07) Mar. 1980
Avail: NTIS HC A16/MF A01

The development of turbine wheels consisting of hot-pressed silicon nitride is reported. The preliminary tests carried out to examine the thermal shock characteristics of hot-pressed silicon nitride are described. An explantation of the aerodynamic design and calculation of the turbine wheel is included. Reference is also made to turbine wheel manufacturing and the results of tests carried out so far. J.M.S.

N80-29351# Naval Air Systems Command, Washington, D. C. *Materials and Processes Branch*
CERAMICS IN ROLLING ELEMENT BEARINGS
C. F. BERSCH *In* AGARD Ceram. for Turbine Eng. Appl. 6 p (SEE N80-29342 20-07) Mar. 1980 refs
Avail: NTIS HC A16/MF A01

The feasibilty of using hot pressed silicon nitride (HPSN) for rolling elements and for races in ball bearings and roller bearings is explored. The HPSN offers opportunities to allenviate many current bearing problems including DN and fatigue life limitations, lubricant and cooling system deficiencies, and extreme environment demands. The history of ceramic bearings and the results of various element tests, bearing tests in rigs and bearing tests in a turbine engine are reviewed. The advantages and problems associated with the use of HPSN in rolling element bearings are discussed. Author

N80-29352# United Kingdom Atomic Energy Authority, Springfields (England). Springfields Nuclear Power Development Labs.
THE FABRICATION AND PROPERTIES OF REFEL SILICON CARBIDE IN RELATION TO GAS TURBINE COMPONENTS
P. KENNEDY *In* AGARD Ceram. for Turbine Eng. Appl. 13 p (SEE N80-29342 20-07) Mar. 1980 refs
Avail: NTIS HC A16/MF A01

The REFEL silicon carbide was developed as a canning material for high temperature nuclear reactor fuel, because of its high temperature stability, its oxidation resistance and its thermal stress and thermal shock resistance, and the reliability of the manufacturing process and the consistency of the product were established at an early stage in the development. The gas turbine engine is analogous to the nuclear reactor in that the same material characteristics are required and fabrication processes have now been developed which enable most gas turbine components to be formed from REFEL silicon carbide effectively and with a minimum of machining. The material is shown to peform satisfactorily in most stator applications and to be superior to other available ceramic materials for combustors. In the properties of REFEL silicon carbide are discussed, the fabrication processes are outlined and some of the published test data is reviewed. J.M.S.

N80-29353# *Westinghouse Research and Development Center*, Pittsburgh, Pa.
STATIONARY CERAMIC COMPONENT CONSIDERATIONS FOR LARGE INDUSTRIAL COMBUSTION TURBINES
R. J. BRATTON and K. L. RIEKE (Westinghouse Combustion Turbine Systems Div., Concordville, Pa.) *In* AGARD Ceram. for Turbine Eng. Appl. 8 p (SEE N80-29342 20-07) Mar. 1980 refs
Avail: NTIS HC A16/MF A01

Major R&D efforts underway in the United States to improve the performance of industrial combustion turbines are reviewed. The major goals are improved system reliability, capability for fuel flexibility and reduced emissions. Other goals desired are improved efficiency and decreased equipment cost. Design studies have shown that significant performance advantages can be achieved if ceramics can be made to perform reliably. Since stationary ceramic components are likely to find first application in industrial turbine systems, initial efforts will be directed to their development. For the near term, the development of a low emission combustion system that meets regulations for industrial turbines burning heavy fuels has a high priority. Hot-wall combustion systems to help meet the desired performance goals are considered. J.M.S.

N80-29354# Solar Turbines International, San Diego, Calif.
DEVELOPMENT OF CERAMIC NOZZLE SECTION FOR SMALL RADIAL GAS TURBINE
J. C. NAPIER and J. P. ARNOLD *In* AGARD Ceram. for Turbine Eng. Appl. 10 p (SEE N80-29342 20-07) Mar. 1980 refs Prepared in cooperation with Army Mobility Equipment Research and Development Command, Ft. Belvoir, Va.
Avail: NTIS HC A16/MF A01

Ceramics not only offer improved gas turbine performance through higher turbine inlet temperature but can increase engine life because of improved hot and erosion resistance. Development work leading to engine test of both erosion-resistant and high temperature ceramic nozzle concepts is described. The first nozzle concept employs ceramic vane sections and demonstrated a ten to one-hundred fold hot end life improvement under erosive conditions in engine tests. The second concept was engine demonstrated and offers high erosion resistance as well as the capability of operating at elevated turbine inlet temperatures. Work on ceramics manufacturing methods for cost reduction with the goal of providing economic incentives for ceramics in production turbines is described. Author

N80-29355# Volkswagen A.G., Wolfsburg (West Germany). Research and Development Div.
DEVELOPMENT OF A CERAMIC TURBINE NOZZLE RING
H. BURFEINDT, M. LANGER, and P. M. STUART (PMS Analysis AG, Zurich) *In* AGARD Ceram. for Turbine Eng. Appl. 8 p (SEE N80-29342 20-07) Mar. 1980 refs Sponsored in part by The German Ministry of Science and Technology
Avail: NTIS HC A16/MF A01

The way in which experimental testing and finite element design analysis have contributed to the understanding of the special problems associated with the use of ceramic materials in a turbine nozzle is described. During the design analysis two problem areas, the shrouds and the trailing edge, were immediately revealed. The design of an optimized nozzle ring resulted in a reduction of the high stresses in these two areas down to a level acceptable for ceramic materials currently available such as silicon nitride or silicon carbide. E.D.K.

N80-29356# Motoren- und Turbinen-Union Muenchen G.m.b.H. (West Germany).
DEVELOPMENT OF COMBUSTORS OF CERAMIC MATERIALS
G. KAPPLER, G. LANGEL, and L. SCHINDHELM *In* AGARD Ceram. for Turbine Eng. Appl. 12 p (SEE N80-29342 20-07) Mar. 1980 refs Sponsored in part by The German State Dept. for Research and Technology
Avail: NTIS HC A16/MF A01

Following early feasibility tests of various ceramic materials in hot environments, a research program was initiated to develop ceramic combustors for gas turbine applications. The design of the first ceramic combustors was based on experience with metallic flame tubes. Since test results showed that conventionally designed cylindrical combustors fracture during steady operating conditions at combustor exit temperatures above 1000 K, conical flame tubes were developed. Conical combustors which are more suited to ceramic material requirements were manufactured from Si3N4 and siliconized SiC and subjected to cyclic tests. The test results and their evaluation are reviewed. Combustors made from hot pressed silicon carbide have completed long duration cyclic tests at chamber pressures of 4.9 bar, the cyclic temperature variation adjusted at the combustor outlet being 1065 K to 1355 K. A combustor flame tube was installed in a vehicular gas turbine engine operating at 1250 K turbine inlet temperature to improve the technology of ceramic combustor design and to gain experience with ceramic combustor behavior. E.D.K.

N80-29357# Lucas Aerospace Ltd., Burnley (England). Fabrications Dept.
SOME EXPERIENCE IN THE DESIGN AND EVALUATION OF CERAMIC COMBUSTION CHAMBERS
G. SEDGWICK *In* AGARD Ceram. for Turbine Eng. Appl. 15 p (SEE N80-29342 20-07) Mar. 1980 refs
Avail: NTIS HC A16/MF A01

The design, component evaluation, and combustion testing of a small reverse flow annular combustion chamber constructed in silicon nitride is reviewed. Initially heat transfer assessments were made of the temperature levels which components would reach during combustion testing and a thermal test program was formulated which enabled loadings well in excess of those estimated for the actual flame tube environment to be imposed upon specimen components. From calculated thermal stresses, values for the probabilities of survival were obtained using a brittle failure analysis based on a Weibull distribution and a volume flow weakest link hypothesis. A subsequent program of combustion tests carried out on a pressure rig culminated in operation at a chamber exit temperature of 1762 K. A pipe combustion chamber program is also described using a monolithic construction in silicon carbide, in which failure modes are presented and analyzed. E.D.K.

N80-29358*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
STATE-OF-THE-ART SIALON MATERIALS
S. DUTTA *In* AGARD Ceram. for Turbine Eng. Appl. 15 p (SEE N80-29342 20-07) Mar. 1980 refs
Avail: NTIS HC A16/MF A01 CSCL 21E

The state of the art of SiAlONs is examined. The review includes work on phase relations, crystal structure, synthesis, fabrication, and properties of various SiAlONs. The essential features of compositions, fabrication methods, and microstructure are reviewed. High temperature flexure strength, creep, fracture toughness, oxidation, and thermal shock resistance are discussed. These data are compared to those for some currently produced silicon nitride ceramics to assess the potential of SiAlON materials for use in advanced gas turbine engines. E.D.K.

N80-29359# Annawerk Keramische Betriebe G.m.b.H., Roedental (West Germany). Ceranox Div.
PRESSURELESS SINTERING OF SILICON CARBIDE
E. GUGEL and G. LEIMER *In* AGARD Ceram. for Turbine Eng. Appl. 16 p (SEE N80-29342 20-07) Mar. 1980 refs
Avail: NTIS HC A16/MF A01

The stage of development of silicon carbide is reported with respect to the parameters influencing the sintering process, the properties achieved and the forming possibilities for gas turbine components. A comprehensive literature survey is attached. E.D.K.

N80-29360# Allmanna Svenska Elektriska A. B., Robertsfors (Sweden). High Pressure Lab.
HIP SILICON NITRIDE
H. T. LARKER *In* AGARD Ceram. for Turbine Eng. Appl. 4 p (SEE N80-29342 20-07) Mar. 1980 refs
Avail: NTIS HC A16/MF A01

Hot isostatic pressing (HIP) is being developed as a manufacturing process for intricately shaped fully dense silicon nitride parts. The process promises to combine the most attractive features of both the reaction bonding and the hot pressing processes. An encapsulation system compatible with silicon nitride under the HIP conditions was developed. Hubs with protruding blades and airfoils with trailing edges as thin as 0.3 mm were made. It is considered feasible to develop the process to high production and to attractive processing costs. E.D.K.

N80-29361# California Univ., Berkeley. Materials Science and Mineral Engineering.
NONDESTRUCTIVE FAILURE PREDICTION IN CERAMICS
A. G. EVANS *In* AGARD Ceram. for Turbine Eng. Appl. 20 p (SEE N80-29342 20-07) Mar. 1980 refs
Avail: NTIS HC A16/MF A01

The prediction of failure of a ceramic component can be made using nondestructive methods for detecting and characterizing the fracture critical defects. The accept/reject decision based on the nondestructive measurement requires a probabilistic analysis of both the measurement and fracture processes. The general approach for quantitative failure prediction in ceramics using nondestructive methods of defect characterization is described. The current state of knowledge as it impinges on the quantitative failure prediction issue is reviewed. E.D.K.

N80-29362# General Electric Co., Schenectady, N. Y. Ceramics Branch
FRACTURE STATISTICS DESIGN AND APPLICATION
C. A. JOHNSON *In* AGARD Ceram. for Turbine Eng. Appl. 16 p (SEE N80-29342 20-07) Mar. 1980 refs
Avail: NTIS HC A16/MF A01

The use of ceramics for load bearing structural components requires a detailed understanding of the variability in flaw size and the resulting scatter and size dependence of fracture strength. The quantitative description of these effects is known as fracture statistics. Distribution functions approximating the fracture behavior of brittle materials are discussed with emphasis on the Weibull distribution. In the application of fracture statistics as an aid for design of structural components, several factors may introduce errors in the resulting failure analysis. One such source of error, the presence of multiple flaw distributions, is discussed and illustrated. Author

N80-29363# Admiralty Marine Technology Establishment, Holton Heath (England).
REACTION-BONDED, SIALON AND CVD SI3N4 CERAMICS FOR ENGINEERING APPLICATIONS
D. J. GODFREY *In* AGARD Ceram. for Turbine Eng. Appl. 6 p (SEE N80-29342 20-07) Mar. 1980 refs
Avail: NTIS HC A16/MF A01

Recent developments in the development of reaction bonded (RBSN), chemical vapor deposited, and SiAlON and related silicon

nitride ceramics are reviewed in relation to their possible application in engines. Factors which affect the strength of RBSN include nitriding conditions, powder size, and reaction promoting impurities. Significant variations in thermal conductivity have been observed. Oxidative degradation of strength can be serious and oxide impregnation can reduce it. Chemical vapor deposited Si3N4 materials had disappointing strengths and were difficult to apply thickly over large areas, although recently progress was made. Basic scientific research on SiAlON and related materials has continued to elucidate their often complex nature, but recent activity has concentrated successfully on the metal cutting and processing applications of sintered SiAlONs, rather than optimizing them for engine applications. E.D.K.

N80-29364# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Stuttgart (West Germany). Institut fuer Bauweisen- und Konstruktionsforschung.

COMPRESSION LOADED CERAMIC TURBINE ROTOR

R. KOCHENDOERFER *In* AGARD Ceram. for Turbine Eng. Appl. 19 p (SEE N80-29342 20-07) Mar. 1980 refs

Avail: NTIS HC A16/MF A01

The most attractive properties of fiber reinforced materials, high strength to density ratio combined with high stiffness to density ratio, can be utilized with maximum benefit. However, this group of materials does not allow high temperature application. Therefore, in the proposed design the center core of the turbine wheel which is exposed to the hot gas flow is surrounded by a concentrical cooling ring, both kept under compression up to the design speed by a composite ring combination. Cold spin test results of fiber reinforced rings made of carbon epoxy, boron aluminum, and carbon/carbon are presented as well as cold spin test results of a possible wheel/shaft connection and of compression loaded rotors. E.D.K.

N80-29365# Politecnico di Milano (Italy).

OXIDATION AND HOT CORROSION BEHAVIOR OF SINTERED NITROGEN CERAMICS

P. L. CAVALLOTTI, N. DUCATI, and P. C. MARTINENGO *In* AGARD Ceram. for Turbine Eng. Appl. 8 p (SEE N80-29342 20-07) Mar. 1980 refs Prepared in cooperation with Fiat Research Center, Turin

Avail: NTIS HC A16/MF A01

A preliminary study on oxidation and corrosion of some types of nitrogen ceramics based on hot pressed (HPSN), reaction bonded (RBSN), reaction bonded and sintered (RBSSN), and pressureless sintered (PSSN) compacts was completed. These materials were also tested in the presence of contaminants on the temperature range of 1170 to 1470 K. The gravimetric results indicate a more highly qualified resistance of RBSSN when compared with RBSN and PSSN samples; HPSN samples are corroded at somewhat lower rates possibly as a result of the very high density of the samples. E.D.K.

N80-29366# Fiat Research Center, Turin (Italy).

DEVELOPMENT IN SINTERED SILICON NITRIDE

E. CAMPO and P. C. MARTINENGO *In* AGARD Ceram. for Turbine Eng. Appl. 8 p (SEE N80-29342 20-07) Mar. 1980 refs

Avail: NTIS HC A16/MF A01

The most attractive process for Si3N4 production, to avoid the reaction bonding and hot pressing problems, would be one which enables high performance and complexity of shape simultaneously. A pressureless sintering process was studied and developed, and various grades of Si3N4 were produced. Sintering aids employed for commerical Si3N4 powders and also to sinter reaction bonded silicon nitride were MgO and Y2O3. The process and the characterization of these sintered Si3N4 materials particularly in respect to structure and mechanical properties are described. E.D.K

N81-24071# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).

TURBINE ENGINE TESTING

Jan. 1981 471 p refs In ENGLISH and FRENCH Proceedings of the 56th Symp. of the AGARD Propulsion and Energetic Panel, Turin, 29 Sep. - 3 Oct. 1980

(AGARD-CP-293; ISBN-92-835-0282-5; AD-A097615) Avail: NTIS HC A21/MF A01

Increasing demands on turbine engines performance, durability, safety, and pollution emission require an improvement in test methods. Test methods are provided for the engine research and development engineers in order to help them meet the manufacturers', the buyers', and the users' test requirements for engine delivery, reliability, economy, and maintenance. A comprehensive survey on testing requirements for engine qualification and development are provided for both military and civil engines. Engine component testing and complete power plant testing are discussed. Trends for future testing are considered.

N81-24072# Registro Aeronautico Italiano, Rome. Div. Generale.

OVERVIEW OF ALL CIVIL AVIATION ENGINE CERTIFICATION/DEMONSTRATION REQUIREMENTS AND RATIONALE, I.E., FAA, CAA, ETCETERA

V. FIORINI *In* AGARD Turbine Engine Testing 17 p (SEE N81-24071 15-07) Jan. 1981 refs

Avail: NTIS HC A21/MF A01

Two outstanding codes for civil certification of aircraft turbine engines, one adopted in the U.S., FAR 33, and the other widely adopted in Europe, JAR 'E', are discussed and compared. The different existing philosphies, procedures, and different manufacturers positions on both sides of the Atlantic are examined. Significant items are identified and are discussed extensively with the purpose of detailing a comparison between the two sets of rules as follows: power ratings; endurance testing; stress and fatigue aspects of rotating parts; foreign object ingestion; ice protection; and engine fault analysis. T.M.

N81-24073# Naval Air Propulsion Test Center, Trenton, N.J.

SPECIFICATION REQUIREMENTS FOR FIGHTER ENGINES

M. E. DELL *In* AGARD Turbine Engine Testing 16 p (SEE N81-24071 15-07) Jan. 1981 refs

Avail: NTIS HC A21/MF A01

Military Specification MIL-E-5007D, a general specification for the development of turbofan/turbojet engines, has been used by the U.S. Government for the procurement of new engines since 1973. This specification was tailored and applied by the U.S. Navy to the F404-GE-400 engine (F-18 aircraft) development program. The military general specification philosophy for the procurement of turbojet/turbofan engines using MIL-E-5007D is discussed. With heavy emphasis on technical requirements and assurance tests related to engine durability, improvements in MIL-E-5007D over previous specifications, experiences in applying MIL-E-5007D to the F404 engine development program, and assurance test approaches being considered for a revision to MIL-E-5007D are described. T.M.

N81-24074# Bundesamt fuer Wehrtechnik und Beschaffung, Munich (West Germany).

CERTIFICATION PROCEDURE FOR MILITARY ENGINES IN GERMANY

F. BIEL *In* AGARD Turbine Engine Testing 6 p (SEE N81-24071 15-07) Jan. 1981 refs

Avail: NTIS HC A21/MF A01

The procedure is shown to be in agreement with the air transportation legislation of Germany. The activities in the course of development and during usage are presented with special emphasis on the aspect that the BWB-ML is only occupied with the subject of airworthiness, free from the need for the pursuance of schedule and financial matters. Differences in the procedures and the organization of other countries are shown T.M.

N81-24075# Ministry of Defence, London (England). Directorate of Engine Technology.
SPECIFICATION AND REQUIREMENTS RATIONALE FOR MILITARY AND CIVIL HELICOPTER ENGINES
M. D. PARAMOUR *In* AGARD Turbine Engine Testing 14 p (SEE N81-24071 15-07) Jan. 1981
Avail: NTIS HC A21/MF A01

The endurance and supplementary qualification testing required for the granting of Type Approval of military helicopter engines was reviewed. The rationale of these is given, and variations in different nation's requirements are discussed. A comparison is made with civil certification requirements. Attention is drawn to differences between the requirements for helicopter and fixed-wing aircraft engines. It is illustrated how service experience has revealed certain deficiencies in the test requirements, and has led to the development of more realistic procedures. The options considered for the current review of the UK qualification requirements are discussed. T.M.

N81-24076# Boeing Commercial Airplane Co., Seattle, Wash. Propulsion Technology Div.
BOEING COMMERCIAL AIRPLANE COMPANY ENGINE PROCUREMENT PRACTICES
D. C. NORDSTROM, D. W. BOUWER, and R. A. MAYS *In* AGARD Turbine Engine Testing 5 p (SEE N81-24071 15-07) Jan. 1981
Avail: NTIS HC A21/MF A01

For the past decade Boeing had a unique position among the world's commercial airframe companies in offering major portions of product line with a variety of engines supplied by all three large commercial manufacturers. An example is the 747 airplane with 15 engines at 12 thrust in 6 nacelles. New airplanes, the 757 and 767, are also being offered with several engines from the same manufacturers. Boeing developed a framework of interrelated documents and internal evaluation methodology to ensure consistency and control of these multiple engine offerings. The documentary framework currently used is defined and engine performance evaluation and development program monitoring methods are provided. T.M.

N81-24077# Lockheed-California Co., Burbank.
PROPULSION SYSTEM TESTING REQUIREMENTS FOR A COMMERCIAL TRANSPORT
J. F. STROUD *In* AGARD Turbine Engine Testing 13 p (SEE N81-24071 15-07) Jan. 1981 refs
Avail: NTIS HC A21/MF A01

Development and demonstration testing requirements for the next family of transport engines are described. Propulsion system performance and function testing are included with emphasis on performance. Rationale is provided for the major test required. The testing requirements identified reflect experience gained in the L-1011 program. The need for integrated, closely coordinated programs involving the airframe and engine companies is stressed. The test concepts, objectives, and definition of what constitutes performance demonstration are agreed before the airplane program go-ahead. Responsibilities for the various tests are assigned to the engine and airframe companies as appropriate. The requirement for correlating ground and flight propulsion performance results is discussed. T.M.

N81-24078# Societe Nationale Industrielle Aerospatiale, Toulouse (France). Div. Avions.
PERFORMANCE CONTROL AND QUALIFICATION TESTS OF CIVIL AVIATION TURBINE ENGINES IN TESTS CONDUCTED BY AIRFRAME MANUFACTURERS [CONTROLE DES PERFORMANCES ET ESSAIS DE QUALIFICATION DES MOTEURS CIVILS DANS LE CADRE DES ESSAIS AVIONNEURS]
G. THERON *In* AGARD Turbine Engine Testing 7 p (SEE N81-24071 15-07) Jan. 1981 In FRENCH
Avail: NTIS HC A21/MF A01

The economic return of double flow turbine engines rests for a large part on the performance at takeoff; therefore, it is very important to know the evolution of power in the turbine during this phase of flight which is characterized by a particular use of the engine. The airframe manufacturer must study the relations associated with power as a parameter of the principal behavior of the engine, after start-up as well as at increased regimes. The evolution of this same parameter of behavior (constant position of the lever) related to dynamic and thermal characteristics to which the engine is subjected must also be studied. After adjustment of the lever, the regulation system actually put into operation imperfectly controls this parameter of behavior, provoking a dispersion of these evolutions. For the next generation of engines, better performing regulators are proposed which should permit the improvement of performance and of the life of the engines.
Transl. by A.R.H.

N81-24079# Rolls-Royce Ltd., Derby (England).
DEVELOPMENT OF TEST REQUIREMENTS FOR CIVIL ENGINES
J. M. CUNDY *In* AGARD Turbine Engine Testing 16 p (SEE N81-24071 15-07) Jan. 1981
Avail: NTIS HC A21/MF A01

A typical modern testing program is described covering timescale, test hours, number of engines, and the different types of testing, such as performance, environmen[illegible] system, and mechanical testing. The effects on the progran[illegible]ar's with long lead times, and the requirements for separate [illegible]mponent testing are addressed. The testing conducted for ma[illegible]turer's purpose and that required by the certification author[illegible]re compared, both for complete engines and for separate c[illegible]nents and rigs. Typical test programs in altitude test facilit[illegible]d in flight are covered. Comparisons are drawn between m[illegible]grams and associated techniques, and those in the recen[illegible]ar T.M.

N81-24080# Pratt and Whitney Aircraft, West Palm Beach, Fla. Government Products Div.
DEVELOPMENT TEST REQUIREMENTS
J. B. FYTE and J. F. MONTGOMERY (AFAPL, Wright-Patterson AFB, Ohio) *In* AGARD Turbine Engine Testing 6 p (SEE N81-24071 15-07) Jan. 1981 refs
Avail: NTIS HC A21/MF A01

Propulsion system test requirements are established that are to provide an operationally acceptable propulsion system, and maintenance and logistic support plans which are appropriate to the usage requirements. Specific emphasis is given to the impact of changes in weapon system characteristics and usage on engine performance, operability, and life. The concept of baseline engine characteristics, including maintenance requirements based on evolving weapon system characteristics are also considered.
R.C.T.

N81-24081# General Electric Co., Cincinnati, Ohio. Aircraft Engine Business Group.
ENGINE LIFE DEVELOPMENT
B. BRIMELOW *In* AGARD Turbine Engine Testing 9 p (SEE N81-24071 15-07) Jan. 1981 refs
Avail: NTIS HC A21/MF A01

The various parameters effecting the rapid increase of operating and support costs of aircraft engine development are graphically illustrated. The range of conditions required for the aircraft to meet its mission requirements is defined. It is shown that failure to fully establish these requirements results in an inadequate test program followed by frequent engine/control removals because of adverse tolerances stack-ups of otherwise servicable components. It is further shown that given adequate definition of aircraft requirements, shop visits for operability problems can and should be targeted so that refurbishments can be carried out at the time when the engine is removed for replacement of a limited item. R.C.T.

N81-24082# Societe Nationale d'Etudes et de Construction de Moteurs d'Aviation, Moissy-Cramayel (France).
THE SPECIFICATION OF DEVELOPMENT TESTS FOR THE ENGINE OF A COMBAT AIRCRAFT [SPECIFICATION DES ESSAIS DE DEVELOPMENT POUR UN MOTEUR D'AVION DE COMBAT]
J. CARUEL *In* AGARD Turbine Engine Testing 9 p (SEE N81-24071 15-07) Jan. 1981 In FRENCH
Avail: NTIS HC A21/MF A01

The mating of SNECMA engines with Dassault Mirage airframes has given rise to a family of aircraft whose reputation is world wide. The ATAR 9C engine equips the Mirage 3, the ATAR 9K propels the Mirage 4 of the French Strategic Air Force, and the ATAR 9K50 engine is on the Mirage F1 and just recently on the

Mirage 50. Naturally the development of ATAR engines from 9C to 9K50 has been essentially in augmentation of power and PC, since they passed respectively from 4.4T to 5T and from 6.2T to 7.2T. The most recent version of Mirage aircraft, the 2000, as well as the prototype Mirage 4000 are equipped with a double flux M53 simple body engine. The method by which these two engines were developed are described. A.R.H.

N81-24083# AiResearch Mfg. Co., Phoenix, Ariz. Application Development Div.

DEVELOPMENT OF TEST REQUIREMENTS FOR CIVIL AND MILITARY AUXILIARY POWER UNITS

A. L. ROMANIN and S. J. BACZYNSKI *In* AGARD Turbine Engine Testing 26 p (SEE N81-24071 15-07) Jan. 1981
Avail: NTIS HC A21/MF A01

The history of the gas turbine auxiliary power unit (APU) is reviewed to indicate the wide variety of design and usage requirements that have evolved. Particular emphasis is given to the requirements of unattended automatic operation responsive to multiple, variable power demands. Development and proof testing programs for civil and military requirements are formulated as a function of specific user needs and the similarity of the APU and its components to proven designs. R.C.T.

N81-24084# Air France, Paris. Service des Etudes de Propulsion.

TURBINE ENGINE TESTS AS SEEN BY AN AIRCRAFT COMPANY [LES ESSAIS REATEURS VUS PAR UNE COMPAGNIE AERIENNE]

P. CHETAIL *In* AGARD Turbine Engine Testing 13 p (SEE N81-24071 15-07) Jan. 1981 refs In FRENCH
Avail: NTIS HC A21/MF A01

The need for conducting specific tests on turbine engines using ground test stands was felt not only after inspection, but also at the time of their installation in the aircraft and before their being placed in the shop for repair. Monitoring the performance degradation of engines in the course of service appears to be complementary and very desirable and should become possible by virtue of the semicontinuous recording of parameters on the aircraft, as well as by advanced performance analysis such as the GRA which, on the most recent type of civil turbines, permits more reliable evaluation of engine performance at the level of principal modules than is provided by classic methods. A.R.H.

N81-24085# Ministry of Defence, London (England). Directorate of Engine Development.

ENGINE IN-FLIGHT DATA COLLECTION AND ANALYSIS IN UNITED KINGDOM AIRCRAFT

M. F. HURRY and R. B. G. HEDGECOCK *In* AGARD Turbine Engine Testing 13 p (SEE N81-24071 15-07) Jan. 1981 refs
Avail: NTIS HC A21/MF A01

The scenario of aircraft engine data collection and analysis techniques in military aircraft is presented. A status review of the work in this area is provided and some of the more important factors which influenced the work on this subject are highlighted. R.C.T.

N81-24086*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

INVESTIGATION OF PERFORMANCE DETERIORATION OF THE CF6/JT9D HIGH BYPASS RATIO TURBOFAN ENGINES

J. A. ZIEMIANSKI *In* AGARD Turbine Engine Testing 14 p (SEE N81-24071 15-07) Jan. 1981 refs
Avail: NTIS HC A21/MF A01 CSCL 21E

The extent and magnitude of performance deterioration of the Pratt and Whitney JT9D, and the General Electric CF6 engine models is presented. Overall engine and contributing module performance deterioration with respect to flight cycles and/or time are analyzed. The overall engine performance deterioration analyses are based on data obtained from historical records, special engine tests, and tests for specific effects. Hardware inspection data from overhaul shops and special module tests are the basis for the modular performance deterioration data used in the analyses. Various damage mechanisms such as seal rubs, erosion, surface roughness and thermal distortion, and how they contribute to performance deterioration are included in the modular analyses. Results indicate that early performance deterioration occurring within the first few flights of these engines is less than 1 percent in cruise specific fuel consumption (SFC), that it is event oriented, and that it is the result of increased blade tip clearances. This performance deterioration gradually increases to about 2.5 to 3.0 percent (including the initial short term deterioration) after 2500 to 3000 flights where increased blade tip clearances, airfoil quality degradation, and thermal distortion are the contributing causes. R.C.T.

N81-24087# Societe Nationale d'Etudes et de Construction de Moteurs d'Aviation, Moissy-Cramayel (France).

DESIGN DEVELOPMENT, AND CERTIFICATION OF A CFN56 ENGINE: RESISTANCE TO THE INGESTION OF FOREIGN BODIES [CONCEPTION, DEVELOPPEMENT ET CERFIFICATION DU MOTEUR DFM56, RESISTANCE A L'INGESTION DES CORPS ETRANGERS]

In AGARD Turbine Engine Testing 7 p (SEE N81-24071 15-07) Jan. 1981 In FRENCH
Avail: NTIS HC A21/MF A01

The theoretical approach used to proportion the head vanes of a civil turbomachine was correlated with experimental results. The two fold objective was to satisfy requirements for international certification (FAA, JAR-E) and to establish comfortable margins of mechanical resistance in order to minimize the costs of corrective action, thus alleviating the maintenance expenses of user companies. The motor, the theoretical approach, and the results of certification are described. The tests constructed and continually used to affirm the theoretical results, and which led to the final definition of the CFM56 engine are described. A.R.H.

N81-24088# Pratt and Whitney Aircraft, West Palm Beach, Fla. Government Products Div.

DERIVATION AND CORRELATION OF ACCELERATED MISSION ENDURANCE TESTING

J. SAMMONS *In* AGARD Turbine Engine Testing 4 p (SEE N81-24071 15-07) Jan. 1981 refs
Avail: NTIS HC A21/MF A01

An approach to defining the Accelerated Mission Test (AMT) program as an integral part of the overall engine development process is discussed. This includes not only the initial cycle derivation but also the necessary revisions to the AMT cycles in order to more accurately predict and detect certain failure modes. The validity of the test results are also established. A comparison of AMT engine hardware, and operational engine hardware having equivalent cyclic history, is used for this purpose. As an illustration of the benefits of AMT engine testing, data on several gas turbine engines are presented. Also included in the discussion are the various types of failure modes that are currently not detectable in the AMT type program. R.C.T.

N81-24089# National Gas Turbine Establishment, Farnborough (England). Engine Test Dept.

FREE-JET TESTING OF POWERPLANTS FOR AIRCRAFT AND MISSILES

P. F. ASHWOOD and P. D. PHIL *In* AGARD Turbine Engine Testing 24 p (SEE N81-24071 15-07) Jan. 1981 refs
Avail: NTIS HC A21/MF A01

The free-jet test facilities available at the National Gas Turbine Establishment for testing complete aircraft propulsion systems (the air intake, engine, and exhaust system) at conditions reproducing those encountered during flight are described. Supersonic and subsonic flight conditions can be simulated, both steady state and transient; the latter aspect including the effects of time-variant changes in aircraft flight speed, attitude, and engine power. The scope of free-jet testing is reviewed and compared with what can be achieved using direct-connect facilities. Subsonic free-jet tests made under the extreme conditions encountered in an icing cloud are discussed. The tests are designed to determine the effectiveness of intake and engine anti-icing equipment and the ability of the powerplant to operate satisfactorily following the shedding of ice that may have accreted on the inlet duct surfaces. M.G

N81-24090# ARO, Inc., Arnold Air Force Station, Tenn.
INLET-ENGINE COMPATABILITY TESTING TECHNIQUES IN GROUND TEST FACILITIES
J. T. TATE *In* AGARD Turbine Engine Testing 17 p (SEE N81-24071 15-07) AEDC Jan. 1981 refs
Avail: NTIS HC A21/MF A01

A review of the available techniques for the evaluation of turbine engine stability is presented. Recommended test matrix selection criteria, instrumentation and test equipment requirements, test procedures, and analysis techniques are discussed with respect to turbine testing with three basic engine inlet environmental conditions: uniform, steady flow; steady-state distorted flow; and time-variant distorted flow. M.G.

N81-24091# National Research Council of Canada, Ottawa (Ontario). Engine Lab.
GAS TURBINE ENGINE TRANSIENT TESTING
D. M. RUDNITSKI *In* AGARD Turbine Engine Testing 15 p (SEE N81-24071 15-07) Jan. 1981
Avail: NTIS HC A21/MF A01

Methods for conducting extensive steady-state and transient-performance tests on J85-CAN-15 turbojet engines are discussed. In particular the instrumentation and techniques developed to monitor and record experimental data rapidly and accurately during rapid-transient engine operation are described. The technique provides report-quality time-plots and compressor operating lines immediately after test, thus permitting rapid assessments of engine performance. M.G.

N81-24092# General Electric Co., Lynn, Mass. Aeromechanics Group.
EXPERIMENTAL VERIFICATION OF TURBOBLADING AEROMECHANICS
V. M. CARDINALE, H. R. BANKHEAD, and R. A. MCKAY *In* AGARD Turbine Engine Testing 38 p (SEE N81-24071 15-07) Jan. 1981 refs
Avail: NTIS HC A21/MF A01

Experimental aeromechanical procedures are discussed and the process of valid design assessment, avoiding highly theoretical approaches and concepts is addressed. The procedures include methods used in design verification, pre-test preparation, and instrumentation. Examples are given of typical classes of vibratory behavior and their sensitivities to both engine-system variables and in-service and flight environment effects. It is illustrated that early systematic explorations of these variables are necessary to establish these sensitivities and provide adequate margins for long service life. M.G.

N81-24093# Rolls-Royce Ltd., Bristol (England). Test Operations Dept.
BENCH TESTING OF A VECTORED THRUST ENGINE
R. H. BLAKE *In* AGARD Turbine Engine Testing 15 p (SEE N81-24071 15-07) Jan. 1981
Avail: NTIS HC A21/MF A01

The history of plant development to accommodate the test program for the thrust vectored Pegasus engine is described, including the need for thrust vector measurement and exhaust gas collectors to allow nozzle swivelling without hot gas re-ingestion. The evaluation of plant effects on engine performance and the philosophy adopted for simplified production testing in the horizontal thrust mode only are described. M.G.

N81-24094# Messerschmitt-Boelkow-Blohm G.m.b.H., Ottobrunn (West Germany).
PERFORMANCE ASSESSMENT OF AN ADVANCED REHEATED TURBO FAN ENGINE
V. ZEIDLER *In* AGARD Turbine Engine Testing 22 p (SEE N81-24071 15-07) Jan. 1981 refs
Avail: NTIS HC A21/MF A01

Various approaches to determine thrust-in-flight and other appropriaters are discussed. It is noted that the degree of specialization or simplification of some methods points to the applicability; i.e., the quick estimation of actual take off thrust with regard to safety aspects in case of single engine climb-out, requires only a simple option, which produces acceptable results even if the engine is of lower instrumentation standard. On the other hand, for inflight thrust, engine performance assessment and aircraft drag analysis is calculated by an ambitious computer program using test data of engines with a higher instrumentation standard. The influence of altitude test facility testing on the accuracy is described. M.G.

N81-24095# Centre d'Essais en Vol, Istres (France).
FLIGHT TESTS OF THE ENGINES OF COMBAT AIRCRAFT: VALIDATION METHODS USED BY CEV [LES ESSAIS EN VOL DE MOTEURS D'AVIONS DE COMBAT, METHODS DE VALIDATION EMPLOYEES PARLE CEV]
In AGARD Turbine Engine Testing 6 p (SEE N81-24071 15-07) Jan. 1981 In FRENCH
Avail: NTIS HC A21/MF A01

Validation of series standard can be definitively obtained for the engines of combat aircraft only after flight tests. The validation tests used at CEV not only assure the good operation of motors in series under the most critical conditions of use, but also verify in flight their conformity with certain contractual and regulatory requirements. Influential parameters are listed, the conditions of use which must be the object of flight tests are inventoried, and the principles of the methods used are examined. These methods consist either of testing 'extreme' motors built with chosen or regulated elements each within tolerance limits, or by simulating the extreme configurations by appropriate control of the governors. Transl. by A.R.H.

N81-24096# Centre d'Essais des Propulseurs, Orsay (France).
TESTS OF LARGE COMPRESSORS AT CE PR [ESSAIS DE GRANDS COMPRESSEURS AU CENTRE D'ESSAIS DES PROPULSEURS]
P. RAMETTE and J. L. FRESON (Service Technique de la Production Aeronautique, Paris) *In* AGARD Turbine Engine Testing 8 p (SEE N81-24071 15-07) Jan. 1981 In FRENCH
Avail: NTIS HC A21/MF A01

The C3 test bench at CEPr permits testing large double flow compressors whose power can reach 40,000 kW. Methods used to obtain measurements on turning parts are described as well as probes for determining pressure, temperature, and vibration. Test techniques and the use of the computer to obtain the double flow compressor fields, particularly in proximity to the pump line are examined. Transl. by A.R.H.

N81-24097# Motoren- und Turbinen-Union Muenchen G.m.b.H. (West Germany).
FULL ANNULAR COMBUSTOR TEST FACILITY FOR HIGH PRESSURE/HIGH TEMPERATURE TESTING
G. KIRSCHEY and R. WAGNER (DFVLR, Cologne) *In* AGARD Turbine Engine Testing 17 p (SEE N81-24071 15-07) Jan. 1981 refs
Avail: NTIS HC A21/MF A01

A combustor test facility is described which is capable of carrying out annular combustor research with up to 16 bar and 820 K combustor inlet conditions. The requirements for typical test procedures for high pressure/high temperature combustor testing are established and the layouts for the test installations and the test bed are specified. The testing and measuring techniques to achieve accurate high temperature measurement and gas analysis at the exit of the annular combustor are described *in some detail. Results achieved by the testing show close similarity* to those produced by engine testing. M.G.

N81-24098# Fiat Aviazione S.p.A., Turin (Italy).
LOW PRESSURE TURBINE TESTING
F. RODI, M. VARETTI, and R. TOMAT *In* AGARD Turbine Engine Testing 13 p (SEE N81-24071 15-07) Jan. 1981 refs
Avail: NTIS HC A21/MF A01

The engine performance simulation model, the basis of all engine work, is used for a reliable assessment of marketable *performance for the prediction of the flight performance of the* aircraft, for the interpretation of the engine malfunctioning and then for a correct evaluation of the engine growth potential. The accuracy of the engine model is a function of the quality of the performance characteristics used for each component. In accordance with this concept within a turbofan development program, a comprehensive investigation on the low pressure turbine was carried out in order to define the component performance with the best possible accuracy. Different kinds of tests are performed, from bidimensional, rotating cascades and a cold flow rig test to in engine component testing. The advantages and the

intrinsic limits of each kind of test are discussed. Low pressure turbine theoretical prediction methods and a correlation between predictions and rig results are shown. Rig results are compared with the in engine ones measured with an appropriate instrumentation fitted on the engine. S.F.

N81-24099# Alfa Romeo S.p.A., Naples (Italy).
RIG INVESTIGATION OF A TWO STAGE SINGLE SHAFT LOW COST TURBINE
O. NATALE, C. SORRENTINO, and C. MASSARO *In* AGARD Turbine Engine Testing 15 p (SEE N81-24071 15-07) Jan. 1981 refs
Avail: NTIS HC A21/MF A01

The development program of a two stage, single shaft turbine is described. The program is based on tests performed in the single shaft two stage turbine configuration, the objective being the optimization of the off design performance, correct distribution of the first and second stage workload and harmonization of the nozzle throat areas. Tests were carried out or are planned to investigate the effect on the efficiency of the rotor tip clearance, Reynolds number effect and cooling flows. The analysis is compared with the predicted carpet of each stage individually and of the stages together. S.F.

N81-24100# Rolls-Royce Ltd., Derby (England). Mechanical Test Engineering Dept.
THE MECHANICAL TESTING OF COMPRESSORS AND TURBINES FOR AIRCRAFT GAS TURBINE ENGINES
D. NORRIS *In* AGARD Turbine Engine Testing 12 p (SEE N81-24071 15-07) Jan. 1981
Avail: NTIS HC A21/MF A01

Mechanical tests of major rotating components, whose failure is potentially catastrophic to an aircraft, are described in relation to proving and developing the mechanical strength of endurance of the piece. The principal tests, the techniques and some of the equipment which is employed for testing compressor and turbine components are described. The work relates to approximately ten different engine types, including the RB 211 family of engines, and to both civil and military applications. S.F.

N81-24101# Costruzioni Aeronautiche Giovanni Agusta S.p.A., Gallarate (Italy).
HELICOPTER TRANSMISSION QUALIFICATION PROCEDURES AND TESTS
A. GARAVAGLIA and G. GATTINONI *In* AGARD Turbine Engine Testing 10 p (SEE N81-24071 15-07) Jan. 1981
Avail: NTIS HC A21/MF A01

The tests required to qualify helicopter transmission in conformity with the current civil and military requirements, the tests to be conducted for initial development and prequalification as the tests essential to guarantee a satisfactory maturity of the product being released for service are detailed. The features of each test technique and their significance under the various phases of the program are described. The use of ground test vehicles and intensive flight testing are pointed out with particular emphasis. S.F.

N81-24102# Naval Air Propulsion Test Center, Trenton, N.J.
HELICOPTER TRANSMISSION TESTING
P. J. MANGIONE *In* AGARD Turbine Engine Testing 34 p (SEE N81-24071 15-07) Jan. 1981 refs
Avail: NTIS HC A21/MF A01

Helicopter propulsion system evaluation testing is conducted on individual components in the early stages of development. The total propulsion system is not operationally tested until the components are installed in the first aircraft. As such, dynamic interface problems are not detected until this stage of the full scale development program which proves costly. To achieve more development/reliability testing and more meaningful qualification tests of the total system, the Naval Air Propulsion Center, under Naval Air Systems Command sponsorship, developed the only indoor facility in the United States capable of testing a rotorless helicopter propulsion system. The test facility is described and the rationale and capability of an integrated, dynamic test stand for total system testing is presented. S.F.

N81-24103# Societe Microturbo, Toulouse (France).
DEVELOPMENT TESTS OF AN ENGINE WITH LIMITED LIFE [ESSAIS DE DEVELOPMENT DE MOTEUR A DUREE DE VIE LIMITEE]
In AGARD Turbine Engine Testing 7 p (SEE N81-24071 15-07) Jan. 1981 In FRENCH
Avail: NTIS HC A21/MF A01

A propulsion system with short engine life must have mass and surface thrust and a specific consumption while remaining simple in design to assure low production costs. To these qualitities are added ease of integration into the airframe (increased coefficient of distortion of the air inlet, concentrated equipment, simple general shape) and a firm hold in the face of environmental influences. Development and production qualification tests are very different from those performed on piloted aircraft engines. The prinicipal tests conducted on the MICRO-TURBO TRI 60 turbojet engine during four programs for adapting the engine to pilotless vehicles are presented. Possible solutions to obtain low production cost are indicated. Transl. by A.R.H.

N81-24104# Aeronautical Systems Div., Wright-Patterson AFB, Ohio.
PREDICTION OF FUTURE TEST NEEDS, TEST FACILITIES AND PROCEDURES
E. E. ABELL *In* AGARD Turbine Engine Testing 4 p (SEE N81-24071 15-07) Jan. 1981
Avail: NTIS HC A21/MF A01

The requirements for future military turbine engine testing reflect a more reasonable balance between the types of validation necessary to provide satisfactory operational weapon systems. In the past a large emphasis was placed on aerodynamic and thermodynamic aspects of the engine. Durability and reliability tended to be assigned lesser priority. This situation led to problems and failures of engines in operational service. A re-examination was conducted by the USAF of the type and methods associated with qualification of military gas turbine engines. During this examination it became evident that re-emphasis on the durability aspects of the engine was necessary. S.F.

N81-24105# Politecnico di Milano (Italy).
DEVELOPMENT FOR NEW LABORATORIES FOR FUTURE TESTING
C. CASCI *In* AGARD Turbine Engine Testing 28 p (SEE N81-24071 15-07) Jan. 1981 refs
Avail: NTIS HC A21/MF A01

Three fundamental characteristics of aerospace systems are weight, volume, and power. Considering the use of the propeller (military or civil), two other economic factors are taken into consideration: the lowest possible obsoleteness for military use and the lowest cost of utilization for civil use. Themes of theoretical and experimental research are: (1) about the components relative to only the energetic system: subsonic and supersonic combustion processes; traditional and nontraditional combustibles; interaction between the mechanical and combustible system; with combustion in axial fluxes and deviated fluxes: spark ignition; initial combustion and relative phenomena; transitory of the combustion; the combustion regime; (2) of the fluid-dynamic system components: isolated blades of the compressor and turbine with a small rapport in subsonic and supersonic fluxes; elevated load blades in subsonic and supersonic fluxes; annular formation of the compressor and turbine; and (3) electronically servo-assisted automation during the transitory phase of any process. S.F.

N81-27103# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
MICROCOMPUTER APPLICATIONS IN POWER AND PROPULSION SYSTEMS
Mar. 1981 156 p refs Lecture Ser. held in London, 2-3 Apr. 1981, Oberpfaffenhofen, West Germany, 6-7 Apr 1981, and Genoa, 9-10 Apr. 1981
(AGARD-LS-113; ISBN-92-835-1381-9; AD-A099267) Avail: NTIS HC A08/MF A01

Topics include microprocessor characteristics by manufacturer, memory characteristics, software HI and LO level language tradeoffs, and sensor and actuator interfacing. Control logic design methods, redundancy management, and a description of several current applications to engine control are also discussed. For individual titles, see N81-27104 through N81-27112.

N81-27104# Lucas Aerospace Ltd., Birmingham (England).
MICROPROCESSOR CHARACTERISTICS AND COMPARATIVE FEATURES
R. G. BURRAGE *In* AGARD Microcomputer Appl. in Power and Propulsion Systems 17 p (SEE N81-27103 18-07) Mar. 1981
Avail: NTIS HC A08/MF A01

A modern design of control for a gas turbine is used to introduce the concept of computer control. This shows the function of the microprocessor, which associated circuits are needed to complete the control, and the features of the microprocessor that suit it to control tasks. Many tasks other than control can be undertaken by microprocessors. These are discussed to establish which general features are of importance to propulsion systems. These features, plus the normal criteria applied to the procurement of any component, can be used as a guide to the selection of a microprocessor. Comparisons are made of different manufacturer's product using this approach. E.D.K.

N81-27105# Naval Air Propulsion Test Center, Trenton, N.J. Advanced Development Div.
THE PACKAGING OF ELECTRONIC ENGINE CONTROL UNITS AND RELATED SUBCOMPONENTS
R. W. VIZZINI *In* AGARD Microcomputer Appl. in Power and Propulsion Systems 34 p (SEE N81-27103 18-07) Mar. 1981 refs
Avail: NTIS HC A08/MF A01

The data evaluated in this study leads to the engine mounted electronic control system with a choice between two versions; air cooled and fuel cooled. When maintainability, reliability, survivability, vulnerability, safety and life cycle cost are considered, there is no clear choice between an air cooled engine mounted control and a fuel cooled engine mounted control. The air cooled version could be selected based on the slight survivability/vulnerability and safety benefits and the fuel cooled version on the basis of weight and cost benefits. Clearly the two systems are both acceptable and the final decision on configuration must be considered a designer's choice, driven by the overriding selection criteria for the particular aircraft. E.D.K.

N81-27106# Stanford Univ., Calif. Dept. of Aeronautics and Astronautics.
ALGORITHM DESIGN FOR DIGITAL FEEDBACK CONTROL SYSTEMS
J. D. POWELL *In* AGARD Microcomputer Appl. in Power and Propulsion Systems 13 p (SEE N81-27103 18-07) Mar. 1981 refs
Avail: NTIS HC A08/MF A01

The various design methods available to obtain control equations suitable for programming in the microprocessor are described. In order to analyze and compare the methods, the z-transform is discussed and the correspondence between the z and s planes established. There are two broad categories of design methods: (1) continuous design followed by a digitization and (2) direct design. The various digitization methods for the first design category are described and compared in terms of design ease and accuracy. The second category, direct digital design, is described and compared to the first category in terms of design ease and accuracy. Small word size effects and the basic issues in selecting the sample rate are addressed. E.D.K.

N81-27107# Pratt and Whitney Aircraft Group, West Palm Beach, Fla. Government Products Div.
PROPULSION CONTROL SYSTEM COMPUTER SOFTWARE DEVELOPMENT AND MANAGEMENT
R. J. MILLER and W. J. BARRETT *In* AGARD Microcomputer Appl. in Power and Propulsion Systems 12 p (SEE N81-27103 18-07) Mar. 1981 refs
Avail: NTIS HC A08/MF A01

An overview of the major software development requirements for an advanced propulsion control system is presented. The methodology described provides systematic design discipline and program visibility. As part of the software requirements preparation, a top-down process based on modular techniques was defined that results in functionally balanced partitioning of the operating program. The resulting software organization is easily comprehended. The combination of high level languages and fully matured support software provides an effective development tool as well as a means to document the system logic implementation. Strategically timed program reviews keep the development activities on schedule and major design issues in perspective. Configuration control and documentation procedures span the entire software life cycle. Finally, subsystem and engine tests assure that the software and hardware are compatible and that the system is ready for production release. E.D.K.

N81-27108# Smiths Industries Ltd., Basingstoke (England). Aerospace and Defence Systems.
MICROPROCESSOR SYSTEM TEST AND MONITORING
J. F. O. EVANS *In* AGARD Microcomputer Appl. in Power and Propulsion Systems 8 p (SEE N81-27103 18-07) Mar. 1981
Avail: NTIS HC A08/MF A01

Digital control systems for aircraft jet engines require extensive and careful development testing if they are to meet the rigorous performance and safety requirements of the engine and airframe manufacturers and air certification authorities. In order to achieve the level of testing required whilst minimizing expensive engine running hours, relatively sophisticated test procedures and equipment are required. These tests need to cover the system hardware, real time operating system software, and control software. The development of the required testing techniques and the current equipment and procedures are described. E.D.K.

N81-27109# Smiths Industries Ltd., Basingstoke (England). Aerospace and Defence Systems.
FAULT TREES AND SYSTEM RELIABILITY ANALYSIS WITH REFERENCE TO THE CONTROL OF AIRCRAFT ENGINES
J. F. O. EVANS *In* AGARD Microcomputer Appl. in Power and Propulsion Systems 16 p (SEE N81-27103 18-07) Mar. 1981 refs
Avail: NTIS HC A08/MF A01

Control systems for aircraft engines are very precisely and stringently specified with respect to performance and safety. At the same time there is a real need to minimize cost and weight and to improve reliability. These requirements may conflict unless the overall system organization is very carefully designed and proven. It is not possible to prove that the safety requirements were met within the acceptable confidence level by testing alone. Hence, testing needs to be backed up by safety analysis. Current engine control systems organizations, the related analysis techniques, such as fault trees, and some of the special difficulties associated with analyzing systems which include multitask processors are discussed. E.D.K.

N81-27110# Politecnico di Milano (Italy). Ist. di Elettrotecnica ed Elettronica.
FAULT TOLERANT SOFTWARE PROGRAMMING
V. AMOIA and M. SAMI *In* AGARD Microcomputer Appl. in Power and Propulsion Systems 11 p (SEE N81-27103 18-07) Mar. 1981 refs
Avail: NTIS HC A08/MF A01

The reliability of a control system equipped with a microprocessor is dependent both on safe operation of its hardware and on ability of its software to correctly implement the operations required. The two traditional approaches are discussed: fault tolerant and fault intolerant. Some significant examples of system fault tolerance implemented by software mechanism are included. Basic techniques for reliable software are presented. Validation and testing methodologies are outlined. Emphasis is given to the most recent fault tolerant approach. E.D.K.

N81-27111# Laboratoire d'Automatique et d'Analyse des Systemes, Toulouse (France).
DESIGN OF SECURE AND MODULAR MICROCOMPUTERS FOR ENGINE CONTROL
C. BEOUNES, J. C. LAPRIE, and J. M. COLLIN (SNECMA, Seresnes, France) *In* AGARD Microcomputer Appl. in Power and Propulsion Systems 22 p (SEE N81-27103 18-07) Mar. 1981 refs
Avail: NTIS HC A08/MF A01

The large scale integration circuits available provide designers with possibilities for the rational definition of digital automated devices integrated in the power plant control system. In designing these automated devices, the following factors must be taken into consideration: functional specification, operational specifications, especially those related to reliability and mission safety, and technological constraints imposed by adverse environments. A

systematic design methodology is summarized and some special purpose microcomputers for turbojet engine control are described. ● E.D.K.

N81-27112# Naval Air Propulsion Test Center, Trenton, N.J. Advanced Development Div.
FULL AUTHORITY DIGITAL ELECTRONIC CONTROL TURBOFAN ENGINE DEMONSTRATION
R. W. VIZZINI, T. G. LENOX (Pratt and Whitney Aircraft Group, East Hartford, Conn.), and R. J. MILLER (Pratt and Whitney Aircraft Group, West Palm Beach, Fla.) *In* AGARD Microcomputer Appl. in Power and Propulsion Systems 10 p (SEE N81-27103 18-07) Mar. 1981
Avail: NTIS HC A08/MF A01

The design, demonstration and evaluation of a Full Authority Digital Electronic Control (FADEC) capable of controlling an advanced variable cycle gas turbine engine in an advanced supersonic Navy fighter aircraft application is described. The FADEC design incorporates many advanced technology features including the latest microelectronics, extensive fault tolerance capability, and high speed digital communication using a fiber optic link. The advanced technology FADEC system was successfully demonstrated in a comprehensive test program, which included open loop environmental bench testing, closed loop bench testing, and testing on an F401 afterburning turbofan engine at sea level and at nine altitude conditions from 7000 to 50,000 ft, and at Mach numbers from 0.3 to 1.6. Over 7000 hr of electronic control operation were achieved during this program. Over 1100 hr of testing were achieved with the engine mounted control unit, which included over 68 hr of engine testing without a hardware malfunction. In addition to the advanced electronic circuitry employed in the FADEC, the first demonstration of optic communication with engine mounted equipment was achieved.
E.D.K.

N81-30133# Rolls-Royce Ltd., Derby (England).
PROGRAMMES FOR MILITARY ENGINES WITH COST OBJECTIVES
C. FOURE 1980 47 p Transl. into ENGLISH from French Conf. paper presented at AGARD Conf.
(PNR-90058; AGARD-LS-107; TRANS-15261) Avail: NTIS HC A03/MF A01

Management techniques for military aircraft engine design, production and maintenance referred to cost objectives are discussed. Life cycle cost, engine reliability, direct operating cost, purchasing cost, and the relationship between technical and cost objectives are examined. The techniques for cost forecasting are reviewed. The type of organization suited to follow both technical and cost objectives is analyzed. A maintenance method called Individually Repaired Subassemblies is detailed. The maintenance studies done for the Larzac aircraft fleet are presented. The spectrometric analysis of oil, particle analysis, vibration analysis, gammagraphy and endoscopy and maintenance techniques are also discussed. Author (ESA)

N82-17178# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine
THROUGH FLOW CALCULATIONS IN AXIAL TURBOMACHINES
C. HIRSCH, ed. (Vrije Universiteit, Brussels) and J. D. DENTON, ed. (Cambridge Univ.) Oct. 1981 330 p refs
(AGARD-AR-175; AD-A109292) Avail: NTIS HC A15/MF A01

The objectives were to review the existing information on blade performance and wall effect prediction, and to extend this information by systematic application of numerical methods to representative geometries. Only axial turbomachines were examined and they were split into a turbine sub-group and a compressor sub-group. Axial turbine performance predicted included an examination of the influence of correlations and computational procedures on the prediction of overall efficiency. A comprehensive survey of the various loss and deviation mechanisms was conducted for the compressor sub-group. For individual titles, see N82-17179 through N82-17202.

N82-17179# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
REVIEW OF PERFORMANCE PREDICTION METHODS
In its Through Flow Calculations in Axial Turbomachines p 13-28 (SEE N82-17178 08-07) Oct. 1981 refs
Avail: NTIS HC A15/MF A01

The methods are split into two major categories. The first category groups together the so-called overall stage methods. The use of such methods does not in general require any details of the blading and the complex flow patterns in the turbine are deliberately ignored. Turbines are treated more or less as black boxes. These methods are in general derived from overall performance measurements of a large number of turbines with similar characteristics. Their use is justified in the initial design phase for the selection of the turbine design parameters. The optimization of a turbine for a given duty requires, however, a deep understanding of the flow, and only very refined performance prediction methods, which take into account details of the blading and of the meridional flow channel, can be of real help. This is attempted by the second category of performance estimation methods which evaluate the total losses as the sum of a great number of individual loss components, each of which is influenced by a large number of geometric and aerodynamic parameters.
T.M.

N82-17180# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
INFLUENCE OF CORRELATIONS AND COMPUTATIONAL METHODS ON THE PREDICTION OF OVERALL EFFICIENCY
In its Through Flow Calculations in Axial Turbomachines p 29-31 (SEE N82-17178 08-07) Oct. 1981 refs
Avail: NTIS HC A15/MF A01

The process of designing a gas turbine or a steam turbine begins with an evaluation of the influence of component design parameters on the overall cost. For both the steam turbine and the gas turbine, energy costs are rapidly increasing and component efficiency is therefore a primary design objective. For the aircraft gas turbine, the weight of the component influences the fuel consumption and is therefore also an important energy cost consideration. Turbine efficiency predictions, together with information which influence the weight and cost, were obtained from flow field calculations which define the thermodynamic properties and velocity triangles throughout the turbine. These computational methods may be full span through flow calculations which predict the fluid properties from the hub to the tip between each blade row or they may be mean line calculations. In either case they are dependent upon loss and deviation models for their effectiveness in the efficiency optimizaton stage of the design process. The loss and deviation correlations which are in common use by steam turbine and gas turbine manufacturers are frequently developed internally and are maintained as proprietary information. The overall efficiency predictions which are discussed are therefore limited to results obtained using the correlations built into the methods which are described. T.M.

N82-17181# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
INFLUENCE OF CORRELATIONS AND COMPUTATIONAL PROCEDURES ON FLOW FIELD PREDICTIONS
In its Through Flow Calculations in Axial Turbomachines p 33-56 (SEE N82-17178 08-07) Oct. 1981 refs
Avail: NTIS HC A15/MF A01

In order to understand the influence of the empirical input on the results of through flow calculations it is necessary to examine the relative magnitudes of the terms in the radial equilibrium equation. This equation is effectively the momentum equation applied along quasi-orthogonal lines which are roughly perpendicular to the streamlines through the machine. The influences of the streamline slope and curvature, the blade exit, and the loss estimate were examined. The distribution of secondary deviation is discussed. Three dimensional calculations are presented for a two stage gas turbine. T.M.

N82-17182# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
CAMBRIDGE TURBINE: GEOMETRY, TEST DATA AND SAMPLE CALCULATION
In its Through Flow Calculations in Axial Turbomachines p 59-68 (SEE N82-17178 08-07) Oct. 1981 *refs*
Avail: NTIS HC A15/MF A01

The turbine is a free vortex design with hub:tip ratio 0.7 and with incompressible flow. Hence in the absence of viscous and secondary flow effects the axial velocity profiles would be everywhere uniform and constant. At design conditions there should be no absolute swirl at exit from the rotor and the experimental flow rate was set to satisfy this condition at mid-height. The turbine was tested with various values of rotor-stator spacing but only results for a single build were used for comparison with calculations. This build has a larger stator-rotor gap than is usual in axial turbine design practice. Details of the machine and blading are given and all geometrical details are based on design rather than on measured data. T.M.

N82-17183# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
THE TWO STAGE AERO ENGINE TURBINE
In its Through Flow Calculations in Axial Turbomachines p 69-83 (SEE N82-17178 08-07) Oct. 1981 *refs*
Avail: NTIS HC A15/MF A01

The turbine was a model of the H.P. and I.P. stages of an aircraft gas turbine with the two rotors running at different speeds. It was 'cold flow' tested using air at 420 K and 2.95 bar. Both hot wire and pressure probe instrumentation was used with radial and circumferential traverses after each blade row. The throughflow program used to provide sample results is based on a method of solution for axisymmetric and steady flow in axial turbomachines; it solves the complete radial equilibrium equation - acounting for enthalpy and entropy gradients and streamline curvature effects - in a specified number of stations ahead of and after the blade rows. An orthogonal curvilinear system of coordinates, having the meridional coordinates coincident with the generatrices of the flow stream surfaces, is used in the solution. Overall predicted efficiency is 89.1% of the measured results. T.M.

N82-17184# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
ANSALDO STEAM TURBINE. GEOMETRY, TEST DATA AND SAMPLE CALCULATION
In its Through Flow Calculations in Axial Turbomachines p 85-98 (SEE N82-17178 08-07) Oct. 1981 *refs*
Avail: NTIS HC A15/MF A01

The turbine geometry is fairly typical of large low pressure 3000 RPM machines, having 6 stages with a very high casing flare to accommodate the large increase of volume flow. This results in very high blade speeds and pressure ratios for the last stage. The Ansaldo machine has a last stage pressure ratio of over 6:1 which, coupled with a low hub:tip radius ratio, results in very high relative Mach numbers at nozzle root and rotor tip. The layout of the turbine is shown and full geometric details of stage 3-6 are given. Details of steam conditions, bleed flow rates and blade clearances are also given. A complete set of all measurements necessary to obtain a heat balance for the turbine were performed in parallel with the traverse measurements. These consisted of 42 pressure, 67 temperature and 6 mass flow measuring devices. The overall electrical output was also monitored and the LP cylinder output was measured by means of a shaft torquemeter and telemetry. These measurements enabled the LP cylinder efficiency to be evaluated separately from that of the whole turbine. Comparisons of measured and computed results are shown. The agreement is good and similar results were obtained from other calculation methods on this machine. T.M.

N82-17185# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
HANNOVER TURBINE. GEOMETRY, TEST DATA AND SAMPLE CALCULATION
In its Through Flow Calculations in Axial Turbomachines p 99-107 (SEE N82-17178 08-07) Oct. 1981 refs
Avail: NTIS HC A15/MF A01

The facility was basically laid out for a four-stage turbine which was designed to have the same blade sections in all stages at a given radius. The blading is of the free vortex type and the nominal mass flow of the turbines is m = 7.8kg/s and the nominal rotational speed is 7500 RPM. The set up allows each stage of the four-stage turbine to be tested separately. The tests referred to are concerned only with stage No. 4 which was tested in the single-stage mode. Details of the meridional flow path are presented. The turbine has a constant hub diameter of DH = 270 mm. The outer casing is cylindrical except across the blading where it is conical. The rotor has extremely small radial clearances: S = 0.24. mm at nominal RPM. The stator is shrouded and the leakage flow across the stator hub is minimized by multiple seals. Predicted efficiency is compared with the measured results. T.M.

N82-17186# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
SURVEY ON DIFFUSION FACTORS AND PROFILE LOSSES
In its Through Flow Calculations in Axial Turbomachines p 115-126 (SEE N82-17178 08-07) Oct. 1981 refs
Avail: NTIS HC A15/MF A01

Emphasis is placed upon the development of stage and blade design procedure that will replace the simple loss prediction techniques in use today. These techniques are difficult to apply to real machine design because extensive iterative hub-to-tip, blade-to-blade, and boundary-layer flow calculation is needed. Parametric studies with blade-to-blade flow and boundary layer calculation codes were examined which attempt to refine the diffusion factor concept and loss correlation at design as well as off-design compressor operation. The codes begin to demonstrate how the flow parameters (including Mach- and Re-number) and the details of blade geometry interact to produce performance characteristics. T.M.

N82-17187# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
SURVEY OF MODELS FOR SHOCK AND SHOCK/BOUNDARY LAYER INTERACTION LOSS PREDICTION
In its Through Flow Calculations in Axial Turbomachines 127-136 (SEE N82-17178 08-07) Oct. 1981 refs
Avail: NTIS HC A15/MF A01

The calculation of the shock losses has to take into account the losses due to normal shocks as well as the additional losses caused by the shock/boundary layer interaction. Due to the very complex flow behavior, at present this is only possible by empirical correlations for very simplified assumptions. Therefore, additional effort has to be directed to the practical application of analytical methods and to better understanding of the shock/ boundary layer interaction. Basically, transonic cascades have to be designed in such a way that the shocks are not present or occur at minimum shock Mach number. It seems to be possible that for high subsonic inlet Mach numbers the use of new blading design concepts (i.e., supercritical profiles) can meet the first condition, whereas the second condition of minimal shock Mach numbers was successfully verified by the use of wedge type profiles. T.M.

N82-17188# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
END-WALL BOUNDARY LAYER CALCULATION METHODS
In its Through Flow Calculations in Axial Turbomachines p 137-150 (SEE N82-17178 08-07) Oct. 1981 refs
Avail: NTIS HC A15/MF A01

The end-wall boundary layer (EWBL) approach to secondary losses is based on the integration of the pitch-averaged three-dimensional boundary layers along the hub and tip walls, with extra assumptions for the blade force defect terms. From there an efficiency drop is calculated including secondary flow effects, as well as blockage. The method allows in principle for the influence of inlet blockage, clearance, axial gap, aspect ratio and other parameters to be included through their effect on the end-wall boundary layers. From the knowledge of the velocity profiles inside the boundary layers, the full radial variations of incidence and turning can be predicted by coupling a radial equilibrium calculation to the EWBL calculation. T.M.

N82-17189# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
CORRELATION FOR SECONDARY FLOWS AND CLEARANCE EFFECTS
In its Through Flow Calculations in Axial Turbomachines p 151-165 (SEE N82-17178 08-07) Oct. 1981 refs
Avail: NTIS HC A15/MF A01

It is concluded that correlations obtained from straight cascade data will at least provide correct trends for the effect of clearance in compressors. With cascade data, the effect of variation of blade circulation with span is not known. This will cause problems if spanwise distributed correction for losses and angle are to be considered. For turbine, it is well known that for secondary flow effect the loss level as obtained from cascade data may differ of an order of magnitude from the machine losses. This is linked most probably to the effect of relative motion when passing from nozzle to rotor or vice-versa. In compressors this effect tends to bring back the end-wall boundary layer to a more collateral state, and the difference might be somewhat less. T.M.

N82-17190# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
EFFECTS OF REYNOLDS NUMBER AND TURBULENCE LEVEL ON AXIAL CASCADE PERFORMANCE
In its Through Flow Calculations in Axial Turbomachines p 164-170 (SEE N82-17178 08-07) Oct. 1981 refs
Avail: NTIS HC A15/MF A01

A semiempirical theory was developed which will predict the behavior of the shear layer across a laminar separation bubble. The method is proposed for two dimensional incompressible flow and is applicable down to short bubble bursting. The method can be used to predict the length of the laminar bubble, the bursting Reynolds number, and the development of the shear layer through the separated region. As such, it is a practical method for calculating the profile losses of axial compressor and turbine cascade in the presence of laminar separation bubbles. It can also be used to predict the abrupt leading edge stall associated with thin airfoil sections. The predictions made by the method are compared with the available experimental data. T.M.

N82-17191# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
SURVEY ON THE EFFECT OF BLADE SURFACE ROUGHNESS ON COMPRESSOR PERFORMANCE
In its Through Flow Calculation in Axial Turbomachines p 171-180 (SEE N82-17178 08-07) Oct. 1981 refs
Avail: NTIS HC A15/MF A01

Analysis of limited experimental data reveals that critical roughness Reynolds number of compressor blades manufactured with typical present day methods as forging/etching and electrochemical machining are around 90 and therefore very close to sand type roughness if roughness height is based on the largest peaks. Modern high pressure ratio engines suffer from blade surface roughness in the back stages of the compression system. Surface quality needed to keep the flow hydrodynamically smooth exceeds considerably the best present day quality achievable, thus limiting the potential efficiency gain at high Reynolds number flight conditions, i.e., essentially low level flight conditions. L.F.M.

N82-17192# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
PART SPAN DAMPER LOSS PREDICTION FOR TRANSONIC AXIAL FAN ROTORS
In its Through Flow Calculations in Axial Turbomachines p 181-183 (SEE N82-17178 08-07) Oct. 1981 refs
Avail: NTIS HC A15/MF A01

For off design conditions, the maximum loss due to the damper and region of influence at design point are calculated and these values are used as reference quantities for all off design calculations. The point of intersection of a constant throttle or area operating line through the design point with a speed line defines the reference point where the PSD loss is minimum. From this point the suction surface incidence at the damper location is determined from experimental data or off design analysis code. Then the damper maximum loss region of influence is calculated for any point on the speed line by taking the difference in suction surface incidence at that point and the reference incidence. To minimize damper loss, several things should be taken into consideration. Both approaches agree on the following: the damper should be as thin as possible so as to minimize the area influenced; the damper should be located as near to the hub as possible; work input should be minimized at the PSD location. Correlation of experimental results shows further that damper trailing and leading edge thickness should be as sharp as possible. L.F.M.

N82-17193# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
DEVIATION/TURNING ANGLE CORRELATIONS
In its Through Flow Calculations in Axial Turbomachines p 184-211 (SEE N82-17178 08-07) Oct. 1981 refs
Avail: NTIS HC A15/MF A01

In the past, compressor through flow solutions used substantial input from experimental measurements made in actual fan and compressor flow messages or in flows simulating real compressor conditions. For example, almost total reliance was placed on experimentally supported methods for estimation of fluid turning angles in individual blade rows. Compressor design is, as a result, heavily dependent on the quality of the experiment and data correlations associated with these methods. The three principal currently used prediction methods for flow turning angle were developed during the period 1945 to 1960. One of these methods directly predicts fluid turning angles in terms of cascade geometry and aerodynamic parameters. The others predict the exit flow deviation angle, defined as the angle between the average exit flow direction and the direction of a line tangent to the blade section camber line at the trailing edge. There has been no substantial modernization of these deviation/turning angle procedures since 1960, while during this time the methods have been widely applied to airfoil section profiles and in aerodynamic regimes far outside the limits suggested by the original derivations and data correlations. A discussion of these problems is presented. L.F.M.

N82-17194# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
AXIAL COMPRESSOR STALL AND SURGE
In its Through Flow Calculations in Axial Turbomachines p 212-213 (SEE N82-17178 08-07) Oct. 1981 refs
Avail: NTIS HC A15/MF A01

The so called surge line evaluation is an extremely complex area, which deserves in itself full attention. The intention here was only to define the problem. The existing methods of prediction do not take the real physics of the flow into account, and cannot explain or consider or identify all the parameters of importance. They are however quick and useful for the range in which they have been calibrated, but are mostly not available in public literature. A more generalized use of the pseudoend wall boundary layer approach seems interesting. Satisfactory solutions will come however only from the logical approach of instability detection, second flow regime and system response characterization, for which solid elements are now in hand but require further development. L.F.M.

N82-17195# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
SUMMARY OF ANSWERS TO THE QUESTIONNAIRE
In its Through Flow Calculations in Axial Turbomachines p 214-218 (SEE N82-17178 08-07) Oct. 1981 refs
Avail: NTIS HC A15/MF A01

To ascertain better the state of the art, a questionnaire bearing on particular points raised by the general survey paper of Hirsch was prepared and distributed to industry and research groups. Questions concerning compressor loss correlations, flow turning correlations, and secondary and clearance effects were asked. Answers were received from six countries and a summary is presented. L.F.M.

N82-17196# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
SINGLE STAGE TRANSONIC COMPRESSOR AND EQUIVALENT PLANE CASCADE
In its Through Flow Calculations in Axial Turbomachines p 221-228 (SEE N82-17178 08-07) Oct. 1981 refs
Avail: NTIS HC A15/MF A01

The working group 12 activities cover primarily turbomachinery off design performance prediction, however include also blade to

blade calculation on relevant test cases to get more information on those basic flow phenomena that affect flow losses and turning in blade rows. One of the test cases selected is the DFVLR single stage transonic compressor that was tested in great detail with the results well documented, particularly intrablade velocity data of the rotor are available from extensive flow studies with laser velocimetry. The data allow to compare blade to blade calculations to actual transonic compressor flow. Additionally to the rotor tests the rotor blade section at 45% span was investigated in the DFVLR transonic cascade windtunnel. L.F.

N82-17197# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
BBC/SULZER. 4 STAGE TRANSONIC COMPRESSOR
In its Through Flow Calculations in Axial Turbomachines p 229-244 (SEE N82-17178 08-07) Oct. 1981
Avail: NTIS HC A15/MF A01

Tests were performed on the BBC/SULZER 4 stage Transonic Compressor. The overall performance map and some traverse of stagnation pressure and temperature at compressor outlet are presented. L.F.M.

N82-17198# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
RESULTS OF CALCULATIONS
In its Through Flow Calculations in Axial Turbomachines p 245-246 (SEE N82-17178 08-07) Oct. 1981 refs
Avail: NTIS HC A15/MF A01

The types of calculations were performed by various participants, each using his own method for through flow calculations and blade to blade calculations. The Working Group's task was to demonstrate that the use of systematic blade to blade calculations could provide a support for the confirmation of an existing correlation or the development of a new one. It is believed that the present development and state of the numerical tools available in order to compute complex flow structures, should be used more and more extensively in order to develop a deeper understanding of the flow mechanism of loss production and of turning. L.F.M.

N82-17199# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
THE THROUGH FLOW CALCULATIONS
In its Through Flow Calculations in Axial Turbomachines p 247-268 (SEE N82-17178 08-07) Oct. 1981 refs
Avail: NTIS HC A15/MF A01

Through flow calculations of three test cases were performed by various authors belonging to industrial or research organizations. The four-stage transonic compressor, the two-stage compressor, and the single stage compressor are discussed. L.F.M.

N82-17200# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
EVALUATION OF PROFILE LOSS PREDICTIONS BASED ON DIFFUSION FACTORS
In its Through Flow Calculations in Axial Turbomachines p 269-280 (SEE N82-17178 08-07) Oct. 1981 refs
Avail: NTIS HC A15/MF A01

A comparison between theoretically predicted and measured profile losses was made, in order to evaluate the precision of the different prediction methods. These prediction methods are based on the relation between suction side diffusion and profile losses. The evaluation concerns as well the prediction of diffusion factor as predicted values of profile losses. It is further shown that these correlations are not universally valid for all blade shapes and that some correlations perform as well at design as at off design if the suction side diffusion is correctly predicted. Author

N82-17201# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
AXIAL-FLOW TURBOMACHINE THROUGH FLOW CALCULATION METHODS
In its Through Flow Calculations in Axial Turbomachines p 285-305 (SEE N82-17178 08-07) Oct. 1981 refs
Avail: NTIS HC A15/MF A01

Through flow calculation methods are considered to be computational techniques for prediction of fluid velocities and thermodynamic properties at designated locations in the internal flow path of a turbomachine. The objectives are to trace the development of several classes of through flow calculation, to suggest the importance of understanding the assumptions underlying representative examples of each class, and to outline the principal problems in application of through flow methods to current axial-flow compressors and turbines. L.F.M.

N82-17202# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
BLADE-TO-BLADE COMPUTATIONS AND BOUNDARY LAYER CORRECTIONS IN AXIAL COMPRESSORS AND TURBINES
In its Through Flow Calculations in Axial Turbomachines p 307-326 (SEE N82-17178 08-07) Oct. 1981 refs
Avail: NTIS HC A15/MF A01

The number of inviscid calculation methods available today is quite impressive, and they allow an accurate prediction of inviscid incompressible, subsonic compressible and transonic flow. Recent progress has also resulted in a remarkable decrease of required computational effort, which makes them even more attractive to industrial applications. However, as these methods do not account for viscosity, the field of application is quite restricted, and good predictions can be obtained only for flow configurations where viscous effects can be neglected (e.g., turbines and low loaded compressor cascades). A similar conclusion can be drawn about boundary layer methods, with a limitation on shock boundary layer interaction, where complete solutions still require a large amount of compeutational effort. The combination of these two types of calculations started quite recently, and a lot of progress can be expected in the near future. Improvements which can be expected from a better combination of these two types of calculations will be more important than an improvement in the inviscid calculations. Based on the present state of the art concerning shock boundary layer interaction calculations, it appears that integral or inverse methods are the best suited to industrial calculations. However, in view of the considerable efforts currently made towards the development of the Navier-Stokes equation solution, it is more likely that, in the near future, this method will lead to more reasonable computation times and permit practical applications. L.F.M.

N82-17203# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
HELICOPTER PROPULSION SYSTEMS
Sep. 1981 277 p refs Partly in ENGLISH, partly in FRENCH Meeting held in Toulouse, 11-14 May 1981
(AGARD-CP-302; ISBN-92-835-0299-X; AD-A108091) Avail: NTIS HC A13/MF A01

Component technology for turboshaft engines and transmissions, inlet protection systems, engine-airframe dynamic compatibility, and future requirements are described. For individual titles, see N82-17204 through N82-17225.

N82-17204# Textron Bell Helicopter, Fort Worth, Tex.
HELICOPTER PROPULSION SYSTEMS: PAST, PRESENT AND FUTURE
R. R. LYNN and G. E. HOLBROOK *In* AGARD Helicopter Propulsion Systems 12 p (SEE N82-17203 08-07) Sep. 1981 refs
Avail: NTIS HC A13/MF A01

Helicopter propulsion systems are reviewed, and it is noted that helicopter development is paced to a major extent by the power plant. Power available, reliability, fuel consumption, power-to-weight ratio, and life cycle costs are key parameters. The application of emerging technologies such as microelectronics, ceramics and other new materials and approaches, and the continuing refinement of the aerodynamics and dynamics of gas turbine power plants are discussed and noted to result in a significant benefit to the helicopter and its operator. Important airframe-propulsion system interface requirements are given, and the need is discussed for new innovative certification procedures that provide for emergency operation with acceptable economics. Finally, future propulsion system capabilities are projected and their dramatic benefit for the helicopter noted. Author

N82-17205# Societe Turbomeca, Bordes (France).
DEVELOPMENT TEST PROGRAMS ADAPTED TO HELICOPTER ENGINES [PROGRAMMES D'ESSAIS DE DEVELOPMENT ADAPTES AUX MOTEURS D'HELICOPTERES]
J. FRESCO *In* AGARD Helicopter Propulsion Systems 9 p (SEE N82-17203 08-07) Sep. 1981 In FRENCH
Avail: NTIS HC A13/MF A01

The path to follow in a general program of engine development is shown with constraints of various kinds. There are regulatory requirements established by laws of navigability for civil aviation engines, and particular technical specifications for military aviation engines. Requirements of an operational order happen to be juxtaposed to precedents which are set by the different types of usages envisioned: flight profiles of various missions, and the environmental conditions likely to be encountered. This second factor is particularly important for a helicopter turbine because of the different utilizations and environmental conditions compared to a jet or turboprop engine. To address all these requirements, a test program must be built which, among others, takes into consideration this group of sometimes contradictory constraints in order to obtain certification and as well as to bring about development and operation without major risk. Specific tests for a helicopter turbine are examined with emphasis on the MAKILA program turbine which is on the AS-332 super PUMA.
Transl. by A.R.H.

N82-17206# Army Aviation Research and Development Command, St. Louis, Mo.
AIRCRAFT TURBINE ENGINE DEVELOPMENT: CURRENT PRACTICES AND NEW PRIORITIES
C. C. CRAWFORD, JR. and W. J. CRAWFORD, III (GE, Lynn, Mass.) *In* AGARD Helicopter Propulsion Systems 8 p (SEE N82-17203 08-07) Sep. 1981
Avail: NTIS HC A13/MF A01

The T700 engine program was conducted during the 1970's and is representative of recent practices employed in the development of turboshaft engines for U.S. military application. The engine, which is in the 1,600 horsepower class, recently entered service in the twin engine U.S. Army UH-60A Black Hawk helicopter. The T700's field introduction follows an extensive program of technology demonstration, development, qualification and maturity. Requirements applied in the T700 program and associated benefits, challenges and penalties are surveyed. Suggested improvements for future programs are offered, and technology needs revealed during T700 development are identified. Post-qualification maturity testing, which was conducted to provide early exposure of high time failure modes, is described. Program features which are important for development costs payback are summarized. J.D.H.

N82-17207# Ministry of Defence, London (England). Directorate of Engine Technology.
FUTURE TECHNOLOGY AND REQUIREMENTS FOR HELICOPTER ENGINES
M. D. PARAMOUR and M. J. SAPSARD *In* AGARD Helicopter Propulsion Systems 12 p (SEE N82-17203 08-07) Sep. 1981 refs
Avail: NTIS HC A13/MF A01

The design considerations and technology needed to meet possible future operational requirements are discussed and the relevant technological work being carried out or supported by the UK Ministry of Defence (Procurement Executive) is described. Also considered are the tradeoffs which become necessary in seeking a suitable solution to conflicting needs. Finally the sizes of engines required to meet likely aircraft applications are examined. J.D.H.

N82-17208# Rolls-Royce Ltd., Leavesden (England).
MECHANICAL ADVANCES IN THE DESIGN OF SMALL TURBOSHAFT ENGINES
J. DOMINY and K. J. HART *In* AGARD Helicopter Propulsion Systems 12 p (SEE N82-17203 08-07) Sep. 1981
Avail: NTIS HC A13/MF A01

Mechanical components have a significant influence on the efficiency of a small gas turbine engine. Some of the performance losses associated with the design of the power transmission and internal air system are defined and discussed. Improvements in engine efficiency must be considered in conjunction with cost, reliability and size or weight. Many of the problems considered are applicable to gas turbines in general but become acute in small engines due to the adverse effects of scale on many components design parameters. To meet the increasing demand for more efficient powerplants the mechanical research engineer must improve the analysis of mechanical component behavior to produce optimized engine designs. Author

N82-17209# Motoren- und Turbinen-Union Muenchen G.m.b.H. (West Germany).
ADVANCED COMPONENT DEVELOPMENT DESIGN BASIS FOR NEXT GENERATION MEDIUM POWER HELICOPTER ENGINES
J. HOURMOUZIADIS and H. B. KREINER *In* AGARD Helicopter Propulsion Systems 13 p (SEE N82-17203 08-07) Sep. 1981 refs
Avail: NTIS HC A13/MF A01

Assuming an optimized thermodynamic cycle, engine components requiring intensive research and development efforts to produce a mature and reliable production engine are identified. Aerodynamic and structural data from rig and demonstrator test programs are presented. J.D.H.

N82-17210# Societe Turbomeca, Bordes (France).
THE INFLUENCE OF NEW TURBINE TECHNOLOGIES ON THEIR COMPONENTS [INFLUENCE DES NOUVELLES TECHNOLOGIES DES TURBINES SUR LEURS COMPOSANTS]
M. GIRAUD and H. LOUSTALET *In* AGARD Helicopter Propulsion Systems 11 p (SEE N82-17203 08-07) Sep. 1981 In FRENCH
Avail: NTIS HC A13/MF A01

The interdependence of the turbine engine with that of its components is considered as well as the objectives for developing future helicopter engines with average power. The classic design of an engine is used to show that a new architecture is required in order to reduce costs and increase reliability. The engine architecture has a strong impact on the technology and performance of its components and this places imposes on the designer new technologies for construction. High pressure turbines, reverse flow combustion chambers, and axial and centrifugal compressors are discussed. Transl. by A.R.H.

N82-17211# Avco Lycoming Div., Stratford, Conn. Preliminary Design and Advanced Programs.
AERODYNAMIC COMPONENTS FOR SMALL TURBOSHAFT ENGINES
J. W. SCHRADER and W. F. SCHNEIDER *In* AGARD Helicopter Propulsion Systems 15 p (SEE N82-17203 08-07) Sep. 1981
Avail: NTIS HC A13/MF A01

Future developments of advanced helicopter engines are projected from an aerothermodynamic viewpoint. Cycles for engines aiming at lower specific fuel consumption, improved power lapse rates, and implementation of contingency ratings are discussed. These cycles include nonregenerative and regenerative cycles. Design trends are presented for the major engine aerodynamic components. Author

N82-17212# Motoren- und Turbinen-Union Muenchen G.m.b.H. (West Germany).
REGENERATIVE HELICOPTER ENGINES: ADVANCES IN PERFORMANCE AND EXPECTED DEVELOPMENT PROBLEMS
H. GRIEB and W. KLUSSMANN *In* AGARD Helicopter Propulsion Systems 12 p (SEE N82-17203 08-07) Sep. 1981 refs Sponsored by Ministry of Defence of the Federal Republic of Germany
Avail: NTIS HC A13/MF A01

On the basis of modern engine component technology, including and emphasizing recent progress in high temperature heat exchanger technology, a conventional and a regenerative helicopter engine in the 900 kW power class are compared in design, performance and life cycle costs. The comparison shows that the installation properties of the two engines are roughly the same. The variable power turbine, being an indispensable part of a regenerative engine, leads to an extremely favorable transient behaviour with a moderate influence of severe cyclic loading on hot-part lifetime. No significant difference exists in infrared (IR) emission at part load, due to the design of the IR suppressor for the same exhaust temperature at maximum power. The life-cycle costs of a future fleet of attack helicopters equipped with regeneratived engines can be lower than with conventional engines. J.D.H.

07 AIRCRAFT PROPULSION AND POWER

N82-17213# Westland Helicopters Ltd., Hayes (England).
LUBRICATION BREAKDOWN BETWEEN GEAR TEETH
B. A. SHOTTER *In* AGARD Helicopter Propulsion Systems 11 p (SEE N82-17203 08-07) Sep. 1981
Avail: NTIS HC A13/MF A01

Damage to gear teeth attributable to lubrication failure is an important failure mode. Detailed observations of the early stages of breakdown suggest that one may not be dealing with a single process: hence great care is necessary when drawing conclusions from observing a damaged pair of gears. A study of a number of these critical areas and discussion about others highlights the complexity of the problem. J.D.H.

N82-17214# Sikorsky Aircraft, Stratford, Conn.
ADVANCED TRANSMISSION COMPONENT DEVELOPMENT
K. M. ROSEN and H. K. FRINT *In* AGARD Helicopter Propulsion Systems 17 p (SEE N82-17203 08-07) Sep. 1981 refs
Avail: NTIS HC A13/MF A01

Design innovations in helicopter gearbox development which permit high temperature operation at increased speeds without degrading strength or weight goals are discussed. One avenue of investigation, which shows promising strength or weight advantages, is high contact ratio gearing. The means taken to obtain a high contact ratio tends to produce an inherently weaker tooth and reliance must be placed on the multiple load-sharing feature of this design to achieve an advantage over low contact ratio gears. The appropriate consideration which must be addressed in the design stage to achieve optimum results is described. To provide high temperature capability, two UH-60A helicopter main transmission housings were fabricated from a stainless steel alloy to replace the conventional magnesium alloy casing. Design details and fabrication procedures are discussed. J.D.H.

N82-17215# Costruzioni Aeronautiche Giovanni Agusta S.p.A., Gallarate (Italy).
DESIGN CRITERIA OF THE A 129 HELICOPTER DRIVE SYSTEM
A. GARAVAGLIA and G. GATTINONI *In* AGARD Helicopter Propulsion Systems 11 p (SEE N82-17203 08-07) Sep. 1981
Avail: NTIS HC A13/MF A01

The design philosophy of the Agusta-A 129 drive system which is developed to meet the modern requirements for a light helicopter in the antitank role with night and day fighting capability are discussed. The stringent requirements of system layout and achieving low weight, high life, maximum reliability, survivability and ballistic tolerance, through integrated system design, modular concepts, use of redundant system and dry run capability are outlined. E.A.K.

N82-17216# Service Techniques des Programmes Aeronautiques, Paris (France).
HELICOPTER DEVELOPMENT IN FRANCE [LE DEVELOPPEMENT DES HELICOPTERES EN FRANCE]
D. BERTHAULT *In* AGARD Helicopter Propulsion Systems 9 p (SEE N82-17203 08-07) Sep. 1981 In FRENCH
Avail: NTIS HC A13/MF A01

For the French helicopter industry, the last two decades correspond to a period of rapid growth. The national armed forces were supplied with significant quantities of good quality military equipment well adapted to their operational objectives. Considerable successes were met in the sale for exploration of military helicopters as well as other machines for civilian use, which were developed by taking account of market requirements. These were often classed in a very favorable manner in relation to the products of competitors. The essential characteristics of helicopter development in France during this period are traced. The lines of direction and the modality of action taken by various public services in this regard are analyzed. By defining future needs and the centers of action, perspectives for the future are outlined. Transl. by A.R.H.

N82-17217# Societe Nationale Industrielle Aerospatiale, Marignane (France.)
HELICOPTER AIR INLETS [ENTREES D'AIR D'HELICOPTERES]
A. VUILLET *In* AGARD Helicopter Propulsion Systems 9 p (SEE N82-17203 08-07) Sep. 1981 refs In FRENCH
Avail: NTIS HC A13/MF A01

Because of engine architecture, air inlets on low and medium tonnage helicopters are located behind the rotor head, which makes feeding very difficult. This is particularly the case of the Ecureuil AS 350 and the Dauphin SA 365 which are equipped with new generation engines. These turbines have axial or annular intakes behind which the reductor is located beside either the blast pipe or the compressor. An indepth study of the air intakes from the project stage can permit their design with a minimum of unlucky repercussions on the power supplied by the engine, on the layer of the device, and on risks to pumping. For this reason, such a study is needed to reduce the delays and costs of operating such an intake in flight. Methods used at Aerospatial and results obtained on different devices are described. Transl. by A.R.H.

N82-17218# Westland Helicopters Ltd., Yeovil (England).
INTAKE DESIGN WITH PARTICULAR REFERENCE TO ICE PROTECTION AND PARTICLE SEPARATORS
P. A. H. BRAMMER and D. J. RABONE *In* AGARD Helicopter Propulsion Systems 13 p (SEE N82-17203 08-07) Sep. 1981 refs
Avail: NTIS HC A13/MF A01

Total environmental protection for helicopter engines is discussed. The problems associated with different environments and intake systems which are used to give protection against particular environments are outlined. Three intake systems for evaluation in natural environments are proposed. E.A.K.

N82-17219# Societe Nationale Industrielle Aerospatiale, Marignane (France.)
THE DISTRESS REGIME ON THE BIMOTORED HELICOPTER [REGIME DE DETRESSE SUR HELICOPTERE BIMOTEUR]
J. P. DEDIEU, M. RUSSIER, and H. DABBADIE (Societe Turbomeca, Bordes, France) *In* AGARD Helicopter Propulsion Systems 8 p (SEE N82-17203 08-07) Sep. 1981 refs In FRENCH
Avail: NTIS HC A13/MF A01

The trend toward bimotorization of civil and military helicopters raises the question of choice of power level for each engine in order to obtain acceptable performance in case of engine trouble, particularly at very low speed. The use of a distress regime to obtain a very high power level, for a short time, once in the life of an engine seems to be an interesting and promising approach. The relation between the levels of distress power and parameters related to the use of the helicopter, takeoff, mass, ceiling, and operating cost are considered for the case of a bimotored helicopter of average weight. The perspectives of homologization and the civil certification of such a regime on real technology engines are examined. Transl. by A.R.H.

N82-17220# Boeing Vertol Co., Philadelphia, Pa.
ENGINE/DRIVE/AIRFRAME COMPATIBILITY: A WAY OF LIFE
C. ALBRECHT *In* AGARD Helicopter Propulsion Systems 7 p (SEE N82-17203 08-07) Sep. 1981 refs
Avail: NTIS HC A13/MF A01

Engine/drive/airframe compatibility in development stages or during production of a new design were studied. Various compatibility encounters on Boeing Vertol helicopters, analyses, solutions as effected by current technology and engine/airframe manufacturer relationships and dynamic interface items are discussed. E.A.K.

N82-17221# Pisa Univ. (Italy). Ist. di Macchine.
PROBLEMS OF ENGINE RESPONSE DURING TRANSIENT MANEUVERS
D. DINI *In* AGARD Helicopter Propulsion Systems 14 p (SEE N82-17203 08-07) Sep. 1981 refs
Avail: NTIS HC A13/MF A01

Helicopter transition flight regime and extreme flight maneuvers which determine abrupt variation of the rotor drag torque during each revolution, and the corresponding effects on the engine are discussed. Repeated surging and the attendant transient torsional

loads from the engine cause damage to the airframe components. The angular rotor acceleration, cyclically variable, influences the turbine gas producer rotor speed, introducing flow distortions and aeromechanical effects in all the engine. It is found that periodic and inertial blade loading has serious consequences to discs and shaft to which the blades are attached. The higher harmonics of the excitation over the discs provokes relevant flexural modes of forced vibration. Operation in transient rating with pitch increase or decrease has the greatest effect on the helicopter flight performance, owing to the power application capability and the fuel control system adaptability. It is shown that to obtain sufficient engine/airframe dynamic compatibility, aircraft developments have to incorporate technical advances, which include harmonic integrated controls for propulsion and flight systems. E.A.K.

N82-17222# Societe Nationale Industrielle Aerospatiale, Marignane (France.) Helicopter Div.
HELICOPTER PROPULSIONS SYSTEMS. 1: VIBRATION PREVENTION SYSTEMS ON HELICOPTERS 2: PROBLEM OF NOISE IN THE CABIN
G. GENOUX and H. J. MARZE *In* AGARD Helicopter Propulsion Systems 19 p (SEE N82-17203 08-07) Sep. 1981 refs
Avail: NTIS HC A13/MF A01

Two different facets of the propulsion system/structure interaction are presented. The first interaction deals with low frequency vibration associated with the operation of the main rotor. These problems are either mechanical material fatigue and stressing or related to comfort. Implementation for reduction excitations and filtration of their transfer from the source to the cabin are described. The second interaction type is cabin noise associated with the operation of the reduction gear box. The vibratory energy generated at the gears propagates all the way to the passengers via the air and the structure. Cutting the intensity of transmission noise sources, the energy transfer between such sources and the structure and the energy radiation from the structure to the passengers is discussed. E.A.K.

N82-17223# Rolls-Royce Ltd., Leavesden (England).
AN ALTERNATIVE APPROACH TO ENGINEERING STRUCTURES USING MONITORING SYSTEMS
D. LEWIS *In* AGARD Helicopter Propulsion Systems 11 p (SEE N82-17203 08-07) Sep. 1981
Avail: NTIS HC A13/MF A01

The micro processor based engine monitoring system (EMS) which reevaluates the rating structure and presents limitations to the pilots is discussed. The EMS system allows the achievement of a better relationship between the demonstrated capability of the engine and the authorized release for in service use. This is a first step to be followed later by a change of the qualification test to a more representative form in which the EMS gives a more tangible link between bench test and customer operation. This allows better use of the engine to be made for the short time/high power requirements giving a more efficient engine performance at cruise conditions. E.A.K.

N82-17224*# *National Aeronautics and Space Administration.* Ames Research Center, Moffett Field, Calif.
COMPONENT RESEARCH FOR FUTURE PROPULSION SYSTEMS
C. L. WALKER (Army Propulsion Lab., Cleveland, Ohio), G. J. WEDEN (Army Propulsion Lab., Cleveland, Ohio), and J. ZUK *In* AGARD Helicopter Propulsion Systems 12 p (SEE N82-17203 08-07) Sep. 1981 refs
Avail: NTIS HC A13/MF A01 CSCL 21E

The factors affecting the helicopter market for the past, present, and future are reviewed. Acquisition cost, mission reliability, life cycle cost and civil and military aspects are reviewed. The potential for advanced vehicle configurations with substantial improvements in energy efficiency, operating economics, and characteristics to satisfy the demands of the future market are identified. Advanced propulsion systems required to support these vehicle configurations and the component technology for the engine systems are discussed. The selection of components in areas of economics and efficiency is considered. E.A.K.

N82-17225# Ministry of Defence, Bonn (West Germany).
FUTURE REQUIREMENTS FOR HELICOPTER PROPULSION SYSTEMS
H. G. BREE and G. BACKMANN *In* AGARD Helicopter Propulsion Systems 13 p (SEE N82-17203 08-07) Sep. 1981 refs
Avail: NTIS HC A13/MF A01

The measurements for single or twin engine systems are discussed. The trend to more sophisticated engines is reviewed in the light of diminishing resources of materials and fuel. Expected future economic conditions make it mandatory to counteract the increase of life cycle cost experienced in most of today's military systems. Means to reduce LCC are discussed. E.A.K.

N83-11138# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
***FLUID DYNAMICS PANEL SYMPOSIUM ON AERODYNAMICS OF POWER PLANT INSTALLATION* Technical Evaluation Report**
W. P. HENDERSON Jun. 1982 15 p Symp. held at Toulouse, 11-14 May 1981 Prepared in cooperation with NASA. Lewis Research Center
(AGARD-AR-173; ISBN-92-835-1436-2; AD-A119357) Avail: NTIS HC A02/MF A01

Powerplant installations involve complex flows, strongly influenced by viscous effects and often with important aerodynamic interactions between the airframe and propulsion system. The introduction of vehicle propulsion concepts, and points of emphasis in aircraft and missile design requirements, provide an expanding range of aerodynamic problems which cal for both experimental and theoretical study. Aerodynamic problems in powerplant installation are surveyed and work which has improved basic understanding or has enhanced prediction and design methods in this field is reviewed. Powerplant installation effects for both combat and transport aircraft are emphasized. S.L.

08

AIRCRAFT STABILITY AND CONTROL

Includes aircraft handling qualities; piloting; flight controls; and autopilots.

N80-23331# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
DESIGN, DEVELOPMENT AND IMPLEMENTATION OF AN ACTIVE CONTROL SYSTEM FOR LOAD ALLEVIATION FOR A COMMERCIAL TRANSPORT AIRPLANE
R. F. OCONNELL (Lockheed-California Co., Burbank) Feb. 1980 21 p refs Presented at the 49th Struct. and Mater. Panel Meetings, Porz-Wahnm, West Germany, Oct. 1979
(AGARD-R-683; ISBN-92-835-1348; AD-A082959) Avail: NTIS HC A02/MF A01

An active control system for load alleviation was developed for a long range version of the Lockheed L-1011. This system which permits the use of an extended wing span for fuel conservation with minimum structural change, will be introduced into commercial service in early 1980. The system is described and the criteria to which it is of the system installed on the flight test data obtained from a prototype version of the system installed on the flight airplane are presented, and comparsions of these results with analytical predictions are shown. A basis for certification of such systems is presented, assuring a level of safety equivalent to that of a conventional design. R.E.S.

N80-25347# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
TECHNICAL EVALUATION REPORT ON THE 54TH(A) PROPULSION AND ENERGETICS PANEL MEETING ON ADVANCED CONTROL SYSTEMS FOR AIRCRAFT POWERPLANTS
J. D. POWELL (Stanford Univ., Calif.) Mar. 1980 10 p refs See also AGARD-CP-279
(AGARD-AR-152; ISBN-92-835-1353-3; AD-A085462) Avail: NTIS HC A02/MF A01

A survey of the nineteen papers presented and of the discussions which followed each paper given at the meeting is presented as well as conclusions drawn at the Round Table Session. Topics covered include the use of analog electronics, hydromechanics, fluidics, and digital techniques with emphasis on sensors, actuators, redundancy and fault detection. A.R.H.

N80-26330# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
TECHNICAL EVALUATION REPORT ON THE FLUID DYNAMICS PANEL SYMPOSIUM ON AERODYNAMIC CHARACTERISTICS OF CONTROLS
H. H. B. M. THOMAS Mar. 1980 18 p refs
(AGARD-AR-157; ISBN-92-835-1351-7; AD-A085464) Avail: NTIS HC A02/MF A01

The different ways in which active control technology can impact aircraft design and tasks facing the aerodynamist are reviewed, including the effect of aircraft configuration on relaxed stability and the effect of control integration on aerodynamics. The correlation of flight and wind tunnel control effectiveness measurements is considered as well as difficulties in predicting transonic flow and attached flow. A.R.H.

N81-12115# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
REPORT ON A COOPERATIVE PROGRAMME ON ACTIVE FLUTTER SUPPRESSION
London Aug. 1980 55 p refs In ENGLISH and FRENCH Meeting held in Athens, Apr. 1980
(AGARD-R-689; ISBN-92-835-0270-2; AD-A090097) Avail: NTIS HC A04/MF A01

The results of a cooperative program on active flutter suppression on a dynamic model of the YF-17 aircraft are presented. Control laws for active flutter suppression were derived for one explosive wing-store flutter case of the model. Phase control laws were all tested and compared during wind tunnel tests performed in the Langley 16 ft wind tunnel. Results were quite promising and open the way for future cooperation on full-scale aircraft. For individual titles, see N81-12116 through N81-12119.

N81-12116*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
WIND TUNNEL TEST OF A FIGHTER AIRCRAFT WING/STORE FLUTTER SUPPRESSION SYSTEM: AN INTERNATIONAL EFFORT
C. HWANG, E. H. JOHNSON, G. R. MILLS, T. E. NOLL, and M. G. FARMER *In* AGARD Rept. on a Coop. Programme on Active Flutter Suppression 23 p (SEE N81-12115 03-08) Aug. 1980 refs Prepared in cooperation with Northrop Corp., Hawthorne, Calif. and AFFDL, Wright-Patterson AFB, Ohio
Avail: NTIS HC A04/MF A01 CSCL 01C

A 30% scale, half span model of a lightweight fighter aircraft with an active wing/store flutter suppression system was tested in the NASA Langley Research Center sixteen foot transonic dynamics tunnel. The test featured a store configuration that was intentionally designed to exhibit a violent flutter condition. In addition to Northrop organized control laws, three European countries also contributed control laws to stabilize this condition. After the control laws were mechanized by Northrop, they were tested at the Langley facility. The model was tested up to 170% of the open loop flutter dynamic pressure in a number of cases, with the indication that a substantially greater improvement was achievable. Some special features of the test model are discussed and the design and implementation of the control laws as well as the test monitoring techniques and results are presented. R.C.T.

N81-12117# Messerschmidt-Boelkow G.m.b.H., Munich (West Germany). Airplane Div.
ACTIVE CONTROL OF AN EXPLOSIVE WING-STORE FLUTTER CASE
H. HONLINGER, O. SENSBURG, M. KUHN, and H. GODEL *In* AGARD Rept. on Coop. Programme on Active Flutter Suppression 8 p (SEE N81-12115 03-08) Aug. 1980 refs
Avail: NTIS HC A04/MF A01

Control laws were calculated, using optimal control theory, to suppress an explosive wing-store flutter case on a YF-17 dynamically scaled model. The trailing edge flap was used for flutter suppression because usually hydraulically driven ailerons are available in modern fighters. The design aim of 1.5 times the flutter dynamic pressure was demonstrated during the wind tunnel test. It is shown that no changes to the analytically developed control law were necessary in the test which proves that theory has well advanced during the last years. R.C.T.

N81-12118# Office National d'Etudes et de Recherches Aerospatiales, Leclerc (France).
TEST AND ANALYSES OF AN ACTIVE FLUTTER SUPPRESSION SYSTEM ON AN FFDL MODEL OF YF17
R. DESTUYNDER *In* AGARD Rept. on Coop. Programme on Active Flutter Suppression 8 p (SEE N81-12115 03-08) Aug. 1980 refs In FRENCH; ENGLISH summary
Avail: NTIS HC A04/MF A01

A flutter control law was calculated for a YF-17 model equipped with a store at the wingtip. The control law used stiffness injection on the wing by the help of the unsteady aerodynamic forces induced by a control surface. The leading edge control surface and only one accelerometer, located in the wing close to the nodal line of the pitching mode of the external store, were used. During the wind tunnel tests the nominal control law was used without considering the existing differences between eigen modes and frequencies introduced in the calculations and eigen modes and frequencies existing on the model itself when mounted in the wind tunnel. The control at constant Mach number M = 0.80, permitted to increase substantially the dynamic critical pressure and also to reduce considerably the explosivity of the flutter phenomenon. R.C.T.

N81-12119# British Aerospace Aircraft Group, Bristol (England).
WIND TUNNEL TESTS ON A FIGHTER AIRCRAFT WING/STORE FLUTTER SUPPRESSION SYSTEM: THE B.AE CONTROL LAW
M. R. TURNER *In* AGARD Rept. on Coop. Programme on Active Flutter Suppression 10 p (SEE N81-12115 03-08) Aug. 1980 refs
Avail: NTIS HC A04/MF A01

A B.Ae control law designed using analytical data was tested on a model of the YF-17 in the NASA Langley 16 foot wind tunnel and succeeded in meeting the requirement to increase the flutter dynamic pressure by 70% at M = 0.8. Because the store configuration chosen for these tests produced a flutter mechanism which was both hard and near to classical frequency coalescence, it was necessary to use a multiple output control law to achieve the stability margin objectives of + or - 60 deg and + or - 6dB. The B.Ae control law was designed using a novel procedure which provides these stability margins, uses minimum control surface movement in turbulence and can be designed using either analytical or empirical data. Two wing tip accelerometers and a leading edge control surface were used. Empirical open loop transfer functions obtained during the test showed that the analytical data overestimated the response of the flutter mode to leading edge control surface excitation. R.C.T.

N82-10048# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
MULTI-VARIABLE ANALYSIS AND DESIGN TECHNIQUES
Sep. 1981 168 p refs Presented at a Lecture Series held at Ankara, 28-29 Sep. 1981, Bolkesjo, Norway, 1-2 Oct. 1981, and Delft, The Netherlands, 5-6 Oct. 1981
(AGARD-LS-117; AD-A105973) Avail: NTIS HC A08/MF A01

The basic theories and concepts involved in the design of advanced guidance and control systems employing state-space and multi-variable design methods are explained. The main topics reviewed include: (1) analysis and synthesis techniques; (2) application of observer and estimation principles; (3) computer-aided design and analysis methods; (4) system simulation

techniques; and (5) tests evaluation and validation. For individual titles, see N82-10049 through N82-10058.

N82-10049# Honeywell, Inc., Minneapolis, Minn. Systems and Research Center.
THE NEED FOR MULTIVARIABLE DESIGN AND ANALYSIS TECHNIQUES
R. E. POPE *In* AGARD Multi-Variable Analysis and Design Tech. 10 p (SEE N82-10048 01-08) Sep. 1981
Avail: NTIS HC A08/MF A01

Demand for higher accuracy, improved reliability/survivability, and more automation are placing increased emphasis on the control function for successful operation of aircraft weapon systems. Modifications to airframe designs directed at increased maneuverability and reduced weight are placing stringent on flight control systems. Fly-by-wire systems, particularly digital systems, provide the flexibility to not only accommodate but influence airframe design modifications and led to the control configured vehicle (CCV) concept. These advances in air, vehicle design and flight control system implementation are overwhelming traditional design and analysis techniques. Stability and control design specification are inadequate in dealing with statistically unstable vehicles, multiple control loops and high dynamic coupling. Better control system design and analysis techniques are needed which address the multi-input closely coupled dynamic nature of today's and tomorrows aircraft weapon systems. A.R.H.

N82-10050# Cambridge Univ. (England). Dept. of Engineering.
CHARACTERISTIC AND PRINCIPAL GAINS AND PHASES AND THEIR USE AS MULTIVARIABLE CONTROL DESIGN TOOLS
A. G. J. MACFARLANE *In* AGARD Multi-Variable Analysis and Design Tech. 34 p (SEE N82-10048 01-08) Sep. 1981 refs
Avail: NTIS HC A08/MF A01

The key to the generalization of classical frequency-response design techniques to the multivariable case lies in the development of ways of suitably extending the concepts of gain and phase. It is shown how algebraic function theory can be used to generalise Nyquist diagram and Root-Locus diagram techniques for use with systems having many inputs and outputs. This is done in such a way that the main structural features of such diagrams can be related to state-space model parameters. The shortcomings of characteristic gains and phases (used in a generalised Nyquist approach) are then noted. An alternative way of introducing amplitude and phase information, via the polar decomposition of an operator, leads to the introduction of principal gains and principal phases. Their properties are examined and, in particular, it is shown how they may be used to characterise robustness. The use of these techniques for design purposes is discussed. A.R.H.

N82-10051# Honeywell Systems and Research Center, Minneapolis, Minn.
MULTIVARIABLE DESIGN TECHNIQUES BASED ON SINGULAR VALUE GENERALIZATIONS OF CLASSICAL CONTROL
J. C. DOYLE *In* AGARD Multi-Variable Analysis and Design Tech. 15 p (SEE N82-10048 01-08) Sep. 1981 refs
Avail: NTIS HC A08/MF A01

Singular value analysis was used to generalize the fundamental feedback ideas from classical single loop control theory to multiloop systems. The classical view of measuring the benefit of feedback in terms of desensitizing the system to plant variations and disturbances is discussed. Uncertainty is shown to play a critical role in determining the way in which feedback may be used. Certain singular value plots, called sigma-plots, are introduced as natural and effective generalizations of Bode gain plots and form the basic tools for analysis of multiloop feedback systems. These tools provide reliable means for assessing the stability margins, bandwidth, and desensitizing effects of multiloop feedback systems. Examples of a two input oscillator and control of the rotors of the CH-47 helicopter are given to illustrate the use of the sigma-plots and their interpretations. A.R.H.

N82-10052# Honeywell, Inc., Minneapolis, Minn. Systems and Research Center.
LIMITATIONS ON ACHIEVABLE PERFORMANCE OF MULTIVARIABLE FEEDBACK SYSTEMS
J. C. DOYLE *In* AGARD Multi-Variable Analysis and Design Tech. 9 p (SEE N82-10048 01-08) Sep. 1981 refs
Avail: NTIS HC A08/MF A01

The design tradeoffs that are the focus of classical single-loop theory were generalized to multiloop systems using singular value analysis techniques. The first tradeoff is algebraic between large loop gain for good sensitivity properties and small loop gain for stability margins. Another is the functional tradeoff improsed by the Bode gain/phase relations. These tradeoffs impose limitations on the achievable performance of any feedback design. The limitations caused by nonminimum phase zeros are also discussed. The problem of directionality in multiloop systems has no analog in single loop feedback systems is presented and analyzed. A.R.H.

N82-10053# Honeywell, Inc., Minneapolis, Minn. Systems and Research Center.
LQG-BASED MULTIVARIABLE DESIGN: FREQUENCY DOMAIN INTERPRETATION
G. STEIN *In* AGARD Multi-Variable Analysis and Design Tech. 9 p (SEE N82-10048 01-08) Sep. 1981 refs
Avail: NTIS HC A08/MF A01

The use of the Linear-Quadratic-Gaussian (LOG) methodology in designing feedback compensators which meet multivarible performance, stability, and stability robustness requirements expressed as singular value conditions in the frequency domain is demonstrated. A.R.H.

N82-10054# Honeywell, Inc., Minneapolis, Minn. Systems and Research Center.
LQG MULTIVARIABLE DESIGN TOOLS
G. STEIN and S. PRATT *In* AGARD Multi-Variable Analysis and Design Tech. 16 p (SEE N82-10048 01-08) Sep. 1981 refs
Avail: NTIS HC A08/MF A01

The basic design algorithms needed for frequency domain oriented Linear-Quadratic-Gaussian feedback design are described and experimental interactive computer aided design package through which these algorithms can be effectively acessed is introduced. The algorithms and design package are illustrated with several flight control design examples for highly maneuverable aircraft. A.R.H.

N82-10055# Groningen Rijksuniversiteit (Netherlands). Mathematics Inst.
DESIGN OF HIGH INTEGRITY MULTIVARIABLE CONTROL SYSTEMS
J. C. WILLIAMS *In* AGARD Multi-Variable Analysis and Design Tech. 10 p (SEE N82-10048 01-08) Sep. 1981 refs
Avail: NTIS HC A08/MF A01

The notions of (almost) controlled and conditionally invariant subspaces of linear systems are explained and their application to the synthesis of feedback compensators for disturbance rejection and to robust controller is outlined. The disturbance rejection and the robust controller design problems are viewed as a procedure for designing a high integrity feedback control system. A.R.H.

N82-10056# Toronto Univ. (Ontario). Systems Control Group.
A GEOMETRIC APPROACH TO MULTIVARIABLE CONTROL SYSTEM SYNTHESIS
W. M. WONHAM *In* AGARD Multi-Variable Analysis and Design Tech. 21 p (SEE N82-10048 01-08) Sep. 1981 refs
Avail: NTIS HC A08/MF A01

Multivariable control is discussed with emphasis on Multivariable Control: fundamentals, disturbance decoupling and output stabilization, controllability subspaces, noninteracting control, and regulation and tracking in linear systems and structurally stable nonlinear regulation with step inputs. A vers. of the internal model principle for controlled sequential machine is included. A.R.H.

N82-10057# McGill Univ., Montreal (Quebec). Dept. of Electrical Engineering.
MULTIVARIABLES DESIGN: THE OPTIMIZATION OF APPROXIMATE INVERSES
G. ZAMES *In* AGARD Multi-Variable Analysis and Design Tech. 6 p (SEE N82-10048 01-08) Sep. 1981 refs
Avail: NTIS HC A08/MF A01

A mathematical framework for the analysis of sensitivity in multi-input-multi-output linear feedback systems is proposed, based on the concepts of a multiplicative seminorm and an approximate inverse. Many of the empirical results of classical control theory pertaining to the use of lead-lag networks can be deduced in this framework as solutions to well-posed mathematical optimization problems. Moreover, new classes of optimal filters for the reduction of sensitivity are introduced. A definition of optimal sensitivity to plant uncertainty is established. The multiplicative property of seminorms is used to obtain the following principle: for any specified aposteriori accuracy, there is a maximum of apriori plant uncertainty that can be tolerated, and a minimum of identification that is required. *Author*

N82-10058# McGill Univ., Montreal (Quebec). Dept. of Electrical Engineering.
FEEDBACK AND MINIMAX SENSITIVITY
G. ZAMES and B. A. FRANCIS (Waterloo Univ.) *In* AGARD *Multi-Variable Analysis and Design Tech. 8 p (SEE N82-10048* 01-08) Sep. 1981 refs Sponsored in part by National Science and Engineering Research Council of Canada
(Contract NSF ECS-80-12565)
Avail: NTIS HC A08/MF A01

Feedbacks that minimize the sensitivity function of a linear, single variable feedback system represented by its frequency responses were considered. Sensitivity is measured in a weighted H (infinity) norm. The single variable cases are studied. The results are extended to unstable plants, and explicit formulas for the general situation of a finite number of RHP plant zeros or poles are provided. The Q or 'approximate-inverse' parameterization of feedbacks that maintain closed-loop stability is extended to the case of unstable plants. The H (infinity) and Wiener-Hopf approaches are compared. A.R.H.

N82-11073# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). Guidance and Control Panel.
THEORY AND APPLICATIONS OF OPTIMAL CONTROL IN AEROSPACE SYSTEMS
P. KANT, ed. (National Aerospace Lab., Emmeloord, Netherlands) London Jul. 1981 283 p refs
(AGARD-AG-251; ISBN-92-835-1391-6; AD-A106937) Avail: NTIS HC A13/MF A01

The basic concepts of control theory were reviewed. Pratical design techniques that were developed from the theory are presented. Design examples and practical applications in real systems are described. Major emphasis is on flight control of distributed parameter systems. For individual titles, see N82-11074 through N82-11087.

N82-11074# Stanford Univ., Calif. Dept. of Aeronautics and Astronautics.
AN OVERVIEW OF OPTIMAL CONTROL IN AEROSPACE SYSTEMS
A. E. BRYSON, JR. *In* AGARD Theory and Appl. of Optimal Control in Aerospace Systems 5 p (SEE N82-11073 02-08) Jul. 1981 refs
Avail: NTIS HC A13/MF A01

Optimal control started with the calculus of variations (COV). The digital computer made the calculus of variations a practical tool for synthesis of optimal control logic. Optimal control concepts and algorithms are used not only in the field of automatic control but also in fields of structural optmization, econometrics, and operations research T.M.

N82-11075# Universite Catholique de Louvain (Belgium).
THEORY OF STOCHASTIC OPTIMAL CONTROL SOME BASIC NOTIONS
In AGARD Theory and Appl. of Optimal Control in Aerospace Systems 19 p (SEE N82-11073 02-08) Jul. 1981 refs
Avail: NTIS HC A13/MF A01

The optimal control problem for stochastic systems is described in details. Several classes of policy are defined and compared. *The corresponding solutions are deduced from Bellman's principle* and discussed in connection with the concept of dual effect of the control. After the derivation of the optimal closed-loop solution for the linear quadratic gaussian problem, several algorithms are proposed for the nonlinear problem and discussed in the perspective of their implementation in aerospace applications. T.M.

N82-11076# Princeton Univ., N. J. Flight Research Lab.
AN INTRODUCTION TO STOCHASIC OPTIMAL CONTROL THEORY
In AGARD Theory and Appl. of Optimal Control in Aerospace Systems 33 p (SEE N82-11073 02-08) Jul. 1981 refs
Avail: NTIS HC A13/MF A01

The design of control logic that commands a dynamic system to a desired output or that augments the system's stability is facilitated if objectives are expressed in a quantitative criterion, because the optimization of this criterion establishes a feasible design point for control. If the information which the control logic must use is uncertain or if the dynamic system is forced by random disturbances, only the expected value can be optimized. The methodology for design is based upon stochastic optimal control theory. After introducing the dynamic models of interest, optimal control and estimation are presented separately. Limitations of this approach are addressed, and the unified design of linear stochastic optimal controllers for analog and digital implementations is described. The principal benefit of stochastic optimal control theory is that it provides an engineering framework within which practical control design can be accomplished for complex dynamic systems. T.M.

N82-11077# Royal Aircraft Establishment, Farnborough (England). Flight Systems Dept.
DESIGN CONSIDERATIONS FOR OPTIMAL FLIGHT CONTROL SYSTEMS
F. R. GILL *In* AGARD Theory and Appl. of Optimal Control in Aerospace Systems 21 p (SEE N82-11073 02-08) Jul. 1981 refs
Avail: NTIS HC A13/MF A01

Following a review of the several interacting factors affecting the design of control laws for any kind of flight control system (FCS), the modelling problem is discussed, including accuracy requirements for computer models of the aircraft, FCS, external disturbances and sensor noise. The state-of-the-art in designing the control and scheduling laws is surveyed and the limits of conventional control techniques are exposed. To overcome these limits, the use of selected nonlinear control techniques is discussed, including the concept of redundant adaptation with safeguards. T.M.

N82-11078*# Honeywell Systems and Research Center, Minneapolis, Minn. Systems and Control Technology Sect.
DESIGN TECHNIQUES FOR MUTLIVARIABLE FLIGHT CONTROL SYSTEMS
In AGARD Theory and Appl. of Optimal Control in Aerospace Systems 33 p (SEE N82-11073 02-08) Jul. 1981 refs
(Contract NAS4-2518; N00014-75-C-01444)
Avail: NTIS HC A13/MF A01 CSCL 01C

Techniques which address the multi-input closely coupled nature of advanced flight control applications and digital implementation issues are described and illustrated through flight control examples. The techniques described seek to exploit the advantages of traditional techniques in treating conventional feedback control design specifications and the simplicity of modern approaches for multivariable control system design. T.M.

N82-11079# Bodenseewerk Geraetetechnik G.m.b.H., Ueberlingen (West Germany).
PRACTICAL DESIGN AND REALIZATION OF A DIGITAL ADAPTIVE FLIGHT CONTROL SYSTEM
V. KREBS and U. HARTMANN *In* AGARD Theory and Appl. of Optimal Control in Aerospace Systems 22 p (SEE N82-11073 02-08) Jul. 1981 refs Sponsored in part by the West German Ministry of Defense
Avail: NTIS HC A13/MF A01

A new approach for the design and the practical realization of a digital adaptive command and stability system is proposed. The control law for the longitudinal motion of the aircraft is obtained by state vector feedback using the MIL-F-8785 B handling qualities requirements. The design principle is based on decoupling of the angle of attack and pitch rate on the one hand and the pole allocation method for the eigenvalues of the control system on the other hand. Since the necessary gain factors contain unknown and variable aircraft parameters, an on-line fading-memory least squares algorithm for the estimation of these parameters is used. Only conventional aircraft sensors (rate gyros and accelerometers) and an airborne digital computer are necessary. Hybrid simulations of the complete system as well as flight test results demonstrate the efficiency of the concept. T.M.

N82-11080# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick (West Germany).
CONTROL LAW DESIGN FOR TRANSPORT AIRCRAFT FLIGHT TASKS
V. ADAM and H. LEYENDECKER *In* AGARD Theory and Appl. of Optimal Control in Aerospace Systems 13p (SEE N82-11073 02-08) Jul. 1981 refs
Avail: NTIS HC A13/MF A01

An integrated digital flight control system was developed. The primary objective of the program was, both to improve the manual control of the aircraft assisted by control systems, and to develop new control and display systems. In addition, automation is to be provided for loner flight phases which are to be optimized with respect to fuel consumption, flight time, or other criteria. Aspects of the control law design and flight test experience with the integrated digital flight control system are described. DOE

N82-11081# Purdue Univ., Lafayette, Ind. School of Aeronautics and Astronautics.
CONTROL DESIGN OF FLEXIBLE SPACECRAFT
R. E. SKELTON *In* AGARD Theory and Appl. of Optimal Control in Aerospace Systems 28 p (SEE N82-11073 02-08) Jul. 1981 refs
Avail: NTIS HC A13/MF A01

When compared to other large scale systems, flexible spacecraft have some peculiarities which can make control more difficult. Emphasis is placed upon the time domain and suboptimal linear quadratic guassian (LOG) methods, with special attention given to the effects of modeling errors. These effects are discussed in light of the model reduction problem, stability, and control design. Stability, controllability and observability computations are reduced to their simplest form possible to provide insight and to facilitate the location of sensors and actuators. The techniques of modal cost analysis are used to identify the critical parameters and the critical models of the structure. In the final stage of design, component cost analysis reveals which states of the optimal dynamical controller should be deleted to produce a reduced controller which is compatible with the on-line computer software limitations. T.M.

N82-11082*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
OPTIMUM CLIMB AND DESCENT TRAJECTORIES FOR AIRLINE MISSIONS
H. ERZBERGER *In* AGARD Theory and Appl. of Optimal Control in Aerospace Systems 15 p (SEE N82-11073 02-08) Jul. 1981 refs
Avail: NTIS HC A13/MF A01 CSCL 01C

The characteristics of optimum fixed-range trajectories whose structure is constrained to climb, steady cruise, and descent segments are derived by application of optimal control theory. The performance function consists of the sum of fuel and time costs, referred to as direct operating cost (DOC). The state variable is range to go and the independent variable is energy. In this formulation a cruise segment always occurs at the optimum cruise energy for sufficiently large range. At short ranges (400 n. mi. and less), a cruise segment may also occur below the optimum cruise energy. The existence of such a cruise segment depends primarily on the fuel flow vs thrust characteristics and on thrust constraints. If thrust is a free control variable along with airspeed, it is shown that such cruise segments will not generally occur. If thrust is constrained to some maximum value in climb and to some minimum in descent, such cruise segments generally will occur. T.M.

N82-11083*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
APPLICATION OF NONLINEAR SYSTEMS INVERSES TO AUTOMATIC FLIGHT CONTROL DESIGN: SYSTEM CONCEPTS AND FLIGHT EVALUATIONS
G. MEYER and L. CICOLANI *In* AGARD Theory and Appl. of Optimal Control in Aerospace Systems 29 p (SEE N82-11073 02-08) Jul. 1981 refs
Avail: NTIS HC A13/MF A01 CSCL 01C

A practical method for the design of automatic flight control systems for aircraft with complex characteristics and operational requirements, such as the powered lift STOL and V/STOL configurations, is presented. The method is effective for a large class of dynamic systems requiring multi-axis control which have highly coupled nonlinearities, redundant controls, and complex multidimensional operational envelopes. It exploits the concept of inverse dynamic systems, and an algorithm for the construction of inverse is given. A hierarchic structure for the total control logic with inverses is presented. The method is illustrated with an application to the Augmentor Wing Jet STOL Research Aircraft equipped with a digital flight control system. Results of flight evaluation of the control concept on this aircraft are presented. T.M.

N82-11084*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
MANAGEMENT OF REDUNDANCY IN FLIGHT CONTROL SYSTEMS USING OPTIMAL DECISION THEORY
In AGARD Theory and Appl. of Optimal Control in Aerospace Systems 12 p (SEE N82-11073 02-08) Jul. 1981 refs
Avail: NTIS HC A13/MF A01 CSCL 01C

The problem of using redundancy that exists between dissimilar systems in aircraft flight control is addressed. That is, using the redundancy that exists between a rate gyro and an accelerometer--devices that have dissimilar outputs which are related only through the dynamics of the aircraft motion. Management of this type of redundancy requires advanced logic so that the system can monitor failure status and can reconfigure itself in the event of one or more failures. An optimal decision theory was tutorially developed for the management of sensor redundancy and the theory is applied to two aircraft examples. The first example is the space shuttle and the second is a highly maneuvering high performance aircraft--the F8-C. The examples illustrate the redundancy management design process and the performance of the algorithms presented in failure detection and control law reconfiguration. T.M.

N82-11085# Massachusetts Inst. of Tech., Cambridge. Dept. of Aeronautics and Astronautics.
OPTIMAL CONTROL IN THE LUNAR MODULE DIGITAL AUTOPILOT
In AGARD Theory and Appl. of Optimal Control in Aerospace Systems 17 p (SEE N82-11073 02-08) Jul. 1981 refs
Avail: NTIS HC A13/MF A01

The Apollo lunar module (LM) digital autopilot was a first generation computer-based automatic control system. The use of a digital computer permitted the implementation of a controller structure and control algorithms that would have been difficult to synthesize using analog controller technology. Optimal control theory recommended a cascade synthesis for controller design: an observer or estimator of the state followed by memoryless control laws. This structure was utilized in the LM autopilot. The state estimator had some similarities to a Kalman filter, but the variable gains were chosen to minimize nonlinear measurement quantization effects. The memoryless reaction control system (RCS) laws employed parabolic switching curves as suggested by

minimum time/fuel control theory for a double integral plant.
T.M.

N82-11086# Analytic Sciences Corp., Reading, Mass.
APPLICATION OF OPTIMAL CONTROL TECHNIQUES TO TACTICAL MISSILE GUIDANCE
C. F. PRICE *In* AGARD Theory and Appl. of Optimal Control in Aerospace Systems 13 p (SEE N82-11073 02-08) Jul. 1981 refs
(Contract N00014-69-C-0391; F08635-77-C-0034)
Avail: NTIS HC A13/MF A01

A survey of applications reported in the literature is presented. Case studies were developed using several different linear-quadratic-gaussian formulations of stochastic optimal control problems. A new guidance law is presented which explicitly accounts for target parameter uncertainty. Simulation results and parameter sensitivity studies are presented which provide performance comparisons between the optimal guidance techniques and conventional proportional guidance. T.M.

N82-11087# Systems Control, Inc., Palo Alto, Calif.
DEVELOPMENT OF MULTIVARIABLE CONTROLLERS FOR AIRCRAFT TURBINE ENGINES
R. L. DEHOFF, S. M. ROCK, and M. M. AKHTER *In* AGARD Theory and Appl. of Optimal Control in Aerospace Systems 12 p (SEE N82-11073 02-08) Jul. 1981 refs
Avail: NTIS HC A13/MF A01

A model reference structure is discussed which is shown to be a flexible framework within which digital control programs of a wide variety of function and complexity can be formulated. The development of the plant reference model is discussed and trade-offs between accuracy and complexity presented. The techniques used to produce optimized, feed-forward state, control and output trajectories are presented. The well-known methods of regulator synthesis using quadratic performance functions are briefly reviewed and the results of several successful applications of this methodology are summarized. T.M.

N83-10054# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
CRITERIA FOR HANDLING QUALITIES OF MILITARY AIRCRAFT
Jun. 1982 317 p refs Symp. held in Fort Worth, Colo., 19-22 Apr. 1982
(AGARD-CP-333; ISBN-92-835-0313-8) Avail: NTIS HC A14/MF A01

The status of flying qualities criteria for CTOL, V/STOL, and VTOL aircraft is reviewed and current and advanced flight control design techniques and handling quality requirements are examined with attention given to specifications for military aircraft. For individual titles, see N83-10055 through N83-10080.

N83-10055# Air Force Wright Aeronautical Labs., Wright-Patterson AFB, Ohio. Flight Dynamics Lab.
PRESENT STATUS OF FLYING QUALITIES CRITERIA FOR CONVENTIONAL AIRCRAFT
D. J. MOORHOUSE and R. J. WOODCOCK *In* AGARD Criteria for Handling Qualities of Mil. Aircraft 14 p (SEE N83-10054 01-08) Jun. 1982 refs
Avail: NTIS HC A14/MF A01

The development of the U.S. military flying qualities specification up to MIL-F-8785B, issued in 1969 is reviewed and significant criteria proposed in the late 1960s and 70s many are discussed. The equivalent system approach was chosen for MIL-F-8785C and is discussed at length. Future requirements and developments in flying qualities criteria are examined. A.R.H.

N83-10056# Naval Air Development Center, Warminster, Pa. Aircraft and Crew Systems Technology Directorate.
STATUS OF VTOL AND VSTOL FLYING QUALITIES CRITERIA DEVELOPMENT: WHERE ARE WE AND WHERE ARE WE GOING?
J. W. CLARK, JR. and K. W. GOLDSTEIN *In* AGARD Criteria for Handling Qualities of Mil. Aircraft 18 p (SEE N83-10054 01-08) Jun. 1982 refs
Avail: NTIS HC A14/MF A01 CSCL 01C

Over the past decade, a number of weaknesses and omissions were uncovered in the VSTOL and Helicopter Flying Qualities Specifications (MIL-F-83300 and MIL-H-8501A). Identification of these weaknesses spawned technology development in a number of areas. Both interim and final results in some of these areas, the status of existing data bases, and the future criteria development needs as perceived by the US Navy are presented. Specific areas addressed include: (1) information display and IMC (Instrument Meteorological Conditions) flight requirements; (2) criteria definition for highly augmented, multi-mode control schemes; (3) requirements unique to the small seaborne platform operational environment; and (4) requirements unique to varied rotor configurations. Both fixed-wing and rotary-wing criteria are considered. A.R.H.

N83-10057# McDonnell Aircraft Co., St. Louis, Mo.
EQUIVALENT SYSTEMS CRITERIA FOR HANDLING QUALITIES OF MILITARY AIRCRAFT
J. HODGKINSON *In* AGARD Criteria for Handling Qualities of Mil. Aircraft 11 p (SEE N83-10054 01-08) Jun. 1982 refs
Avail: NTIS HC A14/MF A01 CSCL 01C

Low order equivalent systems appear viable for mapping high order augmented systems into a lower dimensional form suitable for specifying flying qualities. Degrees of allowable mismatch between high and low order systems are defined in tentative new criteria. Alternative specification methods, such as the Neal-Smith method and the bandwidth method, are fundamentally similar to equivalent systems. Because the alternative methods involve mapping, they too exhibit mismatch. Author

N83-10058# British Aerospace Public Ltd. Co., Preston (England).
PILOTED HANDLING QUALITIES DESIGN CRITERIA FOR HIGH ORDER FLIGHT CONTROL SYSTEMS
J. C. GIBSON *In* AGARD Criteria for Handling Qualities of Mil. Aircraft 15 p (SEE N83-10054 01-08) Jun. 1982 refs
Avail: NTIS HC A14/MF A01

Several aircraft brought into service with 1970's utilize full authority fly-by-wire control systems. Such systems have not always reached their full potential to provide handling qualities superior to much simpler aircraft of the past. Sluggish response and pilot induced oscillations (PIO) in both pitch and roll axes typify the experience with a high proportion of FBW aircraft. The basic response characteristics of 'low order' aircraft (aircraft with insignificant control system dynamics) are reviewed and satisfactory ranges derived from in-flight experiments are presented. It is shown how 'high order' aircraft responses can be directly and simply related to "low order" requirements as expressed in MIL-F-8785. Several criteria are presented which permit adjustment of handling qualities for some specific tasks, including one assuring satisfactory control at touchdown. A.R.H.

N83-10059# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (West Germany). Aircraft Div.
GAIN AND PHASE MARGIN AS A BASIS OF LONGITUDINAL FLYING QUALITIES EVALUATION
W. ROEGER and H. BEH *In* AGARD Criteria for Handling Qualities of Mil. Aircraft 11 p (SEE N83-10054 01-08) Jun. 1982 refs
Avail: NTIS HC A14/MF A01

A criterion is presented that allows an evaluation of the longitudinal maneuvering characteristics of modern fighter aircraft. The required parameters are the 'gain margin' and the 'phase margin' of the frequency response characteristic of pitch attitude to control force. This criterion permits an evaluation of the dynamic characteristics as well as the steady-state and assumes that the pilot is always looking for a compromise between stability and response time. The criterion enables the estimation of PIO-tendencies, gives a survey about the influence of different parameters like time delay, lead time, natural frequency, damping ratio and the ratio of control force per normal load factor. The design of an advanced flight control system as an example illustrates the conformity of this criterion with MIL-F-8785.
Author

N83-10060# Avions Marcel Dassault-Breguet Aviation, Saint-Cloud (France). Dept. Dynamique du Vol.
FLY BY WIRE CONTROL: TOWARDS NEW NORMS FOR JUDGING FLIGHT QUALITIES. AN EXAMPLE: THE MIRAGE 2000 [LES COMMANDES DE VOL ELECTRIQUES: VERS DE NOUVELLES NORMES DE JUGEMENT DES QUALITES DE VOL. UN EXEMPLE: LE MIRAGE 2000]
P. L. MATHE *In* AGARD Criteria for Handling Qualities of Mil. Aircraft 6 p (SEE N83-10054 01-08) Jun. 1982 In FRENCH
Avail: NTIS HC A14/MF A01

Two fundamental objectives were met by selecting a strictly electric control system for the Mirage 2000 aircraft. The aircraft was made capable of flying in notably natural longitudinal instability conditions, and a significant step was taken in improving piloting qualities as compared with classical control methods. The direct and indirect advantages of suppressing the constraint of longitudinal stability in optimizing aerodynamics and in improving operational efficiency are examined. Transl. by A.R.H.

N83-10061# National Aerospace Lab., Amsterdam (Netherlands).
HANDLING QUALITIES OF TRANSPORTS WITH ADVANCED FLIGHT CONTROL SYSTEMS
H. A. MOOIJ and M. F. C. VANGOOL *In* AGARD Criteria for Handling Qualities of Mil. Aircraft 15 p (SEE N83-10054 01-08) Jun. 1982 refs Sponsored by Netherlands Agency for Aerospace Programs and Dept. of Civil Aviation
Avail: NTIS HC A14/MF A01

Adequate handling quality criteria applicable to system design as well as to airworthiness rule-making are required for the introduction of closed loop primary flight control systems when active control technology, particularly the relaxed static stability principle, is applied to future aircraft. Flight simulation and in-flight simulation using mathematical models of aircraft with rate command/attitude-hold primary flight control systems were performed for the approach and landing flight phase in order to generate data for criteria development. Configurations featuring in addition blended direct-lift control were evaluated as well. Based primarily on pilot ratings and commentary, boundaries between "satisfactory" and "acceptable" handling qualities (Cooper-Harper rating 3.5) were established for a number of criterion formats. While several criteria related to aircraft response are discussed for pitch and roll control, pilot-in-the-loop criteria are proposed for high-precision pitch attitude and altitude control tasks especially. A.R.H.

N83-10062# Dornier-Werke G.m.b.H., Friedrichshafen (West Germany).
HANDLING QUALITIES CRITERIA FOR LONGITUDINAL CONTROL
W. NEUHUBER, L. DIEDERICH, and K. BRAUSER *In* AGARD Criteria for Handling Qualities of Mil. Aircraft 15 p (SEE N83-10054 01-08) Jun. 1982 refs Prepared in cooperation with MBB, Munich
Avail: NTIS HC A14/MF A01

Current specifications (e.g. MIL-F-8785) are not fully aplicable for augmented airplanes (high order systems). Major shortcomings are due to unsuitable mathematical representation of criteria. In addition current criteria are not precise enough, both for augmented and unaugmented systems. Detrimental effects to flying qualities are discussed. Means to reduce these effects are proposed, including nonlinear methods. With respect to the pitch short period a criterion (based on MIL-F-8785 and others) is presented, which states a more precise relationship between the relevant parameters. When transformed into time history and frequency response, this criterion is applicable for any system. It is shown that Nichols-plots can be a useful tool for handling qualities evaluation. Optimal stick force gradient criteria are derived from a quasi-linear pilot-aircraft closed loop analysis. The closed loop characteristics are formulated by means of a bandpass filter frequency response function, the characteristics of which are defined by the equivalent aircraft and a precision pilot model frequency function. Author

N83-10063# Systems Technology, Inc., Hawthorne, Calif.
BANDWIDTH: A CRITERION FOR HIGHLY AUGMENTED AIRPLANES
R. H. HOH, D. G. MITCHELL, and J. HODGKINSON (McDonnell Aircraft Co., St. Louis) *In* AGARD Criteria for Handling Qualities of Mil. Aircraft 11 p (SEE N83-10054 01-08) Jun. 1982 refs (Contract F33615-78-C-3615; F33615-80-C-3604)
Avail: NTIS HC A14/MF A01

A criterion to discriminate between desirable, acceptable, and unacceptable handling qualities for highly augmented airplanes is presented. The criterion is based on an old and well accepted idea; namely, that bandwidth is a key measure of the quality of an airplane's handling characteristics in a tight tracking situation. Correlations are made using recent experimental data for pitch attitude control. Possible shortcomings of the criterion are also discussed. Author

N83-10064# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick (West Germany).
HANDLING QUALITIES ASPECTS OF CTOL AIRCRAFT WITH ADVANCED FLIGHT CONTROLS
D. HANKE, K. WILHELM, and H. H. LANGE *In* AGARD Criteria for Handling Qualities of Mil. Aircraft 17 p (SEE N83-10054 01-08) Jun. 1982 refs
Avail: NTIS HC A14/MF A01

The problems which occur in applying the existing MIL-F-8785C short period frequency requirements to DLC enhanced aircraft in flight path control situations are described. It is indicated that the MIL-Spec. boundaries are only pitch related and not applicable to path control problems. A new generalized flight path control criterion is processed which considers the multiloop landing approach situation characterized by the pitch inner loop and the altitude outer loop. The criterion philosophy is based on the frequency separation of the two control loops necessary for good handling characteristics. The flight path to pitch attitude phase at the frequency of pilot closed inner loop was selected as criterion parameter in representing the pitch/heave harmony or loop separation. This phase criterion is suitable for conventional or DLC enhanced aircraft. It is shown that by using a rate command/attitude hold system to augment pitch inner loop the pilot exhibits discrete control behavior and open loop type control techniques. RC/AH systems lead to very low pilot activity and, combined with DLC, flight path control is improved. E.A.K.

N83-10065# Army Research and Technology Labs., Moffett Field, Calif. Aeromechanics Lab.
THE STATUS OF MILITARY HELICOPTER HANDLING QUALITIES CRITERIA
D. L. KEY *In* AGARD Criteria for Handling Qualities of Mil. Aircraft 9 p (SEE N83-10054 01-08) Jun. 1982 refs
Avail: NTIS HC A14/MF A01

Current helicopter specifications were assessed. It is indicated that MIL-F-83300 has clear advantages in its broad coverage of important handling qualities aspects and its systematic structure. Its disadvantages are that it is primarily based on V/STOL data, and explicit helicopter characteristics are only lightly covered. The deficiencies resulted in a major effort to develop a new specification containing mission oriented handling qualities requirements. A revised specification for adoption as MIL-H-8501B is planned. E.A.K.

N83-10066# Giravions Dorand Co., Suresnes (France).
THE IMPACT OF ACTIVE CONTROL ON HELICOPTER HANDLING QUALITIES
M. KRETZ *In* AGARD Criteria for Handling Qualities of Mil. Aircraft 10 p (SEE N83-10054 01-08) Jun. 1982 refs In FRENCH and in ENGLISH
Avail: NTIS HC A14/MF A01

Changes have occurred in the concepts of controlling the working conditions of helicopter rotors. New trends, prompted by the techniques of active control applied to fixed wings, are oriented towards the automatic control of dynamic phenomena (vibration, instability) and aerodynamic phenomena (stall effects, interaction, gusting). The new trends feature frequency responses much wider than those of conventional autopilots, extending up to 30 Hz. Military helicopter design is much more demanding with regard to handling qualities: higher disk loading, NOE mission requirement, advent of advanced rotor aircraft concepts and a general

broadening of the flight envelope. The impact of active control on handling qualities and its benefits in their implementation are analyzed. It is concluded that present day control system limitations due to the use of monocyclic swashplate principles will have to be removed in the future by unconventional control systems based on multiloop self adaptive control resulting in higher order optimization of handling qualities. E.A.K.

N83-10067# Army Air Corps, Stockbridge (England).
OPERATIONAL CRITERIA FOR THE HANDLING QUALITIES OF COMBAT HELICOPTERS
W. STEWARD *In* AGARD Criteria for Handling Qualities of Mil. Aircraft 5 p (SEE N83-10054 01-08) Jun. 1982 refs
Avail: NTIS HC A14/MF A01

To minimize the threat from air and ground based weapon systems, combat helicopter operations require the use of concealed low level flight. The tasks facing the combat helicopter pilot during a typical antiarmor mission are discussed. Primary consideration is given to daylight operations in VMC, but the requirements for missions at night and in adverse weather, and for training are also addressed, together with the implications for handling qualities posed by the threat of armed helicopters in the air to air role. It is concluded that, by reducing the flying workload, assisting in the exploitation of maximum aircraft performance, and enhancing control accuracy, better handling qualities can contribute to improved operational effectiveness. E.A.K.

N83-10068# National Aeronautical Establishment, Ottawa (Ontario). Flight Research Lab.
FLIGHT EXPERIMENTS WITH INTEGRATED ISOMETRIC SIDE-ARM CONTROLLERS IN A VARIABLE STABILITY HELICOPTER
M. SINCLAIR *In* AGARD Criteria for Handling Qualities of Mil. Aircraft 9 p (SEE N83-10054 01-08) Jun. 1982 refs
Avail: NTIS HC A14/MF A01

The suitability of integrated, multiaxis, isometric controllers for use in helicopters were investigated. The 3 axis and 4 axis isometric side arm control configurations were flown successfully through a wide variety of demanding visual flight tasks and a brief instrument flight precision approach evaluation. The experimental tasks, the evaluated controller arrangements and the developed control laws are described, and the results of comparative assessments between isometric side arm control and conventional control arrangements are presented. E.A.K.

N83-10069# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (West Germany).
STABILITY AND CONTROL FOR HIGH ANGLE OF ATTACK MANEUVERING
W. KRAUS, H. PRZIBILLA, and U. HAUX *In* AGARD Criteria for Handling Qualities of Mil. Aircraft 11 p (SEE N83-10054 01-08) Jun. 1982 refs
Avail: NTIS HC A14/MF A01

The possibilities of maneuvering a fighter aircraft at and beyond maximum lift were examined. On a delta canard configuration an optimum division of control devices for maximum control power at high angle of attack is shown and a special trim schedule gives best directional and lateral stability in this flight regime. The aircraft configuration was used for an air to air combat simulation. The control system layout at high incidence included thrust vectoring in pitch and yaw to support the aerodynamic control surfaces. Simulation results in terms of rates and accelerations in pitch, roll and yaw axis for a set of different poststall maneuvers shown that the aircraft is controllable and that active tactical maneuvers can be flown in this flight region. E.A.K.

N83-10070# British Aerospace Public Ltd. Co., Preston (England).
EXPERIENCE OF NON-LINEAR HIGH INCIDENCE AERODYNAMIC CHARACTERISTICS
D. BOOKER and K. MCKAY *In* AGARD Criteria for Handling Qualities of Mil. Aircraft 5 p (SEE N83-10054 01-08) Jun. 1982 refs
Avail: NTIS HC A14/MF A01

The impact of aerodynamic nonlinearities on aircraft behavior at high angle of attack from both an analytical and a flight test experience viewpoint was considered. The form of some of these nonlinearities and their importance to the design of high incidence control systems is examined. Considerations for the design of future military aircraft for operation at high angle of attack are suggested. E.A.K.

N83-10071# Royal Aircraft Establishment, Farnborough (England). Aerodynamics Dept.
A COMPARISON OF ANALYTICAL TECHNIQUES FOR PREDICTING STABILITY BOUNDARIES FOR SOME TYPES OF AERODYNAMIC OR CROSS-COUPLING NONLINEARITIES
A. J. ROSS *In* AGARD Criteria for Handling Qualities of Mil. Aircraft 12 p (SEE N83-10054 01-08) Jun. 1982 refs
Avail: NTIS HC A14/MF A01

The need to predict stability boundaries for flight at high angles of attack and the possibility of using analytical techniques, rather than studying computed responses is discussed. Two analysis methods are described and compared, for particular forms of nonlinearities, and a relationship is established between nonlinear stability characteristics and linear stability boundaries in terms of the magnitudes of the response variables. The techniques are used to predict some of the flight characteristics likely to occur for a high incidence research model, which is tested to provide wind tunnel and free flight data for establishing mathematical models of aerodynamics at high angles of attack. E.A.K.

N83-10072# Calspan Advanced Technology Center, Buffalo, N.Y. Flight Research Dept.
EFFECT OF CONTROL SYSTEM DELAYS ON FIGHTER FLYING QUALITIES
R. E. SMITH and R. E. BAILEY *In* AGARD Criteria for Handling Qualities of Mil. Aircraft 16 p (SEE N83-10054 01-08) Jun. 1982 refs Sponsored by AFFDL
Avail: NTIS HC A14/MF A01

The significant effects of time delay on fighter flying qualities, both longitudinal and lateral was confirmed. The flying qualities problems of latest fighter aircraft are most often related to the time delay which is introduced into the flight control system by the advanced, typically complex, control system design. Data from inflight simulators demonstrate this point. Typical sources of flight control system time delay and the methods of time delay measurement are reviewed. The application of several candidate flying qualities evaluation criteria or requirements, which are applicable to highly augmented fighter aircraft, is discussed. E.A.K.

N83-10073# Royal Netherlands Air Force, The Hague.
EFFECT OF CONTROL SYSTEM DELAYS ON FIGHTER FLYING QUALITIES
J. T. BAKKER *In* AGARD Criteria for Handling Qualities of Mil. Aircraft 3 p (SEE N83-10054 01-08) Jun. 1982
Avail: NTIS HC A14/MF A01

The effect of head up display (HUD) time delays on power approach handling qualities of the F-16 are discussed. Delays of 30 ms for the flight path marker presentation and of up to 50 ms in angle of attack presentation are observed. The effects of this 80 ms delay of F-16 handling during the approach, landing, and landing roll-out are considered. Modifications of the flight control system to correct the problem of nose-rise during roll-out and problems in the take off and landing phases are described. J.D.

N83-10074# Societe Nationale Industrielle Aerospatiale, Toulouse (France).
AN EXAMPLE OF LONGITUDINAL AND TRANSVERSAL OSCILLATION COUPLING: THE EPSILON AIRCRAFT CORK SCREW
J. IRVOAS *In* AGARD Criteria for Handling Qualities of Mil. Aircraft 13 p (SEE N83-10054 01-08) Jun. 1982 refs
Avail: NTIS HC A14/MF A01

A design analysis of the prototype EPSILON trainer aircraft is presented. During test flights of the prototype aircraft a corkscrew oscillation, a combination of incidence oscillation and Dutch roll, was observed. Wind tunnel tests performed on models installed on a yaw-pitch head simulation by modeling with six degrees of freedom are described. A combined incidence oscillation and yawing criterion was derived. Determination of the structural causes of the corkscrew oscillation is described. Design modifications resulting from the design analysis were implemented, and successful flight tests of the preproduction aircraft performed. J.D

N83-10075# Honeywell Systems and Research Center, Minneapolis, Minn.
ADVANCED FLIGHT CONTROL DESIGN TECHNIQUES AND HANDLING QUALITY REQUIREMENTS
T. B. CUNNINGHAM and R. E. POPE *In* AGARD Criteria for Handling Qualities of Mil. Aircraft 13 p (SEE N83-10054 01-08) Jun. 1982 refs
(Contract N00014-75-C-0144; ET-78-C-01-3391)
Avail: NTIS HC A14/MF A01

The application of control analysis and synthesis techniques in the frequency domain to the analysis of multi-input system performance and stability characteristics is described. A bandwidth hypothesis criterion is applied to specify handling qualities of 6 degrees of freedom systems. The control perspective for multi-input, multi-output systems is described. The use of linear quadratic Gaussian (LQG) design techniques to meet frequency design goals is discussed. These techniques are applied to the design of a YF-4 (F-4 with horizontal canards). J.D.

N83-10076# Societe Nationale Industrielle Aerospatiale, Toulouse (France).
ANALYZING THE ROLE OF CLOSED LOOP SYSTEMS FOR A SUBSONIC AIRCRAFT WITH REDUCED LONGITUDINAL STABILITY [ANALYSE DU ROLE DES ASSERVISSEMENTS POUR UN AVION SUBSONIQUE A STABILITE LONGITUDINALE REDUITE]
F. IANNARELLI *In* AGARD Criteria for Handling Qualities of Mil. Aircraft 15 p (SEE N83-10054 01-08) Jun. 1982 In FRENCH
Avail: NTIS HC A14/MF A01

Introduced essentially to restore acceptable piloting qualities to centering in the rear, closed loop attitude control systems, thanks to their numerous possibilities, will finally by used to improve pilot comfort to the maximum. Both elementary closed loop systems (whose role is to modulate the position of fundamental points of the aircraft) and closed loop systems dictated by conditions (whose function is to assure the automatic trim of the aircraft or the maintenance of conditions) are discussed. These systems are adapted to an aircraft with reduced longitudinal stability such as the AIRBUS. Transl. by A.R.H.

N83-10077# Air Force Flight Test Center, Edwards AFB, Calif. Flight Test Technology Branch.
DEVELOPMENT OF HANDLING QUALITIES TESTING IN THE 70'S: A NEW DIRECTION
B. L. SCHOFIELD, T. R. TWISDALE, W. G. KITTO, and T. A. ASHURST *In* AGARD Criteria for Handling Qualities of Mil. Aircraft 16 p (SEE N83-10054 01-08) Jun. 1982 refs
Avail: NTIS HC A14/MF A01

An overview of the evolution of handling qualities testing at the Air Force Flight Test Center is presented, with emphasis on the significant changes which occurred during the 1970s. The System Identification and Tracking (SIFT) handling qualities test and evaluation techniques are discussed. Examples of SIFT test results are presented and discussed. J.D.

N83-10078# Bundesamt fuer Wehrtechnik und Beschaffung, Munich (West Germany).
EXPERIENCE WITH SYSTEM IDENTIFICATION FROM TRACKING (SIFT) FLIGHT-TEST-TECHNIQUES AT THE GERMAN AIR FORCE FLIGHT TEST CENTER
E. BUCHACKER *In* AGARD Criteria for Handling Qualities of Mil. Aircraft 22 p (SEE N83-10054 01-08) Jun. 1982 refs
Avail: NTIS HC A14/MF A01

Pilot induced oscillations (PIO) which occured mainly during landing approach of a medium size cargo helicopter with a suspended load were investigated using SIFT techniques. The flight test program which was set up to gain insight into the problem is briefly described. Data evaluation showed that a bad combination of eigenfrequencies from a suspended load and the helicopter caused a very poorly damped eigenmode. This mode could be excited by the pilot but was not controllable for a human being because of the frequency (approximately 11 rad/sec) involved. A good correlation between pilot comments and flight test data evaluation was found. Author

N83-10079*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
PREDICTION OF AIRCRAFT HANDLING QUALITIES USING ANALYTICAL MODELS OF THE HUMAN PILOT
R. A. HESS *In* AGARD Criteria for Handling Qualities of Mil. Aircraft 8 p (SEE N83-10054 01-08) Jun. 1982 refs Document also announced as N82-24208
Avail: NTIS HC A14/MF A01 CSCL 01C

The optimal control model (OCM) of the human pilot is applied to the study of aircraft handling qualities. Attention is focused primarily on longitudinal tasks. The modeling technique differs from previous applications of the OCM in that considerable effort is expended in simplifying the pilot/vehicle analysis. After briefly reviewing the OCM, a technique for modeling the pilot controlling higher order systems is introduced. Following this, a simple criterion for determining the susceptibility of an aircraft to pilot-induced oscillations (PIO) is formulated. Finally, a model-based metric for pilot rating prediction is discussed. The resulting modeling procedure provides a relatively simple, yet unified approach to the study of a variety of handling qualities problems. Author

N83-10080# Calspan Advanced Technology Center, Buffalo, N.Y. Flight Research Dept.
SIMULATION FOR PREDICTING FLYING QUALITIES
P. A. REYNOLDS *In* AGARD Criteria for Handling Qualities of Mil. Aircraft 11 p (SEE N83-10054 01-08) Jun. 1982 refs
Avail: NTIS HC A14/MF A01

The role of in-flight simulation in predicting and reproducing flying qualities is discussed. Reliable flying qualities predictions can be difficult. Measuring workload is technically challenging. There are psychological and political pressures on the evaluation pilot. The variety of dynamics and the number of parameters involved in airplane flying qualities are large. The tasks are frequently difficult to accurately simulate on the ground. Examples from several airplane development programs are presented to illustrate some of the faulty predictions that have been made with ground simulators. These examples provide flying qualities situations that can be used for more formal comparisons of ground simulation with in-flight simulation and for developing general hypotheses which could then be tested. Modern in-flight simulation capability is discussed emphasizing model-following accuracy, model complexity, and special effects such as artificial crosswinds, turbulence, and ground effects. Cost effectiveness is addressed. A role complementary to ground simulation is seen for in-flight simulation. The improvement of simulation planning by performing these formal experiments to define the predictive value of various ground simulator features such as large motion and high-quality visual cues is suggested. Author

N83-17555# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
CRITERIA FOR HANDLING QUALITIES OF MILITARY AIRCRAFT
R. J. WOODCOCK (AFWAL, Wright-Patterson AFB, Ohio) Oct. 1982 22 p refs
(AGARD-AR-186; ISBN-92-835-1437-8) Avail: NTIS HC A02/MF A01

Criteria for handling qualities of military aircraft are discuss d. Various aspects of this technology are considered: including equivalent systems, high order flight systems, gain and phase margin as a basis of longitudinal flying qualities, etc. S.L.

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.

N80-23338# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
COMPARATIVE MEASUREMENTS IN FOUR EUROPEAN WIND TUNNELS OF THE UNSTEADY PRESSURES ON AN OSCILLATING MODEL
N. LAMBOURNE (Royal Aircraft Establishment, Bedford, England), R. DESTUYNDER (ONERA, Paris), K. KIENAPPEL, and R. ROOS Feb. 1980 50 p refs Presented at the 49th Struct. and Mater. Panel Meeting, Porz-Wahn, West Germany, Oct. 1979
(AGARD-R-673; ISBN-92-835-1346-0; AD-A082958) Avail: NTIS HC A03/MF A01

The effects of the walls of a wind tunnel on the behavior of dynamic models used for flutter certification of aircraft were investigated. Tests were completed in four European wind tunnels and the results were analyzed. The results and conclusions are summarized. R.E.S.

N80-31412# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
THE USE OF SIMULATORS FOR TRAINING IN-FLIGHT AND EMERGENCY PROCEDURES
E. E. EDDOWES (Air Force Human Resources Lab., Williams AFB, Arizona) and W. L. WAAG (Air Force Human Resources Lab., Williams AFB, Arizona) Jun. 1980 39 p refs
(AGARD-AG-248; ISBN-92-835-1363-0; AD-A087578) Avail: NTIS HC A03/MF A01

The nature of pilot skills is examined and a strategy for using flight simulators to acquire and maintain such skills is suggested. Salient characteristics of state-of-the-art simulators and the visual display system capabilities they provide for training contact flying tasks are described. Research on transfer of learning from simulator to aircraft in a variety of training tasks is reviewed. The use of simulators as aircraft substitutes and their integration within an array of ground training media are compared and contrasted to illustrate the cost effectiveness potential of these two approaches. The rationale for and the characteristics of a simulator oriented emergency procedures training program which emphasizes pilot decision making skills are presented. The development of aircrew performance measurement systems for use in evaluating, refining, and documenting simulator training effectiveness is reported. An interpretation of the impact of current developments on the future use of simulators is offered and a list of conclusions provided. E.D.K.

N81-11048# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
CRYOGENIC WIND TUNNELS
Jul. 1980 271 p refs Lecture series held in Rhode-Saint-Genese, Belgium, 19-23 May 1980 and in Hampton, Va., 27-30 May 1980
(AGARD-LS-111; ISBN-92-835-1360-6; AD-A089050) Avail: NTIS HC A12/MF A01

The advantages of the cryogenic wind tunnel lie mainly in the practical attainment of full scale values of Reynolds number. Up to date information on the aerodynamic and mechanical design of continuous and intermittent cryogenic wind tunnels and their models, and on techniques for controlling test parameters is provided. Design information includes properties of materials, the storage and handling of cryogenic liquids, insulation systems for pipelines and tunnel circuits, and safety requirements. Solutions are included for the special requirements of instrumentation systems for plant, tunnel and model. The physical processes are described which determine the lower limits of operating temperature. For individual titles, see N81-11049 through N81-11067.

N81-11049# Southampton Univ. (England). Dept. of Aeronautics and Astronautics.
THE PRINCIPLES AND APPLICATIONS OF CRYOGENIC WIND TUNNELS
M. J. GOODYER *In* AGARD Cryogenic Wind Tunnels 6 p (SEE N81-11048 02-09) Jul. 1980 refs
Avail: NTIS HC A12/MF A01

The background to the emergencies of the cryogenic wind tunnel is described and its advantages compared with other means for raising the values of test Reynolds number to full scale are discussed. The basic aero and thermodynamics of wind tunnel testing is introduced and the advantages of low temperature in low speed and in transonic testing are quantified. Attention is drawn to secondary advantages unique to this tunnel, and to the potentials of unconventional test gases. Descriptions of current types and applications of cyrogenic wind tunnels are included. R.K.G.

N81-11050# Southampton Univ. (England). Inst. of Cryogenics.
CRYOGENIC ENGINEERING 1
R. G. SCURLOCK *In* AGARD Cryogenic Wind Tunnels 9 p (SEE N81-11048 02-09) Jul. 1980
Avail: NTIS HC A12/MF A01

The concept of a liquid boiling under 1 atm pressure at a temperature which is well below the lowest naturally occurring temperatures (i.e. below -50 C or 223K) and below the region normally associated with refrigeration engineering is introduced. Cryogenic wind tunnels require the use of cryogenic liquids, such as liquid nitrogen, in quantities ranging from 10 to 100 tonnes. The scale of use also means that safety precautions and safe operating procedures are to be rigorously maintained; much more so than with laboratory size quantities. Cryogenic liquids are energy-intensive to produce and expensive to use. Ice or snow covered patches on insulation, and white plumes of boiloff vapor, are specific indications of poor housekeeping techniques. Apart from these considerations, cryogenic liquids are very easy to use and the technology for storage, for transport by road, rail or sea (or air), and for handling is well developed. R.K.C.

N81-11051# Southampton Univ. (England). Inst. of Cryogenics.
CRYOGENIC ENGINEERING 2
R. G. SCURLOCK *In* AGARD Cryogenic Wind Tunnels 7 p (SEE N81-11048 02-09) Jul. 1980
Avail: NTIS HC A12/MF A01

Thermal properties of commercial materials are discussed. Instrumentation at low temperature which includes thermometry, pressure, and fluid flow is described. Conditions to avoid two phase flow are mentioned. R.K.G.

N81-11052# Southampton Univ. (England). Inst. of Cryogenics.
PROPERTIES OF MATERIALS: THE PHYSICAL PROPERTIES OF METALS AND NON-METALS
D. A. WIGLEY *In* AGARD Cryogenic Wind Tunnels 10 p (SEE N81-11048 02-09) Jul. 1980 refs
Avail: NTIS HC A12/MF A01

The requirements of a cryogenic wind tunnel project are considered in the context of the technology already developed for the storage and handling of large quantities of cryogenic fluids. Heat capacities are discussed in relation to the quantity of fluid evaporated during cooling and also to the thermal response time of the tunnel. The thermal conductivities of metals and nonmetals are considered, particularly in the context of good conductors which are used to reduce thermal gradients, and poor conductors which are used to reduce thermal gradients, and poor conductors which can be used as insulants to minimize the heat flowing into the cold regions. Electrical conductivity is discussed particularly with reference to the high resistivity alloys used in strain gauges and heaters, together with reference to thermoelectric effects and possible use of superconducting magnets. The thermal contraction of materials at low temperatures and the more common problems caused by differential contraction are discussed. Some design data is included in the text and references are given to the major data compilations. R.K.G.

N81-11053*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
REAL-GAS EFFECTS 1: SIMULATION OF IDEAL GAS FLOW BY CRYOGENIC NITROGEN AND OTHER SELECTED GASES
R. M. HALL *In* AGARD Cryogenic Wind Tunnels 16 p (SEE N81-11048 02-09) Jul. 1980 refs
Avail: NTIS HC A12/MF A01 CSCL 14B

The thermodynamic properties of nitrogen gas do not thermodynamically approximate an ideal, diatomic gas at cryogenic temperatures. Choice of a suitable equation of state to model its behavior is discussed and the equation of Beattie and Bridgeman is selected as best meeting the needs for cryogenic wind tunnel use. The real gas behavior of nitrogen gas is compared to an ideal, diatomic gas for the following flow processes: isentropic expansion; normal shocks; boundary layers; and shock wave boundary layer interactions. The only differences in predicted pressure ratio between nitrogen and an ideal gas that may limit the minimum operating temperatures of transonic cryogenic wind tunnels seem to occur at total pressures approaching 9atmospheres and total temperatures 10 K below the corresponding saturation temperature, where the differences approach 1 percent for both isentropic expansions and normal shocks. Several alternative cryogenic test gases - air, helium, and hydrogen - are also analyzed. Differences in air from an ideal, diatomic gas are similar in magnitude to those of nitrogen. Differences for helium and hydrogen are over an order of magnitude greater than those for nitrogen or air. Helium and hydrogen do not approximate the compressible flow of an ideal, diatomic gas.
R.K.G.

N81-11054# Southampton Univ. (England). Inst. of Cryogenics.
PROPERTIES OF MATERIALS: THE EFFECT OF LOW TEMPERATURES ON THE STRENGTH AND TOUGHNESS OF MATERIALS
D. A. WIGLEY *In* AGARD Cryogenic Wind Tunnels 24 p (SEE N81-11048 02-09) Jul. 1980 refs
Avail: NTIS HC A12/MF A01

The factors which influence the stiffness, strength and toughness of materials at low temperatures are considered. The relative sensitivity of each major parameter to changes in the structure and purity of a material is discussed in the context of the degree of reliability that can be placed on data taken from the literature. Yield and plastic deformation are highly structure sensitive and the effect of crystal structure is discussed at length. Design data is given for copper, nickel and aluminum-based alloys, which together with Invar and the autenite stainless steels all have face-centred cubic structures. The problems caused by the ductile-brittle transition in metals with body centered cubic structures are outlined, and the use of low alloy and nickel steels in the temperature range 300K to 70K is discussed. Fracture toughness is considered in the context of its use in promoting fail safe design techniques under steady and alternating loads, and other relevant low temperature failure modes are also discussed.
R.K.G.

N81-11055*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
REAL GAS EFFECTS 2: INFLUENCE OF CONDENSATION ON MINIMUM OPERATING TEMPERATURES OF CRYOGENIC WIND TUNNELS
R. M. HALL *In* AGARD Cryogenic Wind Tunnels 21 p (SEE N81-11048 02-09) Jul. 1980 refs
Avail: NTIS HC A12/MF A01 CSCL 14B

Condensation effects are responsible for the minimum operating temperatures of cryogenic wind tunnels at total pressures up to about 9 atmospheres. The two primary modes of condensation homogeneous nucleation and heterogeneous nucleation and the conditions with which either may limit minimum operating temperatures are reveiwed. Previous hypersonic and supersonic condensation data are reviewed as are data taken in the nitrogen gas, Langley 0.3 Meter Transonic Cryogenic Tunnel. Analysis of data in the 0.3 m tunnel suggests that the onset of homogenous nucleation may be approximated by an analysis by sivier and that the onset of heterogeneous nucleation is only apparent just below free stream saturation. Extension of the results from the 0.3 m tunnel to other nitrogen gas cryogenic tunnels is discussed and is shown to depend on length scales, purity of the liquid nitrogen injected for cooling, number of particulates in the flow, and the extent to which the injected liquid nitrogen is evaporated. R.K.G.

N81-11056# Southampton Univ. (England).
CRYOGENIC ENGINEERING 3
R. G. SCURLOCK *In* AGARD Cryogenic Wind Tunnels 6 p (SEE N81-11048 02-09) Jul. 1980 refs
Avail: NTIS HC A12/MF A01

Handling and transfer of LIN are discussed. Cooldown and thermal cycling problems are described. Safety factors including asphyxia, cold burns, explosion and fire hazards are discussed.
R.K.G.

N81-11057*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
MODEL DESIGN AND INSTRUMENTATION EXPERIENCES WITH CONTINUOUS-FLOW CRYOGENIC TUNNELS
R. A. KILGORE *In* AGARD Cryogenic Wind Tunnels 22 p (SEE N81-11048 02-09) Jul. 1980 refs
Avail: NTIS HC A12/MF A01 CSCL 14B

The development of wind tunnels that can be operated at cryogenic temperatures has placed several new demands on the ability to build and instrument wind tunnel models. The experiences at the NASA Langley Research Center relative to the design and instrumentation of models for continuous flow cryogenic wind tunnels are reviewed.
R.K.G.

N81-11058# Douglas Aircraft Co., Inc., Long Beach, Calif. Aerodynamics Subdiv.
MODEL DESIGN AND INSTRUMENTATION FOR INTERMITTENT CRYOGENIC WIND TUNNELS
J. D. CADWELL *In* AGARD Cryogenic Wind Tunnels 8 p (SEE N81-11048 02-09) Jul. 1980 refs
Avail: NTIS HC A12/MF A01

The design and instrumentation of a model for an intermittent cryogenic wind tunnel is discussed. The model requirements including tolerances and data accuracy are noted. The mechanical design of the wing, the considerations for material to be used, and the instrumentation that is to be installed in the wing are discussed. The design of the fuselage center section, the six component balance installation with heaters, and the heater for the balance-to-sting adapter is reviewed. The design and the aft fuselage and empennage, and the fuselage nose including the instrumentation package to be housed in the fuselage nose compartment is shown. The model conditioning that is required to obtain acceptable data, prevent frost buildup on the model after it is cooled, and reheating the model to make model configuration changes is also discussed.
R.K.G.

N81-11059*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
SELECTION AND APPLICATION OF INSTRUMENTATION FOR CALIBRATION AND CONTROL OF A CONTINUOUS-FLOW CRYOGENIC TUNNEL
R. A. KILGORE *In* AGARD Cryogenic Wind Tunnels 10 p (SEE N81-11048 02-09) Jul. 1980 refs
Avail: NTIS HC A12/MF A01 CSCL 14B

Selection and application of calibration and control instrumentation influenced by the extremes in the temperature environment to be found in cryogenic tunnels are described. The instrumentation and data acquisition system used in the Langley 0.3 m transonic tunnel are described along with typical calibration data obtained in a 20 by 60 cm two dimensional test section.
S.F.

N81-11060# Douglas Aircraft Co., Inc., Long Beach, Calif. Aerodynamics Subdiv.
CALIBRATION OF A BLOWDOWN-TO-ATMOSPHERE CRYOGENIC WIND TUNNEL
J. D. CADWELL *In* AGARD Cryogenic Wind Tunnels 9 p (SEE N81-11048 02-09) Jul. 1980 refs
Avail: NTIS HC A12/MF A01

Calibration of short duration cryogenic wind tunnels pose difficulties and requirements beyond those already present in tl · calibration either of conventional short run time facilities or of cryogenic continuous tunnels. The requirements and instrumentation for calibration of a transonic blowdown to atmosphere cryogenic wind tunnel are described, with emphasis

on those aspects differing from the calibration of similar non-cryogenic tunnels. Reference is made of the literature for detailed descriptions of conventional calibration practices which remain applicable for cryogenic blowdown tunnels. Author

N81-11061# Centre d'Etudes et de Recherches, Toulouse (France). Aerothermodynamics Dept.
THE DEVELOPMENT OF A CRYOGENIC WIND TUNNEL DRIVEN BY INDUCTION: FLOW CONTROL AND INSTRUMENTATION STUDIES IN A PILOT FACILITY AT ONERA/CERT
R. MICHEL *In* AGARD Cryogenic Wind Tunnels 12p (SEE N81-11048 02-09) Jul. 1980 refs
Avail: NTIS HC A12/MF A01

A solution for an intermittent cryogenic wind tunnel, using pressure air as a driving gas and nitrogen as cooler, is studied. The cryogenization of the transonic injector driven tunnel is presented. Experimental studies were carried out on a pilot unit, a pressurized return circuit wind tunnel with a 10 by 10 cm test section. Problems related to the control and optimization of short cryogenic runs are summarized. S.F.

N81-11062# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
EXPERIENCE IN THE CONTROL OF A CONTINUOUS FLOW CYROGENIC TUNNEL
R. A. KILGORE *In* AGARD Cryogenic Wind Tunnels 15 p (SEE N81-11048 02-09) Jul. 1980 refs
Avail: NTIS HC A12/MF A01 CSCL 14B

The concept of using liquid nitrogen to cool the test gas of a wind tunnel to cryogenic temperatures lead to the achievement of very high Reynolds number flows in relatively small transonic tunnels. The economical operation of liquid nitrogen cooled cryogenic tunnels is critically dependent on fast and accurate control of the tunnel variables. The control problem of a continuous flow fan driven cryogenic tunnel was addressed, first by developing a lumped multivariable mathematical model of a tunnel and validating the model by reconciling the responses of the Langley 0.3 m transonic cryogenic tunnel to the responses of the mathematical model on a simulator. Finally, the development of laws for the closed loop control of the tunnel pressure and temperature and the successful implementation of a control system for the 0.3 m transonic cryogenic tunnel based on these laws are presented. Author

N81-11063# Douglas Aircraft Co., Inc., Long Beach, Calif. Aerodynamics Subdiv.
THE CONTROL OF PRESSURE, TEMPERATURE AND MACH NUMBER IN A BLOWDOWN-TO-ATMOSPHERE CRYOGENIC WIND TUNNEL
J. D. CADWELL *In* AGARD Cryogenic Wind Tunnels 8 p (SEE N81-11048 02-09) Jul. 1980 refs
Avail: NTIS HC A12/MF A01

The control system that used in a four foot blowdown wind tunnel prior to the modification of the facility to a cryogenic operation is reviewed. The control requirements for a cryogenic blowdown tunnel and the Mach and Reynolds number controls are discussed. The proposed method to be used to control the temperature in the cryogenic tunnel is shown. The start of a blow sequence in a cryogenic blowdown tunnel and the detrimental effect that it has on a pre cooled model is considered. A transient protection system, to be evaluated in a one foot pilot tunnel that will shield the model during the start of a run is shown. The conventional method of measuring model attitude by correcting the pod angle for sting and balance deflections is shown to be inadequate in a cryogenic blowdown tunnel and alternate methods that can be used are discussed. Author

N81-11064# National Aerospace Lab., Amsterdam (Netherlands).
THE EUROPEAN TRANSONIC WIND TUNNEL ETW
J. P. HARTZUIKER and R. J. NORTH *In* AGARD Cryogenic Wind Tunnels 17 p (SEE N81-11048 02-09) Jul. 1980 refs
Avail: NTIS HC A12/MF A01

A high Reynolds number transonic tunnel is described on the basis of preliminary design results. The construction of a cryogenic pilot tunnel and supporting programs on model design and instrumentation are discussed. S.F.

N81-11065*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
CHARACTERISTICS AND STATUS OF THE US NATIONAL TRANSONIC FACILITY
W. B. IGOE *In* AGARD Cryogenic Wind Tunnels 11 p (SEE N81-11048 02-09) Jul. 1980 refs
Avail: NTIS HC A12/MF A01 CSCL 14B

A major application of the cryogenic wind tunnel concept is discussed. A closed return fan driven circuit with a 2.5 meter square slotted test section, pressurized up to 8.85 atmospheres, and providing chord Reynolds numbers of 120 million based on a chord of 0.25 meter at transonic speeds using cold nitrogen as the test gas is described. S.F.

N81-11066# Douglas Aircraft Co., Inc., Long Beach, Calif. Aerodynamics Subdiv.
THE DOUGLAS AIRCRAFT COMPANY FOUR FOOT CRYOGENIC WIND TUNNEL Progress Report
J. D. CADWELL *In* AGARD Cryogenic Wind Tunnels 7 p (SEE N81-11048 02-09) Jul. 1980
Avail: NTIS HC A12/MF A01

The modification of a four foot trisonic wind tunnel to operate at cryogenic temperatures is described. Development of the instrumentation and test techniques are also reviewed, including model design, fabrication, inspection techniques, force and moment, pressure instrumentation, boundary layer transition detection methods, model angle of attack measurement, model precooling evaluation, and selection of materials for the verification model. The current schedule of the tunnel checkout and calibration, and the development of instrumentation and test techniques is discussed as well as the verification test which will provide the data necessary to evaluate the performance of the modified four foot tunnel at cryogenic temperatures for the Mach number range from 0.5 to 1.0. S.F.

N81-11067# Centre d'Etudes et de Recherches, Toulouse (France). Aerothermodynamics Dept.
A CRYOGENIC TRANSONIC INTERMITTENT TUNNEL PROJECT: THE INDUCED FLOW CRYOGENIC WIND TUNNEL T2 AT ONERA/CERT
R. MICHEL *In* AGARD Cryogenic Wind Tunnels 9 p (SEE N81-11048 02-09) Jul. 1980 refs
Avail: NTIS HC A12/MF A01

A cryogenic intermittent tunnel, which use high pressure air as a driving gas and nitrogen as a cooler, is described. A description of its main characteristics at ambient operating temperature is given. Various aspects of its transformation for a low operating temperature are analyzed: modifications of the circuit, thermal insulation technique, liquid nitrogen injection, regulation systems, cryogenic operating mode, and expected performances. S.F.

N81-20091# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
FIDELITY OF SIMULATION FOR PILOT TRAINING
Dec. 1980 66 p refs
(AGARD-AR-159; ISBN-92-835-1377-0) Avail: NTIS HC A04/MF A01

The scope and effectiveness of current flight training in simulators was reviewed. The status of technologies and human behavior important to the fidelity of flight simulation were examined. Research objectives in the areas of simulation technologies and training that might lead to increased cost effectiveness in simulator training were identified. For individual titles, see N81-20092 through N81-20099.

N81-20092# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
FIDELITY OF SIMULATION FOR PILOT TRAINING. INTRODUCTION
In its Fidelity of Simulation for Pilot Training p 1-3 (SEE N81-20091 11-09) Dec. 1980
(AD-A096825) Avail: NTIS HC A04/MF A01

Attention is focused on the subject of fidelity requirements for training simulators and background is provided for the multidisciplined community involved in developing these devices. Weaknesses in current methods of specifying training devices were identified, and a different approach is proposed. Gaps in the required technology were also identified, and appropriate research

topics are suggested. It is hoped that, by establishing a dialog between the training community and the simulator technologists, these recommendations will lead to more cost effective devices. T.M.

N81-20093# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
PILOT TRAINING
In its Fidelity of Simulation for Pilot Training p 4-12 (SEE N81-20091 11-09) Dec. 1980
Avail: NTIS HC A04/MF A01

Two problems in addressing the question of fidelity requirements for training simulators are discussed: the process whereby the effectiveness of the simulator within the training system is assessed, and the process whereby requirements are translated into simulator design requirements. It is shown that simulator design requirements should be based on more than obtaining a close replication of the aircraft. An alternative approach to the definition of simulator design requirements is presented. T.M.

N81-20094# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
PHYSIOLOGICAL FACTORS
In its Fidelity of Simulation for Pilot Training p 13-18 (SEE N81-20091 11-09) Dec. 1980
Avail: NTIS HC A04/MF A01

The sensory mechanisms relevant to simulator motion fidelity were examined. A review of the literature concerning the influence of motion cues of various types, and of out-the-window (VFR) visual scenes, on pilot control strategies and performance. Nearly all of the studies involved continuous pilot control for tracking or disturbance regulation. In general, provision of motion cues, with or without wide-field vision, showed increasing utility for tasks requiring lead compensation, multi-axis control, smooth manipulation, and ample time for scanning alternate displays. T.M.

N81-20095# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
SIMULATION TECHNOLOGY
In its Fidelity of Simulation for Pilot Training p 19-30 (SEE N81-20091 11-09) Dec. 1980
Avail: NTIS HC A04/MF A01

An assessment of existing simulation technology is presented. Those characteristics that could be expected to provide high perceptual fidelity are described, and it is shown where current limitations exist. Visual system technology and motion system technology are discussed. A review of fidelity considerations in crew stations and computer models is presented. T.M.

N81-20096# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
CONCLUSIONS AND RECOMMENDATIONS
In its Fidelity of Simulation for Pilot Training p 31-35 (SEE N81-20091 11-09) Dec. 1980 refs
Avail: NTIS HC A04/MF A01

Training requirements and objectives for pilot training were analyzed. The methods and facilities to perform the training are described along with: objective cues that would be experienced in the aircraft while performing the task being trained; the perceptual cues experienced by the pilot in the aircraft; the perceptual cues needed to train; and the hardware needed to provide the training cues. The development of simulator hardware and the validation of the simulator are discussed. T.M.

N81-20097# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
ASSESSMENT OF TRAINING EFFECTIVENESS
In its Fidelity of Simulation for Pilot Training p 36-41 (SEE N81-20091 11-09) Dec. 1980 refs
Avail: NTIS HC A04/MF A01

The present and future requirements for training simulators were examined. Training facilities are assessed as to their ability to train an aircrew and maintain their skills as effectively and economically as possible, while maintaining high standards of safety, efficiency, and personal confidence. Several training effectiveness models were reviewed. T.M.

N81-20098# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
PILOT ASSESSMENT OF TRAINING SIMULATORS
In its Fidelity of Simulation for Pilot Training p 48-53 (SEE N81-20091 11-09) Dec. 1980 refs
Avail: NTIS HC A04/MF A01

A survey of pilot opinions of existing training facilities is presented. European civil (Lufthansa, Swissair, KLM, and Fokker-VFW) and military (United Kingdom and Germany) facilities were assessed. The U.S. Airline Pilots' Association was surveyed to cover the civil simulators in the United States. T.M.

N81-20099# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
VISUAL SYSTEM TECHNOLOGY: STATUS AND PROBLEMS
In its Fidelity of Simulation for Pilot Training p 54-60 (SEE N81-20091 11-09) Dec. 1980
Avail: NTIS HC A04/MF A01

A list is presented of visual factors relevant to aircraft operation. Some target values for these factors are presented which, while a degradation from the absolute characteristics of the real world and of human perception, if achieved would provide visual information indistinguishable in practice from reality. Four basic systems are discussed: computer-generated imagery; camera/modelboards; film (photographic); and shadowgraph. T.M.

N81-24120# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
WIND TUNNEL CORRECTIONS FOR HIGH ANGLE OF ATTACK MODELS
R. O. DIETZ, ed. and M. L. LASTER, ed. Feb. 1981 120 p refs In ENGLISH and FRENCH
(AGARD-R-692; ISBN-92-835-0283-3; AD-A098058) Avail: NTIS HC A06/MF A01

Several wind tunnel wall correction methods in use or under study are presented for closed, open, and ventilated wall wind tunnels. The Mach number range is generally limited up to high subsonic speeds with some techniques only useful for incompressible flow. Wall correction techniques discussed along with their attributes and disadvantages include vortex lattice, panel, system of images, wall pressure, and adaptive walls. The adaptive wall technique is a method to actively reduce or eliminate the need for wall correction and is becoming more favorable as development problems are solved.

N81-24121# National Aeronautical Establishment, Ottawa (Ontario).
CANADIAN STUDIES OF WIND TUNNEL CORRECTIONS FOR HIGH ANGLE OF ATTACK MODELS
M. MOKRY *In* AGARD Wind Tunnel Corrections for High Angle of Attack Models 11 p (SEE N81-24120 15-09) Feb. 1981 refs
Avail: NTIS HC A06/MF A01

Wind tunnel interference studies relating to testing of high angle of attack models carried out in Canada during the last decade are briefly reviewed. A test section was developed which produces adequately low corrections to test data for a wide range of sizes, shapes, and angles of attack of test airfoil. E.D.K.

N81-24122*# Lockheed-Georgia Co., Marietta.
A REVIEW OF THE WALL PRESSURE SIGNATURE AND OTHER TUNNEL CONSTRAINT CORRECTION METHODS FOR HIGH ANGLE-OF-ATTACK TESTS
J. E. HACKETT, D. J. WILSDEN, and W. A. STEVENS *In* AGARD Wind Tunnel Corrections for High Angle of Attack Models 16 p (SEE N81-24120 15-09) Feb. 1981 refs
(Contract NAS2-9883)
Avail: NTIS HC A06/MF A01 CSCL 14B

Recent developments concerning correction techniques for high angle of attack testing are reviewed and the results are presented of a letter survey on the methods now in use. The application of the wall pressure signature technique is demonstrated in experiments on several types of models. The method is shown to provide good estimates of tunnel blockage effects and extension to lift interference is discussed. It appears that correctability is limited more by the problem of determining the effects of tunnel induced velocity gradients than by ability to determine the flow field. It is suggested that passive boundary measurement

technology diffuses first into high angle of attack production testing, possibly followed by partially adaptive tunnel techniques. E.D.K.

N81-24123# Office National d'Etudes et de Recherches Aerospatiales, Paris (France).
EXPECTED IMPROVEMENTS ON HIGH ANGLE OF ATTACK MODEL TESTING
X. VAUCHERET *In* AGARD Wind Tunnel Corrections for High Angle of Attack Models 22 p (SEE N81-24120 15-09) Feb. 1981 refs In FRENCH; ENGLISH summary
Avail: NTIS HC A06/MF A01

Problems encountered during tests at high angle of attack in wind tunnels are: wall interference, sting interference, and vibrations beyond the stall. The state of the art on wall interference systematically applied to the development tests is shown with several comparisons between wind tunnels or between flight and tunnels tests. The models used in unconfined flow point out some deficiencies as regards apex vortex and active jets. The control of the validity of the wall interference correction method is analyzed. E.D.K.

N81-24124# Aerodynamische Versuchsanstalt, Goettingen (West Germany).
GERMAN ACTIVITIES ON WIND TUNNEL CORRECTIONS
H. HOLST *In* AGARD Wind Tunnel Corrections for High Angle of Attack Models 23 p (SEE N81-24120 15-09) Feb. 1981 refs
Avail: NTIS HC A06/MF A01

Wind tunnel interference factors were calculated for open, closed, slotted, and perforated walls using the vortex lattice method with a homogeneous boundary condition. A more realistic pitching moment correction is obtained when the lift dependent relocation of the trailing vortices is taken into account. The inhomogeneities of lift and blockade interference parameters throughout the test section were investigated for models large in comparison to the test section dimensions. A method was developed using measured wall pressures for the correction of drag in transonic wind tunnels. For closed test sections, the image method and a modified vortex lattice method were used to evaluate wall pressure signals for correction purposes. E.D.K.

N81-24125# National Aerospace Lab., Amsterdam (Netherlands).
A REVIEW OF RESEARCH AT NLR ON WIND-TUNNEL CORRECTIONS FOR HIGH ANGLE OF ATTACK MODELS
R. A. MAARSINGH *In* AGARD Wind Tunnel Corrections for High Angle of Attack Models 11 p (SEE N81-24120 15-09) Feb. 1981 refs
Avail: NTIS HC A06/MF A01

A survey is given of past, current, and planned work at NLR in the field of wind tunnel wall interference on models at high angles of attack at low subsonic speeds. Among long term research activities those concerning alotted wall test sections play a dominant part. It is felt that an approach which makes use of measured distributions of flow quantities near the walls is the most promising one. It may be recommended also as a short term solution for some special wall correction problems arising from modern low speed wind tunnel testing in closed test sections. E.D.K.

N81-24126# Aeronautical Research Inst. of Sweden, Bromma.
A REVIEW OF SOME INVESTIGATIONS ON WIND TUNNEL WALL INTERFERENCE CARRIED OUT IN SWEDEN IN RECENT YEARS
S. E. NYBERG *In* AGARD Wind Tunnel Corrections for High Angle of Attack Models 19 p (SEE N81-24120 15-09) Feb. 1981 refs
Avail: NTIS HC A06/MF A01

For subsonic incompressible flow the mutual circulation induced model wind tunnel interference was calculated by panel methods for large multicomponent two dimensional airfoils, for three dimensional swept wings, full or half models, and for wing-tail configurations. Wake blockage effects from a swept wing with and without high lift devices were studied experimentally. The effects of air flow leakage between half model fuselage and reflection wall were investigated. For transonic flow the flow properties of slotted walls and the influence of wall boundary layer were studied. Based on these results a numerical method was developed and so far axisymmetric calculations were carried out. The results were compared with experimental results for large blockage models. E.D.K

N81-24127# Queen Mary Coll., London (England).
WIND TUNNEL CORRECTIONS FOR HIGH ANGLES OF ATTACK: A BRIEF REVIEW OF RECENT UK WORK
A. D. YOUNG *In* AGARD Wind Tunnel Corrections for High Angle of Attack Models 11 p (SEE N81-24120 15-09) Feb. 1981 refs
Avail: NTIS HC A06/MF A01

The use of adaptive walls, a panel method of model and wake representation for a two dimensional model in a wind tunnel with solid walls, the use of measured pressure distributions on tunnel floor and roof also for a two dimensional model and solid walls, a vortex lattice representation of the tunnel walls to take account of wake curvature, interference limitations on tests on V/STOL models with lifting jets, and work on blockage corrections on models with reverse thrust are discussed. Some discussion is offered on the limitations on the validity of current methods for determining wind tunnel corrections and it is argued that these limitations are least severe with the use of adaptive walls. E.D.K.

N81-28107# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). Flight Mechanics Panel.
CHARACTERISTICS OF FLIGHT SIMULATOR VISUAL SYSTEMS
May 1981 89 p refs
(AGARD-AR-164; ISBN-92-835-1386-X; AD-A101445) Avail: NTIS HC A05/MF A01

Physical parameters that characterize the simulator visual system and determine its fidelity are identified and defined. These characteristics are discussed in terms of the three basic categories of spatial, energy and temporal properties, and for each of the parameters there is a description of its effect, a definition of its appropriate units or descriptors, a discussion of methods of measurement and of its use or importance to imagery quality. S.F.

N82-10063# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
AIR-BREATHING ENGINE TEST FACILITIES REGISTER
J. H. KRENGEL, comp. Jul. 1981 122 p
(AGARD-AG-269; AD-A105194) Avail: NTIS HC A06/MF A01

A register was compiled, aimed at comprising the test facilities relevant for research and development in NATO countries. Included are test facilities being in use or under construction at the various research organizations, industrial firms, and universities. Test facilities and their technical data are given as far as the response to a questionnaire was received or open literature was available. Test engineers will be able to find whether a test facility suiting their specific demands already exists or may be easily adapted to their purposes. T.M.

N82-29334# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). Fluid Dynamics Panel.
WINDTUNNEL CAPABILITY RELATED TO TEST SECTIONS, CRYOGENICS, AND COMPUTER-WINDTUNNEL INTEGRATION
Apr. 1982 64 p refs
(AGARD-AR-174; ISBN-92-835-1420-3; AD-A117518) Avail: NTIS HC A04/MF A01

The roles of computational fluid dynamics and wind tunnels, and their growing interdependence are considered. Transonic test sections, cryogenic testing technology, and integration of computer and wind tunnel testing are discussed. S.L.

N83-20957# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
WALL INTERFERENCE IN WIND TUNNELS
London Sep. 1982 222 p refs Conf. held in London, 19-20 May 1982
(AGARD-CP-335; ISBN-92-835-0321-X) Avail: NTIS HC A10/MF A01

Current usage and basic developments for wind tunnel wall corrections are addressed including Reynold's number corrections, wall and support interference, flow quality and aeroelasticity. Solid wall, ventilated wall, and adaptive wall wind tunnels are among

the topics discussed. Progress in the area of wind tunnel correction is evident with adaptive walls to reduce or eliminate wall interference. For individual titles, see N83-20958 through N83-20973.

N83-20958# Royal Aircraft Establishment, Bedford (England). Aerodynamics Dept.
A METHOD FOR DETERMINING WALL-INTERFERENCE CORRECTIONS IN SOLID-WALL TUNNELS FROM MEASUREMENTS OF STATIC PRESSURE AT THE WALLS
P. R. ASHILL and D. J. WEEKS *In* AGARD Wall Interference in Wind Tunnels 12 p (SEE N83-20957 11-09) Sep. 1982 refs
Avail: NTIS HC A10/MF A01

A method is described for calculating wall interference in solid wall tunnels from measurements of pressures at the walls. The method has the advantage over similar techniques of not requiring a description of the flow in the region of the model. Calculations of wall interference for aerofoil tests at high subsonic speeds are presented, and the wall corrections obtained are compared with results from other methods. Generally good agreement is obtained. A theoretical evaluation of the method suggests that it is suitable for calculating wall corrections for three dimensional configurations that are not amendable to correction by classical methods.
Author

N83-20959# British Aerospace Aircraft Group, Brough (England).
THE USE OF PANEL METHODS FOR THE EVALUATION OF SUBSONIC WALL INTERFERENCE
D. R. HOLT and B. HUNT *In* AGARD Wall Interference in Wind Tunnels 16 p (SEE N83-20957 11-09) Sep. 1982 refs
Avail: NTIS HC A10/MF A01

The use of panel methods is discussed for the evaluation of subsonic wall interference effects in both two and three dimensions. The techniques that the experimenter must adopt in order to use the methods efficiently and accurately were evaluated rather than on once and for all corrections. Particular examples are given to illustrate the general approach together with further uses of panel methods in the general field of support interference. Author

N83-20960*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
SIMILARITY RULES FOR EFFECTS OF SIDEWALL BOUNDARY LAYER IN TWO-DIMENSIONAL WIND TUNNELS
R. W. BARNWELL and W. G. SEWALL *In* AGARD Wall Interference in Wind Tunnels 10 p (SEE N83-20957 11-09) Sep. 1982 refs
Avail: NTIS HC A10/MF A01 CSCL 14B

A simple analysis of the interaction of the model pressure field with the boundary layer on an unventilated wind tunnel wall is presented. It is shown that the effects of this interaction are similar to compressibility effects for sidewall boundary layers in two dimensional wind tunnels. This similarity is used to derive modified forms of the Prandtl Glauert rule for subsonic flow and the von Karman rule for transonic flow which are validated by comparison with experimental data. The three dimensional interaction problem is discussed, and it is shown that model pressure field/wall boundary layer interaction effects are not similar to compressibility effects in three dimensional wind tunnels.
Author

N83-20961# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (West Germany). Unternehmensbereich Flugzeuge.
REYNOLDS NUMBER EFFECTS ON TRANSONIC SHOCK LOCATION
F. AULEHLA and A. EBERLE *In* AGARD Wall Interference in Wind Tunnels 12 p (SEE N83-20957 11-09) Sep. 1982 refs
Avail: NTIS HC A10/MF A01

The example of a variable density transonic wind tunnel shows that the boundary layer displacement at the test section wall is about hundred times bigger than the corresponding effects at the model. Computations using variable boundary conditions at the test section wall show that the shock location on an axisymmetric body is noticeably altered. These computed shifts in shock location agree very well with those measured in the wind tunnel leaving little room for true Reynolds number effects on the model itself. Lastly, an opposite and purely theoretical approach is presented, in which the shock location on a Korn profile was computed for the free flight case and for a model boundary layer assumed to be fully turbulent. The results show that for this particular example with fixed transition there is only a negligible change in shock location when Reynolds number is raised from 4 million to 20,000 million. The conclusion drawn from these three different examples is that the true Reynolds number effects on transonic shock location appear to be by orders of magnitudes smaller than generally quoted from variable density wind tunnel measurements. B.G.

N83-20962# Group for Aeronautical Research and Technology in Europe, Amsterdam (Netherlands).
TWO-DIMENSIONAL TRANSONIC TESTING METHOD
A. ELSENAAR and E. STANEWSKY *In* AGARD Wall Interference in Wind Tunnels 16 p (SEE N83-20957 11-09) Sep. 1982 refs
Avail: NTIS HC A10/MF A01

Measurements were made of the CAST-7/DOA1 airfoil in 7 European facilities, involving perforated, slotted and flexible wall wind tunnels. A comparison was made of the 'best data available' for each tunnel, using various wall interference correction methods. Also, a limited comparison of some of the correction methods themselves was carried out. A large variation in experimental results was found for the uncorrected data. However, different types of correction methods reduce this scatter considerably. From this comparison it can be concluded that measured boundary condition methods and the flexible wall concept appear to be very promising. It is expected that a further analysis of these preliminary results might reduce the experimental uncertainty even more, so establishing a well defined data base for viscous transonic flow computational methods. Author

N83-20963# Royal Inst. of Tech., Stockholm (Sweden).
FLOW PROPERTIES OF SLOTTED-WALL TEST SECTIONS
S. B. BERNDT *In* AGARD Wall Interference in Wind Tunnels 7 p (SEE N83-20957 11-09) Sep. 1982 refs
Avail: NTIS HC A10/MF A01

A brief survey of results and problems relevant to the objective of eliminating wall interference in three-dimensional transonic tests by proper shaping of the slots was evaluated. The principal features of the flow in a slotted test section are described and then illustrated by experimental results from two FFA wind tunnels. The importance of maintaining free stream velocity to the full depth of the slots is stressed; the viscous effects evident in the experiments are viewed against this need. The classical inviscid flow model of two dimensional slotted wall flow is compared with experiments and shown to give fair agreement in its range of validity. A fully three dimensional and general inviscid flow model is described briefly and interference free slot shapes for axisymmetric flows computed with this flow model are reviewed. Finally, problems of correcting the theoretical results for viscous effects are touched upon.
Author

N83-20964# National Aeronautical Establishment, Ottawa (Ontario). High Speed Aerodynamics Lab.
WALL BOUNDARY-LAYER EFFECTS IN TRANSONIC WIND TUNNELS
Y. Y. CHAN *In* AGARD Wall Interference in Wind Tunnels 15 p (SEE N83-20957 11-09) Sep. 1982 refs
Avail: NTIS HC A10/MF A01

Boundary layer developments on the perforated walls and the sidewalls of a transonic two dimensional wind tunnel have been studied experimentally and computationally. For the upper and lower walls, the wall characteristics are strongly modulated by the boundary layer and a correlation depending explicitly on the displacement thickness is obtained. A method of calculating the boundary-layer displacement effect is derived, providing the boundary condition for the interference flow in the tunnel. For the sidewalls, the three dimensional boundary layer developments at the vicinity of the model mount has been calculated and its displacement effect analyzed. The effectiveness of controlling the adverse effects by moderate surface suction is demonstrated.
Author

N83-20965# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Goettingen (West Germany). Aerodynamische Versuchsanstalt.

THREE-DIMENSIONAL WALL CORRECTIONS FOR VENTILATED WIND TUNNELS

H. HOLST *In* AGARD Wall Interference in Wind Tunnels 11 p (SEE N83-20957 11-09) Sep. 1982 refs

Avail: NTIS HC A10/MF A01

Correction factors (angle of incidence and flow curvature) have been calculated or ventilated wind tunnels by the vortex lattice method. For the cases of open and closed test sections these results agree very good with those calculated using the image technique. For ventilated walls (slotted and/or perforated) results are presented. The vortex lattice method is then used to calculate wall pressures in closed and ventilated test sections. Measurements in a 1.3m closed square test section were made using circular discs for blockage and a rectangular wing as a lift generator. The results (wall pressure distributions and force coefficients) are presented and will be a basis of comparison for wall pressures in a slotted wall test section. Author

N83-20966# National Aerospace Lab., Amsterdam (Netherlands).

MEASURED BOUNDARY CONDITIONS METHODS FOR 2D FLOW

J. SMITH *In* AGARD Wall Interference in Wind Tunnels 15 p (SEE N83-20957 11-09) Sep. 1982 refs

Avail: NTIS HC A10/MF A01

Modern developments in wind tunnel wall correction methods are for a major part directed towards the use of in situ measured boundary conditions in order to eliminate the need to describe the complicated aerodynamic characteristics of test section walls. This paper presents a short general review of the principles of such methods for two dimensional flow. The major practical problems associated with the application of the methods are discussed and some typical results are shown. Author

N83-20967# National Aeronautical Establishment, Ottawa (Ontario). High Speed Aerodynamics Lab.

SUBSONIC WALL INTERFERENCE CORRECTIONS FOR FINITE-LENGTH TEST SECTIONS USING BOUNDARY PRESSURE MEASUREMENTS

M. MOKRY *In* AGARD Wall Interference in Wind Tunnels 15 p (SEE N83-20957 11-09) Sep. 1982 refs

Avail: NTIS HC A10/MF A01

Subsonic wall interference corrections by using the Fourier solution for the Dirichlet problem in a circular cylinder, interior to the three dimensional test section were evaluated. The required boundary values of the streamwise component of wall interference velocity are obtained from pressure measurements by a few static pressure tubes located on the cylinder surface. The coefficients of the resultant Fourier-Bessel series are obtained in closed form and the coefficients of the Fourier sine series are calculated by the fast Fourier transform, so that the method is very efficient and suitable for routine tunnel testing. E.A.K.

N83-20968# Office National d'Etudes et de Recherches Aeronautiques, Paris (France).

IMPROVING CALCULATIONS OF WALL EFFECTS IN INDUSTRIAL WIND TUNNELS AT ONERA [AMELIORATIONS DES CALCULS DES EFFETS DE PAROIS DANS LES SOUFFLERIES INDUSTRIELLS DE L'ONERA]

X. VAUCHERET *In* AGARD Wall Interference in Wind Tunnels 12 p (SEE N83-20957 11-09) Sep. 1982 refs *In* FRENCH; ENGLISH summary

Avail: NTIS HC A10/MF A01

Methods used to compute wall interference corrections for the ONERA large wind tunnels were improved over the years. The mathematical description of the model and its sting support is more and more sophisticated, an increasing number of singularities is used until an agreement between theoretical and experimental signatures of the model and sting on the walls of the closed test section is obtained. The effect of the singularity displacement from the central position is calculated when the model reaches large angles of attack. The porosity factor cargography on the perforated walls deduced from the measured signatures avoids to carry out reference tests in large tunnel as previously. The porosity factors obtained from the blockage terms (signatures at zero lift) and from the lift terms are in good agreement. In each case (model + sting + test section) wall corrections are now determined, before the tests, as a function of the fundamental parameters M, CD, CI. During the wind tunnel tests, the corrections are quickly computed from these functions. Author

N83-20969# Technische Univ., Berlin (West Germany) Inst. fuer Luft-und Raumfahrt.

ON THE USE OF ADAPTIVE WALLS FOR TRANSONIC WIND TUNNEL TESTING

U. GANZER *In* AGARD Wall Interference in Wind Tunnels 8 p (SEE N83-20957 11-09) Sep. 1982 refs

Avail: NTIS HC A10/MF A01

A wind tunnel test section with two adaptive walls for aerofoil testing and another one with eight flexible walls for 3-D model tests was developed. The constructional features, the calculation procedure for determining the adapted wall configuration and the computer based automatic control system are described. Test results obtained for the supercritical aerofoil CAST 7 are presented to demonstrate the potentiality of the adaptive wall concept in 2-D model tests. First test result with the 3-D test section using an ONERA C 5 body of revolution verify the feasibility of the adaptive wall technique for three dimensional model tests. An alternative 3-D test section design is discussed. E.A.K.

N83-20970# Office National d'Etudes et de Recherches Aeronautiques, Paris (France). Div. Aerodynamique Experimentale.

USE OF ADAPTIVE WALLS IN 2D TESTS [UTILISATION DE PAROIS ADAPTABLES POUR LES ESSAIS EN COURANT PLAN]

J. P. ARCHAMBAUD and J. P. CHEVALLIER *In* AGARD Wall Interference in Wind Tunnels 14 p (SEE N83-20957 11-09) Sep. 1982 refs *In* FRENCH; ENGLISH summary

Avail: NTIS HC A10/MF A01

A new method for computing wall effects which answers questions arising from wall concept applications is outlined. The method computes: length of adapted regions, fairings with up and downstream regions, residual misadjustments effects, and reference conditions. The acceleration of the iterative process convergence and the development of an efficient technology used in CERT T2 wind tunnel gives the required test conditions in a single run. The efficiency of the whole process to obtain significant results with consideration of 3D case extension is demonstrated. E.A.K.

N83-20971*# Southampton Univ. (England). Dept. of Aeronautics and Astronautics.

THE STATUS OF TWO- AND THREE-DIMENSIONAL TESTING IN THE UNIVERSITY OF SOUTHAMPTON TRANSONIC SELF-STREAMLINING WIND TUNNEL

S. W. D. WOLF, I. D. COOK, and M. J. GOODYER *In* AGARD Wall Interference in Wind Tunnels 14 p (SEE N83-20957 11-09) Sep. 1982 refs

(Contract NSG-7172)

Avail: NTIS HC A10/MF A01

An automated test section was used to develop a flexible walled testing technique which eliminates some sources of uncertainty in boundary interference effects which exist in conventional transonic test sections. The flexible floor and ceiling of the test section were adjusted to contours which produce a constant Mach number distribution along each wall with no model present. These aerodynamically straight contours form the basis for all streamlining. The wall data are to contain information on the models performance and on lift. Two dimensional validation testing has continued with a cambered NPL 9510 section. Lift data up to Mach 0.87 are compared with reference data. Drag information on a NACA 0012-64 section is presented to indicate the powerful effects of streamlining. Preliminary three dimensional testing in the two dimensional test section has demonstrated that model and support blockage can be relieved by wall contouring. E.A.K.

N83-20972*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
ADAPTIVE-WALL WIND-TUNNEL RESEARCH AT AMES RESEARCH CENTER
E. T. SCHAIRER and J. P. MENDOZA *In* AGARD Wall Interference in Wind Tunnels 13 p (SEE N83-20957 11-09) Sep. 1982 refs
Avail: NTIS HC A10/MF A01

Adaptive-wall wind-tunnel research is summarized. This research includes small-scale two- and three-dimensional wind-tunnel experiments and numerical experiments with a three-dimensional adaptive-wall simulator. Airflow through the test-section walls is controlled by adjusting the pressures in segmented plenums. Interference free conditions are successfully attained in subsonic and transonic flows. An adaptive wall test section is constructed for the transonic wind tunnel. Wall interference was reduced in the three dimensional experiment at several angles of attack at Mach 0.60. A wing on wall configuration was modeled in the numerical experiments. These flow simulations showed that free air conditions can be approximated by adjusting boundary conditions at only the floor and ceiling of the test section. No sidewall control was necessary. E.A.K.

N83-20973# ARO, Inc., Arnold Air Force Station, Tenn.
DEVELOPMENT OF A THREE-DIMENSIONAL ADAPTIVE WALL TEST SECTION WITH PERFORATED WALLS
R. L. PARKER, JR. and J. C. ERICKSON, JR. *In* AGARD Wall Interference in Wind Tunnels 14 p (SEE N83-20957 11-09) Sep. 1982 refs
Avail: NTIS HC A10/MF A01

The two dimensional, porous adaptive wall development is described. Three dimensional experiments employing adaptive techniques to adjust variable porosity walls individually to minimize the interference on a generalized transonic model are summarized. The embodiment of the adaptive wall concept for three dimensional applications was investigated. A fully automated, computer controlled, closed loop three dimensional adaptive wall system was designed. Development of the subsystems includes the interface measurement instrumentation, the exterior-flow computation method, the actively controllable wall configuration, microprocessor-controlled hardware for the walls and instrumentation and the overall minicomputer based adaptive wall control algorithm. A two velocity component static pipe system is selected for the interface measurement system. Transonic small disturbance theory is used to compute the exterior flow region and a segmented, variable porosity configuration is selected for the test section walls. E.A.K.

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ASTRONAUTICS (GENERAL)

N82-20208# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
SPACECRAFT POINTING AND POSITION CONTROL
P. P. VANDENBROEK, ed. and S. Z. SZIRMAY, ed. Nov. 1981 255 p refs
(AGARD-AG-260; ISBN-92-835-1408-4; AD-A111405) Avail: NTIS HC A12/MF A01

Recent developments and state-of-the-art technologies were examined in the following areas: attitude control and instrument pointing, orbit determination and control, and flexible satellite control. Emphasis is placed on the stationkeeping of synchronous communication satellites and on satellite attitude control. Control moment devices are also discussed. For individual titles, see N82-20209 through N82-20222.

N82-20209# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Oberpfaffenhofen (West Germany).
ATTITUDE CONTROL OF GEOSTATIONARY SATELLITES WITH DOUBLE GIMBALLED MOMENTUM WHEELS
G. SCHULZ and T. LANGE *In* AGARD Spacecraft Pointing and Position Control 25 p (SEE N82-20208 11-12) Nov. 1981 refs
Avail: NTIS HC A12/MF A01

Conventional control methods are generalized using state vector feedback design procedures. Alternatively, a decoupled control method using a nondiagonal inertia tensor was derived. These are confronted to modern control theory design method with observer, where especially the insensitivity with respect to variants of the moments of inertia was demonstrated. Author

N82-20210# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Oberpfaffenhofen (West Germany).
ANALYSIS AND EXPERIMENTAL VERIFICATION OF THE NUTATION OF A SATELLITE EQUIPPED WITH MAGNETIC BEARING MOMENTUM WHEELS
C. ROUYER (SNIAS, Les Mureaux, France), G. HEIMBOLT, and T. LANGE *In* AGARD Spacecraft Pointing and Position Control 19 p (SEE N82-20208 11-12) Nov. 1981 refs
Avail: NTIS HC A12/MF A01

The problem of the nutation divergence of a 3 axis stablized satellite equipped with hydrodynamic bearing momentum wheels is discussed. The magnetic bearing momentum wheels, having a relatively low transverse rigidity and dissipating energy in the rotor (due to eddy currents), are likely to present an inconvenience of the same nature, if not of the same magnitude. A physical explanation of the phenomenon is given. The results of tests carried out on an air-bearing table are presented and it is shown that phenomenon cannot be detected on a satellite of the INTELSAT size. T.M.

N82-20211# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
AUTONOMOUS ATTITUDE DETERMINATION FROM STAR DATA FOR A DUAL-SPIN PLANETARY SPACECRAFT
E. C. WONG and J. Y. LAI *In* AGARD Spacecraft Pointing and Position Control 15 p (SEE N82-20208 11-12) Nov. 1981 refs
Avail: NTIS HC A12/MF A01

A batch mode process which identifies three reference stars within a rotor-mounted star scanner's field-of-view based on the criteria of intensity and geometry was established. The sequential mode which continuously tracks the reference stars provides star transit times and estimates of rotor's spin rate. A least-square estimator was formulated which sequentially determines the spacecraft attitude from sucessive star crossings by minimizing the error in the star and scanner slit normal orthogonality. This spacecraft attitude also provides intermittent updates for the gyro propagated inertial attitude of the despun science platform. Simulation results are presented, showing successful star identification and attitude convergence in the presence of nutation and star transit time uncertainty. T.M.

N82-20212# Societe Nationale Industrielle Aerospatiale, Cannes (France).
SOFA: SYSTEM D'ORIENTATION FINE D'ANTENNE (AN ANTENNA FIN POINTING) MECHANISM
B. HUBERT and P. BRUNET *In* AGARD Spacecraft and Position Control 13 p (SEE N82-20208 11-12) Nov. 1981
Avail: NTIS HC A12/MF A01

The SOFA system is particularly suited to the transmit-and-receive antennae of television satellites. It is one of the requisites for a radiofrequency type deviation detector. The major characteristic of this system is complete freedom from friction and wear-out, resulting in numerous advantages, such as outstanding precision, virtually endless service life, high simplicity and reliability. The sizing method is described and performances are analyzed. The results from analogue simulations are presented. A functional model of the electrical and mechanical parts were built and subjected to on-ground tests using a 2 axis platform simulating the spacecraft's motions. The results obtained are in keeping with the predictions and simulations. Various possible applications of the SOFA system are mentioned. T.M.

N82-20213# Aerospace Corp., Los Angeles, Calif.
FACTORIZATION METHODS FOR PRECISION SATELLITE ORBIT DETERMINATION FOI HC/MF
G. J. BIERMAN (Factorized Estimation Applications, Inc.), L. A. CAMPBELL, and W. A. FEESS *In* AGARD Spacecraft Pointing and Position Control 16 p (SEE N82-20208 11-12) Nov. 1981 refs
(Contract F04701-80-C-0081)
Avail: NTIS HC A12/MF A01

State-of-the-art square root information filtering and smoothing technology that is incorporated into the Aerospace TRACE orbital analysis program are presented. Topics include a pseudo-epoch state batch-sequential filter formulation, techniques for inclusion of Markov process noise models, a variable dimension filter structure that accomodates state vectors of large size, and inclusion of a GPS second-order Markov clock model within the framework of the square root information filter/smoother formulation. Planned evaluation of filter/smoother performance in a GPS context is also discussed. The filter/smoother is to be used for post-flight orbit determination, covariance analysis, navigation system performance monitoring, and to generate reference 'best estimate' orbits. T.M.

N82-20214# British Aerospace Dynamics Group, Stevenage (England). Space and Communications Div.
GEOSTATIONARY COMMUNICATION SATELLITE CONTROL
L. FLOOK and J. J. POCHA *In* AGARD Spacecraft Pointing and Position Control 11 p (SEE N82-20208 11-12) Nov. 1981
Avail: NTIS HC A12/MF A01

The requirements for the control of the position and attitude of geostationary communications satellites were examined and some of the principle system parameters and options available are outlined. A number of current systems are compared and the principal limitations of their performance are discussed. The overall communication system trends are indicated and the effect of these upon the design of both attitude and position control is indicated. Author

N82-20215# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Oberpfaffenhofen (West Germany).
AUTONOMOUS STATION KEEPING OF GEOSTATIONARY SATELLITES
M. C. ECKSTEIN and A. LEIBOLD *In* AGARD Spacecraft Pointing and Position Control 28 p (SEE N82-20208 11-12) Nov. 1981 refs
Avail: NTIS HC A12/MF A01

The increasing ground operational complexity of controlling the orbits of future 3 axis stabilized geostationary satellites, introduced by more stringent station keeping accuracy requirements over long mission times, suggests the consideration of autonomous orbit control. A self contained onboard navigation system consisting of an Earth sensor, several Sun sensors, a Polaris sensor and an onboard clock was investigated. An epoxy element filter along with a reasonably simple orbit model was used to evaluate the navigational information from the sensor data. The orbit corrections were performed by low thrust electric propulsion according to an optimal strategy. The feasibility and performance of the autonomous system is demonstrated by computer simulation of a one year station keeping period for a large 1000 kg geostationary satellite at 19 deg west. All computations relevant to the station keeping system were carried out in single precision in order to simulate the reduced onboard processor capacity. Author

N82-20216# Dornier-Werke G.m.b.H., Friedrichshafen (West Germany).
DIGITAL ATTITUDE AND ORBIT CONTROL ELECTRONICS FOR LONG-LIFE COMMUNICATION SATELLITES
M. WLAKA *In* AGARD Spacecraft Pointing and Position Control 7 p (SEE N82-20208 11-12) Nov. 1981 refs Sponsored in part by DFVLR-BPT
Avail: NTIS HC A12/MF A01

A modular cost and time efficient data processing system which has found several applications in space projects such as the Spacelab Instrument Pointing System (IPS) and the Microwave Remote Sensing Experiment (MRSE) is described. The requirement for performing complicated control algorithms for attitude and orbit control (AOC) and the desire to use standardized on-board electronics led to the development of the modular, microprocessor based data handling system which consists of a 16 bit-processor, a memory block, and various input/output modules and has the following special features: low weight, small volume, and low power consumption achieved by using multilayer boards and flat-pack CMOS chips. The stringent reliability requirements for long-life satellies led to a high degree of redundancy and cross-strapping capability within the system. The described on-board data processing system provides the possibility of writing programs in PEARL which is idealy suited for realtime applications in the field of automatic attitude control. M.D.K.

N82-20217# Martin Marietta Aerospace, Denver, Colo.
INTEGRATED ORBIT/ATTITUDE DETERMINATION
A. D. MIKELSON *In* AGARD Spacecraft Pointing and Position Control 13 p (SEE N82-20208 11-12) Nov. 1981
Avail: NTIS HC A12/MF A01

The Space Sextant - Autonomous Navigation Attitude Reference System (SS-ANARS), a spacecraft subsystem that has the integrated capability of on-board orbit determination with on-board attitude determination is described. The Space Sextant is a gimballed-two telescope included angle measurement device that is driven by an on-board computer to measure the angles between celestial bodies, as seen from a spacecraft, to an accuracy of 1 arc second. Orbit determination with the system is achieved by measuring the included angles between brighter stars and the limbs of the Moon and Earth, and processing these angle measurements through a Kalman filter with an on-board digital computer. Spacecraft position accuracy from 800 to 1200 feet is determined for any Earth orbit. Attitude determination relative to the celestial sphere is determined with the same device to an accuracy of less than 1 arc second by measuring the included angles between the brighter stars and a reference platform consisting of a mirror and a Porro prism. The SS-ANARS described has progressed through critical technology development, a proof of concept model, a laboratory model, and a flight demonstration system. This flight demonstration system is to be flown as a sortie payload on the Space Transportation System (Space Shuttle) to prove its autonomous-integrated orbit and attitude determination capabilities. M.D.K.

N82-20218*# *National Aeronautics and Space Administration.* Marshall Space Flight Center, Huntsville, Ala.
A MULTILEVEL CONTROL APPROACH FOR A MODULAR STRUCTURED SPACE PLATFORM
F. D. CHICHESTER (Bendix Corp., Teterboro, N.J.) and M. T. BORELLI *In* AGARD Spacecraft Pointing and Position Control 10 p (SEE N82-20208 11-12) Nov. 1981 refs
Avail: NTIS HC A12/MF A01 CSCL 22B

A three axis mathematical representation of a modular assembled space platform consisting of interconnected discrete masses, including a deployable truss module, was derived for digital computer simulation. The platform attitude control system as developed to provide multilevel control utilizing the Gauss-Seidel second level formulation along with an extended form of linear quadratic regulator techniques. The objectives of the multilevel control are to decouple the space platform's spatial axes and to accommodate the modification of the platform's configuration for each of the decoupled axes. Author

N82-20219# British Aerospace Dynamics Group, Stevenage (England). Space and Communications Div.
DYNAMIC CONTROL OF LARGE SPACECRAFT: A SURVEY OF TECHNIQUES
R. C. ROGERS and M. BURTON *In* AGARD Spacecraft Pointing and Position Control 11 p (SEE N82-20208 11-12) Nov. 1981 refs
Avail: NTIS HC A12/MF A01

A number of techniques for the dynamic control of large spacecraft are discussed. The main problems identified are the high order of the system and model accuracy. One basic approach to design a controller for a low order model obtained by truncating modes from the system model is discussed. This may lead to instability problems due to interaction with unmodelled modes. A number of techniques are discussed which aim to avoid or overcome these problems. An alternative approach to controller design aims at ensuring stability in the presence of modelling errors and truncated modes. In the simplest case this involves direct output feedback. A technique which enables a dynamic

approach to be used is also discussed although it uses rate measurement and can therefore only be applied to vibration control. A brief comparison of the various control approaches applied to the control of a large platform is presented. Author

N82-20220# Lockheed Missiles and Space Co., Palo Alto, Calif.
MODELING, CONTROL AND SYSTEM IDENTIFICATION METHODS FOR FLEXIBLE STRUCTURES
N. K. GUPTA (Integrated Systems, Inc., Palo Alto, Calif.), M. G. LYONS (Integrated Systems, Inc., Palo Alto, Calif.), J. N. AUBRUN, and G. MARGULIES *In* AGARD Spacecraft Pointing and Position Control 41 p (SEE N82-20208 11-12) Nov. 1981 refs
Avail: NTIS HC A12/MF A01

Modeling, control design and system identification techniques to synthesize feedback control laws for large space structures are discussed. The theoretical background is covered. Techniques are applied to a mathematical model with complexity comparable to that of real flexible spacecraft. A tutorial description of the problem and summary of recent developments is included. The discussion is oriented towards the control design engineer. Author

N82-20221*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
CONTROL OF LARGE SPACE STRUCTURES USING ANNUAL MOMENTUM CONTROL DEVICES (AMCD'S)
S. M. JOSHI *In* AGARD Spacecraft Pointing and Position Control 12 p (SEE N82-20208 11-12) Nov. 1981 refs
Avail: NTIS HC A12/MF A01 CSCL 22B

A controller design approach for large space structures, which proposes the use of several Annular Momentum Control Devices (AMCD's) for structural damping enhancement, and either torque actuators of AMCD's for primary attitude control, was investigated. The damping enhancement controller makes the system asymptotically stable under certain relatively simple conditions. The closed-loop stability of the system with the primary attitude controller as well as the overall controller was established. It is shown that the same AMCD's can be used for the actuation of the damping enhancement controller and the primary attitude controller. Numerical results were obtained for a finite-element model of a large, thin, completely free, flat aluminum plate. Author

N82-20222# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Oberpfaffenhofen (West Germany).
MODERN SIMULATION TECHNIQUES IN SPACECRAFT DYNAMICS
R. STAPF, G. HEIMBOLD, and J. PULS *In* AGARD Spacecraft Pointing and Position Control 27 p (SEE N82-20208 11-12) Nov. 1981 refs
Avail: NTIS HC A12/MF A01

For investigation of the dynamic behavior of spacecraft systems, simulations are commonly used in nearly every phase of a mission. Three hardware simulation methods are presented: a pure physical simulation method, which makes extensive use of scaling techniques in order to overcome technical and environmental difficulties is demonstrated by means of two examples; a hybrid simulation technique is presented, which allows to include the dynamic behavior of flexible appendages into a physical simulation; and finally, the possibility of implicating satellite hardware in a computer simulation by use of a three axes flight simulator is pointed out. M.D.K.

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GROUND SUPPORT SYSTEMS AND FACILITIES (SPACE)

Includes launch complexes, research and production facilities; ground support equipment, e.g., mobile transporters; and simulators.

N82-10085# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
RANGE INSTRUMENTATION: THE WHITE SANDS MISSILE RANGE DATA SYSTEMS MANUAL
L. R. SUGERMAN (New Mexico State Univ., Las Cruces) Aug. 1981 10 p
(AGARD-AR-168; ISBN-92-835-1395-9; AD-A105969) Avail: NTIS HC A02/MF A01

The manual contains data on the telemetry systems, drone formation control system, optical instrumentation systems, and optical data reduction. Techniques of statistical analysis, least squares, and coordinate systems and map projections were reviewed. The radar systems, and the meterological and timing systems were examined. The data products were analyzed. T.M.

15

LAUNCH VEHICLES AND SPACE VEHICLES

Includes boosters; manned orbital laboratories; reusable vehicles; and space stations.

N81-16082# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
TECHNICAL EVALUATION REPORT ON THE 30TH GUIDANCE AND CONTROL PANEL TECHNICAL MEETING: SYMPOSIUM ON GUIDANCE AND CONTROL ASPECTS OF TACTICAL AIR-LAUNCHED MISSILES
J. M. GONZALEZ (General Research Co., Fort Walton Beach, Fla.) Oct. 1980 15 p refs Symp. held at Eglin AFB, Fla., 6-9 May 1980
(AGARD-AR-154) Avail: NTIS HC A02/MF A01

The evaluation is an assessment and integration of the individual technical presentations, the discussions which followed each presentation, the round table discussion, and the written comments made by the symposium attendees on the evaluation forms. Detailed technical objectives were established for each session based on the symposium theme and remarks made in the keynote address, and then compared with the collective content of each session to establish the area where the objectives were and were not met. T.M.

N81-16092# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
GUIDANCE AND CONTROL ASPECTS OF TACTICAL AIR-LAUNCHED MISSILES
Oct. 1980 148 p refs Presented at the Guidance and Control Panel Symp., Eglin Air Force Base, Fla., 6-9 May 1980
(AGARD-CP-292; ISBN-92-835-1370-3; AD-A092606) Avail: NTIS HC A07/MF A01

Twenty-six papers are presented on the following topics: operational requirements, system considerations, air to surface guided weapons technology, air to air guided weapons technology, and tactical guided weapons evaluation techniques. For individual titles, see N81-16093 through N81-16102.

15 LAUNCH VEHICLES AND SPACE VEHICLES

N81-16093# Army Missile Command, Redstone Arsenal, Ala. Guidance and Control Dept.

PRECISION FIRE CONTROL FOR SEMIACTIVE TERMINAL HOMING MISSILES

J. B. HUFF and J. L. BAUMANN *In* AGARD Guidance and Control Aspects of Tactical Air-launched Missiles 13 p (SEE N81-16092 07-15) Oct. 1980

Avail: NTIS HC A07/MF A01

The US Army Missile Command's technology base for development of the precision pointing and tracking or fire control for laser guidance is examined. General requirements are transformed into specific design parameters for target acquisition and designation; technology hardware and performance are described. A target designation performance evaluation method, developed out of a specific need to handle large quantities of data, is discussed. A.R.H.

N81-16094# Rockwell International Corp., Columbus, Ohio.

STRAPDOWN SEEKER TECHNOLOGY FOR THE TERMINAL GUIDANCE OF TACTICAL WEAPONS

R. D. EHRICH and P. VERGEZ (Air Force Armament Lab., Eglin AFB, Fla.) *In* AGARD Guidance and Control Aspects of Tactical Air-launched Missiles 15 p (SEE N81-16092 07-15) Oct. 1980 refs

Avail: NTIS HC A07/MF A01

Strapdown or body fixed seekers with sufficient field of view for the terminal guidance of many tactical weapons are now approaching state of the art. Such seekers have a number of advantages over gimballed seekers, including increased reliability and unlimited line of sight rate capability. The major disadvantage is that inertial line of sight rates are not directly available for the implementation of proportional navigation. To form line of sight rates, the seeker output must be combined with inertial sensor measurements. This, however, results in a potential instability due to seeker gain errors. This problem has been minimized by a dither adaptive parameter identification approach for the measurement and correction of seeker errors. Simulation studies indicate the performance of such systems can be comparable to that of gimballed seekers. The basic principles and problems involved with mechanizing proportional navigation with strapdown seekers are considered and performance results for the dither adaptive technique are presented. Author

N81-16095# Air Force Armament Lab., Eglin AFB, Fla.

INTEGRATION OF DIGITAL AVIONICS COMPONENTS FOR GUIDED WEAPONS

A. M. HENNE and D. W. GEYER *In* AGARD Guidance and Control Aspects of Tactical Air-launched Missiles 8 p (SEE N81-16092 07-15) Oct. 1980 Prepared in cooperation with General Dynamics/Convair, San Diego, Calif.

Avail: NTIS HC A07/MF A01

The current approach for guided weapon avionics is to use custom digital computational elements connected together with large cables. If these computational tasks can be partitioned into common tasks, and if standard interfaces can be defined, it would promote interchangeable missile guidance and control components and enhance interoperability. The digital integrating subsystem (DIS) program is a current effort to establish these standards and procedures. In the digital integrating subsystem concept, the total data processing requirements of a typical standoff weapon are met by utilizing a number of individual microcomputers that communicate with each other on a serial multiplex bus, the number of microcomputers being dependent upon the total data processing work load of the weapon. Each microcomputer is tasked to do calculations associated with a particular avionics function. Once the computations are completed, the results are 'broadcast' on the multiplex bus. Each computer also listens for only the data it requires on the bus. System design, details on the interface characteristics, and a progress report on the construction of brassboard units are presented. A.R.H.

N81-16096# Lear Siegler, Inc., Grand Rapids, Mich.

INDUSTRY LOW-COST INERTIAL GUIDANCE SYSTEM DEVELOPMENT

W. K. STOB and T. K. WU (Air Force Armament Lab., Eglin AFB, Fla.) *In* AGARD Guidance and Control Aspects of Tactical Air-launched Missiles 22 p (SEE N81-16092 07-15) Oct. 1980 refs

(Contract F08635-79-C-0196)

Avail: NTIS HC A07/MF A01

The necessity for an adverse weather, standoff launch and leave capability in both powered and unpowered guided weapons led to development programs for a low cost inertial guidance subsystem by the United States Air Force. The subsystem, initialized via a prelaunch maneuver sequence to permit transfer alignment and inertial sensor calibration, is used to provide midcourse inertial guidance to a terminal acquisition basket or it can be used with periodic updates provided by other subsystems such as global positioning system, radiometric area correlator, or terrain contour matching for improved accuracy on extended range missions. The history of the low cost inertial guidance system concept development and the design features of the Industry LCIGS configuration are described. Author

N81-16097# McDonnell-Douglas Astronautics Co., St. Louis, Mo.

UNAIDED TACTICAL GUIDANCE FLIGHT TEST

L. D. PERLMUTTER and C. K. FITSCHEN (Air Force Armament Lab., Eglin AFB, Fla.) *In* AGARD Guidance and Control Aspects of Tactical Air-launched Missiles 15 p (SEE N81-16092 07-15) Oct. 1980 refs

(Contract F08637-79-C-0175)

Avail: NTIS HC A07/MF A01

A low cost midcourse guidance technique suitable for standoff tactical weapons uses the launch aircraft navigation system and Kalman filtering to align and calibrate a weapon contained, low cost strapdown navigation system. Post launch, the strapdown system provides unaided inertial guidance along the midcourse trajectory. The strapdown sensor chosen to implement this form of guidance is the low cost inertial guidance subsystem (LCIGS), a modular strapdown package which uses embedded microprocessors, single degree of freedom gyroscopes, and pendulous mass accelerometers. Designed and built for use in tactical weapons, LCIGS features digital torque loops for the gyros and temperature compensation of all six sensors. Studies were conducted to project system performance, and the results indicate that through the alignment and calibration process the predominant LCIGS sensor errors can be reduced by an order of magnitude. A flight test program was structured to demonstrate performance. The unaided tactical guidance concept, the system hardware and software to be tested, the LCIGS and the preflight calibration features incorporated into its support equipment, unique laboratory testing to be performed on the system, and the planned flight tests are described. A.R.H.

N81-16098# Societe Matra (France).

APPLICATION OF MODERN CONTROL THEORY TO THE GUIDANCE OF AN AIR TO AIR DOGFIGHT MISSILE

M. MIRANDE, M. LEMOINE, and E. DOREY *In* AGARD Guidance and Control Aspects of Tactical Air-launched Missiles 12 p (SEE N81-16092 07-15) Oct. 1980 In FRENCH; ENGLISH summary

Avail: NTIS HC A07/MF A01

An 'optimal' guidance law was derived (taking into account the flight time and the consumed energy in the 'cost' function), without having to assume linearization, i.e., low off boresight conditions with respect to the collision path. A condition on miss distance was set by imposing a constraint on the final state missile to target range. A constant speed missile was assumed which has led to a closed form analytical expression for the guidance law. Because this solution requires knowledge of the final state, an algorithm was developed to mechanize the guidance law. The results obtained with the optimal guidance law were compared to the ones obtained with conventional proportional navigations (true P.N and pure P.N). The results show that the derived optimal guidance law derived is always convergent, even in firing conditions where T.P.N. fails (large off boresight); however, it seems that P.P.N. leads to very comparable results, provided the gain is adequately adjusted, without the complication of needing the final state knowledge. A.R.H.

N81-16099# Raytheon Co., Bedford, Mass. Missile Systems Div.
CLASSICAL VERSUS MODERN HOMING MISSILE GUIDANCE
F. W. NESLINE and P. ZARCHAN *In* AGARD Guidance and Control Aspects of Tactical Air-launched Missiles 17 p (SEE N81-16092 07-15) Oct. 1980 refs
Avail: NTIS HC A07/MF A01

It is generally accepted that modern guidance systems yield better performance than classical proportional navigation systems. However, it is not always recognized that this better performance carries with it certain costs in improved components or additional instruments. A modern guidance system, MGS, to a classical proportional navigational, PN, homing missile guidance system in terms of performance, robustness, and ease of implementation. Quantitative first order miss distances are compared to show that MGS has the smallest miss if component tolerances can be met, but as component tolerances or measurement errors degrade, MGS degrades faster than PN until, at relatively large component or measurement errors, PN has less miss distance than MGS.
A.R.H.

N81-16100# Air Force Armament Lab., Eglin AFB, Fla.
OPTIMAL CONTROL AND ESTIMATION FOR TERMINAL GUIDANCE OF TACTICAL MISSILES
T. L. RIGGS, JR. *In* AGARD Guidance and Control Aspects of Tactical Air-launched Missiles 11 p (SEE N81-16092 07-15) Oct. 1980 refs
Avail: NTIS HC A07/MF A01

Good results in developing advanced guidance laws and estimation techniques for application in future tactical weapons were obtained using the linear quadratic, the linear quadratic Gaussian, singular perturbation, reachable set, and f differential game theories. Of the thirty algorithms developed the most simplistic was derived using the linear quadratic Gaussian theory. The derivation of this guidance law is discussed and its performance is compared to proportional navigation. Results show that the use of optimal control and estimation theory can be done without increasing the hardware requirements of the missile system. These concepts also offer the potential for decreasing sensor accuracy specifications without degrading the total system performance.
A.R.H.

N81-16101# Boeing Aerospace Co., Seattle, Wash.
DEVELOPMENT TESTING AND FLIGHT CERTIFICATION TESTING OF TERMINALLY GUIDED SUBMISSILES
J. G. BLAND, H. D. ULRICH, K. L. WISMER, W. D. CLINGMAN, and C. K. GRONEWOLD *In* AGARD Guidance and Control Aspects of Tactical Air-launched Missiles 15 p (SEE N81-16092 07-15) Oct. 1980
Avail: NTIS HC A07/MF A01

The segments of an example terminally guided submissile (TGSM) tactical mission are examined to identify those guidance and control modes employed in performing the mission. Special control problems resulting from drop testing from helicopter carrier vehicles are also identified to further define the elements of the test problem. Boeing's development test program for TGSM vehicles is then described, including descriptions of our terminal guidance laboratory facilities. Additional detail is given on the laboratory configurations for testing TGSM's using both IR and millimeter wave (MMW) seekers. Development of the real time hardware in the loop (HITL) TGSM simulation is then summarized along with those problems addressed through the use of the HITL simulation. Some HITL simulation data generated during the phase 2 assault breaker program are presented, analyzed, and discussed to show their utilization in evaluating TGSM performance. Author

N81-16102# Air Force Armament Lab., Eglin AFB, Fla.
CLUTTER MODEL VALIDATION FOR MILLIMETER WAVE (MMW) SEEKERS
R. SALEMME, D. BOWYER (Systems Control, Inc., Shalimar, Fla.), and R. MERRITT (Systems Control, Inc., Shalimar, Fla.) *In* AGARD Guidance and Control Aspects of Tactical Air-launched Missiles 12 p (SEE N81-16092 07-15) Oct. 1980 refs
Avail: NTIS HC A07/MF A01

In the clutter modeling process, an empirical approach is used in which deterministic map data are used to establish homogeneous terrain subareas. These subareas are then represented, statistically, with a spatial distribution for the median clutter backscatter from each cell and a temporal distribution for the scintillation around this median. In addition, a spatial correlation is applied to the median backscatter for adjacent cells. To validate these clutter models, the primary method is to use the statistics which are derived from measurement data over a variety of different terrain types to verify the statistics in the clutter model. An alternate method is to compare the actual seeker output from flight tests over a specific test site to the output of a simulation of this same test flight. The requirement for validated clutter modes led to the establishment of an extensive clutter measurements program. The requirements for this measurements program were established based on the clutter parameters which must be validated and projected flight configurations of tactical seekers which are currently under development.
A.R.H.

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COMPOSITE MATERIALS

Includes laminates.

N81-11128# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
EFFECT OF SERVICE ENVIRONMENT ON COMPOSITE MATERIALS
Aug. 1980 326 p refs In ENGLISH; partly in FRENCH Presented at the 50th Meeting of the AGARD Struct. and Mater. Panel, Athens, 14-17 April 1980
(AGARD-CP-288; ISBN-92-835-0273-6; AD-A090311) Avail: NTIS HC A15/MF A01

The effects of environmental and mechanical stress on the composite materials of aircraft structures are described. Graphite-epoxy and carbon fiber reinforced plastics are tested for fatigue and tensile creep. Effects of environmental temperature and moisture (humidity) are emphasized. Applications for aerodynamic and aerospace engineering are included. For individual titles, see N81-11129 through N81-11149.

N81-11129# British Aerospace Aircraft Group, Preston (England). Advanced Structural Applications Dept.
THE IMPLICATIONS OF LABORATORY ACCELERATED CONDITIONING OF CARBON FIBRE COMPOSITES
E. C. EDGE *In* AGARD Effect of Serv. Environ. on Composite Mater. 17 p (SEE N81-11128 02-24) Aug. 1980 refs
Avail: NTIS HC A15/MF A01

The evidence on the effects of long term natural weathering of carbon fiber composites is examined and its implications with regard to the conditioning of test specimens discussed. The effects of laboratory accelerated tests on the properties of some composite materials are considered in conjunction with the relevance of data thus acquired to real life situations and the need to generate the data with reasonable speed for design considerations. The changes in conditioning procedure which have taken place are outlined along with the factors which have influenced these changes.
Author

N81-11130# Toronto Univ., Downsview (Ontario). Inst. for Aerospace Studies.
EFFECT OF VARIOUS ENVIRONMENTAL CONDITIONS ON POLYMER MATRIX COMPOSITES
R. C. TENNYSON *In* AGARD Effect of Serv. Environ. on Composite Mater. 21 p (SEE N81-11128 02-24) Aug. 1980 refs
Avail: NTIS HC A15/MF A01

Experimental results obtained on the short and long term behavior of polymer matrix composites subjected to various environmental conditions are given. Changes in mechanical stiffness, strength and coefficient of thermal expansion were measured under ambient pressure and thermal vacuum conditions. In all tests involving the vacuum environment, measurements were made in-situ, necessitating the use of mechanical loading fixtures acting through flexible bellows to provide stiffness and strength data. Results are given on the effects of varying some fabrication parameters (length of post-cure time and rate of cool-down in autoclave) on the changes observed in strength and stiffness.

The materials investigated include: graphite/epoxy, boron/epoxy, PRD-49/epoxy and E glass/epoxy. S.F.

N81-11131# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick (West Germany). Inst. for Structural Mechanics.

PREDICTABILITY OF MOISTURE ABSORPTION IN GRAPHITE/EPOXY SANDWICH PANELS

H. W. BERGMANN and P. NITSCH *In* AGARD Effect of Serv. Environ. on Composite Mater. 11 p (SEE N81-11128 02-24) Aug. 1980 refs

Avail: NTIS HC A15/MF A01

Graphite/epoxy materials tend to degrade in hot and moist environments. The high dependence of the strength loss on the moisture content demands an assessment of the amount and distribution of absorbed moisture, particularly in the case of lightweight sandwich panels. The reliability of such predictions hinges on the formulation of theoretical considerations, the accuracy of numerical processes, the definition of material constants and a proper interpretation of the environmental conditions. The impact of errors in these parameters on predicted moisture contents, and comparisons of analytical forecasts with experimentally determined values, are the topics of this paper. S.F.

N81-11132# Istituto di Tecnologia Aerospaziale, Rome (Italy).

EFFECTS CONNECTED WITH THE SPACE ENVIRONMENT ON COMPOSITE MATERIALS

R. BARBONI, M. MARCHETTI, and I. PERONI *In* AGARD Effects of Serv. Environ. on Composite Mater. 20 p (SEE N81-11128 02-24) Aug. 1980 refs

Avail: NTIS HC A15/MF A01

Experimental and analytical results for the mechanical and thermal behavior of carbon fiber pultrusion and laminate. Particular attention is paid to the temperature effects on the static mechanical characteristics and their nonhookean behavior for the range 300 to 450 K. Dynamic tests in order to find the internal damping are described. The linear coefficients of thermal expansion, are reported for the temperature range 150 to 400K. Calculated values of thermal expansion are in close agreement with those measured. S.F.

N81-11133# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (West Germany).

CONSTANT-AMPLITUDE AND FLIGHT-BY-FLIGHT TESTS ON CFRP SPECIMENS

F. J. ARENDTS, K. O. SIPPEL, and D. WEISGERBER *In* AGARD Effects of Serv. Environ. on Composite Mater. 12p (SEE N81-11128 02-24) Aug. 1980 refs Sponsored in part by Ministry of Defense

Avail: NTIS HC A15/MF A01

Constant amplitude and flight by flight tests with five different load spectra were done with unnotched carbon fiber reinforced plastic specimens. The influence of overloads was investigated. The test results were compared with fatigue life predictions based on 'miner's rule' applied for different conditions. Overloads in all cases cause a significant reduction of the fatigue life. Fatigue life estimations based on 'miner's rule' are on the unsafe side in some cases by more than a factor 10, getting a big scatter among the cases investigated. S.F.

N81-11134# Laboratorium fuer Betriebsfestigkeit, Darmstadt (West Germany).

FATIGUE STRENGTH OF CFRP UNDER COMBINED FLIGHT-BY-FLIGHT LOADING AND FLIGHT-BY-FLIGHT TEMPERATURE CHANGES

J. J. GERHARZ and D. SCHUETZ *In* AGARD Effect of Serv. Environ. on Composite Mater. 24 p (SEE N81-11128 02-24) Aug. 1980 refs

Avail: NTIS HC A15/MF A01

Influence of environment on the fatigue of carbon fiber reinforced plastics unnotched, notched and bolted specimens is studied. The specimens are simultaneously subjected to load and environmental histories. A flight by flight load and environment sequence typical for the wing root of a fighter airplane is applied. Tests with simplified simulation of environment, allowing high loading frequencies, are run. The admissibility of the simplifications is evaluated by comparing the results of each simplified test with the results from long time quasi real time test with temperatures accompanying the loads in each flight. The 'quasi real time' flight by flight program includes temperature cycles and a humidity cycle. The specimens are heated and cooled by preconditioned air forced through the test chamber. The results of room temperature fatigue tests and of static tests at various environmental conditions are available. For a constant fatigue stress level residual strength and stiffness data demonstrate the damage growth made apparent by ultrasonic scan records. S.F.

N81-11135# Royal Netherlands Aircraft Factories Fokker, Rijswijk.

FATIGUE TEST RESULTS OF CARBON FIBER REINFORCED PLASTIC F28 AIRCRAFT COMPONENT AND ITS STRUCTURAL DETAILS

J. A. A. M. DIJNS *In* AGARD Effect of Serv. Environ. on Composite Mater. 5 p (SEE N81-11128 02-24) Aug. 1980

Avail: NTIS HC A15/MF A01

As a part of the development program on the structural application of carbon fiber reinforced plastic composites in aircraft structures, a speedbrake was designed and built in carbon fiber reinforced plastics and aramide fiber composites. Different configurations were studied and one was selected for a detailed design in the form of a schematic model. Test were carried out on structural details and two schematic speedbrake models were fabricated for full scale static and dynamic load tests. One speedbrake was produced for flight testing on an operational aircraft. The tests resulted in a design of the speedbrake in which no metal parts were used and in which all joints were bonded with 120 C and room temperature curing adhesives, without the use of additional fasteners. The first model speedbrake was successfully tested to ultimate load without failure or any plastic deformation. The second model speedbrake was tested at a maximum fatigue load equal to 65 percent of the ultimate load. The full size CFRP speedbrake showed a weight saving of 25 percent when compared with the Al alloy design. S.F.

N81-11136# General Dynamics Corp., Fort Worth, Tex. Materials Research Lab.

EFFECTS OF TEMPERATURE AND MOISTURE ON THE CREEP COMPLIANCE OF GRAPHITE-EPOXY COMPOSITES

K. G. KIBLER *In* AGARD Effect of Serv. Environ. on Composite Mater. 8 p (SEE N81-11128 02-24) Aug. 1980 refs

(Contract F33615-77-C-5109)

Avail: NTIS HC A15/MF A01

Time-dependent environmental behavior of graphite-epoxy composites used in aerospace structural applications is described. Experimental and analytical results are presented for the individual and coupled effects of temperature and absorbed moisture on the creep compliance of unidirectional and cross-plied composites. Measurement of tensile creep response at room temperature and four elevated temperatures (up to the glass transition region of the materials) for dry specimens and for specimens moisture-saturated at 75 percent and 95 percent relative humidity is presented. The stress levels used are demonstrated to be within the range of linearly viscoelastic response. Superposition techniques are used to determine compliance master curves from the results of individual temperature and moisture conditions. S.F.

N81-11137# Royal Aircraft Establishment, Farnborough (England). Materials Dept.

RELATIONSHIPS BETWEEN IMPACT RESISTANCE AND FRACTURE TOUGHNESS IN ADVANCED COMPOSITE MATERIALS

G. DOREY *In* AGARD Effects of Serv. Environ. on Composite Mater. 11 p (SEE N81-11128 02-24) Aug. 1980 refs

Avail: NTIS HC A15/MF A01

A variety of CFRP laminates and one GRP laminate were subjected to impact by steel balls, over a range of incident energies, and residual strengths were measured. Superimposed static load during impact substantially altered the residual strength curves. The laminates were also tested with machined notches and analyzed in terms of fracture toughness. Results of impact performance both during impact and in subsequent residual strength tests were compared, with the aim of correlating service performance with laboratory toughness tests. Effects of materials

and geometric variables are discussed together with possibilities for improvements. R.K.G.

N81-11138# Societe Nationale Industrielle Aerospatiale, Marignane (France.) Div. Helicopteres.
EROSION AND IMPACTS ON COMPOSITE HELICOPTER BLADES [EROSION ET IMPACTS SUR LES PALES D'HELICOPTERES EN COMPOSITES]
M. TORRES *In* AGARD Effect of Serv. Environ. on Composite Mater. 10 p (SEE N81-11128 02-24) Aug. 1980 In FRENCH
Avail: NTIS HC A15/MF A01

Helicopter rotors are subjected to a certain number of aggressions associated with the environment in which they rotate. The use of new materials such as carbon and glass epoxy composites requires the manufacturer to conduct specific qualification research programs for each of these aggressions. The modes of degradation from rain and sand erosion and from civil and military impacts on blades made of composite materials are presented. Research on erosion enabled selection of the most effective protective materials. Experience in the use of blades as well as results from firing and impact tests show an excellent fatigue behavior after shocks and impact, due in a large measure to the fail-safe character of composite materials. This good behavior, associated with the possibility of very extensive repairs, is an important factor to the superiority of composite blades over metal blades. Transl. by A.R.H.

N81-11139*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
GRAPHITE-EPOXY PANEL COMPRESSION STRENGTH REDUCTION DUE TO LOCAL IMPACT
M. F. CARD and M. D. RHODES In AGARD Effect of Serv. Environ. on Composite Mater. 13 p (SEE N81-11128 02-24) Aug. 1980 refs
Avail: NTIS HC A15/MF A01 CSCL 11D

The effects of low velocity impact on the compressive strength of graphite/epoxy structures are reviewed. Extensive tests were conducted on sandwich beams, laminated plates and stiffened panels. Conditions for failures were investigated by impact tests on statically loaded test specimens. Lightly loaded graphite structures (such as aircraft secondary structure) were insensitive to impact damage. In more heavily loaded structures, (such as wing panels), appreciable reductions in compressive strength occurred. The implications of the tests for structural design are discussed by comparing panel masses for designs where ultimate strains were reduced due to impact considerations with the masses of designs with higher ultimate strains. Preliminary test data are presented to show the possibility of improvements in damage to tolerance achievable by using an alternate matrix material. R.K.G.

N81-11140# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Stuttgart (West Germany). Inst. fuer Bauweissen-und Konstruktionsforschung.
THE INFLUENCE OF DEFECTS ON THE BEHAVIOUR OF COMPOSITES
R. AOKI and K. STELLBRINK *In* AGARD Effect of Serv. Environ. on Composite Mater. 25 p (SEE N81-11128 02-24) Aug. 1980 refs
Avail: NTIS HC A15/MF A01

The load carrying capacity of composite structures in aircrafts, spacecrafts etc., is greatly influenced by inherent defects or damages induced during utilization. The effect of simulated defects on the fatigue behaviour and residual strength of GFRP and CFRP laminates is reported. Two kinds of mechanically produced damages in thin laminates caused by dropped tools: a three square identation generated by a tapered triangular tip and a delamination zone produced by a ball shaped tip are discussed. The investigated materials are epoxy resins reinforced with E-glass fabric as well as T300 carbon fiber fabric and unidirectional layup with various orientation sequences. R.K.G.

N81-11141# Centre d'Essais Aeronautique Toulouse (France).
ASSESSING THE BEHAVIOR OF HIGH MODULUS COMPOSITE MATERIALS IN LIGHTNING [EVALUATION DU COMPORTEMENT A LA FOUDRE DE STRUCTURES EN MATERIAUX COMPOSITES HAUT MODULE]
J. ROUCHON and D. GALL *In* AGARD Effect of Serv. Environ. on Composite Mater. 14 p (SEE N81-11128 02-24) Aug. 1980 In FRENCH
Avail: NTIS HC A15/MF A01

Lightning strikes of aircraft in flight are relatively frequent and result in damage and even destruction to both equipment and structures, particularly those made of composite materials. Generalities about lightning are reviewed and methods for measuring it during flight and simulating it on the ground are described. Results are presented for laboratory tests on carbon-epoxy monolithic and boron-epoxy coated sandwich specimens, and on the elements of real structures. Associated control processes are also considered. Transl. by A.R.H.

N81-11142# Boeing Co., Seattle, Wash.
LIGHTNING PROTECTION CONSIDERATIONS FOR GRAPHITE/EPOXY AIRCRAFT STRUCTURE
S. D. SCHNEIDER *In* AGARD Effect of Serv. Environ. on Composite Mater. 6 p (SEE N81-11128 02-24) Aug. 1980 refs
Avail: NTIS HC A15/MF A01

When advanced composites such as graphite/epoxy were first being considered for aircraft structure, a common belief was that lightning would heavily damage the structure. This belief has since proven to be false. Advanced composites react to lightning strikes in a manner different from aluminum, but the resultant damage is by no means alarming. Two basic types of lightning damage to which aircraft structures are subjected, are discussed. Known, documented techniques and design philosophies for protection against lightning caused structural damage are reviewed for classical aluminum aircraft structure fabricated with metal fasteners, and the impact of graphite/epoxy on these classical approaches is addressed. Detailed lightning test criteria, test techniques, and criteria are also given and related to graphite structures. R.K.G.

N81-11143*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
THE POTENTIAL FOR DAMAGE FROM THE ACCIDENTAL RELEASE OF CONDUCTIVE CARBON FIBERS FROM AIRCRAFT COMPOSITES
V. L. BELL *In* AGARD Effect of Serv. Environ. on Composite Mater. 21 p (SEE N81-11128 02-24) Aug. 1980 refs
Avail: NTIS HC A15/MF A01 CSCL 11D

Carbon and graphite fibers are known to be electrically conductive. The rapidly accelerating use of carbon fibers as the reinforcement in filamentary composite materials brought up the possibility of accidental release of carbon fibers from the burning of crashed commercial airliners with carbon composite parts. Such release could conceivably cause widespread damage to electrical and electronic equipment. The experimental and analytical results of a comprehensive investigation of the various elements necessary to assess the extent of such potential damage in terms of annual expected costs and maximum losses at low probabilities of occurrence are presented. A review of NASA materials research program to provide alternate or modified composite materials to overcome any electrical hazards from the use of carbon composites in aircraft structures is described. R.K.G.

N81-11144*# Michigan Univ., Ann Arbor. Dept. of Mechanical Engineering.
EROSION OF COMPOSITE MATERIALS
G. S. SPRINGER *In* AGARD Effect of Serv. Environ. on Composite Mater. 9 p (SEE N81-11128 02-24) Aug. 1980 refs
Avail: NTIS HC A15/MF A01 CSCL 11D

A model for describing the response of uncoated and coated fiber reinforced composites subjected to repeated impingements of liquid (rain) droplets is presented. The model is based on the concept that fatigue is the dominant factor in the erosion process. Algebraic expressions are provided which give the incubation period, the rate of mass loss past the incubation period, and the total mass loss of the material during rain impact. The influence of material properties on erosion damage and the protection offered by different coatings are discussed and the use of the model in

the design in the design of structures and components is illustrated. R.K.G.

N81-11145# Westland Helicopters Ltd., Yeovil (England).
FATIGUE AND DAMAGE PROPAGATION IN COMPOSITE ROTOR BLADES
A. J. BARNARD *In* AGARD Effect of Serv. Environ. on Composite Mater. 17 p (SEE N81-11128 02-24) Aug. 1980 Sponsored by Ministry of Defense, England
Avail: NTIS HC A15/MF A01

The development and flight evaluation of carbon/glass fiber reinforced plastic rotor blades is considered. Results are presented from tests undertaken on tail and main blades. The excellent fatigue and damage propagation characteristics of the composite blades are emphasized. The rig and flight tests demonstrated unlimited fatigue lives for the composite blades and the structural element tests indicated low material scatter factors in both static and fatigue cases. Test results also indicate improved safety through the use of composite blades. J.M.S.

N81-11146# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (West Germany).
SERVICE EXPERIENCE WITH GRC HELICOPTER BLADES (BO-105)
K. BRUNSCH *In* AGARD Effect of Serv. Environ. on Composite Mater. 17 p (SEE N81-11128 02-24) Aug. 1980 refs
Avail: NTIS HC A15/MF A01

The service experience of light helicopters (BO-105) both for civil and military operations is discussed with emphasis on data accumulated on composite (GRC) rotor blades. Full scale fatigue test results with new blades and blades after 4000 hours of flight are compared as are coupons cut out of blades before and after thousands of service hours. Impact strength and erosion-corrosion problems are among the factors considered. J.M.S.

N81-11147*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
COMPOSITE COMPONENTS ON COMMERCIAL AIRCRAFT
H. B. DEXTER *In* AGARD Effect of Serv. Environ. on Composite Mater. 22 p (SEE N81-11128 02-24) Aug. 1980 refs
Avail: NTIS HC A15/MF A01 CSCL 11D

Flight experience gained with numerous composite aircraft structures is discussed. Both commercial transports and helicopters are included. Design concepts with significant mass savings and appropriate inspection and maintenance procedures are among the factors considered. Also, a major NASA/U.S. industry technology program to reduce fuel consumption of commercial transport aircraft through the use of advanced composites is described, including preliminary results. Ground and flight environmental effects on the composite materials used in the flight service programs are also discussed. J.M.S.

N81-11148# Air Force Wright Aeronautical Labs., Wright-Patterson AFB, Ohio. Systems Support Div.
AIR FORCE APPLICATIONS AND IN-SERVICE EXPERIENCE WITH COMPOSITE STRUCTURES
F. J. FECHEK *In* AGARD Effect of Serv. Environ. on Composite Mater. 10 p (SEE N81-11128 02-24) Aug. 1980
Avail: NTIS HC A15/MF A01

Advanced composite development programs which contribute to the capability to use these materials in primary and secondary structures on high performance military aircraft are described. Emphasis is placed on a systematic, periodic nondestructive evaluation of selected composite structures in operational service. Visual and X-radiographic inspection techniques are shown to be quite usable on composite strucutres in the field. However, inefficiencies using available, portable ultrasonic inspection equipment in the field environment accentuate the need for the development of a semi-automated, ultrasonic inspection system specifically designed to be compatible with current, production composite aircraft structures. A system satisfying these needs is shown to be feasible. J.M.S.

N81-11149# Naval Air Systems Command, Washington, D. C.
US NAVY SERVICE EXPERIENCE WITH ADVANCED COMPOSITES
A. SOMOROFF, M. DUBBERLY, J. M. MCGINN, M. TARRICONE, and A. MANNO (Naval Air Development Center, Warminster, Pa.) *In* AGARD Effect of Serv. Environ. on Composite Mater. 16 p (SEE N81-11128 02-24) Aug. 1980 refs
Avail: NTIS HC A15/MF A01

Lifetime durability information encompassing laboratory programs, exposure of ground specimens and observation of flight structures is presented. The specific structures discussed include the F-14 horizontal stabilizer and the H-46 rotor blade which are in production, and the YAV-8B wing developed for production of the AV-8B. Also discussed are S-3 spoilers and F-4 access doors which were developed exclusively to acquire service data. It is noted that the F-18 aircraft makes extensive use of graphite-epoxy composites in primary wing, horizontal stabilizer, and vertical stabilizer skin structure. As of the end of February 1980, eleven F-18 development aircraft are engaged in flight test evaluation. A cumulative total of more than 900 flight hours have been accumulated with the highest number of flight hours for an individual aircraft being 214 and the longest calendar service time for an individual aircraft being 18 months. During this period the graphite-epoxy structure has performed well and without incident. J.M.S.

N81-16144# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
ELECTROMAGNETIC EFFECTS OF (CARBON) COMPOSITE MATERIALS UPON AVIONICS SYSTEMS
F. S. STRINGER, (ed.) (RAE, Farnborough, England) Oct. 1980 369 p refs Partly in ENGLISH and FRENCH Conf. held at 39th Tech. Meeting of the Avionics Panel of AGARD, Lisbon, 16-19 Jun. 1980.
(AGARD-CP-283; ISBN-92-835-0277-9; AD-A093658) Avail: NTIS HC A16/MF A01

The impact of electromagnetic effects generated by the introduction of composite materials in aircraft engineering is discussed. Topics include materials and applications, characteristics, measurements, modelling and standards, electromagnetic effects on radiation patterns, lightning problems, protection, and tradeoff methods. For individual titles, see N81-16145 through N81-16166.

N81-16145*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
CURRENT AND PROJECTED USE OF CARBON COMPOSITES IN UNITED STATES AIRCRAFT
R. LEONARD and D. R. MULVILLE (Naval Air Systems Command, Washington, D.C.) *In* AGARD Electromagnetic Effects of (Carbon) Composite Mater. Upon Avionics Systems 19 p (SEE N81-16144 07-24) Oct. 1980 refs
Avail: NTIS HC A16/MF A01 CSCL 11D

Carbon composite materials are finding limited use in both civil and military aircraft structures to exploit their weight saving potential for improved performance or fuel efficiency. Since these needs are growing, and a manufacturing cost savings potential is also recognized, wider use of composites in the near future may be expected. Carbon composites generally involve fiber volume fractions in excess of 60 percent in a variety of orthotropic sandwich or solid laminates. Bidirectional woven carbon cloth, common in recently designed structure, may provide higher, more uniform laminate conductivities than tape. E.D.K.

N81-16146# Societe Nationale Industrielle Aerospatiale, Paris (France).
THE EFFECT OF THE IN-SERVICE ENVIRONMENT ON COMPOSITE MATERIALS (RESUME OF THE APRIL 1980 ATHENS CONFERENCE) [EFFET DE L'ENVIRONMENT EN SERVICE SUR LES MATERIAUX COMPOSITES (RESUME DUE CONGRES D'ATHENES-AVRIL 80)]
G. JUBE *In its* Electromagnetic Effects of (Carbon) Composite Mater. Upon Avionics Systems 4 p (SEE N81-16144 07-24) Oct. 1980 In FRENCH
Avail: NTIS HC A16/MF A01

Reported experience of the effect of physical and mechanical aggressions (environment) on composite materials and structures is summarized. Topics covered include: (1) the physical chemistry

of the environment and the sensitivity of the composite materials to humidity; (2) the behavior of composite materials in spatial ambience, particularly in vacuum; (3) rules for predicting damage to composite structures and the effect of accidental impact; (4) atmospheric physical phenomena, particularly lightning and rain erosion; and (5) the in service behavior of helicopter blades, NASA experience with transport aircraft structures, and USAF and Navy experience with boron and carbon fiber composites.

Transl. by A.R.H.

N81-16147# British Aerospace Aircraft Group, Preston (England).

APPLICATION OF CARBON FIBRE COMPOSITES TO MILITARY AIRCRAFT STRUCTURES

T. SHARPLES *In* AGARD Electromagnetic Effects of (Carbon) Composite Mater. Upon Avionics Systems 17 p (SEE N81-16144 07-24) Oct. 1980

Avail: NTIS HC A16/MF A01

The high specific strength of CFC offers weight saving potential to the aircraft structural engineers. Design and manufacturing studies have shown that this potential can be realized and that a maximum utilization, where 40 percent of the aircraft structure is made from CFC, mass savings of about 12 percent can be expected. These savings can be increased to as much as 20 percent if the aircraft is resized for constant performance. Cost studies indicate that, if full advantage is taken of automated techniques and the weight reductions structures containing CFC *should cost less than for the metal equivalents. Work is continuing* to assess the EMC problems in order to ensure that full advantage can be taken of these potential weight and cost savings on future military aircraft. E.D.K.

N81-16148# Boeing Aerospace Co., Seattle, Wash.

ELECTROMAGNETIC SHIELDING CHARACTERISTICS OF ADVANCED COMPOSITES

D. F. STRAWE *In* AGARD Electromagnetic Effects of (Carbon) *Composite Mater. Upon Avionics Systems* 15 p (SEE N81-16144 07-24) Oct. 1980 refs

Avail: NTIS HC A16/MF A01

A considerable body of data was gathered on the basic electromagnetic (EM) properties of graphite advanced composite materials. A sampling of that data relevant to the EM shielding applications is presented. A basic set of shielding parameters is introduced which describes the intrinsic shielding characteristics of composite materials, enhanced conductivity coatings, and *electrical joints in those materials and coatings. Measurement* concepts for these parameters are discussed which were used over the frequency range 0 to 18 GHz. Cross axis layups of graphite composites exhibit a uniform conductivity isotropic in the plane of the graphite filaments. This planar conductivity normally falls in the range of 10,000 to 20,000 mhos/meter. The third axis conductivity component, generally unimportant in shielding applications, is commonly an order of magnitude or more smaller. These composites can provide useful shielding from EM environments if they are electrically bonded in a continuous manner to the rest of the structure. Common mechanical joints between composite sections are highly resistive and unreliable electrical joints. Joining concepts which provide good electrical connections over wide frequency ranges were developed and are described.

E.D.K.

N81-16149# GEC-Marconi Electronics Ltd., Chelmsford (England).

THEORETICAL CALCULATION OF RF PROPERTIES OF CARBON FIBRE LAMINATES

D. C. BREWSTER *In* AGARD Electromagnetic Effects of (Carbon) Composite Mater. Upon Avionics Systems 16 p (SEE N81-16144 07-24) Oct. 1980 refs

Avail: NTIS HC A16/MF A01

The purpose of the work presented was to find a mathematical theory to describe the electromagnetic behavior of material consisting of a sequence of carbon fiber composite laminae. The analysis applies to approximately planar regions which are not near joints, bonds, or other electrical discontinuities. The model adopted is an infinite sheet and each carbon fiber lamina is modelled as a homogeneous anisotropic conducting lamina. Some theoretical justification for this is given. An alternative theory based on replacing the entire sheet by a single homogeneous layer was also considered and its range of validity investigated. The conductivities used were obtained experimentally from unidirectional samples by other researchers. The shielding was calculated of a plane wave normally incident on the infinite sheet and also the reflected field. The shielding improvement was calculated for a thin aluminum coating. The variation of apparent resistivity with frequency was investigated. It is shown that as regards shielding and reflection the infinite sheet can be characterized by surface and transfer impedances. These quantities can be used to calculate electromagnetic field shielding of finite objects. Some calculations are given of shielding by a plane screen when illuminated by an electromagnetic pulse. E.D.K.

N81-16150# ERA Ltd., Leatherhead (England).

RF RESISTIVITY AND SCREENING CHARACTERISTICS OF CFC MATERIALS

D. A. BULL, G. A. JACKSON, and B. W. SMITHERS *In* AGARD Electromagnetic Effects of (Carbon) Composite Mater. Upon *Avionics Systems* 21 p (SEE N81-16144 07-24) *Oct. 1980* refs

Avail: NTIS HC A16/MF A01

A series of investigations were made to determine both the electrical resistance characteristics of carbon fiber composite (CFC) samples an their screening properties. Resistivity was examined from dc to 300 MHz and certain effects of environment were noted under dc test conditions. The measurement of screening properties required much larger samples and test frequencies ranged from 150 KHz to 30 MHz for the magnetic mode and from 50 MHz to 1000 MHz for the electric mode. The methods and techniques employed are described with brief comments on some of the theoretical aspects of conduction and screening.

E.D.K.

N81-16151# Rochester Inst. of Tech., N. Y. Dept. of Electrical Engineering.

THE MEASUREMENT OF ELECTRICAL CONDUCTIVITY IN CARBON/EPOXY COMPOSITE MATERIALS OVER THE FREQUENCY RANGE OF 75 MHZ TO 2.0 GHZ

W. F. WALKER *In* AGARD Electromagnetic Effects of (Carbon) Composite Mater. Upon Avionics Systems 15 p (SEE N81-16144 07-24) Oct. 1980 refs

Avail: NTIS HC A16/MF A01

A stripline technique for the measurement of longitudinal and transverse conductivity of graphite (carbon)/epoxy composite materials over the VHF/UHF (75 MHz to 2.0 GHz range) is described. The method is unusual in that it is essentially free of the uncertain effects of contact resistance between the sample and the measurement apparatus. The underlying theory of the method rests on the relationship between the conductivity of the sample and the lossy standing wave patterns established on the strip transmission line. The essentials of this theory are presented. In addition to the presentation of the theory behind the method, the paper includes illustrations of experimental models of the test transmission line. Longitudinal and transverse conductivity measurements on graphite/epoxy are also presented as well as longitudinal measurements of boron/epoxy and aluminum in the 1.0 GHz to 2.0 GHz range. E.D.K.

N81-16152# Messerschmitt-Boelkow-Blohm G.m.b.H., Ottobrunn (West Germany).

EMC, LIGHTNING AND NEMP-PROTECTION-NEW REQUIREMENTS FOR APPROVED SPECIFICATIONS WHEN USING CFRP

D. JAEGER and K. H. RIPPL *In* AGARD Electromagnetic Effects of (Carbon) Composite Mater. Upon Avionics Systems 18 p (SEE N81-16144 07-24) Oct. 1980 refs

Avail: NTIS HC A16/MF A01

The use of carbon fiber reinforced plastics (CFRP) in modern aircraft achieves good advantages for mechanical strength and is weightsaving, compared with aluminum structures. In spite of the advantages there are disadvantages in using CFRP materials. *These are mainly unwanted electromagnetic effects on electronic* equipment, caused by electromagnetic interference lightning, electrostatic discharges, and nuclear electromagnetic pulse (NEMP). The reason for these problems is lower shielding effectiveness of the aircraft structure as compared to aluminum. Specifications used for aircraft today do not pay regard to the

requirements of these materials. Proposals are made as to how the specifications should be modified. E.D.K.

N81-16153# Allen Clark Research Centre, Towcester (England).
THE ELECTRICAL EFFECTS OF JOINTS AND BONDS IN CARBON FIBER COMPOSITES
J. BRETTLE, K. J. LODGE, and R. POOLE (Plessey Electronic Systems Research, Havant, England) *In* AGARD Electromagnetic Effects of (Carbon) Composite Mater. Upon Avionics Systems 17 p (SEE N81-16144 07-24) Oct. 1980 *refs*
Avail: NTIS HC A16/MF A01

The types of joint investigated include dry compression joints, bolted joints, and adhesively bonded structures. Their electrical properties were evaluated from dc up to 50 MHz, as well as certain specific higher frequencies. A variety of pretreatments and assembly methods were investigated. All the joints as initially produced to current aircraft practice had too high an impedance for the electrical requirements of an airframe. Various methods of reducing the joint impedance were proposed and subjected to electrical and environmental tests. It is now possible to produce electrically invisible bolted joints and adhesive joints with much improved conductivity. It was found possible to permanently alter the joint impedance by the passage of a current through the joint. This effect was investigated and a possible mechanism of this effect suggested. The investigation of the possible production of radio frequency intermodulation products at joints were carried out, but few intermodulation products were found from any of the joints examined other than butt joints made with exposed carbon fibers in the joint. E.D.K.

N81-16154# Royal Aircraft Establishment, Farnborough (England).
THE UK MINISTRY OF DEFENCE PROGRAMME ON THE ELECTROMAGNETIC PROPERTIES OF CARBON FIBER COMPOSITES
J. M. THOMSON and R. H. EVANS *In* AGARD Electromagnetic Effects of (Carbon) Composite Mater. Upon Avionics Systems 9 p (SEE N81-16144 07-24) Oct. 1980 refs
Avail: NTIS HC A16/MF A01

With some exceptions, work on the electrical properties of carbon fiber composites (CFV) is regarded as part of an overall program on electromagnetic effects (EMC, EMP, lightning, etc.). The relationship of the CFC work to the remainder of the program is discussed, and the principal investigations outlined and reviewed. One particular package, shielding measurements on a cockpit section is described in detail. It is shown that the major areas of concern are the bonding and jointing of the material and its characteristics at HF and below. This latter topic has an impact on shielding (including EMP and lightning sources) and aerial installation. Finally, the use which is to be made of the information from these programs is discussed. E.D.K.

N81-16155# Office National d'Etudes et de Recherches Aerospatiales, Paris (France).
A FRENCH FLIGHT TEST PROGRAM ON THE ELECTROMAGNETIC EFFECTS OF LIGHTNING [PROGRAMME FRANCAIS D'ESSAIS EN VOL SUR LES EFFETS ELECTROMAGNETIQUES DE LA FOUDRE]
J. C. ALLIOT and D. GALL (Centre d'Essasis Aeronautiques, Toulouse) *In* AGARD Electromagnetic Effects of (Carbon) Composite Mater. Upon Avionics Systems 9 p (SEE N81-16144 07-24) Oct. 1980 refs In FRENCH
Avail: NTIS HC A16/MF A01

Under the aegis of the French Aeronautical Technical Service, a flight test program for evaluating electromagnetic perturbations of lightning has been operating since 1978. This test program, conducted by CEAT, CEV, and ONERA, uses an Air Force TRANSALL C160 carrying instrumentation for detecting phenomena associated with direct or near lightning strikes. These include the current of the lightning (impulsive and continuous components) the current on the skin of different parts of the structure; the internal and external electromagnetic fields; and the overvoltages on diverse equipment and circuits on board. Various sensors allow characterization of the electric state of the aircraft at the time of the lightning strikes (equilibrium potential, current of the charge of the triboelectric origin, external atmospheric electric field). The behavior of panel structures made of composite materials are studied with regard to electromagnetic radiation in order to define protection systems. Following diverse modifications and additions to the instrumentation used in tests since 1978, a new experimental program begins in 1980. Transl. by A.R.H.

N81-16156# Westland Helicopters Ltd., Yeovil (England).
AIRCRAFT MANUFACTURERS APPROACH TO THE E.M.C./AVIONICS PROBLEMS ASSOCIATED WITH THE USE OF COMPOSITE MATERIALS
G. BARTON and I. P. MACDIARMID (British Aerospace, Warton, England) *In* AGARD Electromagnetic Effects of (Carbon) Composite Mater. Upon Avionics Systems 23 p (SEE N81-16144 07-24) Oct. 1980 refs
Avail: NTIS HC A16/MF A01

Detailed examples are given of the approach taken by the U.K. aircraft manufacturers to the EMC/avionic problems associated with the use of carbon fiber composites (CFC). Examples of structures that required flight clearance within relatively short timescales are discussed. These are the fitting of CFC panels to Jaguar and lightning strike investigations on composite demonstrator rotor blades. The work undertaken to address the long term problems of composite aircraft and their effects on avionic systems is outlined. This includes CFC fuselage investigations, conductivity measurements, and an Earth return study. E.D.K.

N81-16157# Notre Dame Univ., Ind. Dept. of Electrical Engineering.
CONDUCTIVITY MODIFICATION OF BORON FIBERS
R. KWOR and C. A. PAZDEARAUJO *In* AGARD Electromagnetic Effects of (Carbon) Composite Mater. Upon Avionics Systems 17 p (SEE N81-16144 07-24) Oct. 1980 refs
Avail: NTIS HC A16/MF A01

Boron fibers have high specific strength and specific modulus, and are widely used in advanced composite materials. Its weakness lies in the low dc conductivity. Two possible ways of increasing the fiber conductivity to alleviate electromagnetic effects are investigated. The first is the doping of boron fiber using high temperature carbon diffusion. It is found that if the temperature is kept low enough not to deteriorate the mechanical properties of the fiber then there is no conductivity enhancement even after 24 hours of heat treatment. The second method is to electroplate the boron fibers with Ni. Plated near room temperature, the Ni forms a thin sheath around the boron fiber which retains its superior mechanical properties. The electrical property of the plated fiber is characterized and the effect of high temperature on the Ni-B system is investigated using a scanning electron microscope.
Author

N81-16158# Centre d'Essais Aeronautique Toulouse (France).
TENSION INDUCED IN THE CABLES INSIDE CLOSED METAL STRUCTURES AND IN CARBON EPOXY SUBMITTED TO A LIGHTNING-TYPE IMPULSE CURRENT [TENSION INDUITE DANS LES CABLES A L'INTERIEUR DE STRUCTURES FERMEES METALLIQUES ET EN CARBONE EPOXY SOUMISES A UNE IMPULSION DE COURANT TYPE FOUDRE]
D. GALL *In* AGARD Electromagnetic Effects of (Carbon) Composite Mater. Upon Avionics Systems 11 p (SEE N81-16144 07-24) Oct. 1980 In FRENCH
Avail: NTIS HC A16/MF A01

Results are presented of theoretical and experimental studies on the mechanics of the induction of overvoltages in electric cables located in the interior of closed structures when they are surrounded by an impulse current of the lightning type. The contribution of two parameters, the diffusion of current on the skin and the internal magnetic field, is considered and compared for a structure made of an aluminum alloy and one made of carbon fibers.
Transl. by A.R.H.

N81-16159# McDonnell Aircraft Co., St. Louis, Mo.
ELECTROMAGNETIC INTEGRATION OF COMPOSITE STRUCTURE IN AIRCRAFT
G. L. WEINSTOCK *In* AGARD Electromagnetic Effects of (Carbon) Composite Mater. Upon Avionics Systems 16 p (SEE N81-16144 07-24) Oct. 1980
Avail: NTIS HC A16/MF A01

Certain U.S. Navy and Marine Corps aircraft are being designed and produced which have significant portions of the skin and substructure fabricated from graphite/epoxy composite material. The F-18 Hornet has approximately 50% of its surface area

composite and the AV-8B V/STOL utilizes composite material for its wing, tail, and forward fuselage. Extensive analysis and testing was performed during the last seven years to define those parameters necessary for successful electromagnetic integration of graphite/epoxy composite into these aircraft. Descriptions of the tests, analyses, and design processes including procedures, methods, results, and design improvements are presented in this paper. The specific investigations addressed are: (1) basic material properties; (2) inherent electromagnetic shielding; (3) intermodulation effects; (4) effects on antennas; (5) panel shielding; (6) joint effects and improvements; (7) joint impedance; (8) access door design and improvements; (9) bonding; (10) large fuselage section shielding; and (11) complete wing shielding. The above tests and supporting analyses were performed on different types of composite construction, thickness, and size and were usually related to comparable aluminum articles. Some of the variations assessed and described in the paper are aluminum honeycomb, syntactic core and monolithic materials, combinations of lap and shear joints, and selected metallic coatings. E.D.K.

N81-16160# Office National d'Etudes et de Recherches Aerospatiales, Paris (France).

FLIGHT TESTS FOR STUDYING RADIOELECTRIC PERTURBATIONS OF AN ELECTROSTATIC ORIGIN [ESSAIS EN VOL POUR L'ETUDE DES PERTURBATIONS RADIOELECTRIQUES D'ORIGINE ELECTROSTATIQUE]

P. LAROCHE, R. WEBER (Societe Nationale Industrielle Aerospatiale, Suresnes, France), and D. GALL (Centre d'Essais Aeronautiques Toulouse) *In* AGARD Electromagnetic Effects of (Carbon) Composite Mater. Upon Avionics Systems 11 p (SEE N81-16144 07-24) *Oct. 1980 refs In FRENCH*

Avail: NTIS HC A16/MF A01

The French Official Aeronautical Services originated a flight test program using the METEOR NF11 aircraft. The program is designed to reduce the radioelectric perturbations of an electrostatic origin. Antistatic protection of an aircraft consists of making the insolated parts of the structure conductive on the surface and installing dissipators of the potential. The flight experiments were preceeded by ground tests of high tension polarization in order to simulate the effects of triboelectricity. Dissipation of the potential was tested by making the entire aircraft conductive. Some instrumented dielectric panels were then put into place by detecting the eventual appearance of rampant electric discharges. Some general results from these tests are presented. Transl. by A.R.H.

N81-16161# United Kingdom Atomic Energy Authority, Abingdon (England).

THE BEHAVIOR OF CFRP PANELS IN METAL AIRCRAFT DURING SIMULATED LIGHTNING STROKES

B. J. C. BURROWS and A. W. HANSON *In* AGARD Electromagnetic Effects of (Carbon) Composite Mater. Upon Avionics Systems 7 p (SEE N81-16144 07-24) Oct. 1980 refs

Avail: NTIS HC A16/MF A01

The current flow-pattern in a CFRP panel and the surrounding metal skin changes significantly during a current pulse simulating a lightning stroke. Measurements of the current distribution changes are made and compared with a theoretical treatment. The effects of different lay-ups of CFRP and different methods of mounting the panel are described. Observations are made of the influence of thin metal foils used to cover the outer surface on the screening provided by CFRP panels to simulated lightning current pulses. Screening by complex panels consisting of an aluminum honeycomb sandwiched between two CFRP skins is compared with these results. The direct damage suffered by both types of panels is also described, and their behavior analyzed theoretically. Author

N81-16162# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (West Germany). Dept. of Antenna.

INFLUENCE ON ANTENNA GAIN AND POLARIZATION PURITY OF REFLECTORS MANUFACTURED FROM CARBON FIBRE COMPOSITE MATERIALS

L. HEICHELE *In* AGARD Electromagnetic Effects of (Carbon) Composite Mater. Upon Avionics Systems 15 p (SEE N81-16144 07-24) Oct. 1980 refs

Avail: NTIS HC A16/MF A01

The effects on the RF antenna performance of reflectors manufactured out of carbon fiber reinforced plastics (CFRP) were investigated by experimental work. The test equipment used are described and an extensive number of results are given. The measurements cover the frequency range from 2 GHz to 18 GHz. The polarization dependency of loss and the effects on the phase are given for different CFRP types. The RF tests of a realized offset reflector satellite antenna manufactured from CFRP with an aperture diameter of 2 m are described. The measured far field characteristics are shown and compared with theoretical results and CFRP sample measurements. Author

N81-16163# Boeing Commercial Airplane Co., Seattle, Wash.

LIGHTNING THREAT DEFINITION FOR COMPOSITE AIRCRAFT

P. GEREN *In* AGARD Electromagnetic Effects of (Carbon) Composite Mater. Upon Avionics Systems 12 p (SEE N81-16144 07-24) Oct. 1980 refs

Avail: NTIS HC A16/MF A01

An approach for calculating the transients induced in aircraft avionic systems by lightning is presented. The method was applied to an aircraft geometry having various combinations of metal and graphite-epoxy structure. The effects of graphite-epoxy joints are considered. Results are shown for common mode open circuit voltage and short circuit current induced on two representative wire bundles (cockpit to tail and cockpit to wingtip). The approach employs standard analytical techniques from transmission line theory and antenna theory to obtain lightning induced fields on the airframe surface, including the effects of airframe resonance. Both the directly attached and nearby lightning strikes are considered. A method for obtaining the concentration of fields as a result of noncylindrical geometries (e.g., along the leading and trailing edges of a wing) is described. The physical coupling mechanisms for penetration of exterior lightning induced electromagnetic fields into the aircraft interior are explained. Author

N81-16164# Aeronautical Systems Div., Wright-Patterson AFB, Ohio. Directorate of Avionics Engineering.

ELECTRICAL/ELECTROMAGNETIC CONCERNS ASSOCIATED WITH ADVANCED COMPOSITE MATERIALS IN AEROSPACE SYSTEMS

C. L. BLAKE and J. C. CORBIN, JR. *In* AGARD Electromagnetic Effects of (Carbon) Composite Mater. Upon Avionics Systems 8 p (SEE N81-16144 07-24) Oct. 1980 refs

Avail: NTIS HC A16/MF A01

The potential electrical/electromagnetic impacts created by the application of advanced composite materials to aerospace systems are assessed. The assessment was specifically limited to two predominantly used varieties of graphite composite materials, GY-70 and T-300, and to Kevlar. The GY-70 has the higher conductivity and is used primarily on missiles and spacecraft. The T-300 grade has a slightly lower conductivity than GY-70 and is the material commonly applied to aircraft based upon its mechanical properties. Kevlar, a dielectric material, has varied aircraft, missile, and spacecraft application. Specific areas of electrical/electromagnetic concern were surveyed. As a result of the survey, a number of significant concerns were defined. There are, however, no show stoppers in the use of composite materials. Leading concerns include shielding effectiveness, joint design, fuel tank design, power system grounding, low frequency antenna performance, analytical techniques, combined space environment effects, and design guides. Recommended actions include technology development programs and the establishment of a combined Tr-Service/NASA effort to address the composite electrical/electromagnetic technical base and to collect, analyze, and distribute related data, establish standard test methods, develop design guides/handbooks, and develop applicable specifications/standards. E.D.K.

N81-16165# Naval Air Systems Command, Washington, D. C.
IN DEPTH STUDIES OF COMPOSITE AIRCRAFT ELECTROMAGNETIC PERFORMANCE
J. A. BIRKEN *In* AGARD Electromagnetic Effects of (Carbon) Composite Mater. Upon Avionics Systems 18 p (SEE N81-16144 07-24) Oct. 1980 refs
Avail: NTIS HC A16/MF A01

Unprotected graphite/epoxy aircraft avionics are significantly more vulnerable to lightning strikes than metallic aircraft while only slightly more vulnerable to nuclear EMP. The addition of a thin highly conductive metallic coating on the surface of the aircraft can significantly reduce this vulnerability. The additional reduction may be readily obtained with currently available box hardening devices. Composite aircraft hardening solely with devices is questionable. The use of a minimal weight savings penalty selection of coatings, hardened joints, and device hardening results in aircraft electromagnetically safe from radar, nuclear EMP, lightning, and severe future electromagnetic environments. E.D.K.

N81-16166# Syracuse Research Corp., N. Y.
ELECTROMAGNETIC COUPLING TO ADVANCED COMPOSITE AIRCRAFT WITH APPLICATION TO TRADE-OFF AND SPECIFICATION DETERMINATION
R. WALLENBERG, E. BURT, and G. DIKE *In* AGARD Electromagnetic Effects of (Carbon) Composite Mater. Upon Avionics Systems 22 p (SEE N81-16144 07-24) Oct. 1980 refs
Avail: NTIS HC A16/MF A01

A major concern with the increasing use of composite materials and low voltage electronics is the amount of electromagnetic coupling to the interior of an aircraft and to the cables and electronic devices within it. Simple methods are described for determining the shielding provided by an aircraft's exterior surface and the coupling of the interior fields to cables and transmission lines within aircraft cavities. The results can be used to determine tradeoffs between electromagnetic shielding, weight, and cost. E.D.K.

N82-19328# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). Materials Dept.
THE SIGNIFICANCE OF DEFECTS ON THE FAILURE OF FIBRE COMPOSITES
S. M. BISHOP Dec. 1981 23 p refs Presented at the 53rd Meeting of the AGARD Struct. and Mater. Panel, Noordwijkerhout, Netherlands, 27 Sep. - 2 Oct. 1981
(AGARD-R-690; ISBN-92-835-1410-9; AD-A111479) Avail: NTIS HC A02/MF A01

Defects produced during manufacture, cracking produced during loading, and in-service damage such as impact were studied together with their effects on mechanical properties and their implications for structural design. There is also work modelling the behavior of notched composites and on the design of composites to give improved toughness and increased tolerance to damage. R.J.F.

N83-17609# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
PRACTICAL CONSIDERATIONS OF DESIGN, FABRICATION AND TESTS FOR COMPOSITE MATERIALS
Sep. 1982 198 p refs Lectures held in Oporto, Portugal, 11-12 Oct. 1982, in London, 14-15 Oct. 1982 and in Ankara, 18-19 Oct. 1982
(AGARD-LS-124; ISBN-92-835-1436-X) Avail: NTIS HC A09/MF /01

Fiber composites used as aircraft construction materials are discussed. Emphasis is placed on the mechanical properties of the composites. Failure analysis, structural integrity, fatigue damage, micromechanical models, and structural analysis are discussed. For individual titles, see N83-17610 through N83-17622.

N83-17610# Bath Univ. (England). School of Materials Science.
THE NATURE OF FIBRE COMPOSITE MATERIALS
B. HARRIS *In* AGARD Pract. Considerations of Design, Fabric. and Tests for Composite Mater. 5 p (SEE N83-17609 08-24) Sep. 1982 refs
Avail: NTIS HC A09/MF A01

The physical and mechanical characteristics of the practical fiber composites that are most prominently of interest to structural and aeronautical engineers are discussed. Some of their applications in the aerospace field are discussed. Various composite materials are compared in terms of strength. The functions of the matrix are discussed. R.J.F.

N83-17611# Ecole Nationale Superieure des Mines, Paris (France). Centre des Materiaux.
CHARACTERISTICS AND SELECTION OF FIBRES FOR AEROSPACE LAMINATES
A. R. BUNSELL *In* AGARD Pract. Considerations of Design, Fabric. and Tests for Composite Mater. 11 p (SEE N83-17609 08-24) Sep. 1982 refs
Avail: NTIS HC A09/MF A01

Fiber composites to be used in aircraft construction materials are discussed. The mechanical properties of several composite materials are discussed. The molecular structure of fibers is discussed. The mechanical properties of some composites are compared to various alloys. The role of heat treatment is discussed. R.J.F.

N83-17612# Ecole Nationale Superieure des Mines, Paris (France). Centre des Materiaux.
THE ROLE OF THE MATRIX
A. R. BUNSELL *In* AGARD Pract. Considerations of Design, Fabric. and Tests for Composite Mater. 10 p (SEE N83-17609 08-24) Sep. 1982 refs
Avail: NTIS HC A09/MF A01

The role of the matrix materials in fiber reinforced composites is discussed. A composite material is composed of fibers enbedded in a matrix. Usually, although not always, the mechanical properties of the fibers are greatly superior to those of the matrix which is usually weaker and more extensible. The role of the matrix is to transfer the load applied to the composite to the fibers and the matrix is rarely expected to support direct tensile loading. Load transfer into and between fibers is assured by shear deformation of the matrix around fibers. If the number of fibers in the composite is too low and the distance between fibers too great reinforcement does not occur. The quality of the adhesion between fiber and matrix plays an important role and the failure of this interface or of the matrix near the interface may be used as a crack stopping mechanism. In this way the fatigue properties of the composite may be influenced. Most composites are based on organic resin matrices but metal, carbon and ceramic matrices for higher temperature applications are also mentioned. R.J.F.

N83-17613# Delaware Univ., Newark.
MICROMECHANICAL MODELS FOR THE STIFFNESS AND STRENGTH OF FIBER COMPOSITES
R. B. PIPES *In* AGARD Pract. Considerations of Design, Fabric. and Tests for Composite Mater. 9 p (SEE N83-17609 08-24) Sep. 1982
Avail: NTIS HC A09/MF A01

One of the major goals of micromechanical models of polymer matrix composites is the prediction of anisotropic material descriptors required in the analysis and design of composite structures. The subsequent coupling of the various scales (micro, mini, and macro) of approach provides an overall design methodology which can fully exploit the potential for tailoring simultaneously material and structure to a given application. Design and analysis of composite materials and structures proceeds at several scales. First, the field of micromechanics examines the individual roles of fiber and matrix in determining bulk composite properties. Contemporary micromechanical models capable of predicting transport properties of composite materials consisting of collimated fibers in isotropic matrices (unidirectional lamina) are discussed. The second scale of examination is often termed minimechanics. At this level the influence of the unidirectional lamina and its orientation upon the properties of the mutidirectional laminates is investigated. By varying the orientation of laminae it

is possible to produce laminates of widely varying properties. Finally, the multidirectional laminate is viewed as a homogeneous material at the macromechanical scale where the geometry of the structure is designed. R.J.F.

N83-17614# Delaware Univ., Newark.
INTRODUCTION TO THIN LAMINATE THEORY
R. B. PIPES *In* AGARD Pract. Considerations of Design, Fabric. and Tests for Composite Materials 11 p (SEE N83-17609 08-24) Sep. 1982
Avail: NTIS HC A09/MF A01

In contrast to micromechanical models which utilize fiber and matrix properties to predict properties of the equivalent homogeneous composite material, laminate theory predicts the behavior of multidirectional laminates from the properties of individual lamina consisting of unidirectional, woven or discontinuous fibers. The lamina is viewed as homogeneous and possessing orthotropic symmetry and as such is the building block for the multidirectional laminate. Laminate theory offers a systematic way to analyze the laminate for prediction of properties of an equivalent homogeneous material, state of stress and strain within each of the lamina, and prediction of failure of any lamina within the laminate. Thus laminate properties and behavior are considered in the macroscopic analysis of a composite structure wherein the fiber and matrix properties are no longer identified. Yet through laminate theory and micromechanics it is possible to trace the effects of constituent properties upon overall structural performance. Author

N83-17615# Royal Aircraft Establishment, Farnborough (England). Materials Dept.
FRACTURE OF COMPOSITES AND DAMAGE TOLERANCE
G. DOREY *In* AGARD Pract. Considerations of Design, Fabric. and Tests for Composite Mater. 12 p (SEE N83-17609 08-24) Sep. 1982 refs
Avail: NTIS HC A09/MF A01

Composite fracture and damage tolerance are discussed. Composite materials are anisotropic in stiffness and in strength, and hence local stresses and strains within these materials are complex. They are also inhomogeneous and may have weak interfaces, which makes fracture more probable in certain directions. Fracture modes are therefore generally more complex than in isotropic homogeneous materials such as unreinforced metals and plastics. Advanced fiber composites tend preferentially to split parallel to the fibers, the initial fracture energy depending mainly on the matrix properties and the fiber-matrix interfacial bond strength; but, due to fiber misalignment, further fracture propagation depends on the fiber and interface properties. The three main stress modes to produce splitting are described. Fracture across fibers is more difficult and some of the energy absorbing mechanisms are discussed. In multidirectional laminates each ply still tends to split parallel to the fibers but the constraints of adjoining plies are significant and the fracture mechanisms and fracture energies depend on the ply orientations and stacking sequence (lay-up) and the ply thickness as well as on the usual fiber, matrix and interface properties. Author

N83-17616# Fraunhofer-Inst. fuer Betriebsfestigkeit, Darmstadt (West Germany).
MECHANISMS OF FATIGUE DAMAGE AND FATIGUE TESTING
J. J. GERHARZ *In* AGARD Pract. Considerations of Design, Fabric. and Tests for Composite Mater. 20 p (SEE N83-17609 08-24) Sep. 1982 refs
Avail: NTIS HC A09/MF A01

The fatigue response of fiber composite materials containing various details of a composite structure is considered. Besides the plain feature, open holes, bolted and bonded joints with differing configuration parameters are covered. All test samples had the same material and laminate structure namely graphite/epoxy 914C/T300 and the laminate built-up. Response of fiber composites to constant amplitude loading of plain and notched materials is addressed. Author

N83-17617# Fraunhofer-Inst. fuer Betriebsfestigkeit, Darmstadt (West Germany).
PREDICTION OF FATIGUE FAILURE
J. J. GERHARZ *In* AGARD Pract. Considerations of Design, Fabric. and Tests for Composite Mater. 22 p (SEE N83-17609 08-24) Sep. 1982 refs
Avail: NTIS HC A09/MF A01

Because no inexpensive and simple inspection methods presently exist for composites, the residual strength distribution is determined. The interest is in the lower end of the frequency distribution and therefore the Weibull extreme value distribution is used to describe the weakest element. Author

N83-17618# Royal Aircraft Establishment, Farnborough (England).
THE ELECTRICAL PROPERTIES OF CARBON FIBRE COMPOSITES
J. M. THOMSON *In* AGARD Pract. Considerations of Design, Fabric. and Tests for Composite Mater. 15 p (SEE N83-17609 08-24) Sep. 1982 refs
Avail: NTIS HC A09/MF A01

The essential electrical difference between a carbon fiber composite and conventional metal alloys is that its resistivity is about three orders higher. This fact affects the electromagnetic compatibility (EMC) of the airframes, its performance as an antenna ground plane, the provision of power and of Earth returns and radar cross-section. Research on the electrical properties of carbon fiber composites under these headings is reviewed and the importance of good bonding and jointing emphasized. The major problem areas (which tend to occur at frequencies less than 30 MHz) are outlined, as are those areas where problems are likely to be minor. Although electrical research lags structures and materials research by some 10 to 15 years, nonetheless sufficient work has been due for some interim design recommendations to be formulated, and these are discussed. Author

N83-17619# Royal Aircraft Establishment, Farnborough (England). Materials Dept.
ENVIRONMENTAL DEGRADATION OF COMPOSITES
G. DOREY *In* AGARD Pract. Considerations of Design, Fabric. and Tests for Composite Mater. 13 p (SEE N83-17609 08-24) Sep. 1982 refs
Avail: NTIS HC A09/MF A01

Advanced composite materials comprise well ordered high strength fibers in a matrix of organic polymer, metal or ceramic material. Carbon fibers are inert to most environments except high temperature oxidizing atmospheres. Ceramic fibers such as glass are sensitive to surface microcracks and can lose strength in corrosive media. Most organic polymers, including aramid fibers and epoxy resins absorb moisture which can affect their chemical structure and typically reduce their high temperature performance. Composites may, in addition, be affected at the fiber/matrix interface, which plays an important part in composite behavior. Certain combinations of moisture and temperature can cause irreversible damage which degrades the composite properties, especially matrix or interface dominated properties such as shear strength or compressive strength, particularly at elevated temperatures. It is important therefore to have sufficient information about the absorption and desorption kinetics to be able to predict the moisture content of composite components in their service environment, and to know what effect that moisture will have on their properties. Author

N83-17620# Grumman Aerospace Corp., Bethpage, N.Y. Automated Manufacturing Systems Development Section.
MANUFACTURING PROCESSES FOR AERONAUTICAL STRUCTURES
R. HADCOCK and J. HUBER *In* AGARD Pract. Considerations of Design, Fabric. and Tests for Composite Mater. 13 p (SEE N83-17609 08-24) Sep. 1982 refs
Avail: NTIS HC A09/MF A01

Current manufacturing processes for fabricating composite aeronautical structures are reviewed. Laminating, autoclave curing, hot press molding, injection molding, pultrusion, drilling and trimming are discussed for three principal composite materials boron/epoxy, graphite/epoxy and Kevlar/epoxy. The unique manufacturing operations associated with each type of material up to and including the curing process are emphasized. The effect

of various tooling concepts and materials on production rates and costs is discussed. Unique processing equipment developed for the several composite materials forms available is described. E.A.K.

N83-17621# Grumman Aerospace Corp., Bethpage, N.Y. Automated Manufacturing Systems Development Section.
SPECIFIC EXAMPLES OF AEROSPACE APPLICATIONS OF COMPOSITES
R. HADCOCK and J. HUBER *In* AGARD Pract. Considerations of Design, Fabric. and Tests for Composite Mater. 13 p (SEE N83-17609 08-24) Sep. 1982 refs
Avail: NTIS HC A09/MF A01

The state of the art for the use of composites in both prototype and production, structural and nonstructural aerospace components is reviewed. Historic material usage trends for both commercial and military applications are presented. The applications show the evolution of composite components from relatively simple parts to the current, large and complex structures. The use of composite materials in the new generation of commercial transport aircraft is presented. Specific areas of application, such as spoilers, flaps and fairings, are discussed for impact on part weight, type of construction, and material selection factors. Selected, major composite programs for military aircraft, are reviewed. Composite materials used in these aircraft are analyzed with respect to the percent of the structural weight, type of material utilized, areas of application, type of construction and special manufacturing processes used in production. The test procedures utilized to evaluate composite structures are reviewed. E.A.K.

N83-17622# Bath Univ. (England). School of Materials Science.
ASSESSMENT OF STRUCTURAL INTEGRITY OF COMPOSITES BY NON-DESTRUCTIVE METHODS
B. HARRIS *In* AGARD Pract. Considerations of Design, Fabric. and Tests for Composite Mater. 22 p (SEE N83-17609 08-24) Sep. 1982 refs Sponsored in part by the UK Science and Engineering Research Council
Avail: NTIS HC A09/MF A01

Composite materials, and particularly structural reinforced plastics, often contain defects as a result of normal manufacturing procedures. During proof testing or service loading additional defects of other kinds are produced. These defects all affect the mechanical properties of the composites and it is important for designers to be aware of their effects and to allow for their presence. A variety of techniques is used to evaluate the quality of composite materials and structures and to study the accumulation of damage in composites subjected to stress, creep, fatigue or impact conditions. Optical methods, X-radiography, ultrasonic techniques, thermal imaging, and acoustic emission analysis are methods capable of revealing certain aspects of the development of damaged regions in a composite, but the usefulness of most of these is limited to certain types of material or specific structural situations. No single technique will prove to be capable of giving a complete picture of the damaged state of a composite to permit satisfactory life prediction, and more refined methods of detecting localized damage levels. E.A.K.

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METALLIC MATERIALS

Includes physical, chemical, and mechanical properties of metals, e.g., corrosion; and metallurgy.

N82-17342# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
CORROSION FATIGUE
Oct. 1981 92 p refs Presented at the 52nd Meeting of the AGARD Struct. and Mater. Panel, Cesme, Turkey, 5-10 Apr. 1981 (AGARD-CP-316; ISBN-92-835-1402-5, AD-A109275) Avail: NTIS HC A05/MF A01

The objectives, scope, and technical requirements of a cooperative program for corrosion fatigue testing and prevention/aircraft environment simulation fatigue testing are presented. An overview of current and supplemental programs designed to assess current protection systems for aircraft structures is also given. For individual titles, see N82-17343 through N82-17348.

N82-17343# Rensselaer Polytechnic Inst., Troy, N. Y. Dept. of Materials Engineering.
MECHANISMS OF CORROSION FATIGUE
D. J. DUQUETTE *In* AGARD Corrosion Fatigue 12 p (SEE N82-17342 08-26) Oct. 1981 refs Sponsored in part by Office of Naval Research
Avail: NTIS HC A05/MF A01

An overview of experimental variables which are considered critical to understanding the mechanisms of corrosion fatigue of high strength aluminum alloys is presented. Based on this overview, an examination of previously proposed mechanisms is attempted. These models include anodic dissolution, surface energy reduction, and hydrogen embrittlement. It is concluded that hydrogen embrittlement of process zones at alloy surfaces (for crack initiation) and at crack tips (for crack propagation) best explains observed results. A general model of corrosion fatigue of these alloys is proposed. This model suggests that the nature of the naturally formed oxide film on aluminum alloys may be a critical factor. Chemical or mechanical damage of the film allows hydrogen ingress. The presence of second phase particles which may act as sinks for dislocation transported hydrogen, may also be a necessary prerequisite to significant amounts of reduction in fatigue resistance associated with corrosion. Author

N82-17344# Toronto Univ. (Ontario). Dept. of Mechanical Engineering.
FRACTURE MECHANICS BASED MODELLING OF THE CORROSION FATIGUE PROCESS
D. W. HOEPPNER, D. MANN, and J. WEEKS *In* AGARD Corrosion Fatigue 17 p (SEE N82-17342 08-26) Oct. 1982 refs Sponsored in part by NSERC and Dept. of Energy, Mines and Resources of Canada
Avail: NTIS HC A05/MF A01

Corrosion fatigue of structural elements involves a synergism between cyclic load and a chemical environment involving both time and temperature as rate-controlling parameters. The development of rational life prediction methods is hampered by both the lack of mechanistic understanding, the large number of corrosion-fatigue synergisms, and the inadequacies of fracture mechanics based models in both pre mode I fatigue cracking and initial mode I cracking. Aspects of mechanisms related to the formulation of corrosion fatigue life prediction models are discussed in relation to micromechanical modelling based on fracture mechanics. Emphasis was placed on the formation of mode I fatigue cracks from pits, and fretting surface damage. A discussion of the needs in this area is presented. It is believed that with further analytical and experimental information the models presented can be verified and provide useful guidance to engineers and scientists attempting to deal with corrosion and fretting fatigue. Author

N82-17345# Societe Nationale Industrielle Aerospatiale, Suresnes (France). Central Lab.
CORROSION FATIGUE BEHAVIOUR OF SOME ALUMINIUM ALLOYS
D. ALIAGA and E. BUDILLON *In* AGARD Corrosion Fatigue 12 p (SEE N82-17342 08-26) Oct. 1981
Avail: NTIS HC A05/MF A01

An evaluation of corrosion fatigue strength of aluminum alloys currently used in the aeronautical industry was made. Crack propagation was evaluated in various different environments (dry argon, wet air, salt water). The effect of frequency, of test specimen thickness, and of ratio R (R Kmin/Kmax) were investigated. And the effect of these various environments on the endurance limit of 10 to the 7th power cycles was likewise studied and some surface protections evaluated. The intent of the survey was to compare the response in fatigue of various aluminum alloys used in the aeronautical construction. The environments studied were the following: dry argon, wet air and salt-water. They were retained so as to simulate and amplify the more or less aggressive nature of these environments in which aircraft can find themselves both on the ground or in the air. The two major aspects of corrosion fatigue namely crack initiation and crack propagation were studied

with an emphasis on in-service behaviour. As far as crack initiation is concerned some surface treatments and protections currently used in aeronautics were examined in various environmental conditions. M.D.K.

N82-17346# Industrieanlagen-Betriebsgesellschaft m.b.H., Ottobrunn (West Germany).
CORROSION FATIGUE OF OFFSHORE AND SHIP-BUILDING STEELS
W. SCHUETZ *In* AGARD Corrosion Fatigue 17 p (SEE N82-17342 08-26) Oct. 1981 refs
Avail: NTIS HC A05/MF A01

The results of several test programs on various steels are discussed where in addition to realistic variable loads a corrosive environment was simulated. For comparison, constant amplitude tests were also carried out as well as testing in air. It was shown that under constant amplitude loading the damaging effect of corrosion was always greater than under realistic loading. In addition, test frequency appears to be not so important as in constant amplitude test; this means that tests under variable amplitude can be carried out at normal test frequencies of the order of 10 Hz, saving time and costs. Finally the results of a research program on welded tubular joints in seawater are described in which the above conclusions were incorporated.
Author

N82-17347# Middle East Technical Univ., Ankara (Turkey).
VARIABLE AMPLITUDE CORROSION FATIGUE BEHAVIOR OF A LOW CARBON STEEL
R. GUERBUEZ and M. DORUK *In* AGARD Corrosion Fatigue 14 p (SEE N82-17342 08-26) Oct. 1982 refs
Avail: NTIS HC A05/MF A01

The results of an experimental study designed to determine the general characteristics of salt water-enhanced fatigue crack growth under conditions of variable amplitude loading are presented. The material used was a sheet of 0.22 percent carbon steel. The tests were done on 13 mm thick CT specimens in L-orientation. The crack mouth opening displacement on the loading line (C(M)OD) was varied at a constant rate, whereby the stress intensity factor varied between zero and the maximum value of C(M)OD. Negative stress ratios were eliminated by means of a special control. Comparison crack growth data were obtained by the more conventional constant load amplitude or K-increasing method and also under decreasing load amplitude. The crack growth rates were compared with reference data measured in the laboratory air. It was found that the rates of crack-growth measured at three different rates of displacement do not agree. However from the shift of curves on decreasing the rate, it is concluded that the growth rate curves would tend to become stationary.
Author

N82-17348# Industrieanlagen-Betriebsgesellschaft m.b.H., Ottobrunn (West Germany).
FLIGHT-BY-FLIGHT CORROSION FATIGUE TESTS
W. SCHUETZ *In* AGARD Corrosion Fatigue 10 p (SEE N82-17342 08-26) Oct. 1981 refs
Avail: NTIS HC A05/MF A01

Corrosion fatigue tests should be conducted under realistic load sequences especially for tests with riveted specimens because the rare high loads of the spectrum may loosen the fasteners, damaging the corrosion protection system and therefore rendering it ineffective. Possibly this does not happen in constant amplitude tests because the loads may not be high enough to crack the protection system. This was the reasoning behind the test program carried out with flight-by-flight tests. Tests were carried out with two aluminum alloys typical for use in modern and in faying aircraft respectively, namely 7475-T 761 and 7075-T6. The sheet materials were exchanged between two laboratories so that both would use materials of the same heats. The specimens used differed, however, in the corrosion protection systems and in the manufacturing of the specimens by different firms. A project status report is made. M.D.K.

N82-17349# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
AIRCRAFT CORROSION
Aug. 1981 194 p refs Partly in ENGLISH, partly in FRENCH Meeting held in Cesme, Turkey, 5-10 Apr. 1981
(AGARD-CP-315; ISBN-92-835-0298-1; AD-A109291) Avail: NTIS HC A09/MF A01

Corrosion resistant materials and protection systems for aircraft are addressed. The incidence of corrosion of aircraft structures under varying environmental conditions is discussed. Maintenance, cost facators, education and retraining, and the communication link among the designers, manufactures and the research community are among the topics covered. For individual titles, see N82-17350 through N82-17364.

N82-17350# Atlantic Fleet, Norfolk, Va.
US NAVAL FLEET AIRCRAFT CORROSION
G. T. BROWNE *In* AGARD Aircraft Corrosion 15 p (SEE N82-17349 08-26) Aug. 1981
Avail: NTIS HC A09/MF A01

Water entry and its associated corrosion problems were minimized. A method for sealing environmental connectors without degrading wire quick disconnect capability was incorporated by sealing the back connector shell rubber grommet with clear room temperature vulcanizing silicone type sealant. The screw holes and equipment lids were also sealed in a similar manner. Drain holes were located and drilled in nonstructural areas at low points to remove trapped water and eliminate the corrosive agents. Hidden corrosion was detected by nondestructive inspection methods during rework. These include ultrasonic, X-ray and eddy current inspection and neutron radiograhy on double skin areas and on areas behind stringers, etc., where corrosion is caused by moisture entrapment. Stress corrosion cracking in high strength components was discovered occasionally. Standard fleet corrosion maintenance is accomplished in accordance with procedures provided in technical manuals. Paint and corrosion removal procedures and tools are discussed. N.W.

N82-17351# Royal Air Force, Dereham (England). Central Servicing and Development Establishment.
DETECTION AND PREVENTION OF CORROSION IN ROYAL AIR FORCE AIRCRAFT
C. R. PYE *In* AGARD Aircraft Corrosion 10 p (SEE N82-17349 08-26) Aug. 1981
Avail: NTIS HC A09/MF A01

The problems that sometimes are created by corrosion in Royal Air Force aircraft are outlined. The problem of the harsh environment facing some military aircraft is described, and some of the materials used in aircraft construction are considered. Corrosion prevention and rectification is also discussed briefly. Some typical examples of corrosion damage found during service are illustrated, and the nondestructive testing methods used for detecting corrosion are described. These methods include visual inspection, eddy current techniques, ultrasonic techniques and X-radiography. The use of neutron radiography and other future developments is also considered. Service methods of removing corrosion and re-protecting the aircraft are mentioned. Finally the need for the manufacturer to consider corrosion at the aircraft design stage is considered. N.W.

N82-17352# British Airways, Middlesex (England). Aircraft Engineering (Structures).
AN AIRLINE VIEW OF THE CORROSION PROBLEM
R. G. MITCHELL *In* AGARD Aircraft Corrosion 11p (SEE N82-17349 08-26) Aug. 1981
Avail: NTIS HC A09/MF A01

Although the corrosion phenomenon is well understood by aircraft manufacturers and operators alike, most current aircraft types continue to exhibit many of the fundamental corrosion defects shown by earlier designs. It is estimated that the total annual cost to IATA member airlines is around $100 million based on 1976 operations. Environmental and maintenance effects are important and should be fully understood in their importance in minimizing corrosive attack. In addition to the more common forms, filiform corrosion and microbiological contamination present hazards to aircraft operating in certain areas of the world. Temporary water displacing fluids are becoming common in their use, and subject to certain limitations are providing valuable short

term protection. The FAA design rules require the effects of corrosion to be considered at the design stage which should result in an improved product for the operator. In addition the IATA document Guidance Material on Design and Maintenance Against Corrosion of Aircraft Structures specifies practices which should also improve the overall product. Author

N82-17353# Middle East Technical Univ., Ankara (Turkey).
SOME OBSERVATIONS ON THE CORROSION OF AIRCRAFT AT THE AIR FORCE BASE IN BANDIRMA, TURKEY
M. DORUK *In* AGARD Aircraft Corrosion 8 p (SEE N82-17349 08-26) Aug. 1981
Avail: NTIS HC A09/MF A01

The types and the causes of corrosion which have been observed primarily on aircraft of Type F-5A in Turkey are studied. Visual inspection showed many locations of concentration of corrosion. The vertical stabilizer attach angle (alloy 7075-T6) fails through exfoliation corrosion and galvanic attack in the bolt holes. Galvanic corrosion has also been observed around the jaw bolts under the main wings. Another case of exfoliation attack has been found on the uplock support rib (Alloy 7075-T6 or 7079-T6) in the main landing gear well. Damage in the honeycomb assembly which appears as a debonding between the honeycomb structure and the top plate has been regarded as a serious problem. Corrosion damage is attributed to the high corrosiveness of the atmosphere of Air Force Base laden with sea salt and polluted from industries in the neighborhood. Author

N82-17354# Technical Univ. of Istanbul (Turkey).
ON THE CORROSION PROBLEMS OF THE TAF F-5 AIRCRAFT
A. INALHAN *In* AGARD Aircraft Corrosion 1 p (SEE N82-17349 08-26) Aug. 1981
Avail: NTIS HC A09/MF A01

Corrosion problems of the F-5 aircraft in Turkey are examined. The importance of atmospheric effects are disputed. The investigation and conclusions are recounted. N.W.

N82-17355# Service Techniques des Programmes Aeronautiques, Paris (France).
THE EXPERIENCE OF CORROSION ON FRENCH MILITARY AERODYNES [L'EXPERIENCE DE LA CORROSION SUR AERODYNES MILITAIRES FRANCAIS]
M. M. HURET *In* AGARD Aircraft Corrosion 9p (SEE N82-17349 08-26) Aug. 1981 In FRENCH
Avail: NTIS HC A09/MF A01

Several examples of corrosion occurring in French military aircraft in detail, e.g., honeycomb sections and metal-to-metal adhesively bonded structures were described. Information about the various measures which were taken to diminish the problem was given. The manufacturing specifications do not take care of all protection requirements. Furthermore, the paint systems which are applied are not the best available, or they have been applied in the wrong way. Bad sealing also occurs frequently. Other preventive measures, e.g., water displacing fluids, can given additional, short term, protection. N.W.

N82-17356# KLM Royal Dutch Airlines, Amsterdam (Netherlands).
DESIGN AND MAINTENANCE AGAINST CORROSION OF AIRCRAFT STRUCTURES
H. J. VERSTEEGEN and M. J. M. VERSTEEG *In* AGARD Aircraft Corrosion 7 p (SEE N82-17349 08-26) Aug. 1981
Avail: NTIS HC A09/MF A01

The publication 'Guidance Material on Design and Maintenance against Corrosion of Aircraft Structures' is reviewed. A greater understanding among manufacturers and airline managements of the magnitude of the corrosion problems and the need for measures to be taken at the design stage is considered. The best available anti-corrosion design knowledge in critical areas as a basic standard is addressed. The guidelines cover basic requirements, including material choice, design principles and manufacturing procedures. Furthermore, they cover the critical areas including origin of problems, design objectives and protective requirements. They are supplemented by an appendix giving a detailed acceptable means of compliance. N.W.

N82-17357# Michigan State Univ., East Lansing. Dept. of Metallurgy, Mechanics, and Materials Science.
FORECASTING CORROSION DAMAGE AND MAINTENANCE COSTS FOR LARGE AIRCRAFT
R. SUMMITT and F. FINK *In* AGARD Aircraft Corrosion 11 p (SEE N82-17349 08-26) Aug. 1981 refs Sponsored by AF
Avail: NTIS HC A09/MF A01

Studies relating environmental and operational factors of large aircraft to corrosion damage were conducted. They provide a basis for predicting maintenance costs and for logistics decisions. The studies included: (1) an Environmental corrosion severity index, based on pollutant and weather factors; (2) an atmospheric testing program to determine environmental corrosiveness; and (3) analysis of corrosion maintenance experience in aircraft systems. Results are discussed. M.D.K

N82-17358# Royal Aircraft Establishment, Farnborough (England). Materials Dept.
CORROSION CONTROL MEASURES FOR MILITARY AIRCRAFT: PRESENT UK REQUIREMENTS AND FUTURE DEVELOPMENTS
V. C. R. MCLOUGHLIN *In* AGARD Aircraft Corrosion 15 p (SEE N82-17349 08-26) Aug. 1981 refs
Avail: NTIS HC A09/MF A01

The philosophy behind selection of aircraft metallic materials based on resistance to corrosion and behind mandatory requirements for processes and materials used in the protection of aircraft structures is discussed. The impact of legislation, current and future, aimed at protecting the environment is reported. The necessity for finding replacements for cadmium, chromates, and various metal finishing operations used in aircraft construction is discussed in terms of both protecting the environment and corrosion control methods used in the aircraft industry. M.D.K

N82-17359# Aeritalia S.p.A., Torino (Italy). G.V.C. Labs
CORROSION PREVENTION METHODS DEVELOPED FROM DIRECT EXPERIENCE WITH AEROSPACE STRUCTURES
M. SCOLARIS *In* AGARD Aircraft Corrosion 18 p (SEE N82-17349 08-26) Aug. 1981
Avail: NTIS HC A09/MF A01

Some examples of various types of corrosion experienced during hardware service are reviewed and the significant remedial action adopted first to repair and then to eliminate the problem are presented. The changes in design incorporated during design development as a function of the experience and technical knowledge acquired are also presented. Examples of effective protection validated through service life and present trends for effective corrosion prevention are also illustrated. Author

N82-17360# Avions Marcel Dassault-Breguet Aviation, Saint-Cloud (France)
CORROSION PREVENTION MEASURES USED IN THE CONSTRUCTION OF AN AIRCRAFT AIRFRAME: THE CASE OF 2014 AND 2214 ALLOYS [SOLUTIONS PREVENTIVES UTILISEES CONTRE LA CORROSION LORS DE LA CONSTRUCTION D'UNE CELLULE D'AVION. CAS DES ALLIAGES 2014 ET 2214]
J. BEVALOT *In* AGARD Aircraft Corrosion 14 p (SEE N82-17349 08-26) Aug. 1981 In FRENCH
Avail: NTIS HC A09/MF A01

Discussions of practical aircraft corrosion problems are presented. Aluminum alloy 2214 is evaluated in terms of its resistance to stress corrosion and its excellent fatigue properties. Heat treatment, aging at 178 C instead of 153 C, and the use of wet sandblasting techniques are discussed in terms of maintaining fatigue resistance while increasing resistance to stress corrosion. M.D.K

N82-17361# Naval Air Development Center, Warminster, Pa.
RECENT DEVELOPMENTS IN MATERIALS AND PROCESSES FOR AIRCRAFT CORROSION CONTROL
S. J. KETCHAM and J. J. DELUCCIA *In* AGARD Aircraft Corrosion 9 p (SEE N82-17349 08-26) Aug. 1981 refs
Avail: NTIS HC A09/MF A01

Advances in materials and processes for aircraft corrosion control currently in use and those under development in the laboratory for future use are described. Areas covered are corrosion preventive compounds, organic and inorganic coatings, alloy

selection and heat treatments. Available materials highlighted are water displacing compounds, sealant primers, aluminum alloys 7050 and 7010 including a state-of-the-art report on the use of exfoliation and stress corrosion resistant tempers. Materials under development that offer promise of contributing to future advances include water displacing paints, flexible primer, crack arrestment compounds, powder metallurgy, aluminum alloys and substitutes for cadmium plating. Author

N82-17362# Systems Research Labs., Inc., Dayton, Ohio.
NEW CONCEPTS IN MULTIFUNCTIONAL CORROSION FOR AIRCRAFT AND OTHER SYSTEMS
M. KHOBAIB and F. W. VAHLDIEK *In* AGARD Aircraft Corrosion 13 p (SEE N82-17349 08-26) Aug. 1981 refs
Avail: NTIS HC A09/MF A01

Multifunctional nonchromate inhibitors were developed for a Rinse Facility to reduce corrosion maintenance costs by removing corrosive contaminants from aircraft which operate in aggressive environments such as marine environments. These inhibitor systems are low cost, water soluble, nontoxic formulations which are effective against general corrosion, localized corrosion, and environmentally assisted crack growth under conditions of stress corrosion and corrosion fatigue. Extensive polarization, immersion, and galvanic-coupling experiments were conducted to determine effectiveness. A borax-nitrite-based inhibitor containing small additions of nitrate, silicate, phosphate, and mercaptobenzothiazole was found to provide excellent corrosion protection for high strength aluminum and steel alloys used in aerospace applications and for copper-bearing alloys used in electronic components and in parts of the Rinse Facility. Envionmental effects upon crack-growth rates of aluminum and high strength steel alloys were eliminated, reducing the rates in corrosion fatigue as compared to those obtained in air. A test program using these inhibitors is described. Tracking of maintenance costs and corrosion damage in being conducted to determine the effectiveness of the inhibited rinse in reducing corrosion costs. M.D.K.

N82-17363# Naval Air Development Center, Warminster, Pa.
CORROSION IN NAVAL AIRCRAFT ELECTRONIC SYSTEMS
I. S. SHAFFER *In* AGARD Aircraft Corrosion 12 p (SEE N82-17349 08-26) Aug. 1981 refs
Avail: NTIS HC A09/MF A01

Naval aircraft electronic equipment suffer frequently from the effects of moisture and corrosion. The critical design features which have led to excessive susceptibility to these failure modes are described. Several examples are cited of inadequately protected equipment located in aircraft installations where they were subjected to repeated moisture intrusion during rainstorms, low level flights over water and high pressure fresh water washdowns. The specific deterioration effects that occurred on the various components that make up the avionic systems are presented. Maintenance data summaries are included to denote further the corrosion problem severity. Corrective measures in design, testing and maintenance are also discussed. Author

N82-17364# Vereinigte Flugtechnische Werke G.m.b.H., Bremen (West Germany).
CORROSION PROTECTION SCHEMES FOR AIRCRAFT STRUCTURES: SOME EXAMPLES FOR THE CORROSION BEHAVIOUR OF AL ALLOYS
H. LAJAIN *In* AGARD Aircraft Corrosion 16 p (SEE N82-17349 08-26) Aug. 1981
Avail: NTIS HC A09/MF A01

A summary of the main groups of aircraft surface protection procedures frequently applied is presented. In addition, some examples are given on the corrosive behavior of aluminum alloys. Information is also given on novel nondestructive test methods serving to recognize corrosion within the scope of aircraft maintenance. The following requirements which must be imposed with regard to the performance and quality of the surface protection are considered and discussed: (1) the potential differences of the materials used are to be kept as low as possible, i.e., constructive measures must be taken; (2) prevention of any local element activity by providing insulating protective coatings, i.e., by preventing a current; (3) inhibition by providing cover layers (e.g., chromate passivation); and (4) introducing layers which act as so-called sacrificial anodes. M.D.K.

N82-22348# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
CRITICAL METALS CONSERVATION RECYCLING AND SUBSTITUTION
E. F. BRADLEY (Pratt and Whitney Aircraft) Jan. 1982 23 p Presented at the 53rd Meeting of the AGARD Struct. and Mater. Panel, Noordwijkerhout, Netherlands, 27 Sep. - 2 Oct. 1981
(AGARD-R-693; ISBN-92-835-1412-2; AD-A112884) Avail: NTIS HC A02/MF A01

Critical metals are reviewed relative to their current importance to the aerospace industry. The roles of conservation, recycling, substitution, stockpiling and market place operations are analyzed. Technologies are discussed relative to their effects on the critical metals, and finally, suggestions are presented for meeting material supply problems. S.L.

N82-23317# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). Structures and Materials Panel.
AN AGARD-COORDINATED CORROSION FATIGUE COOPERATIVE TESTING PROGRAMME
R. J. H. WANHILL (NLR) and J. J. DELUCCIA (Naval Air Development Center, Warminster, Pa.) Feb. 1982 82 p
(AGARD-R-695; ISBN-92-835-1413-0; AD-A113731) Avail: NTIS HC A05/MF A01

The effectiveness of state of the art protection schemes for aluminum alloys with respect to corrosion and corrosion + fatigue were assessed. The development of new protection products, procedures and techniques were considered. A common testing effort that results in a better understanding of the corrosion fatigue phenomenon and the means of mitigating it for aerospace structural materials was conducted. Fatigue capabilities were enhanced by using a controlled atmospheric corrosion environment. S.L.

N83-15428# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
ADVANCED CASTING TECHNOLOGY
London Aug. 1982 332 p refs In ENGLISH and FRENCH Meeting held in Brussels, 4-9 Apr. 1982
(AGARD-CP-325; ISBN-92-835-0314-6; AD-A121910) Avail: NTIS HC A15/MF A01

The current state of developments of advanced casting technology was examined. The use of aluminum alloy castings for main structural application, which is likely to increase significantly, is emphasized. The following topics are discussed: use and developments of casting; developments in casting theory and practice; developments in casting practice; and developments in casting practice and quality control. For individual titles, see N83-15429 through N83-15447.

N83-15429# British Aerospace Aircraft Group, Kingston-upon-Thames (England).
ADVANCED CASTINGS IN THE DESIGN OF MILITARY AIRCRAFT
D. J. DUCKWORTH and R. M. SHAW *In* AGARD Advan. Casting Technol. 10 p (SEE N83-15428 06-26) Aug. 1982 refs
Avail: NTIS HC A15/MF A01

The use of castings and the developments which took place from the user point of view, over a period of years, were reviewed. It is suggested that in any new design the final shape used is always a compromise. Factors as cost, structural efficiency, mechanical properties and quality must be considered. Interaction of these factors and the more important areas where development is required are shown. More extensive use of castings in modern airframes in the future is anticipated. E.A.K.

N83-15430# Vereinigte Flugtechnische Werke-Fokker G.m.b.H., Bremen (West Germany). Materials and Processes Development Dept.
ADVANCED CASTING: TODAY AND TOMORROW
D. MIETRACH *In* Agard Advan. Casting Technol. 18 p (SEE N83-15428 06-26) Aug. 1982 refs Document also announced as N82-28486
Avail: NTIS HC A15/MF A01

The state of foundries and limitations of foundry practice and experience of these foundries are summarized. Components were redesigned in cooperation with the foundries to make them more castable. The aim of the Economic Structures Technology-Metals

program (WST-M) is to demonstrate the practicability of new technologies and to put the economy in the foreground. Cost benefit analyses of different representative military components, castings of primary structure parts by chosen foundries and the mechanical values of static/dynamic tests are reported. A prognosis for use of castings in aviation industry, for the further development of casting techniques and materials in future is given. E.A.K.

N83-15431# Technische Hogeschool, Delft (Netherlands). Dept. of Materials Science.
SOME DEVELOPMENTS IN CASTING TECHNOLOGY
H. NIESWAAG *In* AGARD Advan. Casting Technol. 19 p (SEE N83-15428 06-26) Aug. 1982 refs
Avail: NTIS HC A15/MF A01

Information on the main developments in casting technology and metal processing in the last decades, that improved the quality of modern castings is presented. The metallurgical aspects of the casting process, developments in alloys, ferrous as well as nonferrous, control and understanding of the as cast structure are emphasized. The relation between microstructure and properties for some aluminum alloys is discussed. Improvements in the sand casting practice, that resulted in castings of a more complex shape and higher dimensional accuracy is reviewed. E.A.K.

N83-15432# Aical Ltd., Altrincham (England).
DEVELOPMENT IN ALUMINUM ALLOY INVESTMENT CASTINGS
P. H. JACKSON *In* AGARD Advan. Casting Technol. 12 p (SEE N83-15428 06-26) Aug. 1982
Avail: NTIS HC A15/MF A01

The main objectives in the development of aluminum alloy investment castings as seen by the Investment Foundry Industry are outlined. Some examples of the successful utilization of parts produced by the process for aerospace and high integrity applications are reviewed. The advantages to be derived from close collaboration between design engineers and the foundary are illustrated. Developments in investments casting technology and the possibilities or the extended use of investment cast parts in aerospace and defense equipment to which these could lead in the near future are cited. E.A.K.

N83-15433# Magnesium Elektron Ltd., Swinton (England).
DEVELOPMENT AND TRENDS IN MAGNESIUM ALLOY TECHNOLOGY
W. UNSWORTH and J. F. KING *In* AGARD Advan. Casting Technol. 15 p (SEE N83-15428 06-26) Aug. 1982 refs
Avail: NTIS HC A15/MF A01

Developments in Magnesium alloys, casting technology and corrosion protection are examined. Alloys with improved ambient and elevated temperature capability to meet specific user requirements are described. It is indicated that significant improvements in temperaure stability are possible giving alloys with strength at least comparable with current used aluminum alloys on an equal volume basis. Adoptation of resin bonded sands and the simultaneous development of techniques for producing longer and thinner cored passageways has enabled foundries to meet the aerospace industries requirements for more complex and larger castings. Current protective techniques are reviewed and possible developments to improve cost effectiveness of protection are discussed. E.A.K.

N83-15434# Drexel Univ., Philadelphia, Pa. Dept. of Materials Engineering.
STRUCTURAL CONTROL IN SOLIDIFICATION PROCESSING
D. APELIAN *In* AGARD Advan. Casting Technol. 14 p (SEE N83-15428 06-26) Aug. 1982 refs
Avail: NTIS HC A15/MF A01

Control of heat flow, fluid flow and mass flow during solidification which allows structural control of the cast product is discussed. The importance of the mushy zone width and local solidification time while in the mushy zone are discussed. Three processes rheocasting, diffusion solidification and the VADER melting process are discussed for solidification fundamentals, process advantages and applications E.A.K.

N83-15435# Centre de Recherches Scientifiques et Techniques de l'Industrie des Fabrications Metalliques, Zwijnaarde (Belgium). Foundry Research Centre.
NUMERICAL SIMULATION OF CASTING SOLIDIFICATION APPLICATION TO THE SAND-COATED GRAVITY DIE CASTING PROCESS
G. VANHOUTTE *In* AGARD Advan. Casting Technol. 15 p (SEE N83-15428 06-26) Aug. 1982 refs
Avail: NTIS HC A15/MF A01

Numerical simulation of casting solidification was carried out to develop design rules for the production of sound S.G. iron castings through directional solidification in sand coated gravity dies. The parameters that govern heat transfer during solidification and subsequent cooling were assessed. Heat transfer during the freezing of an alloy in a sand coated metallic mould is fairly complex and cannot be described analytically. Using the finite differnce method for approximating the partial differential equations, a mathematical model was first set up for one dimensional heat transfer phenomena in cartesian coordinates. E.A.K.

N83-15436# GKN Group Technological Centre, Wolverhampton (England). Process Technology Dept.
THE SQUEEZE FORMING OF ALUMINIUM ALLOYS
G. WILLIAMS *In* AGARD Advan. Casting Technol. 15 p (SEE N83-15428 06-26) Aug. 1982 refs
Avail: NTIS HC A15/MF A01

The squeeze forming process is a hybrid manufacturing technology which involves the pressurized solidification of liquid metal in reusable dies. The basic process is described and the importance of various process parameters is discussed. A range of aluminum alloy components which use this technique is shown. Mechanical property data determined in several of these components are presented for a number of aluminum alloys. It is observed that both forging and casting alloys can be successfully squeeze formed, and the mechanical properties achieved compare favorable with conventional properties. The work performed shows that squeeze forming is a potentially powerful technique for the manufacture of a wide range of structural aluminum components in competition with more conventional production methods.
E.A.K.

N83-15437# Messier Fonderie, Arudy (France).
RECENT DEVELOPMENTS IN SAND CASTING UNDER LOW PRESSURE ADAPTED FOR MAKING LARGE CASTINGS OF AERONAUTICAL STRUCTURES [DERNIERS DEVELOPPMENTS DE LA COULEE EN SABLE SOUS BASSE PRESSION ADAPTES A LA REALISATION DE GRANDES PIECES DE STRUCTURES AERONAUTIQUES]
G. BROIHANNE *In* AGARD Advan. Casting Technol. 7 p (SEE N83-15428 06-26) Aug. 1982 refs In FRENCH
Avail: NTIS HC A15/MF A01

Sand casting under low pressure for large areas which allows the structural assembly of forgings of one piece blocks conceived previously by the assembly of metal sheets or machined structures is discussed. The casting offers superior possibilities over classical casting by gravity: filling of fine cloth on large surfaces; metallurgic benefits even for complex structures; perfect reproduction casting of conditions; and the possibility to cast complex areas of high strength alloys. Transl. by E.A.K.

N83-15438# Titan-Aluminum-Feinguss G m b H , Bestwig (West Germany).
NEW DEVELOPMENTS IN ALUMINUM AND TITANIUM INVESTMENT CASTINGS
G. WEDEKING *In* AGARD Advan. Casting Technol 8 p (SEE N83-15428 06-26) Aug. 1982
Avail: NTIS HC A15/MF A01

Aluminum and Titanium are most important basic materials in modern aircraft construction. The contribution of aluminum investment castings for manufacturing of aircraft units is discussed. Integral construction is one of the features of modern aircraft construction. This involves limiting the expensive assembly of individual parts to a minimum. Investment casting has proved to be an especially efficient moulding process as it combines considerable cost savings in material, assembly and machining with the unsurpassed degree of freedom it gives to the designer of the individual casting. The investment casting process has to compete with other moulding processes for the technological

aspects of a component. Tolerances, achievable dimensions and wall thicknesses of a component and, the strength of the material are essential. E.A.K.

N83-15439# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (West Germany). Helicopter and Transport Div.
AN EVALUATION OF VACUUM CENTRIFUGED TITANIUM CASTINGS FOR HELICOPTER COMPONENTS
L. J. MAIDMENT and H. PAWELETZ *In* AGARD Advan. Casting Technol. 7 p (SEE N83-15428 06-26) Aug. 1982 refs Document also announced as A81-41516
Avail: NTIS HC A15/MF A01

The applicability of centrifugally cast Titanium (Ti6Al4V) for a critical helicopter component, a rotor head, was investigated. The economic aspects were considered. The results of the investigation are summarized as follows: the endurance limit of cast Titanium is approximately 63% that of the wrought alloy, a 15% reduction in the machining costs was achieved. Improvements in the centrifugal casting technique leading to enhanced microstructural and mechanical material properties play a decisive role in extending the application of cast Titanium in the Aerospace industry. E.A.K.

N83-15440# Case Western Reserve Univ., Cleveland, Ohio. Dept. of Metallurgy and Materials Science.
GRAIN REFINEMENT OF CAST NICKEL-BASE SUPERALLOYS AND ITS EFFECT ON PROPERTIES
A. F. DENZINE, T. A. KOLAKOWSKI, and J. F. WALLACE *In* AGARD Advan. Casting Technol. 26 p (SEE N83-15428 06-26) Aug. 1982 refs
Avail: NTIS HC A15/MF A01

The influence of refinement of the cast grains on the mechanical properties of nickel base superalloys was studied. The T63 is produced from MAR-M-246 by a vacuum investment casting process. The conventional casting techniques employed in its manufacture result in large columnar grains which cause an anisotropic fatigue behavior. The grain refining technique developed consisted of adding 0.12B to the melt and establishing the proper time temperature cycles so that substrates for effective heterogeneous nucleation were available for grain refinement of the different section sizes in the T-63 rotor. The mechanical properties include tensile properties, low cycle fatigue resistance, combined fatigue, creep lives, thermal fatigue and oxidation properties, and stress rupture behavior were determined for the unrefined, fine columnar, and refined equiaxed structures of the three test alloys. E.A.K.

N83-15441# Detroit Diesel Allison, Indianapolis, Ind.
CAST TITANIUM COMPONENTS FOR ROTATING GAS TURBINE APPLICATIONS
B. A. EWING *In* AGARD Advan. Casting Technol. 14 p (SEE N83-15428 06-26) Aug. 1982
Avail: NTIS HC A15/MF A01

Investment cast titanium compressor impellers and integrally bladed rotor components which offer the potential for significant cost reduction in gas turbine design were examined. Cast titanium development activities are discussed, and examples of rotating components with accompanying dimensional and mechanical property data are presented. Future trends and needs in this technology area are also discussed. E.A.K.

N83-15442# Turbomeca S. A. - Brevets Szydlowski, Bordes (France).
MAKING CRITICAL COMPONENTS BY PRECISION CASTING [REALISATION DE PIECES CRITIQUES EN FONDERIE DE PRECISION]
M. BRUN, G. VANDENDRIESSCHE, D. FOURNIER, and M. MEURTIN *In* AGARD Advan. Casting Technol. 39 p (SEE N83-15428 06-26) Aug. 1982 refs In FRENCH
Avail: NTIS HC A15/MF A01

The construction of critical components for turbomachinery by precision casting is discussed. The construction of components for turbomachinery in cast has increase. This development applied to all kinds of materials like steel, superalloys, titanium, aluminum and other kinds of products. The invention is an extension of this technology in its application to rotating bodies like turbine wheels and compressor wheels. E.A.K.

N83-15443# British Columbia Univ., Vancouver.
ELECTROSLAG CASTING EVALUATION
A. MITCHELL and G. SIDLA *In* AGARD Advan. Casting Technol. 10 p (SEE N83-15428 06-26) Aug. 1982
Avail: NTIS HC A15/MF A01

The development of a cheap, simple version of the electroslag casting process (ESC) process intended for the manufacture of castings in the weight range from 10 - 1000 Kg is reported. The application of ESC to the production of a number of cast shapes, such as gears and shafts and tubular sections is demonstrated. Mechanical property investigations for these components and comments on the range of ESC application are discussed. The electroslag remelting process is an accepted method of producing high quality forgings in a variety of steels and related alloys. At a very early stage in the process's development it was recognized that the technique had the potential to cast not only ingots but also simple shapes. From this recognition stems the electroslag casting (ESC) process, and the product's use in the as cast condition. E.A.K.

N83-15444# Cosworth Research and Development Ltd., Worcester (England).
A NEWLY DEVELOPED PROCESS (THE GKN AND COSWORTH PROCESS) FOR THE PRODUCTION OF HIGH INTEGRITY ALUMINUM ALLOY CASTINGS
J. CAMPBELL and P. S. A. WILKINS (GKN Contractors Ltd., Redditch, England) *In* AGARD Advan. Casting Technol. 6 p (SEE N83-15428 06-26) Aug. 1982 refs
Avail: NTIS HC A15/MF A01

The production of high integrity aluminum alloys castings is a process of high precision, low pressure sand casting technique. The process is characterized by an improvement in accuracy over conventional sand castings by a factor of 4 or 5 in external features, and by a factor of approximately 20 times in internally cored features. Very high integrity and good surface finish are routinely obtained in production. The successful application of the process to certain military vehicle and aerospace products is described. E.A.K.

N83-15445# Titan-Aluminum-Feinguss G.m.b.H., Bestwig (West Germany).
QUALITY ASSURANCE IN TITANIUM AND ALUMINUM INVESTMENT CASTINGS
C. LIESNER *In* AGARD Advan. Casting Technol. 3 p (SEE N83-15428 06-26) Aug. 1982
Avail: NTIS HC A15/MF A01

Quality assurance and its importance in the permanently rising requirements of higher quality of investment casting products as well as new laws with intensifed manufacturing liability of producer is discussed. The presence of an efficient quality assurance system is the basic requirement for approval as supplier for the aircraft and aerospace industry. The integration of the quality assurance department into the company organization as well as its responsibility, jurisdiction and competence are defined in a quality assurance manual. An essential precondition for an efficient quality assurance system is a smooth flow of information between the production areas and quality control department concerned. The main task is to prevent faults occurring. The cost of high quality has to be minimized and its purpose or effectiveness to be maximized. E.A.K.

N83-15446# Societe Nationale d'Etude et de Construction de Moteurs d'Aviation, Evry Cedex (France).
THE QUALITY AND CONTROL OF PRECISION CASTINGS FOR TURBOMACHINES [QUALITE ET CONTROLE DES PIECES DE FONDERIE DE PRECISION POUR TURBOMACHINES]
J. THIERY and J. VOELTZEL *In* AGARD Advan. Casting Technol. 11 p (SEE N83-15428 06-26) Aug. 1982 In FRENCH
Avail: NTIS HC A15/MF A01

The high temperature characteristics of nickel and cobalt base alloys require a perfect matrix for castng so that the potential qualities of the metals are preserved. The principal aircraft turbine components made by precision casting are discussed as well as the problems encountered in their fabrication. The quality of these castings must be considered during these stages: (1) selection of the base material; (2) selection of waxes and shells, mold design, and casting; (3) dissecting, adjusting, and conducting nondestructive tests of the components; and (4) overseeing the

manufacture to determine the total range of quality and ascertain the deviations. Future techniques are needed to lessen the sensibility to microporosity by modifying the alloys or by isostatic pressing. Some method is needed to maintain control of quality when making hollow vanes. A.R.H.

N83-15447# Cercast 1979, Inc., Montreal (Quebec).
METALLURGICAL ASPECTS OF QUALITY CONTROL IN THE PRODUCTION OF PREMIUM QUALITY ALUMINUM INVESTMENT CASTINGS FOR THE AEROSPACE INDUSTRY
S. KENNERKNECHT *In* AGARD Advan. Casting Technol. 51 p (SEE N83-15428 06-26) Aug. 1982 refs
Avail: NTIS HC A15/MF A01

Development and innovations in the metallurgical state of the are in investment casting is discussed. Metallurgical variables which influence the production of premium quality investment castings were examined. An extensive comprehension of grain refinement, modification, chilling, alloy composition, heat treatment, destructive testing and basic metallurgy, are essential tools when confronted with a difficult casting problem. E.A.K.

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PROPELLANTS AND FUELS

Includes rocket propellants, igniters, and oxidizers; storage and handling; and aircraft fuels.

N83-11350# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
PROPULSION AND ENERGETICS PANEL, WORKING GROUP 13 ON ALTERNATIVE JET ENGINE FUELS. VOLUME 1: EXECUTIVE SUMMARY
R. B. WHYTE, ed. Jul. 1982 16 p 2 Vol.
(AGARD-AR-181-VOL-1; AD-A119916) Avail: NTIS HC A02/MF A01

Alternative fuels for gas turbine engines which may entail considerable changes in fuel properties and relaxation of key items in present specifications to ensure adequate supplies are studied. The physical properties as well as the hydrocarbon composition of the fuels and their effects on handling and storage, aircraft fuel systems and engines are investigated. S.L.

N83-11351# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
PROPULSION AND ENERGETICS PANEL, WORKING GROUP 13 ON ALTERNATIVE JET ENGINE FUELS. VOLUME 2: MAIN REPORT
R. B. WHYTE, ed. Jul. 1982 169 p 2 Vol.
(AGARD-AR-181-VOL-2; AD-A119917) Avail: NTIS HC A08/MF A01

Supply/demand of jet engine fuels for use by the in aeronautical research and development efforts was forecast. The effects of potential variations in hydrocarbon fuel properties on the performance, operating envelope, exhaust emissions, durability, maintainability, reliability and safety of aviation gas turbine aircraft was assessed. S.L.

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ENGINEERING (GENERAL)

Includes vacuum technology; control engineering; display engineering; and cryogenics.

N80-25499# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
MATERIALS COATING TECHNIQUES
Mar. 1980 186 p refs Lecture held in Lisbon, 27-28 Mar. 1980, in Athens, 31 Mar. - 1 Apr. 1980 and in Ankara, 3-4 Apr. 1980
(AGARD-LS-106; ISBN-92-835-1357-6; AD-A085603) Avail: NTIS HC A09/MF A01

A review of the principles and the present state of the art of applying metallic, ceramic, and organic layers for the purposes of protection of engineering materials from the effects of corrosion, erosion, and wear is presented. The resultant structure and properties of the coating layers and their interaction with the bulk material is considered. The behavior of coated parts, as determined by the coating technique and material, and the effects in service of such aspects as corrosion, fatigue, tribology problems, and structural stability are considered. Techniques for the analysis and nondestructive evaluation of the composition properties and soundness of the layers are assessed. For individual titles, see N80-25500 through N80-25509.

N80-25500# California Univ , Los Angeles. School of Engineering and Applied Science.
HIGH RATE PHYSICAL VAPOR DEPOSITION PROCESSES
R. F. BUNSHAH *In* AGARD Mater. Coating Tech. 16 p (SEE N80-25499 16-31) Mar. 1980 refs
Avail: NTIS HC A09/MF A01

The physical vapor deposition processes, evaporation, ion plating, and sputtering are reviewed. The deposition of metals, alloys, intermetallic compounds, and refractory compounds by these processes is discussed. The evolution of the microstructure and the influence of process parameters such as deposition temperature and gas pressure are presented and illustrated with examples. Texture and residual stresses in the deposit are considered. E.D.K.

N80-25501# Salford Univ. (England). Dept. of Aeronautical and Mechanical Engineering.
PLASMA AIDED TECHNIQUES
D. G. TEER *In* AGARD Mater. Coating Tech. 13 p (SEE N80-25499 16-31) Mar. 1980 refs
Avail: NTIS HC A09/MF A01

The adhesion, crystallinity, and grain structure of coatings deposited by physical vapor deposition techniques are usually improved if the energy of the depositing particles is increased. Energy can be transferred to the coating atoms by heating the substrate. An alternative method is to increase the kinetic energy of deposition by ionizing the vapor atoms and accelerating them in an electric field. A variety of plasma aided techniques are described and it is shown that all the improvements brought about by high temperature substrates can be achieved at lower substrate temperatures. The very high ion energies can also cause production of unusual phases and a further advantage is the increased reactivity resulting in deposition of compound coatings. E.D.K.

N80-25502# Balzers Aktiengesellschaft (Liechtenstein).
TECHNIQUES OF CHEMICAL VAPOR DEPOSITION
A. J. PERRY and N. J. ARCHER (Fulmer Research Inst. Ltd.) *In* AGARD Mater. Coating Tech. 16 p (SEE N80-25499 16-31) Mar. 1980 refs
Avail: NTIS HC A09/MF A01

Chemical vapor deposition (CVD) which utilizes gas phase chemical reactions to produce metallic and ceramic coatings is described. The technique is used to form thin layers of refractory carbides for wear resistance, layers of metals for corrosion and oxidation resistance, and is also a forming technique which permits the fabrication of complex shapes, particularly in high temperature materials. Chemical vapor deposition depends upon a localized chemical reaction and so it is able to coat complex shapes,

particularly internal surfaces. However, the reactions currently used for CVD require high reaction temperatures and this causes many limitations in terms of the substrates which may be coated. The equipment used and the properties of the materials produced are reviewed. E.D.K.

N80-25503# Dortmund Univ. (West Germany).
SPRAYED COATINGS
H. D. STEFFENS *In* AGARD Mater. Coatings Tech. 29 p (SEE N80-25499 16-31) Mar. 1980 refs
Avail: NTIS HC A09/MF A01

Thermal spraying is shown to be an efficient means for the protection of surface areas against elevated temperature, wear, corrosion, hot gas corrosion, and erosion in structural aircraft components. Particularly in jet engines, numerous parts are coated by flame, detonation, or plasma spraying techniques. The applied methods of flame, detonation, and plasma spraying are explained, as well as electric arc spraying. Possibilities for spray coatings which meet aircraft service requirements are discussed, as well as methods for quality control, especially nondestructive test methods. In particular, coating characteristics and properties obtained by different spray methods are described, and special attention is paid to low pressure plasma spraying. E.D.K.

N80-25504# Fiat Research Center, Orbassano (Italy).
LASER SURFACE ALLOYING
P. G. CAPPELLI *In* AGARD Mater. Coating Tech. 13 p (SEE N80-25499 16-31) Mar. 1980
Avail: NTIS HC A09/MF A01

Techniques based on high power lasers, which modify the chemical composition of the microstructure of the surface of a material in order to improve some of its properties are considered in terms of solving both the high melting point and segregation problems in the fabrication of metal and ceramic alloys. Application of these lasers in such materials processing areas as deep penetration autogeneous welding, cutting, drilling, transformation hardening, and experimental shock hardening is discussed. It is shown that the high power densities that lasers can produce, equivalent to thermal sources of temperature above 20,000 C, facilitate the melting of all phases of the alloy. Furthermore, the high power density of lasers allows melting to be localized at the surface, with negligible subsurface heating, thereby establishing high cooling rates. In this process, laser glazing, the extremely rapid chill rates of thin molten zones produce extremely homogeneous metallurgical microstructures, including amorphous alloys, the ultimate in alloy homogeneity. E.D.K.

N80-25505# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (West Germany).
CORROSION PROTECTION BY ELECTRO-DEPOSITED ALUMINUM
R. SUCHENTRUNK *In* AGARD Mater. Coating Tech. 25 p (SEE N80-25499 16-31) Mar. 1980 refs
Avail: NTIS HC A09/MF A01

Deposition of aluminum on various substrates by using a nonaqueous organic electrolytic system is described. The metallic deposit has a high purity and good corrosion protection properties. It can be used as a substitute for the highly toxic cadmium. Possible fields of application are protection against corrosion of high strength steels without any danger of hydrogen embrittlement, the coating of lightweight materials like aluminum, magnesium, and titanium alloys, and the fabrication of fiber reinforced metal matrix composites. E.D.K.

N80-25506# California Univ., Berkeley. Lawrence Berkeley Lab.
OVERLAY COATINGS FOR GAS TURBINE AIRFOILS
D. H. BOONE *In* AGARD Mater. Coating Tech. 13 p (SEE N80-25499 16-31) Mar. 1980 refs
Avail: NTIS HC A09/MF A01

The degradation modes associated with gas turbine operation under a variety of conditions are reviewed as a preliminary to defining the needs of protective airfoil coatings and processing techniques. These requirements and present coating procedures are briefly described as an introduction to the need for overlay type coatings in general and electron beam (EB) evaporation processed coatings in particular. A discussion of the features of production EB coaters is followed by a detailed description of the individual coating processing steps involved. While most are identical to other coating procedures, a few are significantly different and are discussed in detail. Current overlay coating compositions and their use and experience are reviewed. Future directions in overlay coating processing and composition including electron beam-physical vapor deposition applied ceramics are discussed. E.D.K.

N80-25507# Dortmund Univ. (West Germany).
APPLICATIONS OF SPRAYED COATINGS
H. D. STEFFENS and M. MALIK (Deutsche Lufthansa A.G., Hamburg, West Germany) *In* AGARD Mater. Coating Tech. 12 p (SEE N80-25499 16-31) Mar. 1980 refs
Avail: NTIS HC A09/MF A01

Service demands of the coating properties of sprayed coatings are classified as: preventing, fretting, wear, and corrosion; controlled abradability; and thermal barrier. Developments in both coating techniques and coating materials which have allowed production of coatings which match the performance demands are considered. Applications of sprayed coatings in aircraft components are discussed. E.D.K.

N80-25508# Balzers Aktiengesellschaft (Liechtenstein).
WEAR RESISTANT COATINGS MADE BY CHEMICAL VAPOUR DEPOSITION
A. J. PERRY and N. J. ARCHER (Fulmer Research Inst. Ltd.) *In* AGARD Mater. Coating Tech. 12 p (SEE N80-25499 16-31) Mar. 1980 refs
Avail: NTIS HC A09/MF A01

The methods by which hard layers are formed by chemical vapor deposition and the properties of these hard materials are reviewed. The economics of chemical vapor deposition are discussed as this is an extremely attractive aspect of the process for large batches of small components. E.D.K.

N80-25509# California Univ., Los Angeles. School of Engineering and Applied Science.
APPLICATIONS OF PHYSICAL VAPOR DEPOSITION PROCESSES
R. F. BUNSHAH *In* AGARD Mater. Coating Tech. 10 p (SEE N80-25499 16-31) Mar. 1980 refs
Avail: NTIS HC A09/MF A01

The applications of physical vapor deposition processes are discussed. They are coatings for decorative applications, heat/energy barriers, microelectronic devices, corrosion of aircraft parts, high temperature corrosion, tribological phenomena, cutting tools, optical components, thin transparent conductive layers, and materials conservation. The fabrication of self supporting shapes and potential applications are given. E.D.K.

N81-11266# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
FAULT TOLERANCE DESIGN AND REDUNDANCY MANAGEMENT TECHNIQUES
Sep. 1980 175 p refs Lecture Series held in Athens, 13-14 Oct. 1980; Rome, 16-17 Oct. 1980; and London, 20-21 Oct. 1980 (AGARD-LS-109; ISBN-92-835-0274-4; AD-A090849) Avail: NTIS HC A08/MF A01

Basic theory on concepts involved in the application of advanced software, state estimation, and implementation techniques involved in redundancy management are provided. A review covering the necessary background and state of the art involved in the application of such technologies is given. For individual titles, see N81-11267 through N81-11275.

N81-11267# Honeywell Systems and Research Center, Minneapolis, Minn.
FAULT TOLERANCE DESIGN AND REDUNDANCY MANAGEMENT TECHNIQUES: INTRODUCTION AND OVERVIEW
T. B. CUNNINGHAM *In* AGARD Fault Tolerance Design and Redundancy Management Tech. 2 p (SEE N81-11266 02-31) Sep. 1980
Avail: NTIS HC A08/MF A01

A brief discussion is given of the motivation for fault tolerance through failure management. The technical scope of the lecture series is also bounded. E.D.K.

N81-11268# Massachusetts Inst. of Tech., Cambridge. Lab. for Information and Decision Systems.
FAILURE DETECTION IN DYNAMIC SYSTEMS
A. S. WILLSKY *In* AGARD Fault Tolerance Design and Redundancy Management Tech. 14 p (SEE N81-11266 02-31) Sep. 1980 refs
Avail: NTIS HC A08/MF A01

An introduction to the basic concepts behind the design of algorithms for the detection of failures in dynamic systems is presented. Attention is focused on two important methods: the multiple model (MM) technique and the generalized likelihood ratio (GLR) method. In the context of these two methods many of the fundamental issues that arise in failure detection are explored, including the structure of failure detection algorithms, the computational complexity of different approaches, and the different modeling and system configuration assumptions on which different algorithms are based. Following these discussions attention is focused on two issues: the robust use of analytical redundancy in practical applications and the design of decision rules that reflect the system tradeoffs that must be made. E.D.K.

N81-11269# Saab-Scania, Linkoping (Sweden). Aerospace Div.
COMPUTER BASED IN-FLIGHT MONITORING
K. FOLKESSON *In* AGARD Fault Tolerance Design and Redundancy Management Tech. 23 p (SEE N81-11266 02-31) Sep. 1980
Avail: NTIS HC A08/MF A01

Various computer techniques used to monitor flight safety critical flight control systems components such as sensors, servos, and the FSC computer itself are described. Flight safety critical FCS sensors and usually redundant. The degree of redundancy is a function of the control authority of the sensors, the stability of the aircraft, and existing back-up arrangements. The digital FCS computer can be used for servo monitoring in many different ways. The servo configuration usually determines the best monitor solution. In redundant servo configurations, various signals, such as electrical current, differential pressure, velocity, or servo position, can be provided to the digital comptuer and monitored for failure detection. The FCS digital computer is usually a flight safety critical element and must be closely monitored. Failures must be detected and isolated with very high confidence. In redundant digital FCS computers, both computer self test and monitoring of the computer outputs are used to detect computer failures. The monitoring can be relized in software or in external hardware. E.D.K.

N81-11270# Departement d'Etudes et de Recherches en Technologie Spatiale, Toulouse (France).
DETECTING THE FAILURE OF AIRCRAFT SENSORS USING ANALYTICAL REDUNDANCY [DETECTION DE PANNE DE CAPTEURS D'AVION PAR UTILISATION DE LA REDONDANCE ANALYTIQUE]
M. LABARRERE *In* AGARD Fault Tolerance Design and Redundancy Management Tech. 17 p (SEE N81-11266 02-31) Sep. 1980 refs In FRENCH; ENGLISH summary
Avail: NTIS HC A08/MF A01

Failure detection techniques implemented on-board aircraft must be simple and robust. By replacing a triplex vital system with a duplex system associated with analytical redundancy, the problem is reduced to isolating the failed sensor. Estimation techniques are well suited here because of the atmospheric turbulence factor. Different techniques have been used according to whether the nature of the analytical redundancy is stochastic, deterministic, static, or dynamic. Various estimation algorithms used include: (1) mixed observations; (2) estimation by observers or Kalman filters, using one or several quations and one or several measurements; and (3) autoadaptive techniques by identifying the flight configuration. A solution based on the choice and use of deterministic redundancy relations which are independent of atmospheric disturbances is presented and applied to the records of real flights. Transl. by A.R.H.

N81-11271*# SRI International Corp., Menlo Park, Calif. Computer Science Lab.
SOFTWARE VALIDATION AND VERIFICATION TECHNIQUES
K. N. LEVITT *In* AGARD Fault Tolerance Design and Redundancy Management Tech. 9 p (SEE N81-11266 02-31) Sep. 1980 refs
(Contract NAS1-15528)
Avail: NTIS HC A08/MF A01

Computers are being increasingly used as a critical component in nuclear reactors, aircraft, and other applications, where a failure can be life-threatening. Recent studies revealed that a centralized computer controlling a commercial aircraft should have a mean time to failure of at least 10,000 years. By the judicious application of hardware redundancy, such a reliability can be approached assuming perfect software. The emerging technique of program verification gives promise of leading to vastly more reliable programs. Program verification is, at least conceptually, a very simple idea: by mathematical reasoning a program, for all input values, is shown to yield output values defined by an independently supplied formal specification. The state of the art in program verification is summarized addressing the following issues: available techniques and on-line tools: the cost of verifying a system; possible sources of unreliability in an alleged proof; and outstanding technical problems. A brief description is given of the SIFT (Software Implemented Fault Tolerance) computer, and efforts to prove the correctness of its operating system. E.D.K.

N81-11272# Honeywell Systems and Research Center, Minneapolis, Minn.
FAILURE MANAGEMENT TECHNIQUES FOR HIGH SURVIVABILITY
T. B. CUNNINGHAM *In* AGARD Fault Tolerance Design and Redundancy Management Tech. 25 p (SEE N81-11266 02-31) Sep. 1980 refs
Avail: NTIS HC A08/MF A01

Survivability of aircraft can be greatly enhanced by employing a number of considerations and techniques in design and placement of avionics components. The initial sizing and location of surfaces should include the impact of survivability. Avionics hardware sharing offers cost reductions and can provide high performance if reliability and survivability issues are successfully addressed. Observers offer a structure for seeking solutions to surivability problems. Observers for in the loop sensor reconstruction often require stability margin enhancement. Techniques for examining this problem and improving stability exist. These considerations are discussed in detail and are combined with trends in sensor and computer technology to formulate a candidate for a flutter mode control implementation. E.D.K.

N81-11273# Saab-Scania, Linkoping (Sweden). Aerospace Div.
FAILURE MANAGEMENT FOR THE SAAB VIGGEN JA37 AIRCRAFT
K. FOLKESSON *In* AGARD Fault Tolerance Design and Redundancy Management Tech. 21 p (SEE N81-11266 02-31) Sep. 1980 refs
Avail: NTIS HC A08/MF A01

The JA-37 Viggen is the first military aircraft in series production and field-service equipped with a digital automatic flight control system. The JA-37 Digital Automatic Flight Control System has high control authority and is a flight safety critical system. It has duplex sensors, a single channel digital computer, and simple secondary servos. The digital computer performs control-law calculation and sensor and servo monitoring, as well as extensive self test on ground and during flight. The sensors are monitored by comparison. The servos are monitored by comparing the output from a software model with the servo output. E.D.K.

N81-11274*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Center, Edwards, Calif.
FLIGHT EXPERIENCE WITH FLIGHT CONTROL REDUNDANCY MANAGEMENT
K. J. SZALAI, R. R. LARSON, and R. D. GLOVER *In* AGARD Fault Tolerance Design and Redundancy Management Tech. 27 p (SEE N81-11266 02-31) Sep. 1980 refs
Avail: NTIS HC A08/MF A01

Flight experience with both current and advanced redundancy management schemes was gained in recent flight research programs using the F-8 digital fly by wire aircraft. The flight

performance of fault detection, isolation, and reconfiguration (FDIR) methods for sensors, computers, and actuators is reviewed. Results of induced failures as well as of actual random failures are discussed. Deficiencies in modeling and implementation techniques are also discussed. The paper also presents comparison off multisensor tracking in smooth air, in turbulence, during large maneuvers, and during maneuvers typical of those of large commercial transport aircraft. The results of flight tests of an advanced analytic redundancy management algorithm are compared with the performance of a contemporary algorithm in terms of time to detection, false alarms, and missed alarms. The performance of computer redundancy management in both iron bird and flight tests is also presented. E.D.K.

N81-11275# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Oberpfaffenhofen (West Germany). Inst. for Flight System Dynamics.

ROBUST CONTROL SYSTEM DESIGN

J. ACKERMANN *In* AGARD Fault Tolerance Design and Redundancy Management Tech. 14 p (SEE N81-11266 02-31) Sep. 1980 refs

Avail: NTIS HC A08/MF A01

The short period longitudinal mode of an F 4-E with horizontal canards is instable in subsonic flight and unsufficiently damped at supersonic speed. The control system has to provide acceptable pole locations according to military specifications for flying qualities. A fixed gain controller using three paralleled gyros is designed, such that the pole region requirements in four typical flight conditions are robust with respect to gain reduction to one third. Thus nothing bad happens immediately after one or two gyro failures. Failure detection and redundancy management may be performed at a higher hierarchical level, which does not have to be extremely fast. The use accelerometers or air data sensors for angle of attack or dynamic pressure is totally avoided in this concept and no gain scheduling is necessary. The design for robustness with respect to different flight conditions and sensor failures is performed by a novel parameter space design tool. E.D.K.

N82-13274# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). Structures and Materials Panel.

FATIGUE TEST METHODOLOGY

Oct. 1981 255 p refs Proc. of Lecture Series held at Lyngby, Denmark, 19-20 Oct. 1981; Lisbon, 22-23 Oct. 1981; Athens, 26-27 Oct. 1981

(AGARD-LS-118; ISBN-92-835-1401-7; AD-A107561) Avail: NTIS HC A12/MF A01

Laboratory fatigue testing of small components and specimens is considered with the emphasis on: testing philosophies, hardware systems required to carry out these philosophies, and the associated test specimens. For individual titles, see N82-13275 through N82-13285.

N82-13275# Royal Aircraft Establishment, Farnborough (England). Structures Dept.

THE ROLE OF FATIGUE TESTING

P. R. EDWARDS *In* AGARD Fatigue Test Methodology 15 p (SEE N82-13274 04-31) Oct. 1981 refs

Avail: NTIS HC A12/MF A01

Fatigue testing which involves proving and developing components, materials and processes, investigating particularly factors such as corrosion which can be damaging and those such as fatigue resistant fasteners which are beneficial to fatigue is discussed. Modern electrohydraulic machines and computers allow application of more representative loading conditions, tests to be monitored, and efficient data analyses. Use of standard loading sequences offers considerable benefits to fatigue programs. The monitoring of fatigue damage through the life since these techniques are very different between metals and composites is emphasized. Metals test techniques which determine cyclic stresses and strains at points of fatigue initiation have led to considerable improvements in accuracy of life prediction. Author

N82-13276# Fraunhofer-Inst. fuer Betriebsfestigkeit, Darmstadt (West Germany).

PLANNING AND ANALYSIS OF A FATIGUE TEST PROGRAMME

D. SCHUETZ *In* AGARD Fatigue Test Methodology 22 p (SEE N82-13274 04-31) Oct. 1981 refs

Avail: NTIS HC A12/MF A01

Advances in fatigue testing methods are presented. The increasing amount of service load data, the use of fracture mechanics, and the application of prediction methods which emphasize local stresses and/or strains are discussed. It is suggested that fatigue tests are still imperative in determining the fatigue performance of components or built up structures. Fatigue tests are the most important part of a fatigue life evaluation in spite of the current level of knowledge of fatigue mechanisms. E.A.K.

N82-13277# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Cologne (West Germany). Inst. fuer Werkstoff-Forschung.

FATIGUE TEST MACHINES

H. NOWACK *In* AGARD Fatigue Test Methodology 23 p (SEE N82-13274 04-31) Oct. 1981 refs

Avail: NTIS HC A12/MF A01

Conventional and servohydraulic testing machines are reviewed. The main ranges in application of the systems are described. Servohydraulic resonance machines enable both, random tests and constant amplitude tests. For component and full scale tests of structures sophisticated test systems become necessary, which have to fulfill numerous specific requirements. The testing machines devices for the control, monitoring, and recording of the test parameters are described. It is concluded that online computers are a most efficient tool for the performance of fatigue tests. E.A.K.

N82-13278# Fraunhofer-Inst. fuer Betriebsfestigkeit, Darmstadt (West Germany).

VARIABLE AMPLITUDE FATIGUE TESTING

D. SCHUETZ *In* AGARD Fatigue Test Methodology 31 p (SEE N82-13274 04-31) Oct. 1981 refs

Avail: NTIS HC A12/MF A01

The blocked program tests made possible through the introduction of a testing machine with a hybrid loading system consisting of a resonant type frequency device for blocks of loads with many cycles, and a hydraulic device for load blocks with a small number of cycles and single load cycles with differing amplitudes are discussed. It is pointed out that it is the introduction of electroservohydraulic closed loop testing machines which marked the first real breakthrough. The machines allow a component to be loaded in any load sequence at relatively high frequencies. Advancements are also made in the field of servohydraulics. Machines on which complicated load sequences can be applied are used for a large variety of variable amplitude loading sequences. E.A.K.

N82-13279# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Cologne (West Germany). Inst. fuer Werkstoff-Forschung.

ON-LINE COMPUTERS IN FATIGUE TESTING

H. NOWACK *In* AGARD Fatigue Test Methodology 11 p (SEE N82-13274 04-31) Oct. 1981 refs

Avail: NTIS HC A12/MF A01

The introduction of online computer systems into fatigue testing are discussed. Different application schemes of computerized systems are described: dedicated systems, multiple purpose systems, and maximum flexibility systems. Essential viewpoints of the development of computerized systems are given. It is shown, that professional systems can offer significant advantages in many cases. Various aspects and examples for the practical work with computerized systems are given. E.A.K.

N82-13280# Bath Univ. (England). School of Materials Science.
FATIGUE TESTING OF FIBRE COMPOSITES
B. HARRIS *In* AGARD Fatigue Test Methodology 18 p (SEE N82-13274 04-31) Oct. 1981 refs
Avail: NTIS HC A12/MF A01

The progress of fatigue in composites was monitored by most of the usual methods: the determination of S/N curves and master diagrams using constant stress or strain amplitude or random fluctuations, the determination of residual strength, and the observation of crack growth rates. The interpretation of these results and their translation to the design process demand consideration of the mode of failure, the definition of failure used in any given instance, and the relevance of the test procedure to practical applications. E.A.K.

N82-13281*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
ELEVATED TEMPERATURE FATIGUE TESTING OF METALS
M. H. HIRSCHBERG *In* AGARD Fatigue Test Methodology 18 p (SEE N82-13274 04-31) Oct. 1981 refs
Avail: NTIS HC A12/MF A01

Material characterization and evaluation conducted for the purpose of calculating fatigue crack initiation lives of components operating at elevated temperatures are discussed. The major technology areas needed to perform a life prediction of an aircraft turbine engine hot section component and the steps required for life prediction are outlined. These include: the determination of the operating environment, the calculation of the thermal and mechanical loading of the component, the cyclic stress strain and creep behavior of the material required for structural analysis, the structural analysis to determine the local stress strain temperature time response of the material at the critical location in the component, and from a knowledge of the fatigue, creep, and failure resistance of the material, a prediction of the life of the component. E.A.K.

N82-13282# Royal Aircraft Establishment, Farnborough (England). Materials Dept.
FATIGUE TESTS WITH A CORROSIVE ENVIRONMENT
R. N. WILSON *In* AGARD Fatigue Test Methodology 20 p (SEE N82-13274 04-31) Oct. 1981 refs
Avail: NTIS HC A12/MF A01

The techniques used to study the fatigue behavior of metals and alloys in vacuum, gas and liquid environments are outlined. The methods used to simulate service conditions in the laboratory are described and the variables which must be considered when planning a corrosion fatigue test programme are discussed. An attempt to control or eliminate some of the experimental variables is illustrated. The fatigue performance of a fully protected 1.5 dog bone aluminium alloy test piece which is prestressed at low temperature and exposed to a corrosive environment prior to fatigue testing in salt fog is evaluated. E.A.K.

N82-13283# Royal Aircraft Establishment, Farnborough (England). Structures Dept.
METHODS OF OBTAINING CRACK GROWTH DATA IN METALS
P. R. EDWARDS *In* AGARD Fatigue Test Methodology 22 p (SEE N82-13274 04-31) Oct. 1981 refs
Avail: NTIS HC A12/MF A01

Methods of obtaining crack growth data in metals are subdivided into several groups. Crack length is determined by measuring compliance which changes as a crack grows. Compliance is measured across the faces of the crack with a clip gauge. Optical methods include surface crack length measurement techniques. With electrical methods a DC, pulsed DC or AC electric current is passed through the specimen and, across any crack, a potential drop is created indicating the crack size. Sonic methods include ultrasonics and acoustic emission, the former measuring crack length by interpreting reflected or transmitted ultrasonic beams and the latter obtaining an indication of crack rate by recording stress waves emitted as energy is released when the tip of the crack advances. Mechanical devices which fracture with the crack are used either as individual conductors bonded across the crack path or as a foil which changes in resistance as the crack grows through it. It is feasible to design specimens in which cracks occur in an area favorable for accurate or simple measurement. Fracture surface readback is the only method which offers the possibility of determining crack rates on a specimen retrospectively after failure. E.A.K.

N82-13284# Bath Univ. (England). School of Materials Science.
MONITORING OF DAMAGE IN FIBRE COMPOSITES
B. HARRIS *In* AGARD Fatigue Test Methodology 23 p (SEE N82-13274 04-31) Oct. 1981 refs
Avail: NTIS HC A12/MF A01

Various techniques were used to study the accumulation of damage in composite subjected to fatigue. Optical methods, x-radiography, ultrasonic techniques, thermal imaging, and acoustic emission analysis are all methods which are capable of revealing certain aspects of the development of damaged regions in a composite, but the usefulness of most of these is limited to certain types of material or specific structural situations. E.A.K.

N82-13285# Waterloo Univ. (Ontario). Dept. of Civil Engineering.
CYCLIC STRAIN APPROACH TO FATIGUE IN METALS
T. H. TOPPER and P. AU *In* AGARD Fatigue Test Methodology 25 p (SEE N82-13274 04-31) Oct. 1981 refs
Avail: NTIS HC A12/MF A01

The progress of a crack from its initiation in a notch root through the notch stress field was simulated based on local notch root strains. Strains at the notch root or at the tip of the advancing crack are simulated or calculated and used to describe crack growth. These approaches are mainly applicable to blunt notches in which threshold stress continuously increases with crack length, while fracture mechanics approaches are adequate for sharp notches in which the maximum threshold stress occurs inside the material rather than at the surface. Methods of simulating cyclic plastic notch strains and the resulting crack advance and methods of simulating the effect of variable amplitude loading and biaxial stress states are described. E.A.K.

N82-20340# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). Fluid Dynamics Panel.
MODERN DATA ANALYSIS TECHNIQUES IN NOISE AND VIBRATION PROBLEMS
Nov. 1981 164 p refs Proc. of Conf. held at Rhode-St-Genese, Belgium, 7-11 Dec. 1981
(AGARD-R-700; ISBN-92-835-0303-1) Avail: NTIS HC A08/MF A01

Mathematical and statistical procedures are applied to the analysis of noise and vibration. For individual titles, see N82-20341 through N82-20356.

N82-20341# Office National d'Etudes et de Recherches Aeronautiques, Paris (France). Acoustique Div.
MODERN DATA ANALYSIS TECHNIQUES IN NOISE AND VIBRATION PROBLEMS WITH PARTICULAR EMPHASIS ON AEROACOUSTIC APPLICATIONS
M. PERULLI *In* AGARD Mod. Data Anal. Tech. in Noise and Vibration Probl. p 1-11 (SEE N82-20340 11-31) Nov. 1981 refs In FRENCH; ENGLISH summary
Avail: NTIS HC A08/MF A01

Classical methods are reviewed and the principles and general theorems and domains of application of modern methods of data analysis presented. Details of the instrumentation requirements for the implementation of these methods and of the practical problems which arise are described. Applications to noise and vibration problems are considered, with reference to particular examples, many of which are chosen to illustrate the intimate connection between acoustics and vibrations in aeroacoustics. J.D.H.

N82-20342# Southampton Univ. (England). Inst. of Sound and Vibration Research.
FLUCTUATING STRESS FIELDS IN CONTINUOUS MEDIA
P. E. DOAK *In* AGARD Mod. Data Anal. Tech. in Noise and Vibration Probl. p 12-18 (SEE N82-20340 11-31) Nov. 1981
Avail: NTIS HC A08/MF A01

The fundamental nature and behavior of stress wave fields in real materials and the selection and interpretation of techniques for measuring stress waves are considered. Nonlinearity is removed from the analysis problem according to the Lighthill acoustic

analogy. Finite difference forms of the partial differential equations for linear continuous mechanical systems are derived. This approach simplifies understanding how complicated networks can be approximated by simpler ones, providing insight into the devising of approximate partial differential equations to replace the full elasticity equations representing beams, plates, and shells. The homogeneous isotropic Hookean (stress proportional to strain) continuum is demonstrated to be the simplest ideal continuum model. Employment of the Kelvin-Voight thermoviscoelastic continuum model permits inclusion of viscous and thermal stresses. Orthogonal representations of stress wave fields (eigenfunction series, or Fourier frequency or wave number transforms) are determined to be the most reliable for analytical and/or computational purposes. J.D.H.

N82-20343# Southampton Univ. (England). Inst. of Sound and Vibration Research.
VIBRATION OF STRUCTURES EXCITED ACOUSTICALLY
B. L. CLARKSON *In* AGARD Mod. Data Anal. Tech. in Noise and Vibration Probl. p 19-37 (SEE N82-20340 11-31) Nov. 1981 refs
Avail: NTIS HC A08/MF A01

The analytical methods available to estimate the response of structures to vibration are developed on the assumption that the structure itself does not change the properties of the incident sound field by any feed back or flutter type mechanism. The normal mode method is used for the majority of the work to estimate the response to any sound field. Special cases considered are jet noise excitation, turbulent boundary layer pressure excitation, and a reverberant field excitation. The alternative traveling wave method is also introduced. J.D.H.

N82-20344# Cambridge Acoustical Associates, Inc., Mass.
FUNDAMENTAL CONCEPTS OF SOUND RADIATION
M. C. JUNGER *In* AGARD Mod. Data Anal. Tech. in Noise and Vibration Probl. p 38-42 (SEE N82-20340 11-31) Nov. 1981 refs
Avail: NTIS HC A08/MF A01

The fundamental physical concepts underlying sound radiation are reviewed. The wave equation is derived and its solution constructed for plane waves. Impedance and wave number concepts are introduced. The sound field for a uniformly pulsating spherical radiator and its limiting case, the point source, is derived. Finally, the scaling laws of acoustical model experiments are stated. Author

N82-20345# Naval Ship Research and Development Center, Bethesda, Md.
FUNDAMENTAL CONCEPTS OF FLOW-GENERATED NOISE
W. K. BLAKE *In* AGARD Mod. Data Anal. Tech. in Noise and Vibration Probl. p 43-53 (SEE N82-20340 11-31) Nov. 1981 refs
Avail: NTIS HC A08/MF A01

The fundamental properties of flow-generated sound and vibration are summarized. The elementary source types, the physical parameters governing sound and vibration, and general similarity rules are derived. The rudimentary effects of surfaces on flow generated noise are reviewed. J.D.H.

N82-20346# Cambridge Acoustical Associates, Inc., Mass.
EXTENDED SOUND SOURCES
M. C. JUNGER *In* AGARD Mod. Data Anal. Tech. in Noise and Vibration Probl. p 54-59 (SEE N82-20340 11-31) Nov. 1981 refs
Avail: NTIS HC A08/MF A01

The point source solution is used to construct the far field of line arrays and its extension to planar sources is described. The alternative, more generally applicable transform technique whereby the far field is evaluated analytically by the method of stationary phase is derived for axisymmetric planar radiators and illustrated for rigid circular piston sources. The transform solution of the sound field radiated by a finite cylinder of arbitrary dynamic configuration is presented. J.D.H.

N82-20347# Naval Ship Research and Development Center, Bethesda, Md.
STOCHASTIC EXCITATION OF ELASTIC STRUCTURES AND EXAMPLES OF FLOW-GENERATED NOISE
W. K. BLAKE *In* AGARD Mod. Data Anal. Tech. in Noise and Vibration Probl. p 60-71 (SEE N82-20340 11-31) Nov. 1981 refs
Avail: NTIS HC A08/MF A01

The fundamentals of flow generated sound are used to determine the important parameters that must be measured to make quantitative evaluations. Using as an example the flow excited vibration of cylinders the principles are related to actual measurements and, as well, the fundamentals of self sustained vibrations are introduced. The important semi-empirical relationships that govern the more complex generation mechanisms of different types are surveyed. J.D.H.

N82-20348# Cambridge Acoustical Associates, Inc., Mass.
SOUND RADIATION BY ELASTIC STRUCTURES
M. C. JUNGER *In* AGARD Mod. Data Anal. Tech. in Noise and Vibration Probl. p 72-75 (SEE N82-20340 11-31) Nov. 1981 refs
Avail: NTIS HC A08/MF A01

Realistic finite impedance sound radiators whose vibrations are modified by the radiation loading of the ambient fluid are considered. Source fluid interaction is illustrated for the elementary case of a pulsating gas bubble. Sound radiation by flexural waves in plates is also considered. The flexural wave velocity in vacuo and in the radiation loaded plate is derived. Finally, a full fledged interaction problem is solved by the transform technique. The sound field radiated by a force excited effectively infinite elastic plate is constructed, radiation loading being rigorously accounted for. J.D.H.

N82-20349# Southampton Univ. (England). Inst. of Sound and Vibration Research.
THE APPLICATION OF STATISTICAL ENERGY ANALYSIS TO VIBRATION OF STRUCTURES EXCITED ACOUSTICALLY
B. L. CLARKSON *In* AGARD Mod. Data Anal. Tech. in Noise and Vibration Probl. p 76-79 (SEE N82-20340 11-31) Nov. 1982 refs
Avail: NTIS HC A08/MF A01

In the high frequency range of vibration which can be excited by acoustic pressures, there are usually very many modes of vibration. The individual mode by mode analysis becomes impracticable and an alternative approach based on the energy of vibration in broad frequency bands is more appropriate. By its very nature of averaging the effects over many modes the method is only suitable for randomly excited vibrations. The method is outlined and some experimental results for the parameters required are presented. J.D.H.

N82-20350# Southampton Univ. (England). Inst. of Sound and Vibration Research.
LINEAR SIGNAL PROCESSING 1
J. K. HAMMOND *In* AGARD Mod. Data Anal. Tech. in Noise and Vibration Probl. p 80-91 (SEE N82-20340 11-31) Nov. 1981 refs
Avail: NTIS HC A08/MF A01

Methods of signal processing emphasizing digital methods applicable to deterministic data are reviewed. Following a discussion of analog to digital conversion, Fourier methods for continuous and sampled data are described, noting the problem of aliasing and the importance of circular convolution. Digital filtering techniques are referred to and methods of 'zoom' analysis are explained. The problem of deconvolution is discussed. J.D.H.

N82-20351# Southampton Univ. (England). Inst. of Sound and Vibration Research.
LINEAR SIGNAL PROCESSING 2
J. K. HAMMOND *In* AGARD Mod. Data Anal. Tech. in Noise and Vibration Probl. p 92-106 (SEE N82-20340 11-31) Nov. 1981 refs
Avail: NTIS HC A08/MF A01

The treatment of random (stochastic) processes is discussed. This is often referred to as time series analysis in the statistical literature. Computation methods referred to use digital techniques, and the basic principles outlined refer to continuous time processes.

Stationary random processes are considered. Correlation functions and spectra are defined. Conventional estimation methods implemented using digital schemes are reviewed. Next the concepts of residual spectra and partial and multiple coherence functions for multi-input systems are explained. Functions of more than one variable are treated. This relates directly to quantities that depend both on space and time. Aspects of two dimensional signal processing are reviewed and some applications are discussed. J.D.H.

N82-20352# Southampton Univ. (England). Inst. of Sound and Vibration Research.
NON-STATIONARITY AND NONLINEARITY IN DATA ANALYSIS
J. K. HAMMOND *In* AGARD Mod. Data Anal. Tech. in Noise and Vibration Probl. p 107-116 (SEE N82-20340 11-31) Nov. 1981 refs
Avail: NTIS HC A08/MF A01

Both time and frequency domain methods are considered, with emphasis on procedures that are generalizations of methods applicable to stationary processes and linear systems. The problem of modeling of processes is also considered. Nonstationary random processes are dealt with. General considerations related to analysis of nonstationary data are discussed, and a time domain approach to the modeling of vehicles traveling over rough ground at variable speed is outlined. This is followed by a description of a class of nonstationary phenomena using the evolutionary spectral density. Nonlinear phenomena in the time domain are considered. A body of theory devoted to the solution of randomly driven nonlinear systems is surveyed. A frequency domain approach for nonlinear systems using the bispectrum is described. A signal processing approach that might be called 'nonlinear' is explained. This is homomorphic signal processing, which has wide application, one of which is the treatment of echo-like processes. J.D.H.

N82-20353# Southampton Univ. (England). Inst. of Sound and Vibration Research.
PARAMETRIC METHODS IN SIGNAL ANALYSIS
J. K. HAMMOND *In* AGARD Mod. Data Anal. Tech. in Noise and Vibration Probl. p 117-123 (SEE N82-20340 11-31) Nov. 1981 refs
Avail: NTIS HC A08/MF A01

Parametric spectral analysis using the maximum entropy method is described. General linear models for time series and how the maximum entropy spectral density relates to autoregressive processes are described. A list of applications of the method is included. A few other parametric approaches to data analysis and system characterization are summarized. J.D.H.

N82-20354# Technische Univ., Berlin (West Germany). Inst. fuer Technische Akustik.
VIBRATION TRANSMISSION AND SOUND RADIATION
M. HECKL *In* AGARD Mod. Data Anal. Tech. in Noise and Vibration Probl. 124-141 (SEE N82-20340 11-31) Nov. 1981 refs
Avail: NTIS HC A08/MF A01

Waves in solids and in gases or fluids are governed by very similar equations which are based on continuity of mass, continuity of momentum, and an equation of state. Therefore sound radiation and vibration transmission into solid media have much in common. Radiation from planar sources, reflection at plane boundaries, the behavior of wave guides, source impedances, etc., are compared and discussed. Author

N82-20355# Cambridge Acoustical Associates, Inc., Mass.
PROCEDURES RELATING THE NEAR- TO THE FAR-FIELD: IMAGING TECHNIQUES
M. C. JUNGER *In* AGARD Mod. Data Anal. Tech. in Noise and Vibration Probl. p 142-149 (SEE N82-20340 11-31) Nov. 1981 refs
Avail: NTIS HC A08/MF A01

The formulation of the pressure field of an arbitrary sound source in terms of the Helmholtz integral is discussed. Analytical and experimental approaches to the evaluation of this integral are described. The latter emphasize the use of measurements taken in the near field. The plane wave asymptotic technique is described. The concept of intensity is introduced and its measurement for harmonic and random signals described. Finally, two types of computer holography are described: one of these provides a wavenumber filtering procedure which reconstructs only the supersonic components of the dynamic configuration of the source; the other reconstructs the actual configuration of the source, as well as the three dimensional pressure and vector intensity fields. J.D.H.

N82-20356# Hewlett-Packard France, Les Ulis (France).
MODAL ANALYSIS USING DIGITAL TEST EQUIPMENT
P. GARCIA *In* AGARD Mod. Data Anal. Tech. in Noise and Vibration Probl. p 151-159 (SEE N82-20340 11-31) Nov. 1981 refs
Avail: NTIS HC A08/MF A01

Modal analysis methods based upon the measurement and post test processing of transfer functions in digital form are discussed. The analysis which shows how modal data can be identified from transfer function measurements is reviewed. This is followed by a discussion of alternative methods for identifying modal data from transfer function measurements. Finally, the effect of vibration in terms of acoustics is covered. Author

N83-11390# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
IMAGE PROCESSING TECHNIQUES
May 1982 233 p refs Lecture held in Athens, 14-15 Jun. 1982; Paris, 17-18 Jun. 1982 and the Hague, 21-22 Jun. 1982 Original document contains color illustrations
(AGARD-LS-119; ISBN-92-835-1425-4; AD-A119489) Avail: NTIS HC A11/MF A01

Image processing techniques, the human visual system, digital imagery and display, image generation and display, picture formatting and hardware considerations, image processing system design and implementation, image transmission and coding, feature extraction, optical information processing, and remotely sensed phenomena are discussed. For individual titles, see N83-11391 through N83-11400.

N83-11391# Rensselaer Polytechnic Inst., Troy, N. Y. Electrical, Computer, and Systems Engineering.
IMAGE PROCESSING TECHNIQUES
L. A. GERHARDT *In* AGARD Image Process. Tech. 5 p (SEE N83-11390 02-31) May 1982
Avail: NTIS HC A11/MF A01

Image generation, image processing, image transmission, image enhancement, and interpretation are discussed. Author

N83-11392# Twente Univ. of Technology, Enschede (Netherlands). Dept. of Electrical Engineering.
THE HUMAN VISUAL SYSTEM
D. BOSMAN *In* AGARD Image Process. Tech. 22 p (SEE N83-11390 02-31) May 1982 refs
Avail: NTIS HC A11/MF A01

The psycho-physical limits of performance are determined by the physical stimulus values at which there is 50% probability of detection: thresholds of the visual channel. Such visual characteristics are discussed. Author

N83-11393# Twente Univ. of Technology, Enschede (Netherlands). Dept. of Electrical Engineering.
FUNDAMENTALS OF DIGITAL IMAGERY AND DISPLAY
D. BOSMAN *In* AGARD Image Process. Tech. 21 p (SEE N83-11390 02-31) May 1982 refs
Avail: NTIS HC A11/MF A01

Images are two dimensional distributions of luminance L(x,y) wherein x and y are the spatial (distance) coordinates of the local luminance L. They can be represented by landscapes with plains for uniform gray patches, slopes and hills for luminance gradients, towers and pits for speckles and dots, walls and canals for lines and vectors, and so on. The spatial resolution required for faithful reproduction of the image is determined by very steep luminance gradients and small radii in curvature of contours, and by just noticeable differences (JND's) in low gradients. The required luminance resolution is determined by discernible luminance contrasts. The spatial resolution depends on the luminance contrast. In the luminance ranges of displays, one may assume that most operations are linear. Author

N83-11394# Royal Signals and Radar Establishment, Malvern (England).
IMAGE GENERATION AND DISPLAY
T. R. BERRY *In* AGARD Image Process. Tech. 25 p (SEE N83-11390 02-31) May 1982 refs
Avail: NTIS HC A11/MF A01

The various scanning patterns used by conventional airborne sensors and the implications of displaying the data generated by them on a cockpit display based on commercial interlaced TV are reviewed. The challenge posed by flat panel displays to the dominance of the CRT in the TV field is considered briefly, and the relative merits of photographic film and magnetic tape as a means of providing a permanent record of the displayed data are explored. Author

N83-11395# Royal Signals and Radar Establishment, Malvern (England).
PICTURE FORMATTING AND HARDWARE CONSIDERATIONS
T. R. BERRY *In* AGARD Image Process. Tech. 21 p (SEE N83-11390 02-31) May 1982 refs
Avail: NTIS HC A11/MF A01

The basic requirements of an airborne Digital Scan Converter are explored, and the major design criteria established. Techniques for applying coordinate conversion are discussed in some detail, and two forms of polar to cartesian transformation compared. The effects of platform motion and the scanning mechanism of the sensors on the displayed imagery are considered and illustrated using simple examples. A distinction is made between real and off line viewing, and typical viewing times for various airborne sensors are determined. Author

N83-11396# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Oberpfaffenhofen (West Germany). Inst. Fuer Optoelektronik.
DFVLR'S DIBIAS, DESIGN AND IMPLEMENTATION OF A DIGITAL INTERACTIVE IMAGE PROCESSING SYSTEM
K. A. ULBRICHT *In* AGARD Image Process. Tech. 12 p (SEE N83-11390 02-31) May 1982 refs
Avail: NTIS HC A11/MF A01

The basic philosophy, as well as design considerations, of an interactive versus an automatic digital image processing system are discussed at the implementation of the Digital Interactive Bavarian Image Analysis System (DIBIAS). Its peripheral hardware and software are documented, and applications in the visible and near infrared part of the spectrum with fundamental programs on geologic and hydrologic topics are demonstrated. A short review of image processing possibilities is added. Author

N83-11397# Rensselaer Polytechnic Inst., Troy, N. Y. Dept. of Electrical, Computer and Systems Engineering.
DIGITAL IMAGE TRANSMISSION AND CODING
J. W. MODESTINO (California Univ. at San Diego, La Jolla) *In* AGARD Image Process. Tech. 8 p (SEE N83-11390 02-31) May 1982 refs
Avail: NTIS HC A11/MF A01

A survey is provided of digital processing techniques for the coding, transmission and remote reconstruction of imagery data. The coding techniques considered include PCM, DPCM, and its logical extension tree coding, as well as block transform techniques. Particular emphasis is given to the effects of channel errors on each of these techniques, as well as techniques for combatting these effects. Combined source channel coding approaches which have proven particularly effective in optimizing image reconstruction quality subject to a constraint on the overall transmission bandwidth are considered. Author

N83-11398# Rensselaer Polytechnic Inst., Troy, N. Y. Dept. of Electrical, Computer and Systems Engineering.
DIGITAL IMAGE PROCESSING WITH APPLICATIONS TO FEATURE EXTRACTION
J. W. MODESTINO (California Univ. at San Diego, La Jolla) *In* AGARD Image Process. Tech. 11 p (SEE N83-11390 02-31) May 1982 refs
Avail: NTIS HC A11/MF A01

Digital image processing techniques are surveyed in the context of an overall image processing system characterized by extensive use of feature extraction for subsequent object detection and/or classification. This overall system is described in some detail identifying functional processing blocks. This is followed by discussion of various approaches to implementing each of these functional processing blocks. Emphasis is placed upon stochastic modeling assumptions and subsequent development of model based processing algorithms. Author

N83-11399# Rensselaer Polytechnic Inst., Troy, N. Y. Dept. of Electrical, Computer and Systems Engineering.
OPTICAL INFORMATION PROCESSING
H. STARK *In* AGARD Image Processing Tech. 11 p (SEE N83-11390 02-31) May 1982 refs
Avail: NTIS HC A11/MF A01

An overview of optical information processing is presented. The emphasis is on coherent optical systems since they allow a broader range of image processing manipulations than incoherent ones. The Fourier transform property of a lens is discussed. How this property can be used in a linear system to filter images is shown. The Vander Lugt technique for constructing a complex spatial filter is reviewed and its application to image enhancement, pattern recognition, noise smoothing, phase object visualization and other problems is illustrated. Author

N83-11400# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Oberpfaffenhofen (West Germany). Inst. Fuer Optoelektronik.
IMAGE PROCESSING OF REMOTELY SENSED PHENOMENA
K. A. ULBRICHT *In* AGARD Image Process. Tech. 18 p (SEE N83-11390 02-31) May 1982 refs Original document contains color illustrations
Avail: NTIS HC A11/MF A01

A review of application possibilities of digital image processing of remotely sensed phenomena of the Earth is given. Several application examples processed on DIBIAS and representing different disciplines are discussed, showing possibilities of image processing. Among them are geologic, oceanographic, and cartographic examples, as well as applications in the field of atmospheric physics, correlation of SEASAT SAR to a LANDSAT scene, and an evaluation of a commercial compression algorithm. Author

N83-15504# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
PROBLEMS IN BEARINGS AND LUBRICATION
London Aug. 1982 459 p refs In ENGLISH and FRENCH Symp. held in Ottawa, 31 May - 3 Jun. 1982
(AGARD-CP-323; ISBN-92-835-0318-9) Avail: NTIS HC A20/MF A01

Performance prediction and performance limitation problems in bearing and lubrication technology, manifested in the life, durability, and design of engines and transmissions, are addressed. For individual titles, see N83-15505 through N83-15540.

N83-15505# Anderson (William J.), North Olmsted, Ohio.
BEARINGS: TECHNOLOGY AND NEEDS
W. J. ANDERSON *In* AGARD Probl. in Bearings and Lubrication 16 p (SEE N83-15504 06-31) Aug. 1982 refs Previously announced as N82-26679
Avail: NTIS HC A20/MF A01

A brief status report on bearing technology and present and near-term future problems that warrant research support is presented. For rolling element bearings a material with improved fracture toughness, life data in the low Lambda region, a comprehensive failure theory verified by life data and incorporated into dynamic analyses, and an improved corrosion resistant alloy are perceived as important needs. For hydrodynamic bearings better definition of cavitation boundaries and pressure distributions for squeeze film dampers, and geometry optimization for minimum power loss in turbulent film bearings are needed. For gas film bearings, foil bearing geometries that form more nearly optimum film shapes for maximum load capacity, and more effective surface protective coatings for high temperature operation are needed. Author

N83-15506# Defence Research Establishment Pacific, Victoria (British Columbia).
DETECTION AND DIAGNOSIS OF BEARING DETERIORATION IN AIRCRAFT PROPULSION SYSTEMS BY WEAR DEBRIS ANALYSIS
C. A. WAGGONER *In* AGARD Probl. in Bearings and Lubrication 13 p (SEE N83-15504 06-31) Aug. 1982 refs
Avail: NTIS HC A20/MF A01

Aspects of wear revealed by advanced analytical methods, and the manner in which these methods are being successfully applied to detect and diagnose bearing deterioration in aircraft propulsion machinery are reviewed. Author

N83-15507# Pratt and Whitney Aircraft, East Hartford, Conn. Commercial Products Div.
INCREASING THE WEAR LIFE OF GAS TURBINE ENGINE ROLLER BEARINGS
P. F. BROWN, L. J. DOBEK, M. J. CARRANO, R. A. VALORI (Naval Air Propulsion Center, Trenton), and R. D. DAYTON (AFWAL) *In* AGARD Probl. in Bearings and Lubrication 14 p (SEE N83-15504 06-31) Aug. 1982 refs
Avail: NTIS HC A20/MF A01

Life limiting roller end wear of the eccentric type, which ultimately results in cage failure, was demonstrated in high speed rig tests to levels of 3.0 MDN. Seventeen parameters having the potential for influencing the skew action of the roller and its end wear were selected for experimental evaluation on a series of 124 mm experimental roller bearings. The corresponding statistical test plan is described and the essentials of a mathematical model are covered that ultimately defines the motion of the roller and its interaction with other parts of the bearing. The test results showed roller corner radius runout as having the most influence on wear with roller length to diameter ratio and end clearance demonstrating modest effects. Author

N83-15508# Technische Hogeschool, Eindhoven (Netherlands). Dept. of Mechanical Engineering.
CONDITION MONITORING OF BEARINGS: A MEASURING TECHNIQUE IN AN EXPERIMENTAL STAGE
M. J. W. SCHOUTEN *In* AGARD Probl. in Bearings and Lubrication 9 p (SEE N83-15504 06-31) Aug. 1982 refs
Avail: NTIS HC A20/MF A01

Two bearing measurement techniques are described. Thermodynamic measurement and measurement with thin film transducers are presented briefly. Both were used under laboratory conditions. Author

N83-15509# Tribology Consultants, Inc., Paoli, Pa.
SILICON NITRIDE BEARING ELEMENTS FOR HIGH-SPEED HIGH-TEMPERATURE APPLICATIONS
L. B. SIBLEY *In* AGARD Probl. in Bearings and Lubrication 12 p (SEE N83-15504 06-31) Aug. 1982 refs Sponsored in part by Naval Air Systems Command, the Dept. of Army, Norton Co., Solar International and SKF Industries, Inc.
Avail: NTIS HC A20/MF A01

Progress to date in the use of silicon nitride ceramics for critical high-speed high-temperature ball and roller bearings is reviewed. The properties of silicon nitride are presented that make it an attractive bearing material compared to steel, such as high hardness, excellent high temperature performance and low density which reduces high speed bearing centrifugal loads and skidding. Design procedures are demonstrated for bearing applications using computer analysis codes to evaluate the cross-coupled effects of these material properties and bearing operating characteristics. Silicon nitride processing, inspection criteria and rolling-contact fatigue performance are reviewed. Successful test results are presented for an oil-lubricated hybrid silicon nitride bearing (silicon nitride balls with tool steel rings) in a 93,500 rpm turbine application. Solid lubricant development studies are reviewed, demonstrating low bearing wear at operating temperatures over 500 C. Therefore, it is expected that solid lubricated silicon nitride rolling bearings will find increasing application in future high-speed high-temperature aircraft systems. Author

N83-15510# SKF Engineering and Research Centre, Nieuwegein (Netherlands). Material Development Dept.
LIGHTWEIGHT MATERIALS FOR ROLLING ELEMENTS IN AIRCRAFT BEARINGS
R. T. CUNDILL and F. GIORDANO (RIV-SKF Industrie S.p.A.) *In* AGARD Probl. in Bearings and Lubrication 10 p (SEE N83-15504 06-31) Aug. 1982 refs
Avail: NTIS HC A20/MF A01

Using in-house experience with powder metallurgy, two approaches in the development of lightweight rolling elements were followed. Balls were made from both silicon nitride and proprietary composite material using process routes based on hot isostatic compaction. The composite material consisted of titanium carbide in a superalloy matrix and the finished balls had densities of 5.4 to 5.75 g/cc with hardness values above 1500 Hv. The performance of silicon nitide balls was compared with that of T1 tool steel balls in a test in which two mainshaft bearings were run at progressively increasing loads and speeds. Inspection after testing showed that there was much less distortion of raceway profiles in the bearing with silicon nitride balls indicating better kinematic behavior. As a consequence, the silicon nitride balls showed little change in physical form, whereas there was marked deterioration of the tool steel balls for the bearing design and test conditions considered. Author

N83-15511# Motoren- und Turbinen-Union Muenchen G.m.b.H. (West Germany).
THE OIL/AIR SYSTEM OF A MODERN FIGHTER AIRCRAFT ENGINE
J. SCHMIDT, W. K. HANK, A. KLEIN, and K. MAIER *In* AGARD Probl. in Bearings and Lubrication 19 p (SEE N83-15504 06-31) Aug. 1982 refs
Avail: NTIS HC A20/MF A01

The specification requirements of the oil/air system of modern fighter aircraft engine are defined and interpreted. Taking a three-spool engine as an example, the basic features of the design and functioning of the oil/air system are explained. The importance of the sealing air system and of its reliable computation is demonstrated. The advantages and disadvantages of interconnected and separated bearing chambers are pointed out. Attention is drawn to the vent system and to some special conditions of the turbine bearing chamber. Problems of highly loaded bearings are dealt with in some detail in view of a long bearing life, in particular the optimization of the oil supply and the bearing behavor in the event of an oil supply interruption. Finally, the reasons and consequences of a possible bearing chamber overheating are described as well as means to avoid such overheating. Author

N83-15512*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
LUBRICATION OF 35-MILLIMETER-BORE BALL BEARINGS OF SEVERAL DESIGNS AT SPEEDS TO 2.5 MILLION DN
H. R. SIGNER (Industrial Tectonics, Inc.) and F. T. SCHULLER *In* AGARD Probl. in Bearings and Lubrication 15 p (SEE N83-15504 06-31) Aug. 1982 refs
(Contract NAS3-19779)
Avail: NTIS HC A20/MF A01 CSCL 13I

Parametric tests were conducted with 35mm bore, angular contact ball bearings with either a single or double-outer-land-guided cage. The bearings were either lubricated by oil jets or employed inner ring lubrication. Outer ring cooling was added in selected tests. Test conditions were a radial load of 222 N (50 lb) and/or a thrust load of 667 N (150 lb), shaft speeds to 72,000 rpm, and an oil inlet temperature of 394 K (250 F). Lubricant flow to the bearing ranged rom 300 to 1900 cc/min (0.08 to 0.50 gal/min). All bearings were successfully run at speeds to 2.5 million DN. Increasing the lubricant flow decreased bearing ring temperatures but increased bearing power loss. The power loss and race temperatures of a jet lubricated bearing with double-outer-land-guided cage were always higher than those of the single-land-guided-design at similar test conditions. The lowest bearing operating temperatures were achieved when inner ring lubication and outer ring cooling were combined. Cage slip of a double-outer-land-guided cage was approximately twice that of a single-outer-land-guided cage. Author

N83-15513# Cranfield Inst. of Tech., Bedfordshire (England). School of Mechanical Engineering.

MITIGATION OF THERMAL HAZARDS IN ROLLING CONTACT BEARINGS THROUGH CORRELATED COMPUTER ANALYSIS

V. A. SCHWARZ and B. R. REASON *In* AGARD Probl. in Bearings and Lubrication 15 p (SEE N83-15504 06-31) Aug. 1982 refs Sponsored in part by Escola Federal de Engenharia de Itajuba and CAPES

Avail: NTIS HC A20/MF A01

Investigations on the development of a predictive computer program for establishing the likelihood of thermal hazards in rolling contract bearing assemblies are outlined. Based on extensive experimental investigations carried out on a multi-capability test rig, the necessary data was established, resulting in a program capable of predicting temperature distributions within bearing units operating under a wide variety of industrial conditions. Author

N83-15514*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

ELASTOHYDRODYNAMIC LUBRICATION OF ELLIPTICAL CONTACTS

B. J. HAMROCK *In* AGARD Probl. in Bearings and Lubrication 14 p (SEE N83-15504 06-31) Aug. 1982 refs Presented at the 1st Symp. INTERTRIBO, Stvbske Pleso Czechoslovakia, 27-29 Apr. 1981

Avail: NTIS HC A20/MF A01

Fully flooded, elastohydrodynamically lubricated, elliptical contacts are discussed. The relevant equations used in the elastohydrodynamic lubrication (EHL) of elliptical contacts are briefly described. Film thickness equations are developed for materials of high elastic modulus, such as metal, and for materials of low elastic modulus, such as rubber. In addition to the film thickness equations that are developed, plots of pressure and film thickness are presented. A theoretical study of the influence of lubricant starvation on film thickness and pressure in hard and soft elliptical elastohydrodynamic contacts is presented. From the results for both hard and soft EHL contacts a simple and important dimensionless inlet boundary distance is specified. It is also found that the film thickness for a starved condition can be written in dimensionless terms as a function of the inlet distance parameter and the film thickness for a fully flooded condition. contour plots of pressure and film thickness in and around the contact are shown for fully flooded and starved conditions. The theoretical findings are compared directly with results obtained experimentally. Author

N83-15515# Institut National des Sciences Appliquees de Lyon, Villeurbanne (France). Lab. de Mecanique des Contacts.

FILM THICKNESS AND FRICTION ON ENERGY IN THE ELASTOHYDRODYNAMIC REGIME IN THE CONTACT OF A BALL AND THE PATH OF A ROLLING DISK [EPAISSEUR DU FILM ET FORCE DE FROTTEMENT EN REGIME ELASTOHYDRODYNAMIQUE DANS LE CONTACT BILLE-CHEMIN DE BAGUE D'UN ROULEMENT]

G. DALMAZ and N. GADALLAH *In* AGARD Probl. in Bearings and Lubrication 12 p (SEE N83-15504 06-31) Aug. 1982 refs In FRENCH Sponsored in part by Direction des Recherches et Moyens d'Essais

Avail: NTIS HC A20/MF A01

The elastohydrodynamic lubrication of elliptic contacts, such as those between a ball and the path of a rolling ring with oblique contact, was studied on a high precision simulation device which permitted simultaneous measurement, at ambient temperature, of the normal load, the energy of tangential friction, the velocities, and the film thickness by an interferometric method. Results show that for a mineral oil, elastohydrodynamic theory can be extended to very high pressure (2 GPA) The effects of sliding velocity and of pivoting superposed on the rolling velocities have little effect on film thickness but considerably decrease the friction energy. Under these conditions, the film behaves as an amorphous solid. Friction energy was theoretically calculated in the elastohydrodynamic regime using the nonlinear isotherm model of Maxwell, Johnson, and Tevaarwerk. The Daniels model used to compute the heat conduction across the film thickness, and the Tevaarwerk model used to compute the covect convection in the case of pivoting are described Transl. by A R H

N83-15516# Leeds Univ. (England). Dept. of Mechanical Engineering.

THE LUBRICATION OF RIGID ELLIPSOIDS BY A PIEZO-VISCOUS FLUID

D. DOWSON, J. F. DUNN, and C. M. TAYLOR *In* AGARD Probl. in Bearings and Lubrication 5 p (SEE N83-15504 06-31) Aug. 1982 refs

Avail: NTIS HC A20/MF A01

The lubrication of non-conformal contacts such as those occurring between gear teeth and the rolling elements and raceways of rolling bearings is influenced by two major physical effects. These are the extent to which the lubricant viscosity is enhanced due to the pressures to which it is subjected and the degree of elastic distortion of the bounding surfaces. Tribologists have defined four forms of fluid film lubrication depending on the extent of these effects, namely; rigid (solids) - isovicous (lubricant); elastic-iso-viscous; elastic-piezo-viscous; and rigid-piezo-viscous The latter regime of lubrication has not previously been analyzed for point contacts with the same general set of conditions as have been applied to the other forms. Such an analysis has been undertaken here and the results are presented in a formula enabling the limiting minimum film thickness to be calculated directly. Author

N83-15517# Timken Co., Canton, Ohio.

REGIMES OF FLUID FLIM LUBRICATION AT THE RIB-ROLLER CONTACT IN A TAPERED ROLLER BEARING

C. L. SWINGLER *In* AGARD Probl. in Bearings and Lubrication 10 p (SEE N83-15504 06-31) Aug. 1982 refs

Avail: NTIS HC A20/MF A01

A recent analysis for determining the regime of lubrication in elliptical contacts is applied to the rib roller contact of axially loaded tapered roller bearings. The results indicate that the contact operates in either the isoviscous-rigid or isoviscous-elastic regimes depending on the conditions of load and speed. Although the corresponding calculated film thicknesses are an order of magnitude or more greater than those predicted by the traditionally adopted EHD theory, actual lubrication conditions may be marginal due to the effects of sliding and starvation at the rib. Author

N83-15518# State Univ. of Gent (Belgium). Lab. of Machines and Machine Construction.

THE INFLUENCE OF THE SHEAR THINNING EFFECTS OF NON-NEWTONIAN OILS ON THE PERFORMANCE OF FINITE LENGTH JOURNAL BEARINGS

M. VERMEULEN and H. S. YOO (INHA Univ., Incheon, Korea) *In* AGARD Probl. in Bearings and Lubrication 15 p (SEE N83-15504 06-31) Aug. 1982 refs

Avail: NTIS HC A20/MF A01

The behavior of nonNewtonian lubricants in journal bearing is very complex. Previous results for considering the shear thinning phenomena were negative for nonNewtonian lubricants, which was not in agreement with experiments. In this paper we analyze this behavior by assuming the same velocity profile for the nonNewtonian lubricants as the Newtonian one, splitting the viscosity into two parts nx and ny, which have relation with x and y directional velocity gradient respectively, and considering side leakage. The results are positive for the nonNewtonian lubricants, which agrees with experiments. The gains are 3 - 10% for most working ranges. Author

N83-15519# Institut National des Sciences Appliquees de Lyon, Villeurbanne (France). Lab de Mecanique des Contacts.

SLIDING IN THE WORKING OF A ROLLER BEARING: THE INFLUENCE OF THE LUBRICANT [GLISSEMENT DANS LES ROULEMENTS A ROULEAUX INFLUENCE DU LUBRIFIANT]

D. BERTHE and L. FLAMAND *In* AGARD Probl. in Bearings and Lubrication 9 p (SEE N83-15504 06-31) Aug. 1982 refs In FRENCH Sponsored in part by DRET

Avail: NTIS HC A20/MF A01

In rotations of cylindrical rollers, the condition of pure rolling of rolling bodies in relation to the track is only verified when the speeds of rotation are raised and when the loads transmitted are weak. This skidding condition must be limited because it can be the source of important heating and of premature wear. For this reason, the conditions for the mechanical equilibrium of the constitutive elements of a given roller are examined. The kinematics and particularly the speeds of sliding between the rolling bodies

and the paths are determined from the normal and tangential actions transmitted by the lubricating films. Consequently, the rheological behavior of the lubricant must be accounted for. Rheology models used for aeronautical lubricants are discussed. The different contacts encountered in the rollers studied are modeled and the total rolling equilibrium is illustrated. A.R.H.

N83-15520*# Missouri Univ., Rolla. Dept. of Mechanical and Aerospace Engineering.

A DETAILED TREATMENT OF TWO-DIMENSIONAL, STARVED LUBRICATION IN THE VICINITY OF TWO COUNTER-ROTATING CYLINDERS

R. A. MEDROW and L. R. SHIPERS *In* AGARD Probl. in Bearings and Lubrication 10 p (SEE N83-15504 06-31) Aug. 1982

(Contract NSG-3113)

Avail: NTIS HC A20/MF A01 CSCL 13I

The problem of starved lubrication in the inlet region for the case of line contact between two nondeforming, equal radii cylinders rotating in opposite directions with equal surface speeds is considered. The lubricant is assumed to be a constant density, isoviscous, Newtonian fluid. The usual approach, which involves the use of Reynolds equation everywhere, is not followed. Instead, the situation is restricted to one in which the lubricant enters the contact region in thin films which adhere to the cylinders. Using Reynolds equation only at the line of centers and a suitable thin film approximation far from that point, the intervening region is treated as a general creeping flow region. Solutions, incorporating complete free surface boundary conditions, are obtained numerically. The hitherto unobtained results due to this approach include the existence of a unique free surface location for a fixed set of operating conditions. Author

N83-15521# FAG Kugelfischer Georg Schaefer und Co., Schweinfurt (West Germany).

THE BEHAVIOR OF VARIOUS ROLLING BEARING MATERIALS UNDER UNFAVORABLE LUBRICATION CONDITIONS

H. K. LOROESCH, P. DRESCHMANN, and R. WEIGAND *In* AGARD Probl. in Bearings and Lubrication 9 p (SEE N83-15504 06-31) Aug. 1982 refs

Avail: NTIS HC A20/MF A01

Since the service life of rolling bearings is not only influenced by the material, but also very decisively by the lubrication, the behavior of various rolling bearing materials has been investigated in extensive field - like tests at elevated temperatures and under unfavorable lubrication conditions. These tests revealed that with increasingly unfavorable lubrication conditions the high temperature resistant rolling bearing materials S18-0-1 (AISI T1) and M50 were superior to the conventional rolling bearing material 100Cr6 (SAE 52 100). With pronounced starved lubrication that is caused by lubricating only with the oil vapor produced at a temperature of 215 C (488 K) and still reducing this oil vapor by exhaustion, the following results were found out: the bearings of high temperature resistant rolling bearing materials still reached lives of more than 3% of the rated L10 life, whereas bearings of 100Cr6 (SAE 52 100) steel could not be run any more under these conditions. Both high temperature resistant materials turned out to be comparable under these marked conditions of starved lubrication. The results reveal that rolling bearings of the high temperature resistant steels S18-0-1 (AISI T1) and M50 should not only be used at elevated operating temperatures, as it is the general rule, but also when it is important to obtain a higher operational reliability with starved lubrication conditions. L.F.M.

N83-15522*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio

GEOMETRY AND STARVATION EFFECTS IN HYDRODYNAMIC LUBRICATION

D. BREWE (AVRADCOM) and B. J. HAMROCK *In* AGARD Probl. in Bearings and Lubrication 12 p (SEE N83-15504 06-31) Aug. 1982 refs

Avail: NTIS HC A20/MF A01

Numerical methods were used to determine the effects of lubricant starvation on the minimum film thickness under conditions of a hydrodynamic point contact. Starvation was effected by varying the fluid inlet level. The Reynolds boundary conditions were applied at the cavitation boundary and zero pressure was stipulated at the meniscus or inlet boundary. A minimum film thickness equation as a function of both the ratio of dimensionless load to dimensionless speed and inlet supply level was determined. By comparing the film generated under the starved inlet condition with the film generated from the fully flooded inlet, an expression for the film reduction factor was obtained. Based on this factor a starvation threshold was defined as well as a critically starved inlet. The changes in the inlet pressure buildup due to changing the available lubricant supply are presented in the form of three dimensional isometric plots and also in the form of contour plots. Author

N83-15523*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

LUBRICANT EFFECTS ON EFFICIENCY OF A HELICOPTER TRANSMISSION

A. M. MITCHELL and J. J. COY (AVRADCOM) *In* AGARD Probl. in Bearings and Lubrication 14 p (SEE N83-15504 06-31) Aug. 1982 refs

Avail: NTIS HC A20/MF A01 CSCL 11H

Efficiency tests were conducted using eleven different lubricants in the NASA Lewis Research Center's 500 hp torque regenerative helicopter transmission test stand. The test transmission was the OH58A helicopter main transmission. The mechanical power input to the test transmission was 224 kW (300 hp) at 6060 rpm. Tests were run at oil-in temperatures of 355 K (180 F) and 372 K (210 F). The efficiency was calculated from a heat balance on the water running through an oil-to-water heat exchanger while the transmission was heavily insulated. The following results were obtained: (1) Among the eleven different lubricants, the efficiency ranged from 98.3 to 98.8 percent, which is a 50 percent variation relative to the losses associated with the maximum efficiency measured; (2) For a given lubricant, the efficiency increased as temperature increased and thus a viscosity decreased. There were two exceptions which could not be explained on the basis of available data; (3) Between lubricants, efficiency was not correlated with viscosity. There were relatively large variations in efficiency with the different lubricants whose viscosity generally fell in the 5 to 7 centistoke range; and (4) The lubricants had no significant effect on the vibration signature of the transmission. Author

N83-15524# Pisa Univ. (Italy). Dipartimento di Costruzioni Meccaniche e Nucleari.

THE DYNAMIC PERFORMANCE OF THE SELF-REGULATED HYDROSTATIC OPPOSED-PAD BEARING

R. BASSANI and B. PICCIGALLO (Accademia Navale) *In* AGARD Probl. in Bearings and Lubrication 12 p (SEE N83-15504 06-31) Aug. 1982 refs

Avail: NTIS HC A20/MF A01

The work deals with the behaviour, under dynamic loading, of a special hydrostatic opposed-pad bearing: the 'self-regulated' bearing (capable of dividing the lubricant flow into two equal partial flows in the two recesses as a consequence of its own shape). The bearing is studied in a constant pressure system. The effect of a hydraulic resistance in series with the bearing is also considered. Consequences which may arise from dimensional inaccuracies due to tolerances are also accounted for. Like the static performance, the dynamic performance of the self-regulated bearing is often better than that of conventional bearings; stiffness in particular is much greater. The influence of tolerances may not always be negligible. The design of a standardizing self-regulated bearing is also presented. Author

N83-15525# Poitiers Univ. (France). Lab. de Mecanique des Solides.

DYNAMIC BEHAVIOR OF A SMOOTH BEARING: STABILITY CRITERIA [COMPRTEMENT DYNAMICE D'UN PALIER LISSE CRITERES DE STABILITE]

J. FRENE, D. NICOLAS, and N. A. WAHED *In* AGARD Probl. in Bearings and Lubrication 10 p (SEE N83-15504 06-31) Aug. 1982 refs In FRENCH Prepared in cooperation with Institut National Sciences des Appliquees de Lyon, Villeurbanne

Avail: NTIS HC A20/MF A01

The dynamic behavior of a bearing depends not only on its geometry, but also on the operating conditions to which it is subjected. It is important to review the domain for which bearing operation is stable, i.e., define the stability criteria. In addition, in the dynamic regime, the response of the bearing must be obtained by calculating the trajector from the center of the shaft to the

interior of the pad. The study of the stability of the bearing is approached beginning with the dynamic coefficients calculated using linear theory. The conditions of stability of different types of bearings of fixed geometry are presented in the form of stability charts. The influence of the value of each of these coefficients on the stability of the bearing is examined using the Routh-Hurwitz criteria which shows that Lund's stability criteria leads to identical results while Smith's static stability criteria leads to erroneous results in certain cases. This last point is confirmed in a study of the transitory regime of one particular bearing. Transl. by A.R.H.

N83-15526# Cranfield Inst. of Tech., Bedfordshire (England). School of Mechanical Engineering.

THE COMPUTER AIDED DESIGN ENTITY (CADE): A NEW APPROACH TO JOURNAL BEARING DESIGN

A. H. SIEW and B. R. REASON *In* AGARD Probl. in Bearings and Lubrication 12 p (SEE N83-15504 06-31) Aug. 1982 refs Sponsored in part UK Sciences Research Council

Avail: NTIS HC A20/MF A01

The main features of a newly developed software suite bearing with the steady-state performance of solid and porous journal bearings are outlined. Variable bearing geometry, groove configuration, oil-supply pressure, matrix permeability (for the porous case) and journal misalignment are all within the capabilities of the suite. The suite developed is design-orientated and circumvents many of the existing bearing design problems. It is particularly suitable for: (1) Analysis and performance prediction of the journal bearings' behavior under conventional and newly established boundary conditions. (2) optimization of bearing performance by progressive modification through direct computer/user interaction whilst observing, in real-time, the effect both numerically and graphically on a direct visual display. Good agreement was ound between the results from the use of 'Computer Aided Design Entity' and the experimental findings from various sources. Author

N83-15527# *Middle East Technical Univ., Ankara (Turkey). Dept.* of Mechanical Engineering.

AN EXPERIMENTAL METHOD FOR THE DETERMINATION OF JOURNAL BEARING COEFFICIENTS

M. AKKOEK *In* AGARD Probl. in Bearings and Lubrication 12 p (SEE N83-15504 06-31) Aug. 1982 refs

Avail: NTIS HC A20/MF A01

It is now widely agreed that journal bearing characteristics can be represented by the linearized stiffness and damping coefficients for the purpose of rotor dynamic calculations. The concept of linearized coefficients can only be verified by successful comparison with experimenta data. Feasible methods of experimental determination of the coefficients from the dynamic response are discussed. It is attempted to present an experimental method which makes use of the dependence of the oil film impedances on the excitation frequency. The linearized bearing coefficients are determind with small numerical perturbations about the bearing equilibrium position. The responses to external excitations at synchronous and half-synchronous speeds are calculated. The advantage of low damping at half-synchronous speed makes it possible to get completely different response characteristics. The inverse problem of calculating the bearing coefficients from these responses is solved by assuming practical values of measurement errors in vibration amplitudes. The direct comparison of calculated coefficients and theoretical coefficients over a range of eccentricity ratios shows that this method is adequately accurate for the experimental determination of the coefficients. Author

N83-15528# Technical Univ of Denmark, Lyngby. Dept. of Machine Elements.

AN ANALYTICAL STUDY OF THE HEAT BALANCE FOR A JOURNAL BEARING

P. K. HANSEN (Det Norske Veritas) and J. W. LUND *In* AGARD Probl. in Bearings and Lubrication 9 p (SEE N83-15504 06-31) Aug. 1982 refs

Avail: NTIS HC A20/MF A01

The thermohydrodynamic lubrication problem for a journal bearing was studied. The heat balance for the bearing is emphasized. The flow is assumed to be laminar, the lubricant is Newtonian and incompressible. Allowance is made for the viscosity temperature dependence. The shaft surface temperature is taken to be constant, and at the outer surface of the hearing bush the temperature is determined from heat flux continuity. It is found that: (1) the viscosity temperature dependence has a pronounced influence on the temperature level; (2) heat conduction to the bearing sleeve and the shaft must be taken into account; (3) the temperature variation across the fluid film thickness is significant; (4) the mean temperature in the lubricant is well represented by the parabolic approximation; and (5) under normal operating conditions the axial temperature variation is negligible. E.A.K.

N83-15529# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Stuttgart (West Germany). Inst. fuer Technische Physik.

BEHAVIOR OF AIRCRAFT ENGINE OILS AT HIGH TEMPERATURE

E. JANTZEN *In* AGARD Probl. in Bearings and Lubrication 11 p (SEE N83-15504 06-31) Aug. 1982 refs

Avail: NTIS HC A20/MF A01

Higher temperatures in current and future aircraft engines which lead to a stronger thermal and oxydative attack of the engine oils were examined. The reversible and irreversible change of the engine oil is reported and the influence of hot surfaces on aircraft engine oils is shown. Different types of deposits, their properties, and the current knowledge about the influencing parameters are reported. Possibilities to avoid deposit formation are shown. E.A.K.

N83-15530*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

EXPERIMENTAL AND ANALYTICAL DETERMINATION OF GEAR TOOTH TEMPERATURES WITH OIL JET LUBRICATION

D. P. TOWNSEND and L. S. AKIN (Western Gear Corp.) *In* AGARD Probl. in Bearings and Lubrication 14 p (SEE N83-15504 06-31) Aug. 1982 refs Presented at the ASME 3rd Intern. Power Transmission and Gearing Conf., San Francisco, 18-22 Aug. 1980

Avail: NTIS HC A20/MF A01

Gear tooth average and instantaneous surface temperatures were measured with a fast response infrared radiometric microscope, while operating at arious speeds, loads and oil jet pressures. Increased oil jet pressure had a significant effect on both average and peak surface temperatures at all test conditions, increasing the speed at constant load and increasing the load at constant speed causes a significant rise in average and peak surface temperatures of gear teeth. A gear tooth temperature analysis was conducted by a finite element method combined with a calculated heat input and oil jet impingment depth with estimated heat transfer coefficients based on the experimental data. It is concluded that oil jet pressures required for adequate cooling at high load and speed conditions must be high enough to get full penetration depth of the teeth. E.A.K.

N83-15531# Franklin Research Center, Philadelphia, Pa.

AN ADVANCED METHOD FOR PREDICTING HYBRID BEARING PERFORMANCE

R. COLSHER, I. ANWAR, and S. KATSUMATA *In* AGARD Probl. in Bearings and Lubrication 12 p (SEE N83-15504 06-31) Aug. 1982 refs

Avail: NTIS HC A20/MF A01

At computerized technique was developed to predict performance for hydrodynamic, hydrostatic and hybrid bearings operating with an incompressible lubricant. The numerical technique utilizes the finite difference cell approach coupled with Gaussian elimination to solve the lubrication equation (Reynolds equation). The recess pressures are treated as boundary conditions and the lubrication equation is solved in terms of the recess pressures. The recess pressure is determined by coupling the recess flow conditions with the external lubrication supply system. E.A.K.

N83-15532# Universite de Technologie de Compiegne (France). Div. Electromecanique.
THEORETICAL AND EXPERIMENTAL STUDY OF AN AXIAL MAGNETIC BEARING OF THE ACTIVE TYPE [ETUDE THEORIQUE ET EXPERIMENTALE D'UN PALIER MAGNETIQUE AXIAL DU TYPE ACTIF]
M. KANT and R. KESSOU *In* AGARD Probl. in Bearings and Lubrication 6 p (SEE N83-15504 06-31) Aug. 1982 refs In FRENCH
Avail: NTIS HC A20/MF A01

The active axial magnetic bearing which serves vertical or horizontal supports is discussed. The bearing is used on the principles of ferrogravitaion. The originating electromagnetic force is proportionally inverted in the square distance, which separates the two parts; the bearing's dynamic functions for the constant electromagnetic force are unstable. To stabilize the bearing the present inductor has to be brought under control to a balanced deposition. The bearing is modelled by finite element method which allows calculation of the supporting forces, and to identify a chain of optimal control. E.A.K.

N83-15533# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). Dept. Chemin.
THE ACTIDYNE ACTIVE MAGNETIC BEARING [LE PALIER MAGNETIQUE ACTIF ACTIDYNE]
H. HABERMANN *In its* Probl. in Bearings and Lubrication 9 p (SEE N83-15504 06-31) Aug. 1982 refs In FRENCH
Avail: NTIS HC A20/MF A01

The active magnetic bearing which is based on the utilization of a force developed by a magnetic field, to maintain a rotor by magnetic lifting without mechanical contact between the fixed and the moving parts is discussed. It is necessary to have two electromagnets which only work by gravitation to control a degree of freedom. Controls obtained by application of tension makes fast separation unnecessary. E.A.K.

N83-15534# Sussex Univ., Brighton (England).
AN INVESTIGATION OF SQUEEZE-FILM DAMPERS IN FLEXIBLE SUPPORT STRUCTURES
R. HOLMES and M. DOGAN *In* AGARD Probl. in Bearings and Lubrication 9 p (SEE N83-15504 06-31) Aug. 1982 refs Sponsored in part by Rolls Royce
Avail: NTIS HC A20/MF A01

Rig investigations in which structural flexibility is included experimentally is discussed and measured and predicted vibration results are compared. Squeeze film dampers are a means of reducing vibration amplitudes in rotating shaft assemblies. Their efficiency depends very much on the condition of the oil, which in turn depends on inlet and outlet arrangements, on daper geometry and on the flexibility of the rotor and surrounding structure.
E.A.K.

N83-15535# CEMUL, Lisbon (Portugal).
SQUEEZE-FILM BEARING SUPPORT ANALYSIS
F. A. P. DASILVA *In* AGARD Probl. in Bearings and Lubrication 8 p (SEE N83-15504 06-31) Aug. 1982 refs Sponsored in part by UK Sciences Research Council
Avail: NTIS HC A20/MF A01

The effect of the nonuniformity on the performance of the squeeze film was investigated. Squeeze film bearings operate on high frequency vibration of one the bearing surfaces. The time averaged pressurization effect is mainly due to the compressibility of the gas film and this degree of pressurization depends on the amplitude and frequency of oscillation of the moving surface. If this supporting surface is sufficiently flexible, the amplitude of vibration is not uniform. The characteristics of the supporting member are demonstrated to be critical as they dictated the frequency of operation at low input power. Cases considered respect discs and conical shapes. For discs a particular parameter, the ratio between the inner and the outer edges, is analyzed.
E.A.K

N83-15536# Cranfield Inst. of Tech., Bedfordshire (England). School of Mechanical Engineering.
UNCENTRALIZED SQUEEZE-FILM DAMPER BEARINGS APPLIED TO AN OVERHUNG DISC/ROTOR SYSTEM
R. A. COOKSON and X. H. FENG (Chinese Aeronautical Establishment) *In* AGARD Probl. in Bearings and Lubrication 13 p (SEE N83-15504 06-31) Aug. 1982 refs Sponsored in part by UK Sciences and Engineering Research Council
Avail: NTIS HC A20/MF A01

A shaft disc system which is closer to a practical gas turbine is considered. This model includes a disc (turbine) supported noncentrally between two squeeze-film damper bearings, and an overhung disc. It is indicated that the forces transmitted into the support structure can be drastically reduced if a correct combination of damper parameters is chosen. Also, this investigation would appear to indicate that the design of squeeze film damper is almost always more efficient, and never less efficient, than the squirrel caged design. E.A.K.

N83-15537# Karlsruhe Univ. (West Germany). Inst. fuer Maschinenkonstruktionslehre.
AERODYNAMIC COMPLIANT BEARINGS FOR SMALL TURBO-ENGINES
M. EHINGER, J. GLIENICKE, and H. HUNGER *In* AGARD Probl. in Bearings and Lubrication 13 p (SEE N83-15504 06-31) Aug. 1982 refs Sponsored in part by Bundesministerium fuer Wirtschaft
Avail: NTIS HC A20/MF A01

Aerodynamic spring bearings, the elastic bearing bushing structure of which can stand thermal deformations without any inadmissably large changes in the bearing clearance were investigated. The spring bearings be suitable for the mounting of small turbo machines under extreme operating conditions. A method to determine the static and dynamic spring bearing characteristic curves was developed and applied to the tilting pad, 'Garrett' and multiwedged spring bearing. In the static and dynamic bearing characteristic curves determined in this way the parameters of the resilient bearing bushing structure are dominant over wide ranges. The applicability of these hearings to extreme circumferential speeds. The reliability of the calculated bearing characteristic values is shown. E.A.K.

N83-15538# Garrett Turbine Engine Co., Phoenix, Ariz.
HIGH-TEMPERATURE (649 DEG C/1200 DEG F) COATINGS FOR GAS-LUBRICATED FOIL BEARINGS OF THE NAVY'S ADVANCED AUXILIARY POWER UNIT CONCEPTS
F. J. SURIANO, R. J. KEISER, F. G. WOESSNER (Naval Air Propulsion Center, Trenton), and R. VALORI (Naval Air Propulsion Center, Trenton) *In* AGARD Probl. in Bearings and Lubrication 17 p (SEE N83-15504 06-31) Aug. 1982 refs
Avail: NTIS HC A20/MF A01

The materials development task and the identified coatings for high temperatures are described. In a high temperature foil bearing development effort a separate materials task was directed at identifying and developing coatings and coatings combinations for use in a turbine end journal foil bearing of an advanced design auxiliary power unit. The coatings are required to operate in thermal environments up to 649 C. E.A.K.

N83-15539# Middle East Technical Univ., Ankara (Turkey). Dept. of Mechanical Engineering.
EVALUATION OF ANTI STICK-SLIP BEHAVIOUR OF BRONZE FILLED PTFE AS BEARING MATERIAL
O. ANLAGAN *In* AGARD Probl. in Bearings and Lubrication 7 p (SEE N83-15504 06-31) Aug. 1982 refs
Avail: NTIS HC A20/MF A01

The performance of bronze filled PTFE at slow speeds was evaluated. The mechanism involved in wear which is primarily responsible for the loss of slow speed performance is explained. The behavior change is attributed to the mechanical changes that takes peace on sliding surface of plastic as wear progresses, which leads to change of friction velocity profile from positive to negative E.A.K.

N83-15540# Pisa Univ. (Italy). Ist. di Macchine.
APPLICATION OF DYNAMIC GAS BEARINGS TO CRYOGENIC COMPRESSORS AND TURBINES
G. NARDI *In* AGARD Probl. in Bearings and Lubrication 7 p (SEE N83-15504 06-31) Aug. 1982 refs
Avail: NTIS HC A20/MF A01

A design of dynamic gas bearing containing tilting pads, for cryogenic compressor and turbine applications, is discussed. The bearing system has no gas input during normal operation to prevent entirely the exchange of hot and cold gas. A pressure increase is generated in the wedge shaped gas film between the shaft and the pad. A portion of the gas stream flowing through the wedge is introduced through the pad into the gas between the pad and the pad housing. In this manner, the pressure in the gap is a factor of the pressure in the wedge. The pad is completely surrounded by a gas film. It adjusts itself automatically in accordance with the equilibrium of the forces. The angle of incidence of the pads is determined by the equilibrium of torques relative to the axis of rotation of the pad. It is shown that the gas bearing offer the advantage of improved reliability because no control system is necessary. E.A.K.

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COMMUNICATIONS

Includes land and global communications; communications theory; and optical communications.

N81-10259# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
PROPAGATION EFFECTS IN SPACE/EARTH PATHS
H. J. ALBRECHT, ed. Aug. 1980 509 p refs Presented at the Electromagnetic Wave Propagation Panel Symp., London, 12-16 May 1980
(AGARD-CP-284; ISBN-92-835-0269-8; AD-A090850) Avail: NTIS HC A22/MF A01

The effects of electromagnetic wave propagation on paths between locations on or near the Earth surface and a position in space are discussed. The topics included: general tropospheric effects; experimental data on SHF/EHF paths; remote sensing; general ionospheric dispersion effects; new data on ionospheric irregularities and propagation limitations in the systems. For individual titles, see N81-10260 through N81-10297.

N81-10260# Bradford Univ. (England). Dept. of Electrical Engineering.
CHARACTERISATION OF THE EFFECTS OF THE LOWER ATMOSPHERE
P. A. WATSON *In* AGARD Propagation Effects in Space/Earth Paths p 9 (SEE N81-10259 01-32) Aug. 1980 refs
Avail: NTIS HC A22/MF A01

The ability to predict the attenuation experienced on Earth space radio links for any satellite-Earth station configuration in terms of the percentage time given attenuation thresholds are exceeded on average, and in terms of statistics of fade duration is discussed. The on-average occurence of cross polarization and the relationship of this to the occurrence of attenuation is predicted along with the magnitude of incoherent emissions (thermal and forward scatter) causing an enhanced noise background on coherent radio systems. Characterization of off axis scattering from atmospheric structures, causing interference between systems and characterization of any other channel impairments, for example dispersion, which may place limits on broadband systems operation is discussed. R.K.G.

N81-10261# Kansas Univ. Center for Research, Inc., Lawrence. Remote Sensing Lab.
TROPOSPHERIC PROPAGATION EFFECTS ON EARTH-SPACE LOW ELEVATION ANGLE PATHS
R. K. MOORE *In* AGARD Propagation Effects in Space/Earth Paths 19 p (SEE N81-10259 01-32) Aug. 1980 refs
Avail: NTIS HC A22/MF A01

Extensions and reduction of horizon distance were determined for a satellite transmitter under climatologically realistic conditions for refraction in the troposphere. The increase in elevation (grazing) angle was determined under the same conditions. The computations were made, where possible, using parameters available climatologically on a global basis. The effects of normal variations in refractivity, of ducting, and of subrefraction were all considered. Likely limits were placed on the basis of climatology. Examples considered show possible variations in horizon distance from 22 km closer than for a vacuum under extreme conditions of subrefraction to 340 km beyond the free space horizon for an extreme duct condition. Horizon variations due to variations in surface refractivity with normal refraction amount to 109 km. Grazing angle variations between minimum and maximum surface refractivity amount to only about 5 mr, but in a duct they may become as great as 32 mr. R.K.G.

N81-10262# Essex Univ., Colchester (England).
A REVIEW OF THEORETICAL PREDICTION TECHNIQUES OF TRANSMISSION PARAMETERS FOR SLANT-PATH, EARTH-SPACE COMMUNICATIONS
B. G. EVANS and A. R. HOLT *In* AGARD Propagation Effects in Space/Earth Paths 17 p (SEE N81-10259 01-32) Aug. 1980 refs
Avail: NTIS HC A22/MF A01

A review of the methods needed to calculate transmission parameters such as attenuation and cross polarization due to a precipitation filled medium on an Earth-space path are given. A comparative view of the electromagnetic techniques associated with single particle scattering as applied to rain and ice are given. A model which is composed partly of ice and partly of rain is proposed and some results of its application are given. The importance of the ice/rain model in determining actual cross polarization on a satellite path are discussed. In addition, details of backscattering calculations which have been performed are presented. Some results of the extension of the theoretical techniques to millimeter waves are given. R.K.G.

N81-10263# Bradford Univ. (England).
PLANE WAVE SPECTRUM TREATMENT OF MICROWAVE SCATTERING BY HYDROMETEORS ON AN EARTH-SATELLITE LINK
D. P. HAWORTH *In* AGARD Propagation Effects in Space/Earth Paths 11 p (SEE N81-10259 01-32) Aug. 1980 refs
Avail: NTIS HC A22/MF A01

For satellites operating at frequencies above 10 GHz, the effects of propagation through atmospheric hydrometeors are of major import nce. In particular, the hydrometeors attenuate, cross polarize a id scatter signals causing respectively: a loss in signal level, a decrease in the efficiency of dual polarized channels and station to station interference. For large Earth station antennas operating at high frequencies, the near or Fresnel region of the antenna can extend several kilometers from the antenna and consequently, during disturbed weather, a significant proportion of the hydrometeors affecting propagation are in the near or Fresnel region of the antenna. Previous treatment of propagation through hydrometeors in the Fresnel region of an antenna has proved unsatisfactory and the plane wave spectrum technique was used to accurately characterize antenna scatterer interaction in both the near and far fields of an antenna. The Van de Hulst refractive formula for the coherent propagation and the basis of the radiative transfer equation for the incoherent scattering are derived.
R.K.G.

N81-10264# Shape Technical Center, The Hague (Netherlands).
THE FREQUENCY DEPENDANCE OF MICROWAVE PROPAGATION THROUGH RAINFALL
P. T. THOMPSON, A. W. DISSANAYAKE, and P. A. WATSON *In* AGARD Propagation Effects in Space/Earth Paths 9 p (SEE N81-10259 01-32) Aug. 1980 refs Prepared in cooperation with Bradford Univ., England
Avail: NTIS HC A22/MF A01

The prediction of rainfall induced attenuation and depolarization at various microwave frequencies is discussed. Experiments are conducted to evaluate such effects on both terrestrial and satellite paths. The sensitivity of the prediction of rainfall induced attenuation and depolarization to various meteorological parameters is discussed. Regression analysis of the resulting predicted propagation factors leads to a simple formulation of such effects.

For attenuation in particular the implications of scaling in frequency from one band to another are presented with respect to the use of such regression techniques. It is pointed out that such frequency scaling is not straight forward. S.F.

N81-10265# Lockheed Missiles and Space Co., Sunnyvale, Calif.
SIMULATION OF EHF PROPAGATION THROUGH THE ATMOSPHERE
J. D. HOPPONEN *In* AGARD Propagation Effects in Space/Earth Paths 11 p (SEE N81-10259 01-32) Aug. 1980 refs
Avail: NTIS HC A22/MF A01

The effect of the clear, nonturbulent air mass on the propagation of extremely high frequency radio waves at various slant path angles is examined. Molecular absorption spectra (principly of O2 and H2O) cause frequency dependent signal attenuation, phase delay, ray bending, and medium noise. The interaction between the physical environment and the traversing radiation is expressed by a complex refractivity Nc, which is a function of frequency f, total pressure p, partial water vapor pressure Pw, and temperature T. The Earth's magnetic field strength, which enters into Zeeman splitting of the absorption lines at high altitudes, is regarded as a nearly negligible background parameter. The means of calculating Nc utilizes a recent spectroscopic data base for the 60 GHz oxygen band and the 22.235 GHz water vapor line. In addition to the 183 GHz water vapor line, 6 higher frequency lines plus a nonresonant term are included. A distribution of the gas variables P, Pw, and T for the neutral air (surface to 80 km) leads to a profile of Nc which provides the basis for calculating the various propagation effects along a specified radio path (ground to ground, aircraft, or spacecraft. The distribution of atmospheric data may be obtained from in situ soundings (e.g., radiosonde) or from standard atmospheric models. The computer model assumes a symmetric, spherically stratified atmosphere in which the layers need not be regarded as homogeneous, as a consequence of the interpolation methods developed for Nc. Noise integrals are detailed. S.F.

N81-10266*# Applied Physics Lab., Johns Hopkins Univ., Laurel, Md.
RADAR ESTIMATION OF SLANT PATH RAIN ATTENUATION AT FREQUENCIES ABOVE 10 GHZ AND COMPARISONS WITH MEASURED MULTI-SEASON RESULTS
J. GOLDHIRSH *In* AGARD Propagation Effects in Space/Earth Paths 12 p (SEE N81-10259 01-32) Aug. 1980 refs
(Contract NASA ORDER S-40113-B)
Avail: NTIS HC A22/MF A01 CSCL 20N

Techniques and results pertaining to estimating Earth satellite path rain attenuation events and statistics using radar at nonattenuating wavelengths are presented. The radar formulation and beam scanning methods are described and the procedure for relating the radar measured Rayleigh reflectivity to the high frequency Mie attenuation coefficient are given. Examples of radar derived single terminal statistics and estimation criteria as they relate to path angle and frequency are reviewed. Radar derived space diversity statistics and their dependence on terminal spacing and frequency are described. Site diversity performance curves obtained by radar and radiometry are compared with each other demonstrating the utility of radar methods. Results of a multi-year experiment to test, refine, and establish accuracies of radar methods for arriving at estimates of rain attenuation along an Earth-satellite path are discussed. Comparisons of measured and radar estimated fade events are presented and found to be good. Comparisons of cumulative fade distributions show agreement to be excellent giving an rms deviation of 1 dB. S.F.

N81-10267# Science Research Council, Slough (England).
DUAL-POLARIZATION RADAR DATA FOR EVALUATION OF EARTH-SPACE RADIO LINK ATTENUATION
M. P. M. HALL, S. M. CHERRY, and J. W. F. GODDARD *In* AGARD Propagation Effects in Space/Earth Paths 10 p (SEE N81-10259 01-32) Aug. 1980 refs
Avail: NTIS HC A02/MF A01

Using conventional radar data to assess attenuation due to rain on Earth space paths requires the assumptions that the drops have a particular statistical distribution of sizes, and that the drops are of water. In the very localized regions of intense rain which influence such paths most severely, these assumptions can lead to large errors. Comparisons between direct measurements of attenuation and those computed using data from a dual-polarization radar technique are presented. This technique reduces the errors of radar-derived estimates of attenuation. It also gives a clear distinction between ice and water. By contrast, estimation of attenuation using raingauge data is of less value. S.F.

N81-10268# Science Research Council, Slough (England).
REVIEW OF SLANT PATH PROPAGATION MEASUREMENTS MADE AT THE APPLETON LABORATORY, SLOUGH, UNITED KINGDOM
P. G. DAVIES and E. C. MACKENZIE *In* AGARD Propagation Effects in Space/Earth Paths 22 p (SEE N81-10259 01-32) Aug. 1980 refs
Avail: NTIS HC A22/MF A01

An evaluation of the degradation of system performance due to atmospheric attenuation of radio communications is presented. The OTS and SIRIO satellites were used to characterize the properties of the transmission medium along space to Earth and Earth to space paths. Transmissions at frequencies above 10 GHz were considered. T.M.

N81-10269# Post Office Research Dept., Ipswich (England).
THE 20 AND 30 GHZ SLANT-PATH PROPAGATION MEASUREMENTS AT MARTLESHAM HEALTH, UNITED KINGDOM
J. THIRLWELL and R. G. HOWELL *In* AGARD Propagation Effects in Space/Earth Paths 9 p (SEE N81-10259 01-32) Aug. 1980 refs
Avail: NTIS HC A22/MF A01

A summary of some of the measurements carried out at the Post Office Research Center during 1975 to 1976 using the 20 and 30 GHz linearly polarized transmissions from the ATS 6 satellite is presented. The measurement of attenuation ratio between the two frequencies and depolarization measurements at 20 GHz are presented. Calibration of 20 and 30 GHz radiometers directed along the slant-path was carried out. The results of these measurements are compared with a theoretical model and the CCIR depolarization equation. Also the statistical data for depolarization and attenuation is presented. The need to present depolarization/attenuation data in the joint probability of occurrence form is emphasized. Due to nonattenuating ice depolarization effects, there is no simple relationship between depolarization and attenuation. The long term radiometer derived attenuation data is also presented and comments on scintillation at elevation angles from 30 deg down to the horizon are made. T.M.

N81-10270# Birmingham Univ. (England). Dept. of Electronic and Electrical Engineering.
A REVIEW OF SOME CROSS-POLARIZATION EFFECTS ON SLANT PATHS IN THE 11-30 GHZ FREQUENCY RANGE
T. PRATT *In* AGARD Propagation Effects in Space/Earth Paths 9 p (SEE N81-10259 01-32) Aug. 1980 refs Supported in part by Science Research Council
Avail: NTIS HC A22/MF A01

The results of experimental observations of fading and cross-polarization at 30 GHz on a slant path to central England are summarized. The wide variation in cross-polarization caused by ice particles in the propagation path which was observed at sites in the UK and USA were examined. Some results for propagation on slant paths at low elevation angles are presented showing reliable conditions at angles as low as 2 deg. Several events in which cross-polarization was caused by ice clouds are discussed, for a number of frequencies and sites, and one event showing cross-polarization in clear air is presented. The performance of typical analogue and digital satellite communication links using the 20 and 30 GHz bands was examined. Atmospheric cross-polarization does not seriously degrade the performance of the link, particularly at 30 GHz, when frequency reuse by orthogonal polarizations is employed. T.M.

N81-10271# Bell Telephone Labs., Inc., Holmdel, N. J.
ATTENUATION, DEPOLARIZATION AND DISPERSION BY ATMOSPHERIC HYDROMETERS ALONG A 19 AND 28 GHZ EARTH-SPACE RADIO PATH
D. C. COX, H. W. ARNOLD, H. H. HOFFMAN, and R. P. LECK *In* AGARD Propagation Effects in Space/Earth Paths 11 p (SEE N81-10259 01-32) Aug. 1980 refs
Avail: NTIS HC A22/MF A01

Quantitative relationships relating attenuation, depolarization, and dispersion measured at 19 and 28 GHz along an Earth-space path to a COMSTAR satellite are presented. Median rain and ice depolarization was minimized for linear polarizations oriented horizontally and vertically at the Earth terminals. Median depolarization was maximized for 45 deg linear polarization and circular polarizations. Maximum depolarization was at least 10 dB to 20 dB greater than the minimum. Phase and amplitude dispersion due to rain and other atmospheric processes was minimal and should not affect the performance of wide bandwidth satellite communication systems. T.M.

N81-10272# *Consiglio Nazionale delle Ricerche, Milan (Italy).* Centro di Studio per le Telecommunicazioni Spaziali.
RESULTS OF PROPAGATION EXPERIMENTS AT ITALIAN TERMINALS USING THE SIRIO SATELLITE
F. CARASSA, M. MAURI, and A. PARABONI *In* AGARD Propagation Effects in Space/Earth Paths 4 p (SEE N81-10259 01-32) Aug. 1980 refs
Avail: NTIS HC A22/MF A01

Attenuation data in two bands, acquired throughout two years of experiment, are presented and compared to each other. Preliminary data about fade duration and fade rate of variation are also presented. Deep fade occurred only during heavy rain events: as a consequence a significant year-to-year and site-to-site variability was observed because of the remarkable time and space non-uniformity of the climatology existing throughout Italy. T.M.

N81-10273# Centre National d'Etudes des Telecommunications, Issy-les-Moulineaux (France).
USING RADAR TO STUDY THE ATTENUATION AND DEPOLARIZATION OF SUPERHIGH FREQUENCIES OBSERVED OVER AN OBLIQUE COURSE [UTILISATION D'UN RADAR POUR ETUDIER L'ATTENUATION ET LA DEPOLARISATION DES HYPERFREQUENCES OBSERVEES SUR UN TRAJET OBLIQUE]
P. GOLE, J. P. MON, and P. RAMAT *In* AGARD Propagation Effects in Space/Earth Paths 10 p (SEE N81-10259 01-32) Aug. 1980 refs In FRENCH
Avail: NTIS HC A22/MF A01

Interest in using radar to study signal propagation is discussed with emphasis on attenuation and depolarization prediction, and the evaluation of signal reception at various locations. During a two month period, the reflectivity mode over the Paris area was measured with the aid of a Ronsard system radar and data obtained in the 11 GHz band with the aid of the OTS satellite. In determining the a and b parameters of the empirical relation A = Z sub b, it was possible to calibrate the radar by linking the attenuation (A) and the measured reflectivity (b). Further measurements are needed to establish a satisfactory correlation between the polarization and reflectivity uncoupling. Transl. by A.R.H.

N81-10274# Dutch Post Office, Dr. Neher Lab., Leidschendam. Transmission Div.
JOINT STATISTICS OF ATTENUATION AND CROSS-POLARIZATION MEASURED WITH THE OTS SATELLITE
J. VANCAPPELLEN, A. MAWIRA, and J. NEESSEN *In* AGARD Propagation Effects in Space/Earth Paths 10 p (SEE N81-10259 01-32) Aug. 1980 refs
Avail: NTIS HC A22/MF A01

Methods which can be applied to the calculation of the fading margin in satellite communication systems using orthogonally polarized radio channels are considered. A transmission model is introduced and it is discussed whether the joint statistics or the separate statistics of XPD and attenuation can be used for the determination of the fading margin. Propagation data are presented, which were collected with the experimental Earth station at Nederhorst den Berg by measurements on OTS beacons. The measured data are used for the evaluation of the methods, which are presented for the calculation of the fading margin. J.M.S.

N81-10275# Technische Hogeschool, Delft (Netherlands). Microwave Lab.
RAIN ATTENUATION PREDICTION AT THE NETHERLANDS OTS/SIRIO RECEIVING SITE USING INEXPENSIVE X-BAND RADAR
E. P. W. ATTEMA and H. J. M. HEEMSKERK (Dutch Post Office, Dr. Neher Lab., Leidschendam) *In* AGARD Propagation Effects in Space/Earth Paths 11 p (SEE N81-10259 01-32) Aug. 1980 refs
Avail: NTIS HC A22/MF A01

Along with OTS propagation experiments at The Netherlands experimental groundstation, radar reflectivity profiles along the slant path to the satellite were recorded at X-band using an inexpensive mass-produced ship's navigation radar transceiver, slightly modified to produce accurate reflectivity data at X-band. Based on the system parameters, the radar equation for distributed targets is derived, expressing the average reflected power in terms of a radar calibration factor, radar range and reflectivity. Using Laws and Parsons dropsize distribution the theoretical relation between reflectivity and attenuation at the radar frequency (9.4 GHz) and the satellite beacon frequency (11 GHz) were calculated. Following a discussion of some hardware aspects and the residual uncertainties in the attenuation estimates selected precipitation events are examined. Overall correlations are given between radar derived attenuation values and those actually measured. Finally radar derived attenuation statistics are compared to radiometer derived statistics and direct measured results using the OTS beacon. Author

N81-10276# Technische Hogeschool, Eindhoven (Netherlands). Dept. of Electrical Engineering.
OTS PROPAGATION MEASUREMENTS AT EINDHOVEN UNIVERSITY, NETHERLANDS
J. DIJK, C. N. F. HANSEN, and E. J. MAANDERS *In* AGARD Propagation Effects in Space/Earth Paths 14 p (SEE N81-10259 01-32) Aug. 1980 refs
Avail: NTIS HC A22/MF A01

Since the launch of O.T.S.-2 in May 1978 nearly permanent reception of the TM and B sub 0/B sub 1 beacon took place, with respect to attenuation on the path satellite-groundstation. A large amount of fades could be registered, the largest of about 15 dB lasting nearly 10 minutes. Daily variations of the TM beacon of 500 Hz and long time variations over a period from June 1978 to October 1979 of more than 5000 Hz have been recorded. The B sub 0 beacon showed very large frequency variations of 20 to 30 kHz per day and long time variations of about 130 kHz over the same period as the TM variations. Statistical material, inclusive cumulative distributions became available over the entire period of measurements. Author

N81-10277# Deutsche Bundespost, Darmstadt (West Germany). Research Inst.
THE 11-GHZ PROPAGATION MEASUREMENTS ON SATELLITE LINKS IN THE FEDERAL REPUBLIC OF GERMANY
F. DINTELMANN and F. W. RUECKER *In* AGARD Propagation Effects in Space/Earth Paths 9 p (SEE N81-10259 01-32) Aug 1980 refs
Avail: NTIS HC A22/MF A01

Research programs on wave propagation above 10 GHz along Earth-space paths found nearly ideal conditions for their research with the launch of the Italian SIRIO satellite in 1977, and the OTS 2 in 1978. Both, attenuation and depolarization measurements are carried out. Since the SIRIO satellite provides a coherent three-line spectrum in a 532 MHz band, the attenuation characteristic and differential phase effects can be studied. OTS, on the other hand, allows meaningful polarization measurements because its telemetry signal is transmitted in linear polarization and its other emissions in the band are circularly polarized. Hence, the performance of linear polarization can be judged against that of circular polarization on the same link. In addition to these measurements, point rainfall intensities are recorded at various locations in the vicinity of the ground station. L F M

N81-10278# Royal Norwegian Council for Scientific and Industrial Research, Kjeller. Environmental Surveillance Technology Programme.

TARGET ADAPTIVE RADAR, PROPAGATION MEDIUM ADAPTIVE COMMUNICATION SYSTEMS, PRESENT DAY METHODOLOGY AND FUTURE PERSPECTIVES. A REVIEW

D. T. GJESSING *In* AGARD Propagation Effects in Space/Earth Paths 21 p (SEE N81-10259 01-32) Aug. 1980 refs

Avail: NTIS HC A22/MF A01

With recent advances in radio science and growing interest in *environmental monitoring, remote sensing based on* electromagnetic waves became an important field of study. Using a radar system in which the illuminating frequency can be controlled by a computer system and likewise the receiving system can be matched to the backscattered signal, a system which adapts itself both to the transmission medium and to a target of special interest can be designed. From information theory it is well known that the more information one requires, the wider must the bandwidth of the communication channel be. In terms of radar terminology, the more information we require about the target, the more widebanded must the illuminating radar wave be. The radar wave must pass through the intervening propagation medium with a minimum of distortion, and at the same time, upon reflection by the object of interest give optimum information about this object.

L.F.M.

N81-10279*# Kansas Univ. Center for Research, Inc., Lawrence. Remote Sensing Lab.

USE OF A SATELLITE MULTI-FREQUENCY RADIOMETER TO DETERMINE ATTENUATION SUFFERED BY A SATELLITE RADAR

G. J. DOME, R. K. MOORE, I. J. BIRRER, and K. VANSICKLE *In* AGARD Propagation Effects in Space/Earth Paths 12 p (SEE N81-10259 01-32) Aug. 1980 refs Sponsored by NASA

Avail: NTIS HC A22/MF A01 CSCL 20N

The antenna temperature of the radiometer observing the sea without attenuation can be calculated, for vertical polarization and at Seasat Scanning Multifrequency Microwave Radiometer (SMMR's) 49 deg angle of incidence, if the surface temperature is known. Thus, an increase in the observed value above this value is an excess temperature caused by attenuation in the atmosphere. The amount of this excess temperature was determined for various model cloud and rain conditions, as was the attenuation. An empirical relation was determined between excess temperature at 37 GHz and 18 GHz, and the attenuation at 14.6 GHz. An algorithm was then developed to use the 37 GHz radiometer to establish small attenuations and the 18 GHz radiometer to establish moderate attenuations and large attenuations. This method was tested against some of the early Seasat observations, and was shown to be reasonably successful, within limitations posed by poor knowledge of the actual attenuation with which the results for the algorithm must be compared.

L.F.M.

N81-10280# Cologne Univ. (West Germany). Inst. fuer Geophysik und Meteorologie.

THE EFFECT OF TURBIDITY ON REMOTE SENSING OF OCEAN COLOR

G. METZIG and E. RASCHKE *In* AGARD Propagation Effects in Space/Earth Paths 6 p (SEE N81-10259 01-32) Aug. 1980 refs

Avail: NTIS HC A22/MF A01

Accurate correction for the atmospheric effects on the backscattered radiation of multispectral satellite measurements is described. A one dimensional radiative transfer model for the atmosphere-ocean system is presented. T.M.

N81-10281# National Oceanic and Atmospheric Administration, Boulder, Colo. Space Environment Lab.

RADIO BEACON STUDIES OF IONOSPHERIC IRREGULARITIES

K. DAVIES *In* AGARD Propagation Effects in Space/Earth Paths A01 (SEE N81-10259 01-32) Aug. 1980 refs Presented at the NATO/AGARD Symp., London, May 1980

Avail: NTIS HC A22/MF A01

Satellite observations of ionospheric irregularities with dimensions ranging from thousands of kilometers to around 100 meters are discussed. These observations were made using the ATS 6 synchronous satellite. European values for the total columnar electron content and the plasmaspheric columnar electron content are larger than those over the USA. Maps of electron content were used in making corrections for ionospheric refraction. Multifrequency observations of Fresnel type fading by intense irregularities were used to determine some properties of the irregularities. T.M.

N81-10282# University Coll. of Wales, Aberystwyth. Dept of Physics.

AN EMPIRICAL MODEL OF IONOSPHERIC SLAB THICKNESS

L. KERSLEY *In* AGARD Propagation Effects in Space/Earth Paths 8p (SEE N81-10259 01-32) Aug. 1980 refs

(Contract AF-AFOSR-2267-72)

Avail: NTIS HC A22/MF A01

An empirical model of slab thickness was developed. The model is combined with foF2 to estimate total electron content and hence *group delay for prevailing conditions in timing and positioning* systems. T.M.

N81-10283# Nebraska Univ., Lincoln. Dept. of Electrical Engineering.

ANISOTROPIC MEDIUM EFFECTS ON THE PROPAGATION OF 1.5 GHZ SIGNALS CODED BY PHASE REVERSALS: FULL-WAVE SOLUTIONS

E. BAHAR and B. S. AGRAWAL *In* AGARD Propagation Effects in Space/Earth Paths 10p (SEE N81-10259 01-32) Aug. 1980 refs Submitted for publication Sponsored in part by NSF and ARO

Avail: NTIS HC A22/MF A01

The distortion and depolarization of 1.5 GHz transient signals that propagate through an inhomogeneous anisotropic model of the ionosphere were investigated using a full wave approach. In addition to determining the signal delays and the phase shifts of the transmitted signals, features that distinguish between the depolarized and nondepolarized signals were also identified.

T.M.

N81-10284# Universite Catholique de Louvain (Belgium). Lab. de Telecommunications et dHyperfrequences.

THE 1979-1980 DATA PROCESSING AND RESULTS FROM THE OTS BEACONS B0/B1 AND TM, AND RADIOMETRY AT 11.4 AND 35 GHZ

A. VANDERVORST and P. SOBIESKI *In* AGARD Propagation Effects in Space/Earth Paths 14p (SEE N81-10259 01-32) Aug. 1980 refs

Avail: NTIS HC A22/MF A01

Measurements on the beacons of the OTS satellite are presented. Measurements by a dually polarized radiometer at 12 GHz and by a radiometer at 35 GHz are also presented. These measurements yielded the simultaneous recording of the copolar and the crosspolar components of the beacon, two sky temperatures at 12 GHz in orthogonal linear polarization as well as the differential sky temperature at the same frequency, and the sky temperature at 35 GHz. Data processing was improved to compensate for regular variations of the clear sky level of the copolar signal, the crosspolar discrimination and its phase. T.M.

N81-10285# General Electric Co., Syracuse, N.Y.

IONOSPHERIC DISPERSION EFFECTS ON WIDEBAND TRANSMISSIONS

G. H. MILLMAN and K. A. OLSEN *In* AGARD Propagation Effects in Space/Earth Paths 12p (SEE N81-10259 01-32) Aug. 1980 refs

Avail: NTIS HC A22/MF A01

An evaluation was made of the effects of the dispersive characteristics of the ionosphere on a frequency-modulated and an unmodulated, no frequency modulation, Gaussian shaped pulse. The distortion of the signal amplitude, envelope, pulse length, modulation and phase caused by the ionosphere was examined.

T.M.

N81-10286# Lancaster Univ. (England). Dept. of Environmental Sciences.
ELECTRON CONTENT MEASUREMENTS AT LANCASTER: HARMONIC ANALYSIS OF ATS-6 MEASUREMENTS
E. M. POULTER and J. K. HARGREAVES *In* AGARD Propagation Effects in Space/Earth Paths 14p (SEE N81-10259 01-32) Aug. 1980 refs
Avail: NTIS HC A22/MF A01

The radio beacon experiment carried on the ATS 6 satellite allowed the measurement of the signal group delay and hence the electron content along the ray path. The more usual electron content measurement, the Faraday rotation angle, could also be obtained independently. Since this latter quantity represents the electron content weighted by the geomagnetic field, it provides an additional parameter relating to the shape of the electron density profile. Alternatively it may be used to separate the total electron content into ionospheric and protonospheric components during periods of geomagnetic quiet. Additional information on the ionospheric layer shape was obtained from concurrent ionosonde data. These data cover a range of seasonal variations and changing conditions of geomagnetic activity. For consideration of the gross features, the data were reduced to 30 minute mean values, comprising the electron content, shape factor, and slant slab thickness. An adequate empirical description of these parameters is supplied by harmonic analysis. L.F.M.

N81-10287# SRI International Corp., Menlo Park, Calif.
TRANSIONOSPHERIC RADIOWAVE PROPAGATION AND SIGNAL STATISTICS Final Report
C. L. RINO *In* AGARD Propagation Effects in Space/Earth Paths 23p (SEE N81-10259 01-32) Aug. 1980 refs
Avail: NTIS HC A22/MF A01

With the advent of satellites such as NTSS/TRANSIT, ATS 6, and WIDEBAND that carry multifrequency phasecoherent beacons, a large body of phase-scintillation data obtained. These data made important contributions to our overall understanding of scintillation phenomena. Theoretical results that characterize intense scintillation in power-law environments also recently emerged. A unified review of these developments is presented. These together with refinements in morphological models and a rapidly improving comprehension of the instability mechanisms that cause the irregularities, should improve our ability to predict or mitigate the deleterious effects of radiowave scintillation. L.F.M.

N81-10288# Max-Planck-Institut fuer Aeronomie, Katlenburg-Lindau (West Germany).
RECENT ASPECTS OF IONOSPHERIC SCINTILLATION OBSERVATIONS
G. K. HARTMANN *In* AGARD Propagation Effects in Space/Earth Paths 12p (SEE N81-10259 01-32) Aug. 1980 refs
Avail: NTIS HC A22/MF A01

Scintillation occurrence and scintillation intensity depend upon frequency, location, propagation path geometry, geophysical conditions, receiving equipment characteristics, - such like the receiving antenna beamwidth, the receiver resolution and stability, and the data acquisition facilities - and the measure used to describe scintillation. This causes many problems by comparing data from different sources. After fifty years of ionosphere research and more than twenty years of intensive scintillation measurements future experimental trends might be as much determined by some already visible limitations as by the application of the very recent advanced technologies. Both aspects are mentioned here. There are two principally different methods to investigate the scintillation producing irregularities in the ionosphere: 1. In situ measurements, 2. Remote sensing methods. It is shown that three different experimental possibilities to improve our knowledge about the scintillation producing irregularities in the ionosphere. The first one, possibly the most important at present is based upon a new experimental technique (VIGODOS) which possibly will allow a better, faster and easier understandable and more efficient combination of preedited data that stem from radar experiments, satellite radio beacon experiments, aurora and airglow measurements, as well as from in situ experiments. L.F.M.

N81-10289# Illinois Univ., Urbana-Champaign. Dept. of Electrical Engineering.
STATISTICAL PROPERTIES OF TRANSIONOSPHERICALLY PROPAGATED RADIO SIGNALS UNDER THE INTENSE SCINTILLATION CONDITIONS
K. C. YEH and C. H. LIU *In* AGARD Propagation Effects in Space/Earth Paths 11p (SEE N81-10259 01-32) Aug. 1980 refs
(Contract NSF ATM-77-22485)
Avail: NTIS HC A22/MF A01

The simplest indicator of scintillation activities is the value of scintillation index. There are several scintillation indexes commonly in use, but they are all derived from the amplitude data and they are all related. For precise work the index, which is defined as the fractional mean square deviation of the received power from the mean power, is recommended. This index was found to be rather sensitive to radio frequencies in the weak scatter regime, but increasingly insensitive to radio frequencies in the multiple scatter regime. Such a behavior is also predicted theoretically and has been ascribed to the saturation effects. As for phase, the results are not so consistent possibly because of its sensitivity to the data processing technique. In terms of quadrature components it was found that most of the power resides in the phase-quadrature component in the weak scatter limit, but gradually becomes equalized among the two components as the scintillation index increases. Other considerations such as the power spectrum and the correlation interval of the amplitude, phase and quadrature components were also investigated and reviewed. L.F.M.

N81-10290# Air Force Geophysics Lab., Hanscom AFB, Mass.
RECENT OBSERVATIONS OF EQUATORIAL AND HIGH LATITUDE SCINTILLATIONS
J. AARONS and H. E. WHITNEY *In* AGARD Propagation Effects in Space/Earth Paths 17 p (SEE N81-10259 01-32) Aug. 1980 refs
Avail: NTIS HC A22/MF A01

At equatorial latitudes, combined airborne and ground measurements of radar backscatter, electron density profiles, scintillations, airglow at 6300 A, and total electron content yielded data on the development and decay of the irregularity patches containing the hundred meter irregularities responsible for amplitude and phase scintillation. The use of airglow measurements from aircraft allowed the form of the patch to be deduced. At auroral latitudes, sheets of irregularities were observed at Poker Flat, Alaska and at Goose Bay, Labrador using phase fluctuations of the WIDEBAND signals. WIDEBAND phase and amplitude deviations when correlated with DMSP photographs show intense activity over diffuse and discrete aurora. The increase of intensity of scintillation activity at equatorial and polar latitudes was noted during 1979 and 1980 when very high solar flux levels were recorded. These increases take place even under quiet magnetic conditions when solar flux is high and take place during the increased number of magnetic storms. L.F.M.

N81-10291# Communications Satellite Corp., Clarksburg, Md.
THE 4/6-GHZ IONOSPHERIC SCINTILLATION MEASUREMENTS
D. J. FANG *In* AGARD Propagation Effects in Space/Earth Paths 12 p (SEE N81-10259 01-32) Aug. 1980 refs
Avail: NTIS HC A22/MF A01

Most of the data presented were collected at the Taipei Earth Station from June 1976 to June 1977, the first year of sunspot cycle 21, during which the low solar activity level began to increase. Annual and worst month cumulative statistics for ionospheric scintillations were provided for use in system studies and planning. The worst month statistics varied considerably, depending on the definition of worst month; therefore, a formal definition for engineering applications was warranted. Power spectral density analyses confirmed an f to the minus 3rd power dependence, indicating that the conventional weak scattering theory for a thick screen with a power law electron density fluctuation spectrum of p 4 would be adequate to explain the weak gigahertz ionospheric scintillation events observed at Taipei. L.F.M.

N81-10292# Air Force Wright Aeronautical Labs., Wright-Patterson AFB, Ohio.
PROPAGATION ANOMALIES AFFECTING AIRBORNE SATELLITE COMMUNICATIONS
A. L. JOHNSON *In* AGARD Propagation Effects in Space/Earth Paths 12 p (SEE N81-10259 01-32) Aug. 1980 refs
Avail: NTIS HC A22/MF A01

Airborne satellite communication and navigation systems can be disrupted by propagation anomalies. Ionospheric scintillation fading and earth multipath fading can cause 15 to 30 db amplitude fading and over 1000 deg per second phase variations which can reduce message intelligibility and navigation accuracy. The ionospheric scintillation effects are particularly severe in the polar and equatorial regions. The multipath effects are worse over water at low elevation angles to the satellite. Diversity techniques can be used to mitigate the disruptive effects of both the ionospheric scintillation and earth multipath. While frequency, space and time diversity all improve the signal performance against Earth multipath fading, only time diversity offers a significant improvement against ionospheric scintillation fading in an airborne environment.
Author

N81-10293# Naval Research Lab., Washington, D. C.
ENVIRONMENTAL CONSTRAINTS IN EARTH-SPACE PROPAGATION. A REVIEW PAPER
J. M. GOODMAN *In* AGARD Propagation Effects in Space/Earth Paths 27 p (SEE N81-10259 01-32) Aug. 1980 refs
Avail: NTIS HC A22/MF A01

The general utilization of space to introduce the importance of Earth space radio propagation with special emphasis directed toward DoD mission areas are reviewed. An outline of the basic properties of Earth-space RF propagation follows and an assessment of the major effects is given. R.K.G

N81-10294# Air Force Geophysics Lab., Hanscom AFB, Mass.
A PRELIMINARY EVALUATION OF THE TWO-FREQUENCY IONOSPHERIC CORRECTION FOR THE NAVSTAR-GLOBAL POSITIONING SYSTEM
J. A. KLOBUCHAR, H. SOICHER (Army Communications Research and Development Command, Fort Monmouth, N.J.), and J. A. PEARSON (Aerospace Corp., Los Angeles) *In* AGARD Propagation Effects in Space/Earth Paths 10 p (SEE N81-10259 01-32) Aug. 1980 refs
Avail: NTIS HC A22/MF A01

The Navstar Global Positioning System (GPS) is an advanced worldwide navigation system with a design accuracy of 16 meters spherical error probability for 50 percentile in 3 dimensions. The largest potential error source in the navigation system is due to the group path retardation of the Earth's ionosphere which can produce range delays of up to 100 meters on a worst case basis. Analytic models can be utilized to reduce the ionospheric error contribution, but the use of a state of the art ionospheric time delay model is expected to reduce the ionospheric range error by not more than 75 percent, still leaving worst case delays of approximately 25 meters, well above the system design specifications. The ionosphere is a dispersive medium with the amount of the ionospheric time delay proportional to the inverse square of the operating frequency. A second modulated frequency, called L2, was incorporated on the GPS signal structure to allow the system user's receiver to automatically correct for the ionospheric time delay. The initial tests of the correction capability of this dual frequency signal structure was provided by a GPS modulator which was orbited on the NTS 2 satellite in late 1977. The effects of multipath at lower elevation angles are clearly seen as increased system noise, though multipath did not affect the two frequency ionospheric correction capability. R.K.G.

N81-10295# Directorate of Radio Technology, London (England).
THE INTERACTIONS OF A SOLAR POWER SATELLITE TRANSMISSION WITH THE IONOSPHERE AND TROPOSPHERE
K. A. HUGHES *In* AGARD Propagation Effects in Space/Earth Paths 7 p (SEE N81-10259 01-32) Aug. 1980 refs
Avail: NTIS HC A22/MF A01

In a system of solar power satellites, (SPS), solar energy is collected by a large array of solar cells in geostationary orbit, converted to rf power at microwave frequencies and beamed to Earth for conversion into dc. The propagation of the high power microwave beam through the Earth's atmosphere initiates interactions in the ionosphere and troposphere that have disruptive effects on existing radio services. In addition, the transmission of the SPS beam is also affected. Radio interference on the SPS frequency occurs from scattering of the beam in both the ionosphere and troposphere; more serious broad-band interference may arise from ionospheric modification, resulting from intense ohmic heating. The problems associated with these interactions are discussed and the effects on existing radio services are quantified. S.F.

N81-10296# AEG-Telefunken, Bonn (West Germany).
ON MICROWAVE POWER TRANSMISSION AND THE FEASIBILITY OF POWER SATELLITES FOR EUROPE
D. KOEHN *In* AGARD Propagation Effects in Space/Earth Paths 6 p (SEE N81-10259 01-32) Aug. 1980 refs
Avail: NTIS HC A22/MF A01

Considerations of giant power plants in remote areas (because of the environmental contamination) or in space suggest or even force a noncable bound transmission of power, e.g., by a collimated microwave beam. However, the propagation of microwaves is affected by tropospheric and ionospheric effects (attenuation, diffraction, reflection, decollimation, depolarization) which degrade the power transmission efficiency. Power satellite concepts are discussed and the principles of the proposed microwave power transmission system are explained. The main interfering atmospheric effects are explained and an appraisal of their influence on the transmission path and the overall power transmission system is given. Some of those effects show a latitudinal dependence, and conclusions on the feasibility of power satellite systems for Europe are derived. S.F.

N81-10297# Institute for Telecommunication Sciences, Boulder, Colo.
POTENTIAL IMPACT OF THE SATELLITE POWER SYSTEM ON COMMUNICATION AND ELECTRONIC SYSTEMS AND THE IONOSPHERE
W. B. GRANT, C. M. RUSH, and E. L. MORRISON *In* AGARD Propagation Effects in Space/Earth Paths 19 p (SEE N81-10259 01-32) Aug. 1980 refs
Avail: NTIS HC A22/MF A01

The impact of the operation of the satellite power system upon the ionosphere and telecommunication systems is described. Analysis of possible functional and operational degradation of electromagnetic systems (communication systems, radars, navigation aids, satellites) and environment sensitive instruments and systems (computers, sensors, electronic medical instruments and security devices) due to direct SPS power coupling are studied in detail. Development of mitigating techniques when unacceptable degradation is discovered in a given equipment or system is described. Assessment of possible impacts upon telecommunication systems and implications for electromagnetic compatibility are discussed. The degree to which the ionosphere will be modified by the passage of the microwave power beam and what impact this modification has upon telecommunication systems are discussed. Theoretical efforts to simulate SPS operational impacts are described. S.F.

N81-16380# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
REQUIREMENTS, DESIGN AND DEVELOPMENT OF LARGE SPACE ANTENNA STRUCTURES
May 1980 48 p refs Presented at the 49th Struct. and Mater. Panel Meeting, Porz-Wahn, West Germany, 7-12 Oct. 1979
(AGARD-R-676; ISBN-92-835-1358-4; AD-A086709) Avail: NTIS HC A03/MF A01

The structural and materials requirements for space antennas are reviewed. The constraints imposed by the particular application and the space environment are addressed. In addition, structural design problems of large space structures and space telescopes are considered. For individual titles, see N81-16381 through N81-16383.

N81-16381# Communications Research Centre, Ottawa (Ontario). Dept. of Communications.
STRUCTURAL REQUIREMENTS AND CONSTRAINTS OF HIGH GAIN SATELLITE ANTENNAS FOR 30/20 GHZ COMMUNICATIONS
S. AHMED *In* AGARD Requirements, Design and Develop. of Large Space Antenna Struct. 9 p (SEE N81-16380 07-32) May 1980 refs
Avail: NTIS HC A03/MF A01

The types of satellite antennas, the mission constraints and environments for which they must be designed and the demands placed on the materials and structures of a reflector antenna to satisfy mission requirements are briefly outlined. The advantages and disadvantages of lens and phased array antennas are covered. The dimensional accuracy requirement of reflector antennas for 30/20 GHz communications is extremely stringent. The factors that contribute to dimensional inaccuracies are the structural design process, the physical properties of the constituent materials and the fabrication process that is utilized. Other antenna structural requirements include: low mass, to obtain the most payload in orbit; high strength, to withstand both launch loads and ground handling; and high stiffness, to withstand launch loads and to minimize interactions with the satellite control system. The antenna design must be capable of being verified in the 1 g environment on the ground. It must be capable of maintaining its designed geometric configuration in the space thermal environment. To meet this last requirement, an important design factor is the choice of materials which have low coefficients of thermal expansion and high thermal conductivity. Additional thermal protection is obtained from multilayer insulation blankets made of metallized plastic. Suggestions for structures and materials development are given. M.G.

N81-16382*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
NASA TECHNOLOGY FOR LARGE SPACE ANTENNAS
R. A. RUSSELL, T. G. CAMPBELL, and R. E. FREELAND (JPL) *In* AGARD Requirements, Design and Develop. of Large Space Antenna Struct. 2 p (SEE N81-16380 07-32) May 1980 refs
Avail: NTIS HC A03/MF A01 CSCL 09C

Some leading concepts for deployable antennas are described and an assessment of the state of the art in deployable antennas is presented. The advanced sunflower precision antenna, the radial rib antenna and the maypole (hoop/column) antenna, the wrap rib antenna and the parabolic erectable truss antenna are covered. In addition, a discussion on the technology development program for two deployable antenna concepts that are responsive to the antenna mission requirements as defined in the NASA mission model is presented. M.G.

N81-16383# British Aerospace Dynamics Group, Stevenage (England).
TYPICAL EXAMPLES OF EUROPEAN TECHNOLOGY FOR HIGH STABILITY SPACE STRUCTURES
J. F. CLEMMET *In* AGARD Requirements, Design and Develop. of Large Space Antenna Struct. 10 p (SEE N81-16380 07-32) May 1980
Avail: NTIS HC A03/MF A01

Two contrasting, primary areas of application of highly underformable space structures are identified to illustrate the state of the art in the European space industry. The technologies associated with the structures of high gain antennas and space telescopes are illustrated by selected examples. The philosophies adopted in translating the electrical or optical requirements initially into mechanical and thermal designs, and subsequently into hardware, are presented. Attention is given to deformations induced by launch and on station environments, to methods of controlling local environments and to demands from terrestrial assembly and integration. In addition to existing designs and hardware, current trends and developments are identified. Author

N81-31449# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
AURAL COMMUNICATION IN AVIATION
K. E. MONEY, ed. Jun. 1981 184 p refs Presented at the Aerospace Med. Panel Specialist Meeting, Soesterberg, Netherlands, 30 Mar. - 2 Apr. 1981
(AGARD-CP-311; ISBN-92-835-1388-6; AD-A103395) Avail: NTIS HC A09/MF A01

In modern military aircraft, it is essential that aircrew should be able to perceive and respond to audio information with minimum effort and highest reliability. However, the low quality of most airborne voice communications systems imposes such a high additional workload that messages are liable to misinterpretation or to being missed altogether. Reliable voice communication and the effective use of audio warnings are discussed. Hearing standards and conservation techniques are reported.

N81-31450# Aerospace Medical Research Labs., Wright-Patterson AFB, Ohio.
VOICE COMMUNICATION RESEARCH AND EVALUATION SYSTEM
R. L. MCKINLEY *In* AGARD Aural Commun. in Aviation 7 p (SEE N81-31449 22-32) Jun. 1981 refs
Avail: NTIS HC A09/MF A01

The basic system is comprised of a multistation voice communication network consisting of the USAF standard aircraft intercommunication system, a standard A-19 diluter demand oxygen regulation system and an on line computer data collection and data analysis system that displays results in real time. The system is housed in a large reverberation chamber containing a programmable sound source capable of reproducing the spectrum and level of any AF operational noise environment. Standardized voice communication effectiveness test materials are used to assess the performance of any aspect of the total voice communication link, however, emphasis is usually placed upon the performance of the aircrew members. Examples of its application to voice communication problems are provided. T.M.

N81-31451# Aerospace Medical Research Labs., Wright-Patterson AFB, Ohio.
VOICE COMMUNICATIONS JAMMING RESEARCH
T. J. MOORE *In* AGARD Aural Commun. in Aviation 6 p (SEE N81-31449 22-32) Jun. 1981 refs
Avail: NTIS HC A09/MF A01

The effect of various types of jammers, J/S power ratios and background noise levels on voice communication materials processed by a standard Air Force voice communication system was evaluated. The measurement instruments employed were the Modified Rhyme Test (MRT) and a nonstandard voice communication performance task. Good agreement is found between the two measurement instruments in ranking the relative effectiveness of the jammers evaluated. The effect of training on naive subjects' ability to listen to voice communications under conditions of noise and jamming was studied. The results of this exploratory study indicate that training improved the performance of the listeners under all conditions tested. T.M.

N81-31452# Naval Aerospace Medical Research Lab., Pensacola, Fla.
PHONOLOGICAL VARIANTS IN MEDIAL STOP CONSONANTS UNDER SIMULATED OPERATIONAL ENVIRONMENTS: IMPLICATIONS FOR VOICE ACTIVATED CONTROLS IN AIRCRAFT
J. D. MOSKO, R. W. REMINGTON, and G. R. GRIFFIN *In* AGARD Aural Commun. in Aviation 4 p (SEE N81-31449 22-32) Jun. 1981 refs
Avail: NTIS HC A09/MF A01

A motion disorientation test was used to determine potential effects on voice characteristics. Speech samples from 14 subjects were obtained under a STATIC (control) and a DYNAMIC (experimental) condition. The 10 subjects completing both phases of the test did not exhibit significant changes in fundamental frequency, word token duration, or voice level. Four subjects who voluntarily curtailed the DYNAMIC mode exhibited significant changes in the same acoustic characteristics. The implications of these results for automatic speech recognition are discussed. DOE

N81-31453# Naval Aerospace Medical Research Lab., Pensacola, Fla.
CLEAR SPEECH: A STRATEGEM FOR IMPROVING RADIO COMMUNICATIONS AND AUTOMATIC SPEECH RECOGNITION IN NOISE
J. D. MOSKO *In* AGARD Aural Commun. in Aviation 6 p (SEE N81-31449 22-32) Jun. 1981 refs
Avail: NTIS HC A09/MF A01

The acoustic characteristics of conversational speech production and clear speech production were compared for three different talkers. Increases in fundamental frequency, word token duration, and voice level for the clear speech were obtained. These results are compared to the results of similar studies and implications for improved intelligibility of speech and automatic speech recognition are discussed. T.M.

N81-31454# Army Avionics Research and Development Activity, Fort Monmouth, N. J.
ELECTRONIC VOICE COMMUNICATIONS IMPROVEMENTS FOR ARMY AIRCRAFT
M. S. MAYER and A. W. LINDBURG *In* AGARD Aural Commun. in Aviation 12 p (SEE N81-31449 22-32) Jun. 1981 refs
Avail: NTIS HC A09/MF A01

A communications system for Army aircraft, and two specifications which contain the test procedures required to accurately test and evaluate the various components of the communication system are decribed. The components of the system include: high impedance dc powered noise cancelling microphones; earphone elements designed and tested to have flat frequency response when inside the circumaural earcup of the hearing protective device; and intercoms which replace positive peak clipping with fast acting AGC circuits and expander/compander circuits for maximum output signal without distortion, even under conditions of extreme stress. T.M.

N81-31455# Amsterdam Univ. (Netherlands).
THE EFFECT OF NOISE ON THE VESTIBULAR SYSTEM
W. J. OOSTERVELD, A. R. POLMAN (Royal Dutch Airlines, Schiphol), and J. SCHOONHEYT (Royal Dutch Airlines, Schiphol) *In* AGARD Aural Commun. in Aviation 5 p (SEE N81-31449 22-32) Jun. 1981 refs
Avail: NTIS HC A09/MF A01

The aim of the study was to find out if men with a noise induced hearing loss had detectable functional changes in the functioning of their vestibular system. The study was carried out in a group of 29 technicians who had worked in the rather noisy environment of the workshop for more than five years and all had a hearing loss on both ears of more than 40 dB on the tone audiogram at the frequency of 4000 Hz. The vestibular examinations showed that 18 of the 29 persons (62%) had spontaneous nystagmus with a speed of the slow component exceeding 5 deg/second. A positional nystagmus exceeding 5 deg/second, appearing in three or more positions, was found in 24 subjects (83%). In all cases the nystagmus was direction fixed. A cervical nystagmus could be provoked in 17 subjects (59%). T.M.

N81-31456# Royal Air Force Inst. of Aviation Medicine, Farnborough (England). Flight Skills Sect.
THE SPEED OF RESPONSE TO SYNTHESIZED VOICE MESSAGES
J. L. WHEALE *In* AGARD Aural Commun. in Aviation 11 p (SEE N81-31449 22-32) Jun. 1981 refs
Avail: NTIS HC A09/MF A01

The effectiveness of synthesized cockpit voice warning messages using measures of reaction time (RT) was evaluated. Research has shown that voice messages are comparable to audio warnings and that synthesized voice messages are easily recognizable at low signal to noise ratios. Four different warning arrangements were used of which three had a Votrax voice component. The four warning systems represent possible warning combinations for transport aircraft. Subjects had to deal with simulated emergencies while performing a psychomotor tracking task and monitoring ATC messages. Thirty commercial pilots took part in the study. Overall the four warning systems were equally effective in terms of RT. However, voice messages had significantly slower RT's than audio warnings. Voice messages and illuminated legends caused significantly less disruption of ATC monitoring than audio warnings. Pilots also consistently cross checked voice and audio inputs with visual indicators. T.M.

N81-31457# Southampton Univ. (England). Audiology and Human Effects Group.
ASSESSING THE EFFECTIVENESS OF AUDITORY WARNINGS
P. A. WILKINS *In* AGARD Aural Commun. in Aviation 13 p (SEE N81-31449 22-32) Jun. 1981 refs Sponsored in part by the United Kingdom Health and Safety Executive
Avail: NTIS HC A09/MF A01

Two laboratory experiments and a field study are described which found that while inattention need not necessarily impair the perception of an auditory warning, the combination of inattention and the need to recognize the warning may result in failures in the perception of sounds which can be heard and recognized when listened for deliberately. The results indicated that to be effective a warning sound should be distinct from both the ambient noise and other nonsimultaneous discrete sounds present. T.M.

N81-31458# Air Force Inst. of Aviation Medicine, Manching (West Germany).
VOICE WARNING SYSTEMS: SOME EXPERIMENTAL EVIDENCE CONCERNING APPLICATION
M. REINECKE *In* AGARD Aural Commun. in Aviation 8 p (SEE N81-31449 22-32) Jun. 1981 refs
Avail: NTIS HC A09/MF A01

Two experiments with voice warning systems (VWS), one in a helicopter UH-1D and the other one in a F 104 flight simulator are described. In the first experiment recognition times to identify simulated failures were measured in cruise and low level flights with 5 pilots. It was proved that voice warnings compared to light warnings do reduce recognition time. This is especially true during low level flight, and when only precise warning texts are used. In the second experiment the interaction of voice warnings and radio communication was investigated. Eleven pilots had to do a navigation flight and to react with correct emergency procedures when failures were introduced. Reaction times suggest that additional light warnings tend to slow down pilots reactions. The findings stress the possibility that the pilot might become overloaded when voice warnings do occur while radio communication is going on. T.M.

N81-31459# Human Engineering Labs., Aberdeen Proving Ground, Md.
THE BACKGROUND AND BASES FOR THE PROPOSED MILITARY STANDARD ON ACOUSTICAL NOISE LIMITS IN HELICOPTERS
G. R. GARINTHER and D. C. HODGE *In* AGARD Aural Commun. in Aviation 9 p (SEE N81-31449 22-32) Jun. 1981 refs
Avail: NTIS HC A09/MF A01

A design standard for interior noise of helicopters was prepared to provide the developer and user with realistic noise limits which consider hearing damage risk, speech intelligibility, mission profile, state-of-the-art in noise reduction, and helicopter weight. The levels selected meet the current hearing conservation limits of the Department of Defense and permit electrically aided sentence intelligibility of 98%. Helicopters below 20,000 pounds are treated separately from those above because of the strong positive relation between internal noise and vehicle gross weight. This standard defines the locations and flight conditions under which noise measurements shall be made for compliance. It also specifies the types of instrumentation and the test procedures to be used to collect interior noise level data. T.M.

N81-31460# *Institute for Perception RVO-TNO, Soesterberg* (Netherlands).
THE EFFECT OF NOISE-INDUCED HEARING LOSS ON THE INTELLIGIBILITY OF SPEECH IN NOISE
G. F. SMOORENBURG, J. A. P. M. DELAAT, and R. PLOMP *In* AGARD Aural Commun. in Aviation 8 p (SEE N81-31449 22-32) Jun. 1981 refs
Avail: NTIS HC A09/MF A01

Speech reception thresholds, both in quiet and in noise, and tone audiograms were measured for 14 normal ears (7 subjects) and 44 ears (22 subjects) with noise-induced hearing loss. Maximum hearing loss in the 4-6 kHz region equalled 40 to 90 dB (losses exceeded by 90% and 10%, respectively). Hearing loss for speech in quiet measured with respect to the median

speech reception threshold for normal ears ranged from 1.8 dB to 13.4 dB. For speech in noise the numbers are 1.2 dB to 7.0 dB which means that the subjects with noise-induced hearing loss need a 1.2 to 7.0 dB higher signal-to-noise ratio than normal to understand sentences equally well. A hearing loss for speech of 1 dB corresponds to a decrease in sentence intelligibility of 15 to 20%. The relation between hearing handicap conceived as a reduced ability to understand speech and tone audiogram is discussed. The higher signal-to-noise ratio needed by people with noise-induced hearing loss to understand speech in noisy environments is shown to be due partly to the decreased bandwidth of their hearing caused by the noise dip. T.M.

N81-31461# Royal Netherlands Air Force, Soesterberg. Aeromedical Dept.

HEARING STANDARDS FOR AIRCREW

M. P. C. GLOUDEMANS *In* AGARD Aural Commun. in Aviation 4 p (SEE N81-31449 22-32) Jun. 1981

Avail: NTIS HC A09/MF A01

Standards for aircrew in six NATO countries were examined. The large discrepancy in audiometric requirements from country to country is discussed. Emphasis is placed on those tests that examine speech recognition in quiet and in noise environments. T.M.

N81-31462# Aerospace Medical Research Labs., Wright-Patterson AFB, Ohio.

COMPARATIVE INTELLIGIBILITY OF SPEECH MATERIALS PROCESSED BY STANDARD AIR FORCE VOICE COMMUNICATION SYSTEMS IN THE PRESENCE OF SIMULATED COCKPIT NOISE

T. J. MOORE, C. W. NIXON, and R. L. MCKINLEY *In* AGARD Aural Commun. in Aviation 5 p (SEE N81-31449 22-32) Jun. 1981 refs

Avail: NTIS HC A09/MF A01

Among the systems evaluated was the ARC-164 radio which will serve as the reference system against which the performance of jam-resistant, secure systems developed in the immediate future will be compared. Relative differences found between male and female talkers under various levels of simulated cockpit noise are reported. T.M.

N81-31463# Institute of Aviation Medicine, Oslo (Norway).

SECOND LANGUAGE SPEECH COMPREHENSION IN NOISE: A HAZARD TO AVIATION SAFETY

H. M. BORCHGREVINK *In* AGARD Aural Commun. in Aviation 5 p (SEE N81-31449 22-32) Jun. 1981 refs

Avail: NTIS HC A09/MF A01

Simple Norwegian and English sentences were read by a bilingual adult, tape recorded and presented individually to bilingual adults with English or Norwegian as their first language and good command of the other. Each 65 dB sentence was first presented in so strong background USASI noise (75dB) that it could not be perceived, and was repeated with the noise level progressively reduced in 2 dB steps from presentation to presentation until the sentence was adequately repeated by the subject. The results demonstrated that for both groups the first (native) language sentences were correctly repeated after fewer presentations, that is at a lower signal-to-noise ratio, than the second language sentences. The difference between the first (native) language comprehension threshold and the second language comprehension threshold was statistically significant for both the Norwegian and the English subject groups. T.M.

N81-31464# Air Force Inst. of Aviation Medicine, Fuerstenfeldbruck (West Germany).

THE EFFECTS OF EAR PROTECTORS AND HEARING LOSSES ON SENTENCE INTELLIGIBILITY IN AIRCRAFT NOISE

G. R. FROEHLICH *In* AGARD Aural Commun. in Aviation 2 p (SEE N81-31449 22-32) Jun. 1981

Avail: NTIS HC A09/MF A01

Flight line personnel with hearing defects often complain that face-to-face speech communication in noise is considerably reduced when ear protectors are worn. Whether this could be confirmed or not was determined. An effective noise protecting flight helmet changes the flat aircraft cabin noise spectrum into a spectrum with predominance of lower frequencies. Whether the additional wearing of earplugs under the ear cups might improve speech perception was investigated. T.M.

N81-31465# Institute for Perception RVO-TNO, Soesterberg (Netherlands).

STI: AN OBJECTIVE MEASURE FOR THE PERFORMANCE OF VOICE COMMUNICATION SYSTEMS

T. HOUTGAST and H. J. M. STEENEKEN *In* AGARD Aural Commun. in Aviation 6 p (SEE N81-31449 22-32) Jun. 1981 refs

Avail: NTIS HC A09/MF A01

A measuring device was developed for determining the quality of speech communication systems. It comprises two parts, a signal source which replaces the talker, producing an artificial speech-like signal, and an analysis part which replaces the listener, by which the signal at the receiving end of the system under test is evaluated. Each single measurement results in an index (ranging from 0-100%) which indicates the effect of that communication system on speech intelligibility. The index is called STI (Speech Transmission Index). A careful design of the characteristics of the test signal and of the type of signal analysis makes the present approach widely applicable. It was verified experimentally that a given STI implies a given effect on speech intelligibility, irrespective of the nature of the actual disturbance (noise interference, band-pass limiting, peak clipping, etc.). T.M.

N81-31466# Institute for Perception RVO-TNO, Soesterberg (Netherlands).

SOME APPLICATIONS OF THE STI-METHOD IN EVALUATING SPEECH TRANSMISSION CHANNELS

H. J. M. STEENEKEN and T. HOUTGAST *In* AGARD Aural Commun. in Aviation 6 p (SEE N81-31449 22-32) Jun. 1981 refs

Avail: NTIS HC A09/MF A01

A description is given of a measuring device for the application of the STI-method. The application of the device in evaluating speech communication channels as radio communication links, digital communication channels and microphones and telephones in noisy environments is demonstrated. Consequently the STI might well be used as a design specification for speech communication systems. T.M.

N81-31467# Aerospace Medical Research Labs., Wright-Patterson AFB, Ohio.

VOICE COMMUNICATION CAPABILITY OF SELECTED INFLIGHT HEADGEAR DEVICES

R. L. MCKINLEY, C. W. NIXON, and T. J. MOORE *In* AGARD Aural Commun. in Aviation 8 p (SEE N81-31449 22-32) Jun. 1981

Avail: NTIS HC A09/MF A01

The voice communication effectiveness (MRT word intelligibility) of selected Air Force communications terminal equipment was evaluated in simulated operational noise environments. Analyses of the resulting data indicate: standard AF communications headsets H-133, HGU-26/P and H-157 performed in a manner consistent with their purposes with the H-133 providing the best communication, the HGU-26/P second and the H-157 third; percent correct intelligibility in the 115 dB noise condition was reduced as much as 15% for the H-133 and 50% for the H-157 over the ambient noise condition; communication performance varied over 5 to 10 percent when used with the AIC vs the AIC and RF radio; and the UK chemical defense hood provided a slightly better talking environment than the MBU-5/P and a worse listening environment than the HGU-26/P. T.M.

N81-31468# Royal Air Force Inst. of Aviation Medicine, Farnborough (England).

AN AUTOMATED MULTIPLE CHOICE INTELLIGIBILITY TESTING SYSTEM

R. L. PRATT *In* AGARD Aural Commun. in Aviation 3 p (SEE N81-31449 22-32) Jun. 1981 refs

Avail: NTIS HC A09/MF A01

The test material used is the Modified Rhyme Test and the Clarke's Vowel Test (CVT). The MRT consists of groups of single syllable words which differ only in their initial or final consonant, for the CVT only the vowel is different. The relative performance of various noise cancelling microphones was compared by recording MRT and CVT word lists against a background of rotary

wing noise provided using a prerecorded sample formed into a tape loop. The word lists were then replayed to subjects, seated in the same noise environment used for the recordings, through a communications headset with attenuation properties similar to helmets used in rotary wing aircraft. Subjects were required to select the word they thought they heard from a group of six words (five in the case of the CVT) presented on a Visual Display Unit (VDU). It is suggested that subjects' reaction time, when used in conjunction with the percentage correct score, may assist in discriminating between microphones of comparable performance. T.M.

N81-31469# Air Force Inst. of Aviation Medicine, Fuerstenfeldbruck (West Germany).
EFFECTS OF AGE, FLYING TIME AND TYPE OF AIRCRAFT ON THE HEARING OF GERMAN MILITARY PILOTS, AND ITS SIGNIFICANCE FOR INFLIGHT COMMUNICATION
G. R. FROEHLICH *In* AGARD Aural Commun. in Aviation 3 p (SEE N81-31449 22-32) Jun. 1981
Avail: NTIS HC A09/MF A01

The analysis of pure tone audiograms of 4,034 German military pilots revealed that 73% of total ears have normal hearing up to at least 6000 Hz, 26% have only very slight hearing losses above 2000 Hz with 22 + or 14 dB at 3000 Hz, 36 + or - 18 dB at 4000 Hz, and 40 + or - 18 dB at 6000 Hz. This allows reliable speech communication in every day life and aboard the aircraft. The total of marked hearing losses requiring a waiver was 0.65%, mostly unilateral with prevalence of the left ears and induced by impact noise on the shooting range in the early stages of the career. Thus, from the pilots' side, all higher speech frequencies are available for improved voice communication systems and should be used in high noise environment. T.M.

N81-31470# Southampton Univ. (England). Inst. of Sound and Vibration Research.
AN ACTIVE NOISE REDUCTION SYSTEM FOR AIRCREW HELMETS
P. D. WHEELER and S. G. HALLIDAY *In* AGARD Aural Commun. in Aviation 8 p (SEE N81-31449 22-32) Jun. 1981 refs
Sponsored in part by Ministry of Defense
Avail: NTIS HC A09/MF A01

A system was developed in which the acoustic noise field inside the ear defender is detected using a minature microphone, and an antiphase signal is fed back to a communications telephone within the ear defender. The objectives for this development were to improve speech intelligibility, and to reduce noise exposure. In laboratory trials, a group of eighteen subjects, wearing an ANR-modified helmet, were exposed to an external noise field similar to that experienced by aircrew in a high performance strike aircraft. Comparisons of attenuation and speech intelligibility scores, with and without the ANR system in operation, were made. The modified helmet's performance was also compared to that of the standard helmet. In order to eliminate user controls, an adaptive control facility was added which optimises the degree of noise cancellation to compensate for variations in helmet fit between wearers. T.M.

N81-31471# Army Aeromedical Research Lab., Fort Rucker, Ala.
HEARING IMPAIRED AVIATORS IN THE U.S. ARMY
S. LIFF and J. L. GOLDSTEIN *In* AGARD Aural Commun. in Aviation 3 p (SEE N81-31449 22-32) Jun. 1981 refs
Avail: NTIS HC A09/MF A01

An audiometric profile of a group of US Army aviators who had failed to meet the minimal acceptable hearing loss standard and were granted permission to continue to fly under medical waiver is presented. The flight safety records of this group were evaluated to determine if any relationship existed between hearing loss and flight mishaps or accidents involving these individuals. T.M.

N81-31472# Ministry of Defence, London (England). Directorate of Civilian Medical Services.
HEARING CONSERVATION
S. KANAGASABAY *In* AGARD Aural Commun. in Aviation 6 p (SEE N81-31449 22-32) Jun. 1981 refs
Avail: NTIS HC A09/MF A01

Impairment of hearing is one of the adverse effects of noise. The measures adopted to minimize hearing impairment, conveniently termed Hearing Conservation, include specifying an acceptable noise exposure, identification of personnel at risk, provision of suitable protective equipment, limitation of exposure time where this is necessary and medical monitoring by audiometry. Proposals in the United Kingdom for noise criteria and for audiometry in industry are presented. T.M.

N81-31473# Royal Aircraft Establishment, Farnborough (England). Human Engineering Div.
FLYING HELMET ATTENUATION, AND THE MEASUREMENT, WITH PARTICULAR REFERENCE TO THE MK 4 HELMET
G. M. ROOD *In* AGARD Aural Commun. in Aviation 13 p (SEE N81-31449 22-32) Jun. 1981 refs
Avail: NTIS HC A09/MF A01

To predict the intelligibility of communication systems, it is necessary to be able to measure helmet attenuation accurately and repeatably, and it is this particular aspect which is highlighted. Some of the results from a comprehensive series of tests involving subjective and semiobjective measurement of the attenuation of noise by flying helmets are discussed. The analysis shows that the semiobjective method of ascertaining hearing protector or flying helmet attenuation, using miniature measuring microphones, is a viable alternative to the existing standard REAT methods, and has considerable advantages in providing more useful information in less time. Additionally, high correlations exist between laboratory and in-flight mesurements of attenuation, clearly indicating that laboratory measurements reproduce helmet attenuation actually found in the air. T.M.

N81-31474# Naval Avionics Center, Indianapolis, Ind. Applied Research Dept.
A MULTIPLEXED DIGITAL VOICE INTERCOMMUNICATIONS SYSTEM COMPATIBLE WITH FUTURE VOICE CONVERSION TECHNIQUES
R. F. BOLT and B. D. SANDERSON *In* AGARD Aural Commun. in Aviation 7 p (SEE N81-31449 22-32) Jun. 1981 refs
Avail: NTIS HC A09/MF A01

This system will be usable in a variety of aircraft. The individual stations are interchangeable from aircraft-to-aircraft, and the stations are comprised of plug-in modules that can be easily replaced by maintenance personnel. This modularity allows the system to be updated with future voice conversion techniques without rework or redesign. Currently available voice conversion techniques were evaluated for intelligibility in some military acoustic noise environments. A detailed description of the system is presented. T.M.

N81-31475# Defence and Civil Inst. of Environmental Medicine, Downsview (Ontario). Behavioral Sciences Div.
SIDETONE-LEVEL CONSIDERATIONS IN AIRCRAFT COMMUNICATION SYSTEMS
S. E. FORSHAW *In* AGARD Aural Commun. in Aviation 5 p (SEE N81-31449 22-32) Jun. 1981 refs
Avail: NTIS HC A09/MF A01

It is known that the loudness of an individual's speech is governed by two possibly related feedback phenomena: the 'sidetone-amplification effect', the tendency for a speaker to decrease his vocal effort when he hears his voice at an amplified level, and the 'Lombard effect', the tendency for a speaker to increase his vocal intensity in the presence of noise. The limited noise cancelling capabilities of current microphones are the major source of system amplified noise listeners ears. It may be possible to reduce the level of this source of noise, and hence increase a system's signal to noise ratio and speech intelligibility, by optimizing the level of a speaker's transmit sidetones to elicit an increase in his vocal output. T.M.

N82-10306# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
ELECTROMAGNETIC COMPATIBILITY
Aug. 1981 131 p refs Lecture held in Bolkesjo, Norway, 31 Aug. - 1 Sep. 1981, in Munich, 3-4 Sep. 1981, and in Rome, 7-8 Sep. 1981
(AGARD-LS-116; ISBN-92-835-1396-7; AD-A105093) Avail: NTIS HC A07/MF A01

Various aspects of electromagnetic compatibility (EMC) are presented. The major focus is on impact of the increasing complexity and density of avionics systems on the special demands of those responsible for achieving EMC within host weapon platforms. For individual titles, see N82-10307 through N82-10313.

N82-10307# Rome Air Development Center, Griffiss AFB, N.Y.
THE EMC CONCEPT FOR WEAPON SYSTEMS
J. F. SPINA *In* AGARD Electromagnetic Compatibility 9 p (SEE N82-10306 01-32) Aug. 1981 refs
Avail: NTIS HC A07/MF A01

Electromagnetic compability (EMC) is discussed as it pertains to various weapon systems. The focus is on those weapon systems where the density of electronics is such that EMC must be reconed. Several weapon system EMC solution methods are also discussed. The status of computer aided EMC analysis techniques is given. R.C.T.

N82-10308# Syracuse Univ., N. Y. Dept. of Electrical and Computer Engineering.
EMC ANALYSIS AT THE SYSTEM LEVEL
D. D. WEINER *In* AGARD Electromagnetic Compatibility 22 p (SEE N82-10306 01-32) Aug. 1981
Avail: NTIS HC A07/MF A01

A computer program is described which determines whether signals entering a receptor port from one or more emitters may cause interference. The characterization of emitter ports in terms of power spectral densities is discussed and narrowband and broadband components of the spectrum are defined. System compatibility is described in terms of electromagnetic interference margins. R.C.T.

N82-10309# Kentucky Univ., Lexington Dept. of Electrical Engineering.
EMC ANALYSIS AT THE EQUIPMENT LEVEL
C. R. PAUL *In* AGARD Electromagnetic Compatibility 23 p (SEE N82-10306 01-32) Aug. 1981 refs
Avail: NTIS HC A07/MF A01

A summary of the techniques and problems involved in the assessment of the vulnerability of components of an electronic system is provided. Modeling emitters and receptors of electromagnetic energy are discussed as well as the predominant coupling paths (wire to wire, field to wire, and antenna to antenna). Various computer aided methods for evaluating the coupling are considered. R.C.T.

N82-10310# Rome Air Development Center, Griffiss AFB, N.Y.
AN INTRASYSTEM EMC ANALYSIS PROGRAM
G. T. CAPRARO *In* AGARD Electromagnetic Compatibility 22 p (SEE N82-10306 01-32) Aug. 1981 refs
Avail: NTIS HC A07/MF A01

Various aspects of the intrasystem electromagnetic compatibility analysis program (IEMCAP) are discussed. Emphasis is placed on the input data requirements and coupling models contained in IEMCAP. The computer aspects and size constraints are given with helpful hints for the user on how to apply IEMCAP to systems whose size violates these constraints. Data are also provided showing the relative accuracy of IEMCAP's major coupling modes. Various modifications to IEMCAP are also presented. R.C.T.

N82-10311# Concordia Univ., Loyola Campus, Montreal (Quebec). Dept. of Electrical Engineering.
COMPUTER GRAPHIC AIDS TO WEAPON SYSTEMS EMC ANALYSIS
S. J. KUBINA *In* AGARD Electromagnetic Compatibility 13 p (SEE N82-10306 01-32) Aug. 1981 refs Sponsored in part by the Canadian Dept. of National Defense
Avail: NTIS HC A07/MF A01

The full potential of interactive computer graphics for the achievement of an unprecedented level of appreciation of the electromagnetic interference interaction elements are illustrated. Examples are taken from the computer code called advanced antenna to antenna coupling plus graphics. It is shown that the input modelling data used in the large, powerful electromagnetic compatibility codes can be presented as comprehensive images of the aircraft or the system port characteristics. It is further shown that the results can be presented in a format which makes visible the constituent components that produce the images. R.C.T.

N82-10312# Royal Aircraft Establishment, Farnborough (England).
THE EMC TESTING OF AIRCRAFT EQUIPMENT
N. J. CARTER *In* AGARD Electromagnetic Compatibility 20 p (SEE N82-10306 01-32) Aug. 1981 refs
Avail: NTIS HC A07/MF A01

The repeatability and usefulness of the electronics in flight critical equipment were measured in terms of their effectiveness in aiding aircraft clearance. Specific emphasis was placed on the electromagnetic compatibility requirements of military aircraft. R.C.T.

N82-10313# Aeritalia S.p.A., Caselle Torinese (Italy). Gruppo Equipaggiamenti.
A NEW APPROACH TO EMC SYSTEM TESTING
B. AUDONE *In* AGARD Electromagnetic Compatibility 8 p (SEE N82-10306 01-32) Aug. 1981 refs
Avail: NTIS HC A07/MF A01

An approach is described which encompasses the quantitative measurement of electromagnetic compatibility of aircraft equipment. The general testing philosophy is explained and a series of generally applicable test methods are described. R.C.T.

N82-27613# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
MEDIUM, LONG AND VERY LONG WAVE PROPAGATION (AT FREQUENCIES LESS THAN 3000 KHZ)
J. S. BELROSE Feb. 1982 266 p refs In ENGLISH; partly in FRENCH Meeting held in Brussels, 21-25 Sep. 1981
(AGARD-CP-305; ISBN-92-835-0311-2; AD-A113969) Avail: NTIS HC A12/MF A01

Electromagnetic wave propagation information at ELF and VLF frequencies is reviewed and the current state of knowledge in this frequency band is summarized with emphasis on the propagation medium, ELF propagation, VLF propagation, LF propagation, MF propagation, numerical modelling of the propagation medium, and applications. For individual titles, see N82-27614 through N82-27651.

N82-27614# Communications Research Centre, Ottawa (Ontario).
THE PROPAGATION MEDIUM: AN OVERVIEW
J. S. BELROSE *In* AGARD Medium, Long and Very Long Wave Propagation 18 p (SEE N82-27613 18-32) Feb. 1982 refs
Avail: NTIS HC A12/MF A01

Electron and ion number density and collision frequency height profiles in the lower E region and in the D region of the ionosphere (heights below 100 km) are reviewed. Sources of ionization, electron loss rates, the height distribution of nitric oxide, ozone, and 02(delta g), and D region modelling are discussed. Variations with latitude, over dawn, and during winter are considered as well as geomagnetic post storm effects. Solar X-ray flares effects, solar proton events, and high energy patparticle (electron) events are among the geophysical disturbances considered. A.R.H.

N82-27615# Army Research Office, Research Triangle Park, N. C.

STUDIES OF THE D-REGION BY THE PARTIAL REFLECTION OF MF RADIO WAVES Ph.D. Thesis

W. A. FLOOD, H. N. TURNER, T. E. SHIRLEY, and S. D. COLLINS *In* AGARD Medium, Long and Very Long Propagation 15 p (SEE N82-27613 18-32) Feb. 1982 refs

Avail: NTIS HC A12/MF A01

A series of coordinated measurements of the D-region was carried out at a frequency of 2.66 MHz. It was shown that the *randomly phased angular spectrum approximation which is central* to the measurement of ionospheric winds is valid for D-region echoes. Measurements of the complex spatial correlation coefficient of D-region echoes were used to estimate the half power, half cone angle of arrival of D region echoes. The mean half cone angle was found to increase between 68-80 kilometers and then to remain constant at a value of 13 deg. Above 80 kilometers the variance of the angle of arrival increased with altitude. The implications of these cone angle measurements on the accuracy of D-region electron density profiles measured by the partial reflection technique are discussed. Screened noon-time values of D-region electron density profiles derived from the 'partial reflection' technique were analyzed to determine seasonal variations of electron density over the altitude range 68-88 kilometers. Examples of days of anomalous winter absorption are clearly evident. Amplitude distribution of D-region echoes supports the hypothesis that the echoes were drawn from a Rayleigh population. This result and the fact that D-region echoes are continuous with altitude are considered evidence that the source of these echoes is volume backscattering from fluctuations of refractive index. A.R.H.

N82-27616# Rome Air Development Center, Hanscom AFB, Mass. Propagation Branch.

VLF/LF PULSE REFLECTION MEASUREMENTS OF THE POLAR D-REGION DURING QUIET AND DISTURBED IONOSPHERIC CONDITIONS

J. P. TURTLE, J. E. RASMUSSEN, W. I. KLEMETTI, and P. A. KOSSEY *In* AGARD Medium, Long and Very Long Wave Propagation 12 p (SEE N82-27613 18-32) Feb. 1982 refs

Avail: NTIS HC A12/MF A01

A short pulse VLF/LF ionosounder to determine the characteristics of the polar D-region during quiet and disturbed conditions is described. Data obtained at Thule AB, Greenland, near the center of the polar cap, are presented giving information *on the D-region's height and reflectivity as a function of time.* Under quiet conditions there are marked variations in the D-region due to the effects of diurnal and seasonal changes in solar illumination. Energetic particle events produce dramatic changes in both the height and reflectivity of the D-region which can exhibit a complex behavior throughout the duration of the event. The severity of the D-region effects is highly dependent on seasonal illumination conditions. Data on ionospheric reflectivity illustrate normal seasonal and diurnal variations, data from disturbed periods show the interaction between propagation parameters and energetic particle ionization, solar ionizing and photodetaching radiations. A.R.H.

N82-27617# Lockheed Missiles and Space Co., Palo Alto, Calif.

THE INFLUENCE OF PRECIPITATING ENERGETIC PARTICLES ON THE PROPAGATION MEDIUM

W. L. IMHOF, R. C. GUNTON, J. B. REAGAN, R. E. MEYEROTT, E. E. GAINES, and T. R. LARSEN (Norwegian Defence Research Establishment, Kjeller) *In* AGARD Medium, Long and Very Long Wave Propagation 9 p (SEE N82-27613 18-32) Feb. 1982 refs

Avail: NTIS HC A12/MF A01

Measurements of precipitating particles with electron/proton spectrometers and also with bremsstrahlung X-ray sensors from several satellites during the 1971-1980 time frame provide the basis for studying the morphology of the propagation medium as related to long-wave signal transmission. From the measured fluxes, energy spectra, and pitch-angle distributions of the particles, ion-pair production profiles are calculated and electron density profiles subsequently obtained with application of effective electron loss rates. The temporal, latitude, longitude, and altitude variations associated with electron precipitation and with major solar particle events summarized along with calculations of their effects on ELF propagation. Particular use is made of the nearly simultaneous worldwide measurements of electron precipitation performed via the newly developed satellite bremsstrahlung X-ray technique. A.R.H.

N82-27618# Rome Air Development Center, Hanscom AFB, Mass. Propagation Branch.

VLF/LF PULSE REFLECTIONS FROM LAYERS BELOW THE IONOSPHERIC D-REGION

J. E. RASMUSSEN, P. A. KOSSEY, and J. P. TURTLE *In* AGARD Medium, Long and Very Long Wave Propagation 10 p (SEE N82-27613 18-32) Feb. 1982 refs

Avail: NTIS HC A12/MF A01

Long wave ionospheric reflectivity data are described from experiments using a VLF/LF pulse ionosounding system. The sounding technique utilized pulses so short, that even at distances of a few hundred kilometers from the transmitter, ground wave and ionospherically reflected sky wave pulses were received separated in time. Pulse reflection data are shown that strongly suggest *the simultaneous presence of at least two discrete* reflections from different heights in the daytime ionosphere. The upper reflections are identified with the classical D-region, caused primarily by Lyman alpha radiation, while the low-altitude reflections, which occur from shortly before sunrise to shortly after sunset, are believed to be due to ionization caused by cosmic rays and photodetachment. The variability of the low altitude daytime ionosphere is described from VLF/LF pulse reflection data obtained during different seasons, at mid- and low-geomagnetic latitudes, and over different phases of the solar cycle. The effects of the low altitude ionization on the propagation of long radio waves are estimated. Author

N82-27619# Bonn Univ. (West Germany). Radioastronomical Inst.

VLF ATMOSPHERICS AS A TOOL FOR PROBING VLF PROPAGATION CONDITIONS

J. SCHAEFER and H. VOLLAND *In* AGARD Medium, Long and Very Long Wave Propagation 12 p (SEE N82-27613 18-32) Feb. 1982 refs

Avail: NTIS HC A12/MF A01

A technique for receiving and analyzing atmospherics signals and for deriving the VLF-propagation conditions is described. The equipment consists mainly of a receiver/analyzer with an on-line desktop computer. The computer controls the observations and analyses the received parameters in real time, so that the results, *e.g., the reference height of the lower ionosphere or the strengths* and locations of the thunderstorm activity centers, can be printed out immediately or displayed on a world map with a small desktop plotter. The data are also stored on magnetic tape cassettes. These measurements are used to investigate the short and long-term as well as the local and global behavior of the lightning activity and the VLF-propagation conditions and to elucidate their correlation to atmospheric electric and possibly also external (e.g. solar) parameters. Some results of the measurements, including statistical analyses of the received parameters and typical real time plot charts are shown to demonstrate the methods and capabilities of the present system. Author

N82-27620# Paris VI Univ. (France). Lab. de Physique et Dynamique de l'Atmosphere.

PARTICLE-WAVE AND WAVE-WAVE INTERACTIONS GENERATED DURING T.B.F. TRANSMISSION FROM KAFJORD, NORWAY [INTERACTIONS ONDES-PARTICULES ET ONDE-ONDE ENGENDREES PENDANT LES TRANSMISSIONS T.B.F. DE KAFJORD, NORVEGE]

M. GARNIER, N. CAVACIUTI, H. C. KOONS, and M. H. DAZEY *In* AGARD Medium, Long and Very Long Wave Propagation 14 p (SEE N82-27613 18-32) Feb. 1982 refs In FRENCH; ENGLISH summary Prepared in cooperation with Aerospace Corp., Los Angeles

Avail: NTIS HC A12/MF A01

Interactions in the magnetosphere between man-made VLF waves and electrons can produce either an enhancement of the wave or the generation of waves at a different frequency. Furthermore natural emissions can be frequency shifted or modified by a nearby transmitter signal. Injections of VLF waves into the magnetosphere was initiated using a 15 km power line (antenna) tuned at the transmitted frequency. A 1 KW transmitter was used

to drive the antenna with a maximum current of 8 amperes. Transmissions were conducted when the SCATHA and GOES II satellites were near the magnetic meridian of the transmitter. Transmitted signals were either keyed fixed frequency or continuous waves swept in frequency. Signals correlated with the transmissions were detected by the satellite receivers on several dates. With the first types of transmission, signals similar to power line harmonic radiation were recorded. Artificially stimulated emissions, chorus elements, and magnetospheric induced quiet band are also likely to have been triggered. Both types of transmissions triggered or enhanced hiss at a constant frequency during fixed frequency transmissions or at a variable frequency during a swept frequency transmission. A.R.H.

N82-27621# Max-Planck-Institut fuer Aeronomie, Katlenburg-Lindau (West Germany).

GENERATION OF ELF AND VLF WAVES BY MODULATED HF HEATING OF THE POLAR ELECTROJET

P. STUBBE, H. KOPKA, M. T. RIETVELD, and R. L. DOWDEN (Otago Univ., Dunedin, New Zealand) *In* AGARD Medium, Long and Very Long Wave Propagation 6 p (SEE N82-27613 18-32) Feb. 1982 refs Sponsored in part by Deutsch Forschungsgemeinschaft

Avail: NTIS HC A12/MF A01

Modulated heating of the lower ionosphere, with modulation frequencies in the ELF and VLF range, gives rise to a corresponding modulation of the electron temperature and, thus, of the electrical conductivity. If a polar electrojet current exists, the current density is modulated, and an ELF or VLF signal is generated. Experiments were performed to test this mechanism, using the new ionospheric heating facility at Ramfjordmoen, Norway. It was found that this mechanism is sensitive in the full ELF range and for VLF frequencies exceeding 7 kHz, the upper limit of the VLF receiver used. Author

N82-27622# Naval Underwater Systems Center, New London, Conn. Submarine Electromagnetic Systems Dept.

OVERVIEW OF ELF PROPAGATION

P. R. BANNISTER *In* AGARD Medium, Long and Very Long Wave Propagation 13 p (SEE N82-27613 18-32) Feb. 1982 refs

Avail: NTIS HC A12/MF A01

The extremely low frequency (ELF) band (30 to 300 Hz) has serious deficiencies compared with conventional radio frequencies. It is characterized by a very restricted bandwidth (low data rates) and an extremely large wavelength (inefficient antennas). For special applications, however, involving some of the propagation paths conducted through rock or sea water, it offers the possibility of communication where conventional bands offer none. In the case of long-range communication with submerged submarines, it can also provide low-loss highly-stable propagation in the Earth-ionosphere waveguide. A general overview of ELF propagation is presented. Recently derived simple-form approximate expressions (relating ELF propagation constants to realistic-ionospheric conductivity profiles) are compared with experimentally derived results for daytime and nighttime propagation conditions. Current (unpublished) data measured, simultaneously, in Connecticut and other, more distant, locations are included to elucidate anomalous ELF nighttime field strength degradiations. Author

N82-27623# Pacific-Sierra Research Corp., Santa Monica, Calif.

ELF PROPAGATION IN DISTURBED ENVIRONMENTS

E. C. FIELD, JR. *In* AGARD Medium, Long and Very Long Wave Propagation 10 p (SEE N82-27613 18-32) Feb. 1982 refs

Avail: NTIS HC A12/MF A01

The effects on long-range ELF propagation from ionospheric disturbances such as solar particle events or nuclear environments, which substantially constrict the Earth-ionosphere waveguide are described. A few results pertain to more common ionospheric phenomena, such as sporadic-E patches. Stratified disturbances usually cause both the excitation factor and the attenuation rate of the TEM waveguide mode to increase. Thus, the signal increases somewhat at short distances, but decreases by several decibels at long distances. The main loss mechanism is Ohmic heating of heavy ions in the lower ionosphere. Numerical solutions show that a localized disturbance behaves like a cylindrical lens filling a narrow aperture. Lateral diffraction, focusing, and reflection can cause the TEM mode to exhibit a transverse pattern of maxima and minima beyond the disturbance, and a standing wave pattern in front of it. Such phenomena can contribute to spatial fluctuations occasionally observed on ELF transmissions. The focusing and diffraction diminish when the transverse dimension of the disturbance approaches the width of the first Fresnel zone--typically, several megameters. A.R.H.

N82-27624# Norwegian Defence Research Establishment, Kjeller.

ELF PROPAGATION IN POLAR AREAS, MEASUREMENTS AND THEORETICAL FIELD STRENGTH PREDICTIONS

T. R. LARSEN, W. L. IMHOF, R. C. GUNTON, J. B. REAGAN, E. E. GAINES, and R. E. MEYEROTT *In* AGARD Medium, Long and Very Long Wave Propagation 16 p (SEE N82-27613 18-32) Feb. 1982 refs Prepared in cooperation with Lockheed Missiles and Space Co., Palo Alto, Calif.

Avail: NTIS HC A12/MF A01

The influence of the ionosphere upon ELF propagation at 75 Hz is discussed using results for the propagation path from the U.S. Navy ELF Wisconsin Test Facility transmitter to Tromso, Norway. This 6 megameter path crosses the Greenland icecap and passes twice through the auroral regions. Full wave computations were made using a waveguide mode program. The propagation path was divided into eight segments taking into account in an approximate way the varying boundary conditions of the actual waveguide. Results are presented and discussed for conditions ranging from ambient to severely disturbed. Disturbed ionospheric conditions such as sporadic E-layers, relativistic electron precipitation, auroral events and solar proton events were modelled. Electron and ion density profiles were deduced from satellite observations in the vicinity of the path. The importance of the electron as well as the ion concentrations is discussed. A.R.H.

N82-27625# Naval Underwater Systems Center, New London, Conn.

ELF NOISE SURVEYS: A REVIEW

E. F. SODERBERG *In* AGARD Medium, Long and Very Long Wave Propagation 12 p (SEE N82-27613 18-32) Feb. 1982 refs

Avail: NTIS HC A12/MF A01

Noise measurement surveys were conducted in various geographical areas to determine the characteristics of ELF noise in power spectral variation with season and time of day, and of noise correlation between widely separated locations. By far, the majority of measurements were made at ground stations, with a small number having been made above the Earth and in space, and even fewer having been made in the sea. The various surveys are reviewed and the ELF noise characteristics in each area are discussed. Author

N82-27626# Leicester Univ. (England). Dept. of Physics.

A REVIEW OF THE ANALYTICAL TECHNIQUES FOR DETERMINING THE PHASE AND AMPLITUDE OF A VLF RADIO WAVE PROPAGATING IN THE EARTH-IONOSPHERE WAVEGUIDE

T. B. JONES and K. MOWFORTH *In* AGARD Medium, Long and Very Long Wave Propagation 16 p (SEE N82-27613 18-32) Feb. 1982 refs

Avail: NTIS HC A12/MF A01

The variation of the phase and amplitude of a VLF wave as a function of distance from the transmitter is calculated by each of three analysis techniques for several Earth ionosphere models and the results obtained compared with each other at various radio frequencies. The zonal harmonic analysis method employs the application of Maxwell's equations and the appropriate boundary conditions, allowing the vertical electric field strength to be calculated at any point remote from the transmitter. The form of the solution is a series summation of zonal harmonics. An approximation permitting the series summation to be performed without a computer consists of forming a complex integral for the Hertz vector which is expressed as a sum of residues which, after suitable transformation, become the waveguide modes. The propagation is then described in terms of the propagating modes in the spherical waveguide formed by the Earth as one wall and the ionosphere as the other. In the wave hop technique, the

propagation path is divided into three principal regions and computer computation yields solutions not unlike those of geometrical optics. J.D.

N82-27627# Pacific-Sierra Research Corp., Santa Monica, Calif
VLF PROPAGATION IN DISTURBED ENVIRONMENTS
E. C. FIELD, JR. *In* AGARD Medium, Long and Very Long Wave Propagation 10 p (SEE N82-27613 18-32) Feb. 1982 refs
Avail: NTIS HC A12/MF A01

Long-range VLF/LF propagation of transverse magnetic (TM) and transverse electric (TE) signals at frequencies from 10 to 50 kHz is considered. Model ionospheres corresponding to solar proton events or spread-debris nuclear environments are used in full wave calculations. Such disturbances constrict the Earth ionosphere waveguide, increasing excitation factors and attenuation rates. The signals are therefore usually degraded beyond a few megameters, although either enhancement or degradation can occur at shorter distances. Ohmic heating of heavy ions in the lower ionosphere is the main loss mechanism for intense disturbances. Only TM modes are efficiently radiated by ground based transmitters. However, TE signals can be important for air-to-air links with terminal elevations of 20 kft or more, and nearly horizontal trailing wire antennas. Air-to-air TE signals propagate better than TM modes over poorly conducting ground such as exists throughout Greenland and much of Canada, and can fill nulls in the TM signal. For paths over highly conducting ground, TM modes suffer less degradation than TE signals during intense disturbances; but, for ground conductivities less than about 0.0001mhos/m, TM signals are more adversely affected than TE signals. Author

N82-27628# Hulburt (E. O.) Center for Space Research, Washington, D.C. Ionospheric Effects Branch.
MULTIPATH VLF PROPAGATION EFFECTS ON CORRELATION RECEIVERS
F. J. KELLY, J. P. HAUSER, H. M. BECK, and F. J. RHOADS *In* AGARD Medium, Long and Very Long Wave Propagation 50 p (SEE N82-27613 18-32) Feb. 1982 refs
Avail: NTIS HC A12/MF A01

The effect of electromagnetic propagation at very low frequency in the Earth ionosphere waveguide can distort wideband communication waveforms and produce a splitting of the correlation peak of the received signal at a modal interference null where multipath signals arrive out of phase. Propagation from an inclined dipole antenna trailed behind an orbiting aircraft can cause the split correlation pattern to fluctuate throughout the orbit period. For the case of an MSK (minimum shift keying) signal format, expressions and graphs are given for the correlation vector, as a function of receiver synchronization time and aircraft flight direction. Author

N82-27629# Rome Air Development Center, Hanscom AFB, Mass.
RELATIVE CHARACTERISTICS OF TE/TM WAVES EXCITED BY AIRBORNE VLF/LF TRANSMITTERS
P. A. KOSSEY, E. A. LEWIS, and E. C. FIELD, JR. (Pacific Sierra Research Corp., Santa Monica, Calif.) *In* AGARD Medium, Long and Very Long Wave Propagation 10 p (SEE N82-27613 18-32) Feb. 1982
Avail: NTIS HC A12/MF A01

Studies of the characteristics of long radio waves excited by airborne VLF/LF transmitting antennas are described. These antennas provide a source of both conventionally used transverse magnetic (TM) waves and heretofore unused transverse electric (TE) waves. A variety of experimental and theoretical studies are described. Included are discussions of TE/TM signal and atmospheric noise data obtained using balloon, rocket and aircraft platforms, and theoretical studies on the propagation of TE/TM waves under both normal and disturbed ionospheric conditions. The exploitation of the TE polarization for improving the range and reliability of VLF/LF air-to-air communications is also considered Author

N82-27630# Admiralty Surface Weapons Establishment, Portsdown (England). Communication Div.
PHASE AND AMPLITUDE PERTURBATIONS ON VLF SIGNALS RECEIVED IN THE SEA
C. J. RIGDEN *In* AGARD Medium, Long and Very Long Wave Propagation 9 p (SEE N82-27613 18-32) Feb. 1982
Avail: NTIS HC A12/MF A01

An experimental investigation into the stability of VLF signals from the GBR (16 kHz) transmitter at Rugby, England when received in the sea is described. The effect of a rough sea surface on these signals is shown. The measured phase and amplitude perturbations on the signals are very small when received above the sea surface or in the sea under calm conditions, but as the sea surface roughness increases the perturbations on the signals received in the sea increase significantly. The results are explained by a simple model which takes into account the variations in sea path length for the VLF signals caused by sea surface waves passing over the receiving aerial. Author

N82-27631# Hulburt (E. O.) Center for Space Research, Washington, D.C. Ionospheric Effects Branch.
ATMOSPHERIC VLF RADIO NOISE AT ELEVATED RECEIVERS: HORIZONTAL AND VERTICAL POLARIZATION
F. J. KELLY, J. P. HAUSER, and F. J. RHOADS *In* AGARD Medium, Long and Very Long Wave Propagation 16 p (SEE N82-27613 18-32) Feb. 1982 refs
Avail: NTIS HC A12/MF A01

A working computer program model for predicting the horizontally and vertically polarized atmospheric noise at any location, season, time of day, and altitude is presented. The programs which are combined to form the model are described. The WAVEGUID program contains the algorithms necessary to compute all the electric and magnetic components of a propagating electromagnetic wave in a given waveguide mode at any height above the ground, if the vertical electric component of the wave at the ground is known. The COMPWR and NOISLAN programs calculate the amplitudes of the vertical electric VLF noise in the three dominant quasi-transverse magnetic waveguide modes from each equivalent atmospheric noise source. Predictions obtained using the model are compared with observed data. J.D.

N82-27632# Communications Research Centre, Ottawa (Ontario).
LF PROPAGATION: AN OVERVIEW
J. S. BELROSE *In* AGARD Medium, Long and Very Long Wave Propagation 10 p (SEE N82-27613 18-32) Feb. 1982 refs
Avail: NTIS HC A12/MF A01

A survey of those areas where knowledge of LF propagation is inadequate is presented. Studies of propagation on a global scale are stressed. Propagation at frequencies in the LF band (30 to 300 kHz) alter with change in frequency, but there is a drastic difference between propagation characteristics in these adjacent bands. Ionospheric attenuation therefore increases rapidly with frequency, particularly during summer day time. The radiation field and its measurement is discussed. Diurnal variations in phase and amplitude, the variation of amplitude with the solar cycle, and solar/geophysical disturbance variations and post-magnetic storm effects are considered. J.D.

N82-27633# Hulburt (E. O.) Center for Space Research, Washington, D.C. Space Science Div.
LOW FREQUENCY RADIO WAVE PROPAGATION IN THE ATLANTIC AND MEDITERRANEAN AREAS
F. J. KELLY, F. J. RHOADS, D. J. BAKER, and J. A. MURRAY *In* AGARD Medium, Long and Very Long Wave Propagation 22 p (SEE N82-27613 18-32) Feb. 1982 refs
Avail: NTIS HC A12/MF A01

Data from eighteen long range aircraft flights are compared with the wave hop propagation model of Berry, and areas of agreement and disagreement noted. The field strength of low frequency radio waves from transmitting stations in Iceland, Scotland, Morocco, and Greece was measured under daytime and nighttime conditions. The nighttime waves at about 1 mm seem to oscillate with distance more dramatically than the current model predicts. The daytime fields over all-water paths are often in good agreement with theory, but ground conductivity changes and rough terrain effects not contained in available computer models appear to influence the received fields. The unsatisfactory state of

mathematical propagation models for this frequency regime is discussed and some areas for improvement recommended. J.D.

N82-27634# Brussels Univ. (Belgium).
MEASURE OF E.C.D., TIME OF ARRIVAL, AMPLITUDE AND PHASE OF BOTH GROUND AND REFLECTED WAVES OF LORAN-C PULSES
J. C. LIEVIN, J. P. HAMAIDE, W. SCHOLIERS, and J. P. LECHIEN *In* AGARD Medium, Long and Very Long Wave Propagation 8 p (SEE N82-27613 18-32) Feb. 1982 refs Sponsored in part by Fonds National de la Recherche Scientifique and the US Coast Guard
Avail: NTIS HC A12/MF A01

An investigation of LORAN C pulses emitted at 100 kHz by the Sylt station (Federal Republic of Germany) and received at Brussels situated at 514 km is described. The pulses are analyzed digitally. After deconvolution of the received wave, the ground wave (already measured with high precision) is subtracted to obtain the reflected wave on the ionosphere. This analysis provides accurate results for time of arrival, amplitude, phase, and ECD of both ground and reflected waves. The heights of the D layer of the ionosphere are also given. Author

N82-27635# Telediffusion de France, Montrouge.
CONSIDERING THE SERVICE ZONE OF A POWERFUL TRANSMITTER BROADCASTING IN KILOMETRIC WAVES [CONSIDERATIONS SUR LA ZONE OF SERVICE D'UN EMETTEUR DE RADIODIFFUSION PUISSANT EN ONDES KIOMETRIQUES]
J. FONTEYNE *In* AGARD Medium, Long and Very Long Wave Propagation 8 p (SEE N82-27613 18-32) Aug. 1982 refs In FRENCH
Avail: NTIS HC A12/MF A01

France is one of the countries best served by broadcasting in the kilometric band. While signals are received from four transmitters (Allouis, Saarlouis, Radio Monte Carlo, and Radio Luxembourg), there is concern about the quality of reception, especially from Allouis, the national broadcasting transmitter, because the field of service of this transmitter has always been the entire territory. A study of the conditions of listening and of methods for improving confront led to the establishment of charts of zones of coverage (field contours). The diagram of favorable radiation, the effect of interference between ground and ionospheric waves, the eliminations of radioelectric interferences, and the formation of adequate antiparasite regulations are discussed.
Transl. by A.R.H.

N82-27636# British Broadcasting Corp., London (England). Div. of Engineering.
MEDIUM FREQUENCY PROPAGATION: A SURVEY
P. KNIGHT *In* AGARD Medium, Long and Very Long Wave Propagation 17 p (SEE N82-27613 18-32) Feb. 1982 refs
Avail: NTIS HC A12/MF A01

The propagation of ground waves and sky waves at medium frequencies is considered. Variations in daytime and nighttime propagation are discussed. Published ground wave propagation curves applying to land which is smooth and of uniform conductivity are discussed and method for calculating field strengths along mixed land-sea paths, over irregular terrain, and through built up areas are presented. Coupling losses occurring in sky wave propagation due to the existence of the gyromagnetic frequency band of the Earth within the medium frequency band are considered. Polarization coupling loss, which is of importance in tropical regions, and coupling loss between hops on multihop paths are discussed. Enhanced ionospheric cross modulation also occurs at the gyromagnetic frequency J.D.

N82-27637# Communications Research Centre, Ottawa (Ontario).
REDUCTION IN MF SKYWAVE FIELD STRENGTH AT NIGHT DUE TO MAGNETIC-STORM AND WINTER-ANOMALY-RELATED ABSORPTION
E. L. HAGG *In* AGARD Medium, Long and Very Long Wave Propagation 9 p (SEE N82-27613 18-32) Feb. 1982 refs
Avail: NTIS HC A12/MF A01

Results from a detailed analysis of one year of previously published field strength measurements, taken during high solar activity in 1974-48 at Ottawa on the 1020 kHz KDKA Pittsburgh emissions, show that the strength of the nighttime skywave is controlled by absorption from two apparently unrelated geophysical effects. One of these is the magnetic storm and post-storm effect and the other is the winter anomaly effect. The former effect was dominant throughout the year and was the only factor controlling the field strength during the March through September period. The two-monthly median field strength for this period showed a smooth decrease with increased magnetic activity, from 5 to 19 dB relative to an experimentally determined unabsorbed value. The latter effect was present sporadically during the October through February period. The reduction in field strength due to the winter anomaly alone was from 6 to 11 dB. Author

N82-27638# Bari Univ. (Italy). Inst. di Fisica.
ON THE DISTORTIONS OF THE MODULATED RADIOWAVES IN THE IONOSPHERE
M. CUTOLO, S. FELIZIANI (Camerion Univ.), and E. MORICONI (Naples Univ.) *In* AGARD Medium, Long and Very Long Wave Propagation 6 p (SEE N82-27613 18-32) Feb. 1982 refs
Avail: NTIS HC A12/MF A01

Ionospheric self-modulation at oblique angles of incidence of frequencies varying between 30 to 5000 Hz broadcast at 150 and 50 kW at 60% modulation is discussed. The dependence of the ionospheric distortion on emitting power is demonstrated. The amplitudes of the first, second, and third harmonics are demonstrated to vary as a function of the broadcast power, leading to the determination that the phenomenon is nonlinear. The modulation percentages of each harmonic were calculated using the Vilienskij equations. It was determined that the percentages of the second and third harmonics are too low in relation to those of the first harmonic and to the emitted percentage of the transmitter. J.D.

N82-27639# Camerino Univ. (Italy). Ist. di Fisica.
IONOSPHERIC SELF-MODULATION OF A MODULATED RADIOWAVE WITH FREQUENCY FAR FROM LOCAL GYROFREQUENCY
M. CUTOLO and G. GAFFURI *In* AGARD Medium, Long and Very Long Wave Propagation 12 p (SEE N82-27613 18-32) Feb. 1982 refs Sponsored in part by AF, C. N. R., and Ministero della P. I.
Avail: NTIS HC A12/MF A01

The dependence of self modulation on power transmission was studied. An increase in the percentage of received modulation as related to the percentage emitted by the transmitter and the dependence of demodulation or overmodulation on the electromagnetic power was observed. It is suggested that self modulation may have three difference behaviors and that modulation depends on the power emitted which is a nonlinear phenomenon. E.A.K.

N82-27640# Accademia Nazionale dei Lincei, Rome (Italy).
CALCULATION OF THE RESIDUAL MODULATION OF A MODULATED RADIOWAVE REFRACTED BY IONOSPHERE
L. CARLOMUSTO *In* AGARD Medium, Long and Very Long Propagation 3 p (SEE N82-27613 18-32) Feb. 1982 refs
Avail: NTIS HC A12/MF A01

Residual modulation of a modulated radiowave with variable power refracted by the ionosphere was calculated. Bailey's equation was applied for ionospheric equations of a wave refracted by ionosphere. Bailey's equation is utilized to obtain macroscopic quantities. It is shown that it is possible to have demodulation only, with low power and with low modulation frequency. E.A.K.

N82-27641# Middle East Technical Univ., Ankara (Turkey). Dept. of Electrical Engineering.
MEDIUM WAVE MULTI-SECTION GROUNDWAVE PROPAGATION IN MARMARA AND WEST BLACK-SEA REGION-NUMERICAL RESULTS
A. HIZAL and A. F. FER *In* AGARD Medium, Long and Very Long Wave Propagation 6 p (SEE N82-27613 18-32) Feb. 1982 refs
Avail: NTIS HC A12/MF A01

The medium wave (MF) propagation in maritime communication system in the Black Sea region was numerically analyzed. Two methods were applied: the flat ground two and four section ground wave propagation, and the integral equation solution. Attenuations up to 400 km are needed for estimating the requirements on the

transmitter power and the effective antenna height for manageable signal to noise ratios at this particular frequency. The four section formula obtained represents an efficient technique for prediction attenuation for the last sea section of the propagation path. It is shown that MF ground wave is a suitable mode of propagation for ship to shore communication system. E.A.K.

N82-27642# Naval Ocean Systems Center, San Diego, Calif. Electromagnetic Propagation Div.
NUMERICAL MODELING OF THE PROPAGATION MEDIUM AT ELF/VLF/LF
D. G. MORFITT, J. A. FERGUSON, and F. P. SNYDER *In* AGARD Medium, Long and Very Long Wave Propagation 13 p (SEE N82-27613 18-32) Feb. 1982 refs
Avail: NTIS HC A12/MF A01

Available procedures to determine ionospheric profiles to be used in computing reliable predictions of ELF/VLF/LF signal levels are presented. To design communications and navigational circuits at ELF/VLF/LF, knowledge of radio signal amplitude and phase characteristics are required. Accurate predictions of signal levels as a function of propagation frequency and range is important for reliable communication coverage. Computer programs based on *multimodel theory were developed.* The ionospheric electron density and collision frequency profiles are important quantities required to depict the real propagation environment. It is found that proper choice of exponential profile produces field strength levels simulate good experimental data. E.A.K.

N82-27643# Lockheed Missiles and Space Co., Palo Alto, Calif.
MODELING OF THE AMBIENT AND DISTURBED IONOSPHERE MEDIA PERTINENT TO ELF/VLF PROPAGATION
J. B. REAGAN, R. E. MEYEROTT, R. C. GUNTON, W. L. IMHOF, E. E. GAINES, and T. R. LARSEN (Norwegian Defence Research Establishment, Kjeller) *In* AGARD Medium, Long and Very Long Wave Propagation 9 p (SEE N82-27613 18-32) Feb. 1982 refs
(Contract N00014-79-C-0175)
Avail: NTIS HC A12/MF A01

The ion and electron concentration and the electrical conductivity in the ionospheric media during ambient and solar disturbance periods was modelled. Solar particle events (SPE) ranging from moderate to intense in magnitude and differing in spectral hardness are modelled to define the source terms and sometimes electron density profiles. It is shown that during intense SPE's the conductivity at 40 km can be increased over 200 times. The principal ELF attenuation occurs near the bottom of the ionosphere at 20 to 40 km. A secondary loss occurs near the top of the ionosphere due to ohmic dissipation with enhanced electron density. It is concluded that ionospheric modelling provides the basis for experiments with ELF propagation under solar particle disturbed conditions. E.A.K.

N82-27644# Rutherford High Energy Lab., Chilton (England).
MODELS OF THE MIDLATITUDE D REGION AT NOON
W. C. BAIN *In* AGARD Medium, Long and Very Long Wave Propagation 7 p (SEE N82-27613 18-32) Feb. 1982 refs
Avail: NTIS HC A12/MF A01

Two models for the electron density distribution in the D-region of the ionosphere for equinox noon and winter noon were developed. Propagation results are calculated for various frequencies in the 16 to 85 kHz frequencies and for distances below 1000 km and compared with measurements over the same frequency/distance combinations. E.A.K.

N82-27645# Naval Ocean Systems Center, San Diego, Calif.
OMEGA
E. R. SWANSON *In* AGARD Medium, Long and Very Long Wave Propagation 15 p (SEE N82-27613 18-32) Feb. 1982 refs
Avail: NTIS HC A12/MF A01

The Omega system with its major propagational characteristics *was examined. Omega is a long range, very low frequency* (VLF) radio navigation system which provides global coverage for ships and aircrafts. The VLF propagation and application to navigation, and signal coverage are reviewed. An overview is presented of Omega and its administration, synchronization, traditional applications, large ambiguity resolution, special applications, and *differential Omega. Combined systems using both Omega and* VLF communication signals are also mentioned. E.A.K.

N82-27646# Leicester Univ. (England). Dept. of Physics.
THE EFFECTS OF PROPAGATION OF THE ACCURACIES OF POSITIONS DETERMINED USING OMEGA IN THE UK
T. B. JONES and K. MOWFORTH *In* AGARD Medium, Long and Very Long Wave Propagation 29 p (SEE N82-27613 18-32) Feb. 1982 refs
Avail: NTIS HC A12/MF A01

Error correction derived from the ONSOD Omega prediction method were applied, an improvement in accuracy, and a different correction method, in which the Omega data are combined with *position determination from a satellite navigation system are* considered. The signals from three Omega transmitters located on different continents were monitored at three receiving sites in England. Lines of position (LOPs) are derived from the relative phases of the received signals and the intersection of the LOPs yields to receiver location. The derived receiver positions are compared with the known true position of the receivers and the error is determined. Diurnal and seasonal changes in position errors are obtained for all three receivers. At the most northerly receiving *site, the magnitudes of the errors are different from those observed* at the other two locations. E.A.K.

N82-27647# National Aeronautical Establishment, Ottawa (Ontario). *Flight Research Lab.*
THE USE OF VLF-COMMUNICATIONS FOR NAVIGATION
C. D. HARDWICK *In* AGARD Medium, Long and Very Long Wave Propagation 7 p (SEE N82-27613 18-32) Feb. 1982 refs
Avail: NTIS HC A12/MF A01

Very low frequency (VLF) navigation methods are outlined and compared to other systems. Performance results for typical stand alone systems and for one optimally integrated system with a simple Doppler *sensor are presented. It is suggested* that modification is made to the station, which will then enhance the effectiveness of VLF navigation. E.A.K.

N82-27648# *Colorado Research and Prediction Lab., Boulder.*
LORAN-C: AN OVERVIEW OF OPERATIONAL AND PROPAGATION CHARACTERISTICS
R. H. DOHERTY and J. R. JOHLER *In* AGARD Medium, Long and Very Long Wave Propagation 13 p (SEE N82-27613 18-32) Feb. 1982 refs
Avail: NTIS HC A12/MF A01

The Loran-C, a low frequency long range navigation system is discussed. The system's phase format and phase stability are *important for navigation and time synchronization.* Major calibration for the systems are oriented toward measurements. Loran-C pulse transmission allows distinction between ground wave and sky wave transmission. The pulse provides a transient capable of validating transient propagation theory. It is shown that the Loran-C transmissions are effective diagnostic tools for validating ground impedance and topographic models used in propagation theories. E.A.K.

N82-27649# Massachusetts Inst. of Tech., Cambridge. Dept. of Electrical Engineering and Computer Science.
ELECTROMAGNETIC FIELDS OF DIPOLE ANTENNAS IN THE PRESENCE OF LAYERED MEDIA
J. A. KONG, W. C. CHEW, and T. M. HABASHY *In* AGARD Medium, Long and Very Long Wave Propagation 8 p (SEE N82-27613 18-32) Feb. 1982 refs Sponsored in part by Schlumberger-Doll Research Center
Avail: NTIS HC A12/MF A01

Electromagnetic fields due to a dipole antenna in the presence of layered media were formulated in integral forms and solved with the following techniques: brute force integration methods; modal approach by finding the residues for the integrals; image *source approach by using the saddle point method; and hybrid* techniques with combinations of the above approaches. It is found that for very long wavelengths or for sufficiently thin layer thickness the normal mode approach is more useful, for shorter wavelength or thicker layers the image method is more efficient and accurate. Various numerical results are illustrated E.A.K.

N82-27650# Raytheon Co., Portsmouth, R. I.
NEW TECHNOLOGY FOR ELF RADIATORS: A REVIEW OF AIRBORNE, ROCKET-BORNE AND SPACE-BORNE ANTENNAS
M. D. GROSSI *In* AGARD Medium, Long and Very Long Wave Propagation 17 p (SEE N82-27613 18-32) Feb. 1982 refs
Avail: NTIS HC A02/MF A01

Engineering practicality of the ELF system which depends essentially upon the design parameters of the radiator at the transmitting terminal is discussed. Feasibility centers on the achievable intensity of the electric or magnetic moments. Long wires that trail an airplane or are suspended vertically from it are used as effective electric dipoles. Airborne loops, cryogenic and noncryogenic, are also considered. It is shown that there is a large source of electrodynamic primary power, that can be utilized to energize the ELF system. E.A.K.

N82-27651# LuTech, Inc., Berkeley, Calif.
SQUID TECHNOLOGY AND ITS COMING IMPACT ON COMMUNICATION SYSTEMS
C. D. TESCHE *In* AGARD Medium, Long and Very Long Wave Propagation 5 p (SEE N82-27613 18-32) Feb. 1982 refs
Avail: NTIS HC A12/MF A01

The superconducting quantum interference device (SQUID), a low noise flux to voltage transducer used in sensitive superconducting magnetometer systems, is discussed. The dc SQUID consists of a superconducting loop interrupted by two Josephson junctions. A lumped circuit element model for the dc SQUID is presented. The magnetic field resolution of a pick up coil coupled inductively to the device is derived as a function of the device parameters. The operation and resolution of a typical system and the development of high resolution devices with energy factors approaching the quantum limit are described. E.A.K.

N82-29527# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
ELECTROMAGNETIC PROPAGATION PROBLEMS IN THE TACTICAL ENVIRONMENT
Apr. 1982 155 p refs Lecture Series held in Munich, 3-4 May 1982 and Paris, 6-7 May 1982
(AGARD-LS-120; ISBN-92-835-1419-X; AD-A116412) Avail: NTIS HC A08/MF A01

Propagation criteria affecting the performance of electronic equipment under battlefield conditions are discussed. For individual titles, see N82-29528 through N82-29537.

N82-29528# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
GENERAL REVIEW OF EM SPECTRUM CHARACTERISTICS IN TACTICAL APPLICATIONS
H. J. ALBRECHT *In its* Electromagnetic Propagation Probl. in the Tactical Environ. 13 p (SEE N82-29527 20-32) Apr. 1982 refs
Avail: NTIS HC A08/MF A01

Characteristics of propagation media may have a more or less decisive influence upon the performance of systems used in any environment, and thus also in tactical applications. Atmospheric propagation media and their effects typically encountered in a tactical environment are summarized. In order to lead to and to supplement a more detailed treatment of particularly representative propagation conditions, features and limitations governed by the characteristics of media in various portions of the electromagnetic wave spectrum are considered. In addition to the discussion of the present state of the art, possible and feasible future development is addressed. J.D.

N82-29529# National Defence Headquarters, Ottawa (Ontario).
GROUND-WAVE PROPAGATION CHARACTERISTICS OF INTEREST TO THE TACTICAL COMMUNICATOR
F. H. PALMER *In* AGARD Electromagnetic Propagation Probl. in the Tactical Environ. p 16 (SEE N82-29527 20-32) Apr. 1982 refs
Avail: NTIS HC A08/MF A01

The effects of terrain and terrain cover on ground wave propagation at frequencies of interest to the tactical communicator are reviewed. Starting with the simplest case, that of free space propagation, complexities and subsequently added until most of the factors which relate to path loss, path loss variability, and multipath effects are addressed. It is demonstrated that propagation prediction and the choice of appropriate models is as much an art as a science. J.D.

N82-29530# National Telecommunications and Information Administration, Boulder, Colo. Applied Electromagnetic Science Div.
PROPAGATION ASPECTS OF IONOSPHERIC LINKS OVER SHORT AND MEDIUM DISTANCES
C. M. RUSH *In* AGARD Electromagnetic Propagation Probl. in the Tactical Environ. 15 p (SEE N82-29527 20-32) Apr. 1982 refs
Avail: NTIS HC A08/MF A01

Those aspects of ionospheric propagation that are pertinent to understanding, assessing, and predicting the performance of ionospheric-dependent radio links under tactical scenarios are described. Emphasis is given to those aspects of ionospheric propagation that compete for control of overall circuit performance: path geometry, signal loss, ionospheric structure and its variation with location and time, ionospheric parameters, and their relationship to circuit performance. The problems associated with predicting the performance of ionospheric links for long term planning purposes as well as for satisfying short term operational requirements are discussed. J.D.

N82-29531# Boston Univ., Mass. Dept. of Astronomy.
PROPAGATION CHARACTERISTICS OF SATELLITE LINKS
J. AARONS *In* AGARD Electromagnetic Propagation Probl. in the Tactical Environ. 28 p (SEE N82-29527 20-32) Apr. 1982 refs
Avail: NTIS HC A08/MF A01

Lower and upper atmospheric effects on signal characteristics of satellite transmissions are reviewed. The effects of importance produced by the ionosphere are the fading, caused by irregularities in the equatorial and high latitude ionospheres, the time delay errors produced by the passage of radiowaves through the ionospheric electrons, and absorption of the lower ionosphere at auroral and polar cap latitudes. The tropospheric effects include absorption by constituents and the problem of scattering of energy into unwanted polarizations. In some applications low angle effects of refraction and scintillation are also of importance. Author

N82-29532# Siemens A.G., Munich (West Germany).
LIMITATIONS IN SCATTER PROPAGATION
E. W. LAMPERT *In* AGARD Electromagnetic Propagation Probl. in the Tactical Environ. 11 p (SEE N82-29527 20-32) Apr. 1982 refs
Avail: NTIS HC A08/MF A01

A short description of the main scatter propagation mechanisms is presented; troposcatter, meteor burst communication and chaff scatter. For these propagation modes, in particular for troposcatter, the important specific limitations discussed are: link budget and resulting hardware consequences, diversity, mobility, information transfer and intermodulation and intersymbol interference, frequency range and future extension in frequency range for troposcatter, and compatibility with other services (EMC). Author

N82-29533# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
INTRODUCTION TO PROPAGATION EFFECTS ON TYPICAL SYSTEMS
H. J. ALBRECHT *In its* Electromagnetic Propagation Probl. in the Tactical Environ. 4 p (SEE N82-29527 20-32) Apr. 1982 refs
Avail: NTIS HC A08/MF A01

Depending on the actual application of a propagation path between two points, or within an area, a system may display particular behavior. In other words, its characteristics may be affected by certain propagation conditions. A general introduction to such effects is presented. Particular attention is paid to examples which allow the illustration of certain problems and possible remedies, and provide a basis for a more detailed discussion of propagation effects on typical systems. J.D.

N82-29534# North Atlantic Treaty Organization, Brussels (Belgium). Allied Radio Frequency Agency.
E.M. PROPAGATION PROBLEMS FOR TACTICAL RADIO RELAY SYSTEMS
T. K. FITZSIMONS *In* AGARD Electromagnetic Propagation Probl. in the Tactical Environ. 14 p (SEE N82-29527 20-32) Apr. 1982 refs
Avail: NTIS HC A08/MF A01

The designer or user of a tactical radio relay system is faced with a set of technical and operational problems that, for the most part, are not encountered by the designer of a fixed or non-tactical radio relay system. Although the EM propagation mechanisms for tactical and fixed systems are the same, since they both use the radio frequency spectrum from roughly 100 MHz up to tens of GHz, the problems of EM propagation manifest themselves in different ways and the considerations leading to equipment or system optimization are different. A tactical radio relay deployment is described and problems of siting the terminals are discussed. Propagation mechanisms such as refraction, reflection, diffraction, and fading are discussed and an assessment given of attenuation caused by rain. Statistical data based on field observations of a large tactical system are presented. Distributions of signal margin and link lengths are presented together with data on availability of line of sight paths. Different approaches to the prediction of performance are discussed, and likely trends in the use of higher frequency bands and the role of the computer assessed. J.D.

N82-29535# Royal Aircraft Establishment, Farnborough (England).
PROPAGATION PROBLEMS ASSOCIATED WITH AIRCRAFT COMMUNICATIONS SYSTEMS
B. BURGESS *In* AGARD Electromagnetic Propagation Probl. in the Tactical Environ. 10 p (SEE N82-29527 20-32) Apr. 1982 refs
Avail: NTIS HC A08/MF A01

Communications with mobiles is assuming increasing importance in a military context, with the advances in technology enabling not only greater amounts of information to be transferred, but also fostering a much harsher electromagnetic environment. The trend towards digital communications systems coupled with the possible demand for the wider bandwidths means that the propagation medium characteristics that influence the performance of these links are somewhat different from those that need to be addressed for narrowband analogue modulation transmissions. The various types of communications systems that are used with aeromobile platforms are reviewed and the various propagation problems that arise in achieving systems with good overall performance discussed. The links are conveniently divided into two types; beyond line of sight and line of sight systems, and span the frequency range from LF through to microwaves.
Author

N82-29536# *Siemens A.G., Munich (West Germany).*
SYSTEMS OF MULTIFUNCTION INFORMATION DISTRIBUTION AND FOR COMMAND, CONTROL AND COMMUNICATIONS-C3
E. W. LAMPERT *In* AGARD Electromagnetic Propagation Probl. in the Tactical Environ. 8 p (SEE N82-29527 20-32) Apr. 1982 refs
Avail: NTIS HC A08/MF A01

The areas where communication systems in support of command, control, and communications (C3) are used are indicated along with the fundamental characteristics of those systems. Presently, C3 systems heavily rely on voice transmission. The future data processing environment requirements demand highly sophisticated digital C3-systems. In this area the multifunction information distribution system (MIDS) is the best developed system concept. The different features a MIDS can offer to the user are described. These are information transmission, navigation, and identification. These features impose certain requirements upon the propagation path which result in limitations in frequency range, signal, and equipment design of the system. The joint tactical information distribution system (JTIDS) with both variants TDMA and DTDMA and the systeme integre d'identification, de navigation, de trafic control, d'anticollision, de communication (SINTAC) are described as representative examples of MIDS. The points emphasized are link protocols and hardware implementation. The capabilities of these systems are checked against user requirements and the limits within which these general requirements can be fulfilled are shown. Author

N82-29537# Royal Signals and Radar Establishment, Malvern (England).
PROPAGATION EFFECTS IN TACTICAL RADARS
B. A. PREW *In* AGARD Electromagnetic Propagation Probl. in the Tactical Environ. 11 p (SEE N82-29527 20-32) Apr. 1982
Avail: NTIS HC A08/MF A01

Tactical battlefield radars are employed in surveillance and target acquisition roles at ranges of approximately 1 to 20 km, their main targets being enemy ground vehicles and personnel. As with all types of radar the operating environment has a significant effect on the design and performance of these systems and propagation considerations are an important factor. The major propagation factors which limit the performance of tactical radars are the availability of line of sight, ground clutter, and effects of the weather. The ways in which propagation factors affect the choice of such radar parameters as frequency, polarisation, and RF waveform are discussed, and the ways in which propagation constraints can be minimised by the design of the signal processing system are considered. In an EW environment an important operational requirement is to minimize the probability of the location of the position of the radar by the enemy. Propagation effects such as multipath and diffraction are considered in broad terms in this context. Author

N83-17787# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
PROPAGATION EFFECTS OF ECM RESISTANT SYSTEMS IN COMMUNICATION AND NAVIGATION
Aug. 1982 169 p refs Proc. of 30th symp. held in Copenhagen, 24-28 May 1982 2 Vol.
(AGARD-CP-331; ISBN-92-835-1432-7) Avail: NTIS HC A08/MF A01

Propagation characteristics of the medium become more and more essential for the design of modern systems in communication, navigation and related fields. Steady advancement in adapting signal characteristics and modulation methods to modern transmission systems requires increasing attention to limitations governed by parameters other than technological ones. They mainly refer to effects caused by propagation media. Thus operational reliability may ultimately be controlled by the characteristics of this media or, in other words, by the anthropogenic capability of adapting systems to variations in medium behavior. A particularly important field of system-oriented applications concerns communication and navigation systems resistant to Electronic Counter Measures. Propagation limitations may be identified in terms of several categories in surface vicinity, general long-distance links, and medium-area coverage. The Symposium dealt with the present state-of-the-art; future possibilities were also discussed. For individual titles, see N83-17788 through N83-17800.

N83-17788# General Electric Co., Syracuse, N.Y.
HF RADAR IONOSPHERIC CLUTTER
G. H. MILLMAN *In* AGARD Propagation Effects of ECM Resistant Systems in Commun. and Navigation 13 p (SEE N83-17787 08-32) Aug. 1982 refs
Avail: NTIS HC A08/MF A01

The characteristics of HF radar echoes reflected from ionization irregularities aligned along the lines of force of the Earth's magnetic field are presented. Utilizing experimental radar-ionospheric clutter data acquired at frequencies between HF and UHF, an analysis is made of the amplitude, the cross-sectional area and the angular extent statistics of HF field-aligned echoes. The Doppler frequency variation, the frequency of occurrence and the diurnal and seasonal variation of HF ionospheric backscatter echoes and their correlation with solar-geophysical conditions are also discussed. Author

N83-17789# Exeter Univ. (England). Dept. of Physics
FAST FADING CHARACTERISTICS OF MEDIUM RANGE H.F. SIGNALS
V. B. MITCHELL *In* AGARD Propagation Effects of ECM Resistant Systems in Commun. and Navigation 3 p (SEE N83-17787 08-32) Aug. 1982 refs
Avail: NTIS HC A08/MF A01

Medium range (approximately 6000 km) h.f. signals are examined in some detail to establish their fast fading characteristics.

The data base consists of some 5,800 samples recorded in 1975 and 1976. The sample bandwidth is from 8Hz to 240Hz. Thus the results of this work are particularly applicable to estimating the performance of medium rate digital circuits which include similar h.f. radio links. In evaluating the characteristics particular attention was paid to obtaining a clear comparison between single propagation mode signals, where the fading is almost entirely due to the ionosphere, and multimode signals, where a proportion of the fading is due to inter-modal interference at the receiver. A mean ratio is obtained between two of the principal parameters of single and multimode signals and a method is suggested for application in channel simulation systems which is based on the experimental results. Author

N83-17790# German Military Geophysical Office, Traben-Trarbach (West Germany).
VHF-, UHF- AND SHF-PROPAGATION LIMITATIONS IN THE MARINE ATMOSPHERE
K. E. FISCHER *In* AGARD Propagation Effects of ECM Resistant Systems in Commun. and Navigation 22 p (SEE N83-17787 08-32) Aug. 1982 refs
Avail: NTIS HC A08/MF A01

In the marine atmosphere, evaporation ducts, elevated layers, and sea surface reflections are the main features of EM-wave propagation in the VHF-, UHF-, and SHF-bands over the sea. These propagation modes are discussed, especially their limiting effects on telecommunication and navigation systems, e.g. multipathing, pulse distortions, intercept susceptibility, and radar disintegration. Possibilities of analyzing/forecasting the limitation mentioned above are described. For example, applications of meteorological boundary layer theory and relations to simple ray theory and mode theory are suitable, such like actual meteorological measurements on board a ship and predictions and considerations on vertical and horizontally homogeneity of meteorological fields. It will be elucidated that, in many cases, no technical remedies exist to overcome limitations due to the marine atmosphere.
Author

N83-17791# National Telecommunications and Information Administration, Boulder, Colo. Inst. for Telecommunication Sciences.
THE ATMOSPHERIC PROPAGATION MEDIUM BETWEEN 45 AND 75 GHZ
H. J. LIEBE *In* AGARD Propagation Effects of ECM Resistant Systems in Commun. and Navigation 12 p (SEE N83-17787 08-32) Aug. 1982 refs
(Contract ARO-6-82)
Avail: NTIS HC A08/MF A01

The clear atmosphere (dry air mass) represents a unique filter over the 45 to 76 GHz range with frequency-dependent absorption properties caused by the microwave spectrum of oxygen not found at any lower frequency. The basic information necessary for determining molecular line, band, and continuum absorption is contained in a transfer function model. Close to sea level, an unstructured band exists, centered at 60 GHz with a half-width of 8 GHz and a pressure-dependent intensity that is corrected for pressure induced line overlap effects. At elevations above 12 km, the lines separate and radio channels with up to 400 MHz bandwidth can be accommodated between lines. Above 30 km, the line properties become polarization and orientation (i.e., with respect to the direction of a magnetic field) dependent due to the Zeeman effect. Each oxygen line splits proportionally with geomagnetic field strength (0.2-0.8 Gauss) into numerous sub-lines, which conform to Zeeman patterns extending over a megahertz scale around each line center. Using this model in computer routines in conjunction with distributions of pressure, temperature, and humidity along a radio path makes it possible to predict frequency-dependent signal attenuation and delay effects of the neutral atmosphere (h 0 to 100 km). Further analysis investigates possible bandwidth limitations of the propagation medium by employing short-pulsed (less than 1 ns) test signals with carriers in the 45 to 75 GHz range. Examples are presented of specific attenuation (dB/km) and excess delay (ps/km) rates, of zenith path attenuation (dB), and of pulse distortion over a terrestrial link (50 GHz, 35 km) for Gaussian, rectangular, and BPSK modulation. Benefits from the frequency-variable atmospheric properties include a fairly well defined signal range, affording transmission security and trade-offs between range and susceptibility to detection and interference. Author

N83-17792# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (West Germany). Unternehmensbereich Apparate.
MILLIMETER-WAVE PROPAGATION IN SURFACE VICINITY
W. D. SCHUCK and J. DETLEFSEN (Munich Technical Univ.) *In* AGARD Propagation Effects of ECM Resistant Systems in Commun. and Navigation 6 p (SEE N83-17787 08-32) Aug. 1982 refs Original language document announced as N83-13345
Avail: NTIS HC A08/MF A01

For short distance links without broadcasting requirements the use of mm-waves in connection with highly directive antennas is one approach to ECM-resistance. In case of short range surface-surface-missiles, e.g. high speed anti-tank guided weapons, where mechanical links like wire or optical fiber cannot be used, the application of mm-waves may be advantageous compared to the restricted performance of LASER links in a battlefield environment. Multipath fading especially over smooth ground covers like asphalt, requires diversity techniques and/or a transmitter power, which has to be essentially raised compared to a multipath-free LOS (line of sight) link. Thereby the vulnerability of the weapon system by ECM or hard weapon action is strongly affected, since the performance of tankborne ESM-equipment is a direct function of the transmitter power. The objective of the works presented in this paper is to determine propagation effects under various near-surface conditions. The measurement results are compared to theoretical models. Measurements are accomplished in the 35 GHz frequency band. Results are given for surfaces like asphalt, water, gravel and grass. Author

N83-17793# National Telecommunications and Information Administration, Boulder, Colo. Inst. for Telecommunication Sciences.
RELATIVE COST-BENEFITS ASSOCIATED WITH ALTERNATIVE TERRAIN REPRESENTATIONS IN ELECTRONIC WARFARE SIMULATION
J. P. MURRAY *In* AGARD Propagation Effects of ECM Resistant Systems in Commun. and Navigation 13 p (SEE N83-17787 08-32) Aug. 1982 refs
Avail: NTIS HC A08/MF A01

Terrain is widely recognized as a critical influence on VHF and UHF radio signal strengths, and hence on radio communications range. The same terrain influences have major effects on other aspects of tactical operations, particularly mobility of the tactical units. Both classes of influence are considered in various ways in simulating tactical operations. Planners are faced with a conflict between the need to represent physical circumstances as accurately as possible and constraints on the resources available to the planning process. Resources of principal concern are the funds available to develop adequate representations of terrain and their mathematical analogs, and the computational power and time required to apply them during the course of planning simulations. In many cases, the need to evaluate many signal paths in each o' many scenarios produces a computation-intensive process that forces approximations that are substantially cruder than the current state of the propagation prediction art could use to advantage. This paper describes several approaches to terrain treatment, summarizes their relative costs and benefits, and compares the benefits achieved in each case with the fidelity produced by comparable terrain considerations in mobility estimates. The effect on the interpretation of simulation results for both discrete and general studies is also discussed. Author

N83-17794# Mitre Corp., Griffiss AFB, N.Y.
PREDICTIONS OF MULTIPATH LEVELS FOR AIR-TO-AIR ECM-RESISTANT COMMUNICATION SYSTEMS
D. P. KOESTER *In* AGARD Propagation Effects of ECM Resistant Systems in Commun. and Navigation 16 p (SEE N83-17787 08-32) Aug. 1982 refs
Avail: NTIS HC A08/MF A01

The results of an investigation of the relative levels of reflected energy due to ground multipath propagation in Direct Sequence (DS) or Pseudorandom Noise (PN) modulated spread-spectrum systems are presented. Both specularly and diffusely reflected signals were examined with parametric assessments made as a function of airborne transmitter/receiver separation range,

transmitter/receiver altitudes and various terrain characteristics for a PN-modulated spread-spectrum system operating in the UHF band (225-400 MHz) with a 4 megabit-per-second chipping rate. Areas where multipath effects in wideband digital systems are dissimilar to those in narrowband systems are identified and examined. Computer modeling was used to calculate the ratio of reflected signal power to direct path signal power as a function of range for specularly reflected signals and as a function of the number of delayed chips and range for diffusely reflected signals. Author

N83-17795# Boston Univ., Mass. Dept. of Astronomy.
HF PROPAGATION FACTORS AFFECTING THE DESIGN AND OPERATION OF REAL TIME, CHANNEL EVALUATION, ADAPTIVE SYSTEMS
J. AARONS and M. D. GROSSI (Harvard-Smithsonian Center for Astrophysics) *In* AGARD Propagation Effects of ECM Resistant Systems in Commun. and Navigation 16 p (SEE N83-17787 08-32) Aug. 1982 refs
Avail: NTIS HC A08/MF A01

To develop and operate an adaptive system, propagation factors of the ionospheric medium must be given to the designer. The operation of the system must change as a function of multipath spread, Doppler spread, path losses, channel correlation functions, etc. In addition, NATO mid-latitude HF transmission and transauroral paths require varying system operation, which must fully utilize automatic path diversity across transauroral paths. Current research and literature are reviewed to estimate the extent of the available technical information. Additional investigations to allow designers to orient new systems on realistic models of these parameters are suggested. Author

N83-17796# Communications Research Centre, Ottawa (Ontario).
IMPLICATIONS OF THE TIME-VARIANT PROPERTIES OF THE HF SKYWAVE CHANNEL FOR THE DESIGN AND PERFORMANCE OF SMALL ADAPTIVE ANTENNA SYSTEMS
R. W. JENKINS *In* AGARD Propagation Effects of ECM Resistant Systems in Commun. and Navigation 14 p (SEE N83-17787 08-32) Aug. 1982 refs Sponsored in part by the Canadian Dept. of National Defence
Avail: NTIS HC A08/MF A01

The effect of propagation-related time variations on the performance of a 4-element adaptive array was studied by computer-modelling techniques. The signals were modelled to have time variation representative of those expected in HF naval communications, including Doppler shifts, antenna-independent fading, antenna-dependent polarization fading, position-dependent multipath fading and direction changes. Various techniques were modelled. The adaptation algorithms including the LMS algorithm, the LMS algorithm modified to include time-averaged estimates in the weight corrections, and the sample matrix inversion algorithm. The latter two techniques employed time-averaging. The modelled communications included either an additive coded pilot signal or a spread spectrum pilot code, to distinguish it from interference. The corresponding reference signal was either internally generated in the adaptive array, or derived from the output by appropriate filtering. The modelled time variations caused performance deterioration that depended on the adaptation of the array and the amount of time-averaging used. The faster-adapting algorithms performed best. Doppler-shift-associated performance deterioration for slow adapting algorithms was removed by including an output-derived reference. The performance deterioration was greater for longer averaging times. Averaging times between 20 and 50 ms were found to represent a good compromise between the conflicting requirements imposed by the improved statistical accuracy of longer times and the faster response to changes of shorter times. Author

N83-17797# AEG-Telefunken, Ulm (West Germany). Research Inst.
ADAPTIVE EQUALIZATION OF TROPOSCATTER CHANNELS WITH FSK MODULATION: PART 1. THEORY AND COMPUTER SIMULATION
E. BITZER *In* AGARD Propagation Effects of ECM Resistant Systems in Commun. and Navigation 9 p (SEE N83-17787 08-32) Aug. 1982 refs
Avail: NTIS HC A08/MF A01

The basic concept of an adaptive equalizer particularly suited for troposcatter channels with FSK modulation is presented. The three main features of the equalizer are: (1) a new error criterion which needs no explicit carrier synchronization; (2) a new nonlinear feedback branch for improving the equalizer performance and (3) a transversal filter structure, which uses only real coefficients for bandpass signals. The theoretical background of these features is sketched. The performance characteristics of the new equalizer are demonstrated and compared with the performance of conventional equalizers by discussing some simulation results for a data rate of 8.448 Mbit/s. Author

N83-17798# AEG-Telefunken, Backnang (West Germany).
ADAPTIVE EQUALIZATION OF TROPOSCATTER CHANNELS WITH FSK MODULATION: PART 2. HARDWARE STUDY AND MEASUREMENTS
U. BUSE *In* AGARD Propagation Effects of ECM Resistant Systems in Commun. and Navigation 13 p (SEE N83-17787 08-32) Aug. 1982
Avail: NTIS HC A08/MF A01

The experimentally derived performance of a preliminary hardware model of an adaptive equalizer is described. The structure of this equalizer was determined by theoretical investigations and simulation studies which were presented in the previous paper with the reference number 11. The novelty of the equalizer structure is the kind of error-signal derivation, which utilizes the constant IF envelope of the FSK modulation. Distortions in the troposcatter channel were generated by a channel simulator. Carried out were steady-state measurements with fixed tap-coefficients and dynamic measurements with sinusoidal tap-coefficients in the channel simulator. The efficiency of equalization can be determined by comparing the eye-patterns and the bit-error rate as a function of the carrier-to-noise ratio with the equalizer in and out of the circuit. It is possible to adjust for such severe distortions that, even with a high carrier-to-noise ratio, the bit stream cannot be detected. With the equalizer, this is again possible. The transient response of the equalizer was measured by changing the tap-coefficients in accordance with a step-function. The measured response time of the equalizer was about 15 microseconds. This makes the equalizer fast enough for troposcatter applications. Used as bit stream was a binary pseudo-random sequence without an additionally injected identification word at a bit rate of 8.448 Mbit/s. Author

N83-17799# National Telecommunications and Information Administration, Boulder, Colo. Inst. for Telecommunication Sciences.
OPERATIONAL IMPLICATIONS OF PROPAGATION MODELS USED IN COMMUNICATIONS EVALUATION IN TACTICAL ELECTRONIC WARFARE PLANNING
J. P. MURRAY *In* AGARD Propagation Effects of ECM Resistant Systems in Commun. and Navigation 9 p (SEE N83-17787 08-32) Aug. 1982 refs
Avail: NTIS HC A08/MF A01

Propagation models are used to estimate both desired and unwelcome signals in communications systems used in tactical military operations. The variability associated with propagation influences, particularly in the highly mobile and uncertain locales of representative scenarios, introduces unusual factors in the evaluation of simulation results. Practical constraints on resources that can be devoted to communications and jamming effects during simulation require various approximations. The several applications for which propagation models are used are identified and several descriptive classifications within which models may be evaluated are discussed. A series of performance measures popularly used in communications and electronic warfare planning are reviewed and are used as the basis for describing the implications which arise from the use of each class of models. Implications with regard to communications and jamming range, reliability, and detection range are discussed. Author

N83-17800# National Telecommunications and Information Administration, Boulder, Colo. Inst. for Telecommunication Sciences.
AN ATLAS OF PROPAGATION CURVES FOR TACTICAL ELECTRONIC WARFARE PLANNING IN GROUND-TO-GROUND SCENARIOS
J. P. MURRAY *In* AGARD Propagation Effects of ECM Resistant Systems in Commun. and Navigation 14 p (SEE N83-17787 08-32) Aug. 1982 refs
Avail: NTIS HC A08/MF A01

A series of 24 sets of propagation curves suitable for the prediction of communications and jamming system performance are presented. Curves are presented for frequencies of 50 and 300 MHz and transmitter heights from 1 to 200 meters. All curves are for path distances from 2 to 100 kilometers. Results are presented for reliability values of 10%, 50% and 90%. Calculations were made using the Irregular Terrain Model under continuing development at the Institute for Telecommunication Sciences.
Author

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ELECTRONICS AND ELECTRICAL ENGINEERING

Includes test equipment and maintainability; components, e.g., tunnel diodes and transistors; microminiaturization; and integrated circuity.

N80-31743# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
ATMOSPHERIC ELECTRICITY-AIRCRAFT INTERACTION
May 1980 227 p refs Lectures held in London, 9-10 Jun. 1980, in Munich, 12-13 Jun. 1980, and in Menlo Park, Calif., 24-25 Jun. 1980
(AGARD-LS-110; ISBN-92-835-1361-4; AD-A087976) Avail: NTIS HC A11/MF A01

The fundamentals of atmospheric electricity phenomena are reviewed with emphasis on the hazards, criteria, testing, and protection of aircraft. Insights are provided from both pilot and design perspectives. For individual titles, see N80-31744 through N80-31757.

N80-31744# Air Force Wright Aeronautical Labs., Wright-Patterson AFB, Ohio.
ATMOSPHERIC ELECTRICITY INTERACTIONS WITH AIRCRAFT: AN OVERVIEW
G. A. DUBRO *In* AGARD Atmospheric Elec.-Aircraft Interaction 11p (SEE N80-31743 22-33) May 1980 refs
Avail: NTIS HC A11/MF A01

Concern for the vulnerability of aircraft flight-critical and mission-critical avionics to atmospheric electricity hazards has increased over the last fifteen years. The major hazards of concern are lightning and static electrification. Two primary factors have contributed to a potentially increased threat to new generation aircraft: (1) increasingly widespread use of sensitive microelectronics in flight-critical and mission-critical electronic and electrical systems; and (2) the reduced electromagnetic shielding afforded by many advanced structural materials A description of the atmospheric electricity interaction with aircraft and the manner in which it impacts the aircraft avionics is summarized. Key areas of pertinent research and development are identified and the present state of the art in each of these key areas is presented.
E.D.K.

N80-31745# McDonnell Aircraft Co., St. Louis, Mo.
AIRCRAFT MISHAP EXPERIENCE FROM ATMOSPHERIC ELECTRICITY HAZARDS
D. W. CLIFFORD *In* AGARD Atmospheric Elec.-Aircraft Interaction 17 p (SEE N80-31743 22-33) May 1980 refs
Avail: NTIS HC A11/MF A01

Aircraft mishaps resulting from inflight lightning strikes can range from inconsequential to catastrophic A basic understanding of how lightning affects aircraft, based upon both military and commercial experience is established. Pilot reports of some representative incidents are described in detail, illustrating how the various atmospheric conditions and interaction mechanisms have affected aircraft operations. A summary of inflight mishap conditions is presented describing the range of flight circumstances under which aircraft are usually struck. The interaction of high current arcs with structural and external electrical hardware, the effects of electromagnetic coupling to interior avionics, and the effects of corona and high voltage sparking are also discussed.
E.D.K.

N80-31746# Tuebingen Univ. (West Germany).
PHENOMENOLOGY OF LIGHTNING/AIRCRAFT INTERACTION
R. P. MUEHLEISEN *In* AGARD Atmospheric Elec.-Aircraft Interaction 6 p (SEE N80-31743 22-33) May 1980 refs
Avail: NTIS HC A11/MF A01

Two types of lightning discharges having different characteristics are intracloud and cloud to cloud discharges and cloud to ground discharges. The many hypotheses of thundercloud electrification are introduced. Calculation results and graphs are given due to the electric field strength around thunderclouds. The distortion of these fields by aircraft bodies and the initiation of triggered lightnings are described.
E.D.K.

N80-31747# Lightning Technologies, Inc., Pittsfield, Mass.
SUSCEPTIBILITY OF AVIONICS TO LIGHTNING INDIRECT EFFECTS
J. A. PLUMER *In* AGARD Atmospheric Elec.-Aircraft Interaction 27 p (SEE N80-31743 22-33) May 1980 refs
Avail: NTIS HC A11/MF A01

The ways that lightning currents may flow in an airframe and basic mechanisms whereby these currents may induce transient voltages and currents in typical aircraft electrical circuits are described. Examples of induced voltages and currents measured during simulated lightning tests are presented and significant aspects are discussed, together with estimates of the ranges of induced voltages to be expected in typical circuits. Examples of the magnetic fields that are responsible for some of these induced effects are also presented. A discussion of the basic damage effects that lightning induced voltages may have on typical solid state electronic components is included.
E.D.K.

N80-31748# United Kingdom Atomic Energy Authority, Abingdon (England).
MODELS FOR ASSESSING HAZARDS DUE TO LIGHTNING
P. F. LITTLE *In* AGARD Atmospheric Elec.-Aircraft Interaction 14 p (SEE N80-31743 22-33) May 1980 refs Sponsored by the UK Ministry of Defence
Avail: NTIS HC A11/MF A01

The characteristics of lightning current pulses and the radiated fields produced by lightning are summarized. The transmission line model of the ground flash is considered and the derivation of the parameters of the line from the physical processes taking place is treated in various degrees of approximation. Changes in the shape of the current pulse occur as the return stroke is propagating and the implications of these changes in waveform are discussed. The transition from leader channel to return stroke channel may be regarded as a shock front and this aspect is explored also in respect of the leader advance. The coupling of fields and currents due to lightning into the aircraft when it forms part of the return stroke channel and when it is close to an independent stroke is considered in the light of these physical models.
Author

N80-31749# McDonnell Aircraft Co., St. Louis, Mo.
LIGHTNING TEST CRITERIA FOR AIRCRAFT AVIONICS SYSTEMS
D. W. CLIFFORD *In* AGARD Atmospheric Elec.-Aircraft Interaction 12 p (SEE N80-31743 22-33) May 1980 refs
Avail: NTIS HC A11/MF A01

The evolutionary history of the test criteria for lightning testing of aerospace systems and avionics equipment is presented along with a summary of the salient features and the rationale for selection of the parameters specified in the documents Test criteria are set forth in terms of the various current and voltage waveforms to be used in lightning tests. The simulation waveforms are based upon statistical summaries of the natural lightning environment Modern tests criteria documents account for the dynamic nature of the lightning interaction with aircraft by using the zonal concept to more accurately identify the threat to specific systems and

equipment. Test techniques can affect simulated lightning test results and the modern criteria documents include recommended practices for achieving accurate and consistent results. Some predictions of future changes in the criteria documents are made on the basis of information about the lightning threat based upon recent measurements of natural lightning. E.D.K.

N80-31750# McDonnell Aircraft Co., St. Louis, Mo.
LIGHTNING TESTING FOR AIRCRAFT AVIONICS SYSTEMS
D. W. CLIFFORD *In* AGARD Atmospheric Elec.-Aircraft Interaction 23 p (SEE N80-31743 22-33) May 1980 refs
Avail: NTIS HC A11/MF A01

The test techniques used to evaluate lightning effects on avionics equipment are discussed. The facilities necessary to produce the current and voltage waveforms specified in the criteria documents are briefly described as are the sensors and instrumentation used to measure and record the test data. Where test setup details can affect test results, the preferred techniques are described. Techniques for full vehicle tests are discussed briefly as they may impact the next generation of criteria documents. E.D.K.

N80-31751# United Kingdom Atomic Energy Authority, Abingdon (England).
THE COUPLING OF LIGHTNING FIELDS INTO AIRCRAFT AND CABLES
P. F. LITTLE *In* AGARD Atmospheric Elec.-Aircraft Interaction 14 p (SEE N80-31743 22-33) May 1980 refs Sponsored by the UK Ministry of Defence
Avail: NTIS HC A11/MF A01

The current distribution in the skin of an aircraft struck by lightning is described and the effects of airframe resonance are noted. Nearby strikes produce initially an electromagnetic pulse which is scattered by the aircraft, creating circulating currents in the skin: this process is considered. The magnetic fields at the surface diffuse into the skin, and significant currents flow on the interior after a time lag dependent on the skin resistivity. In addition, the surface fields couple directly into the interior through breaks in the conducting skin or through insulating panels. Methods of calculating the magnetic and electric fields in the interior of the aircraft are discussed, and the effects on electrical and electronic systems described. The screening of internal cabling is reviewed. Author

N80-31752# Lightning Technologies, Inc., Pittsfield, Mass.
PROTECTION OF AIRCRAFT AVIONICS FROM LIGHTNING INDIRECT EFFECTS
J. A. PLUMER *In* AGARD Atmospheric Elec.-Aircraft Interaction 26 p (SEE N80-31743 22-33) May 1980 refs
Avail: NTIS HC A11/MF A01

The estimation of magnitudes of voltages and currents induced on shielded and unshielded wiring, and the utilization of shields to reduce the level of these effects in sensitive circuits is discussed. Circuit design practices that also can be utilized to minimize induced effects are reviewed along with the various types of surge suppression devices that are available and the advantages and disadvantages of each. Transient coordination and methods of verification are discussed. M.G.

N80-31753# Lightning Technologies, Inc., Pittsfield, Mass.
LIGHTNING EFFECTS ON AIRCRAFT: A COCKPIT PERSPECTIVE
J. A. PLUMER *In* AGARD Atmospheric Elec.-Aircraft Interaction 12 p (SEE N80-31743 22-33) May 1980 refs
Avail: NTIS HC A11/MF A01

Typical conditions in which strikes have been experienced by large and small aircraft are described, together with effects as experienced by flight crews. Most strikes have occurred when the aircraft is flying at between 3000 and 5000 meters altitude, where the outside air temperature is within 5 deg of 0 C and there exists a light to moderate amount of precipitation. Strikes to aircraft have, however, occurred at altitudes as high as 12,000 m and also when the aircraft are parked on the ground. If an aircraft approaches a highly electrified region it may actually trigger a strike, especially if the aircraft is large and causes a significant perturbation in the nearby electric field. Aircraft lightning strike mechanisms, effects to avionics and electric power systems, engine effects, and effects to personnel are addressed. M.G.

N80-31754# Office National d'Etudes et de Recherches Aeronautiques, Paris (France).
BASIC PHENOMENOLOGY OF ELECTRICAL DISCHARGES AT ATMOSPHERIC PRESSURE
J. TAILLET *In* AGARD Atmospheric Elec.-Aircraft Interaction 19 p (SEE N80-31743 22-33) May 1980 refs
Avail: NTIS HC A11/MF A01

The mechanism of three types of discharge induced by static charging (spark, corona, and surface streamers) is described in detail. From this mechanism, the radioelectric noise emitted by these discharges is predicted. It is concluded that sparks and surface streamers are generators of powerful radioelectric disturbances. Proper bonding eliminates sparks and specific treatments suppress surface discharges. Coronas are necessary for getting rid of the accumulated static charge. On the one hand, attention should be given to reducing as much as possible the coupling between coronas discharges and antennas of the avionic system. On the other hand, use of corona microdischarges can bring a further improvement in static noise reduction. M.G.

N80-31755# SRI International Corp., Menlo Park, Calif. Electromagnetic Sciences Lab.
STATIC CHARGING EFFECTS ON AVIONIC SYSTEMS
J. E. NANEVICZ *In* AGARD Atmospheric Elec.-Aircraft Interaction 15 p (SEE N80-31743 22-33) May 1980 refs
Avail: NTIS HC A11/MF A01

The electromagnetic character of various noise sources--corona discharge, surface streamers, and spark discharges are discussed. The results of flight tests and laboratory discharge simulations are given. In general, the source data exist both as time domain waveforms and as frequency domain spectra. The differences between the noise signals generated by the different sources are discussed, and the dependence of noise levels on aircraft charging current are indicated. Results of laboratory determinations of coupling between source locations and antennas are also presented together with the results of flight test experiments conducted to verify the coupling information. Finally, the source data is combined with the coupling information to predict the equivalent noise fields to be expected at typical antenna locations on aircraft. These noise fields are compared to atmospheric noise levels to determine the degree of system performance degradation that can result from precipitation static noise. M.G.

N80-31756# SRI International Corp., Menlo Park, Calif. Electromagnetic Sciences Lab.
ALLEVIATION TECHNIQUES FOR EFFECTS OF STATIC CHARGING ON AVIONICS
J. E. NANEVICZ *In* AGARD Atmospheric Elec.-Aircraft Interaction 14 p (SEE N80-31743 22-33) May 1980 refs
Avail: NTIS HC A11/MF A01

The various mechanisms by which static charging of aircraft affects avionic systems are identified, and techniques to mitigate the effects are described. Noise reduction schemes intended to eliminate aircraft charging itself are confined to the elimination of surface streamer discharges on electrically insulating frontal surfaces by coating the surface with electrically conductive material. This procedure allows the charging current to flow off the surface as rapidly as it arrives without generating noise. Another technique for eliminating surface streamer noise at the source is simply to relocate insulating materials (i.e., antenna insulating materials) to regions at the aft of the aircraft where they will not be charged by impinging precipitation particles or to install particle deflectors upstream of the dielectric surface. Successful techniques for the control of corona discharge noise involve forcing the discharge to occur from special discharging devices installed at high field regions on the aircraft where corona discharges are likely to occur naturally. The dischargers are designed to reduce the corona source intensity and to decouple the discharge source from the airframe. Practical dischargers are capable of reducing corona discharge noise by as much as 60 dB. Noise generated by sparking between sections of the metal structure can be eliminated by electrical bonding of all portions of the structure. Descriptions of techniques demonstrated by laboratory and flight tests to be successful in controlling precipitation charging interference are given. M.G.

N80-31757# Office National d'Etudes et de Recherches Aeronautiques, Paris (France).
AIRCRAFT STATIC CHARGING TESTING
J. TAILLET *In* AGARD Atmospheric Elec.-Aircraft Interaction 7 p (SEE N80-31743 22-33) May 1980 refs
Avail: NTIS HC A11/MF A01

A procedure is proposed for: (1) characterizing in the laboratory the effects of aircraft charging on the operation of unprotected navigation and communication systems; (2) assessing in the laboratory the validity of the protective methods; (3) checking in the factory the correct application of these methods; (4) routine testing between flights, in the field, of the good condition of the protecting devices and treated surfaces. A test method is developed which would include checking the bonding between metallic surfaces, measuring the value of surface resistance of semi-conductive coatings or resistive paints deposited over insulating substrate, simulating tribo-electric charging or charge collection separately on any surface element of the aircraft, and verifying that the coupling between dischargers and antennas is minimal. M.G.

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FLUID MECHANICS AND HEAT TRANSFER

Includes boundary layers; hydrodynamics; fluidics; mass transfer; and ablation cooling.

N80-23620# *Advisory Group for Aerospace Research and* Development, Neuilly-Sur-Seine (France). Propulsion and Energetics Panel.
TURBULENT TRANSPORT PHENOMENA
M. L. BARRERE (ONERA, Paris) Feb. 1980 51 p refs
(AGARD-AR-150; ISBN-92-835-0259-0; AD-A083430) Avail: NTIS HC A04/MF A01

Methods of making scalar measurements in hot turbulent flow and in combustion flow are examined. The advantages and drawbacks of employing either optical or probe methods for temperature measurements are outlined; for nonconstant concentration and density, spontaneous Raman scattering, methods making use of fluorescence perturbation phenomenon, and coherent anti-Stokes Raman scattering techniques are described. Finally, probe and indirect methods for pressure fluctuation measurements are suggested. M.G.

N80-27647# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
TURBULENT BOUNDARY LAYERS: EXPERIMENTS, THEORY AND MODELING
Jan. 1980 386 p refs Mainly in ENGLISH; partly in FRENCH Presented at the Fluid Dyn. Panel Symp., The Hague, 24-26 Sep. 1979
(AGARD-CP-271; ISBN-92-835-0257-4; AD-A086715) Avail: NTIS HC A17/MF A01

Experimental and theoretical research directed towards understanding the turbulent boundary layer in both incompressible and compressible fluid flow is presented. Specific topics discussed include: computer modeling techniques, coherent vortex structures, flow visualization, hot wire anemometry, nonlinear vortex interactions, decomposition of fluctuating flow fields, and turbulence during, or immediately following transition. For individual titles, see N80-27648 through N80-27672.

N80-27648# Ecole Centrale de Lyon (France). Lab. de Mecanique des Fluides.
EXPERIMENTAL METHODS AND TECHNIQUES IN TURBULENT BOUNDARY LAYER RESEARCH
G. COMTE-BELLOT *In* AGARD Turbulent Boundary Layers 35 p (SEE N80-27647 18-34) Jan. 1980 refs
Avail: NTIS HC A17/MF A01

The state-of-the-art of methods and techniques available to investigate turbulent boundary layers is surveyed. Three specific areas are discussed: objectives of boundary layer research, transducer techniques, and signal processing techniques. R.E.S.

N80-27649# Centre National de la Recherche Scientifique, Marseilles (France). Inst. de Mecanique Statistique de la Turbulence.
AN EXPERIMENTAL STUDY OF INWARD AND OUTWARD FLOW IN A TURBULENT BOUNDARY LAYER [ETUDE EXPERIMENTALE DES APPORTS ET DES EJECTIONS DE FLUIDE DANS UNE COUCHE LIMITE TURBULENTE]
M. ELENA, L. FULACHIER, and R. DUMAS *In* AGARD Turbulent Boundary Layers 21 p (SEE N80-27647 18-34) Jan. 1980 refs In FRENCH; ENGLISH summary
Avail: NTIS HC A17/MF A01

Experimental results concerning the structure of the internal and external zone of the boundary layer are presented. In the viscous sublayer, the flow has obvious intermittent characteristics; particularly the inward flows from regions which are farther from the wall prevail over the outward flows and penetrate the sublayer randomly. As the number of inward flow decreases with uncreasing distance from the wall, it becomes of the same order as the number of outward flow in the fully turbulent region. The measurements of the space-time correlations reveal that, at least in the internal region, there exists a linkage between the inward and outward flows, the latter being the more dominating. Measurements of conditional probabilities show that the trajectories of these disturbances are in agreement with the trajectories obtained through visualizing or measuring thermal diffusion from a point located at the wall. Additionally, measurements of three point space-time correlations indicate that the outward flows are more coherent and spanwise thinner than the disturbances corresponding ti the inward flow. These outward flows expend when moving off the wall and diffuse through the boundary layer. R.E.S.

N80-27650# Koninklijke/Shell-Laboratorium, Amsterdam (Netherlands).
EXPERIMENTAL STUDY OF COHERENT STRUCTURES IN THE TURBULENT BOUNDARY LAYER OF PIPE FLOW USING LASER-DOPPLER ANEMOMETRY
H. R. E. VANMAANEN *In* AGARD Turbulent Boundary Layers 20 p (SEE N80-27647 18-34) Jan. 1980 refs
Avail: NTIS HC A17/MF A01

The coherent structures in the turbulent boundary layer of a pipe flow were investigated. These structures, often called bursts, are thought to be the main mechanism involved in the generation and maintenance of turbulence in flow. Measurements were carried out in a pipe 6 m long and 50 mm in internal diameter, filled with water, using a laser-Doppler velocimeter, down to 0.25 mm from the wall, with the size of the measuring volume in radial direction being 0.1 mm. The output signal of the laser-Doppler anemometer, which can be regarded as the flow velocity, was fed into a burst detector and into an electronic delay line. The output signal of the burst detector was used to conditionally average the delayed signal. The conditional averages close to the pipe wall ($y(+)$ approximately equal to 20) were in good agreement with those found by Blackwelder and Kaplan, but further from the wall significant deviations were observed. Burst phenomena even for $y(+) = 100$ were found indicating that the structure is bigger than expected. Results of the measurements of the burst frequency spread as a function of the Reynolds number, as well as the conditional averages, are presented. R.E.S.

N80-27651# New York Univ., New York. Dept. of Applied Science.
TURBULENT BOUNDARY LAYER AT LOW AND HIGH SUBSONIC SPEEDS
V. ZAKKAY, V. BARRA, and K. HOZUMI *In* AGARD Turbulent Boundary Layers 20 p (SEE N80-27647 18-34) Jan. 1980 refs
Avail: NTIS HC A17/MF A01

Results of simultaneous measurements of velocity, wall pressure, and wallshear fluctuations in a turbulent boundary layer are presented. The results were analyzed in an attempt to obtain a description of the coherent or quasiordered structure of the boundary layer turbulence. On a large scale, the boundary layer is dominated by vortical structures which extend to the viscid-inviscid region. The wall region is dominated by the so called bursting process. The relationship or interaction between the large scale outer structure and the turbulent bursts is still not clearly defined. The results of this investigation at high speed, while confirming some of the previous results with regard to the mean period between coherent events, and their geometrical

configuration, did not yet resolve the question as to whether at high subsonic speeds there is, besides the outer flow processes, a distinct inner region. With the limited instrumentation available it was not possible at the high subsonic speed to resolve any inner sublayer region, although it was found that the outer flow structures exert a strong influence on the wall. The experimental results at low subsonic speeds, on the other hand, did identify an inner and outer region, and duplicated some of the results obtained at low subsonic speed by other investigations. R.E.S.

N80-27652# Wright State Univ., Dayton, Ohio
COHERENT STRUCTURES IN TIME DEPENDENT SHEAR FLOWS
H. VIETS *In* AGARD Turbulent Boundary Layers 14 p (SEE N80-27647 18-34) Jan. 1980 refs
(Contract AF-AFOSR-3525-78)
Avail: NTIS HC A17/MF A01

The existence of large scale coherent structures in forced unsteady flows is demonstrated. The time dependency is produced in the free jet case by a fluidically controlled flapping jet and in the wall boundary layer case by a mechanical vortex generator. Advantages of the unsteady flows and similarities to steady turbulent shear flow structure are discussed. Author

N80-27653# Royal Aircraft Establishment, Farnborough (England). Aerodynamics Dept.
AN INVESTIGATION OF THE STRUCTURE OF EQUILIBRIUM TURBULENT BOUNDARY LAYERS
L. F. EAST and W. G. SAWYER *In* AGARD Turbulent Boundary Layers 19 p (SEE N80-27647 18-34) Jan. 1980 refs
Avail: NTIS HC A17/MF A01

Seven low speed equilibrium boundary layer flows ranging from mildly favorable pressure gradients to adverse pressure gradients almost sufficient to cause incipient separation are described. The flows are turbulent and second and third order correlations of the turbulence are included in addition to measurements of the mean flow. The flow parameters are shown to be consistent with existing equilibrium loci. It is also shown that the law of the wall applies to all the flows and that therefore the value of von Karman's 'constant' in the mixing length formulation of shear stress must vary. The data strongly support the concept of gradient diffusion and it is demonstrated that for flows in strong adverse pressure gradient the shear stress gradient results from the strong diffusion of turbulence towards the wall and not from changes in the dissipation term. Thus, although the mixing length is dependent upon pressure gradient, the dissipation length is not. R.E.S.

N80-27654# British Columbia Univ., Vancouver. Dept. of Mechanical Engineering.
EQUILIBRIUM BOUNDARY LAYERS OVER VERY ROUGH SURFACES
I. S. GARTSHORNE and K. A. DECROOS *In* AGARD Turbulent Boundary Layers 11 p (SEE N80-27647 18-34) Jan. 1980 refs
Avail: NTIS HC A17/MF A01

Commonly used wall shear stress correlations appropriate for rough walls imply a degree of equilibrium between the boundary layer and the wall. For two roughness geometries examined experimentally in zero pressure gradient, equilibrium in the mean velocity appears to exist beyond 350 times the roughness height from the origin of roughness. For moderately close spacing of simple three dimensional roughness elements, a correlation due to Dvorak appears accurate; for less dense spacing (but still fully rough conditions) the correlation underestimates the wall stress significantly. The equilibruim boundary layer studied experimentally showed unexpectedly large turbulent intensities, constant integral length scales, no region of constant stress and a semi-logarithmic region best described with a von Karman constant of 0.36 + or - 02. Author

N80-27655# Centre d'Essais Aeronautique Toulouse (France).
TURBULENCE BEHAVIOR IN A SHOCK WAVE/BOUNDARY LAYER INTERACTION
P. ARDONCEAU, D. H. LEE, T. A. DEROQUEFORT, and R. GOETHALS *In* AGARD Turbulent Boundary Layers 14 p (SEE N80-27647 18-34) Jan. 1980 refs
Avail: NTIS HC A17/MF A01

Two dimensional shock wave boundary layer interaction was investigated. Experiments were carried out at a nominal Mach number of 2.25 for three compression corners of 8 deg, 13 deg and 18 deg corresponding respectively to attached flow, incipient separation, and well separated flow. The measurements involved wall static pressure, static and total pressure profiles, determination of the mean and root of mean square fluctuations of the u and v velocity components with a laser Doppler anemometer, hot wire measurements of the mass flow flutuations, and spectrum analysis of the hot wire signal. R.E.S.

N80-27656# Imperial Coll. of Science and Technology, London (England). Dept. of Mechanical Engineering.
LONGITUDINAL VORTICES IN CONCAVE SURFACE BOUNDARY LAYER
R. I. CRANE, and S. H. WINOTO *In* AGARD Turbulent Boundary Layers 10 p (SEE N80-27647 18-34) Jan. 1980 refs
Avail: NTIS HC A17/MF A01

Local measurements of mean and fluctuating velocity by laser anemometer were made inside the developing concave surface boundary layer in a free surface water channel at Reynolds numbers up to 16000. Concave surface radius was 3.5 times channel width and the ratio of spanwise mean boundary layer thickness to surface radius ranged between 0.03 and 0.11. Systems of longitudinal vortices developed without artificial triggering. Vortex wavelength varied across the span by as much as a factor of 2, but mean wavelength was typically 1.3 times the boundary layer thickness and did not vary significantly in the flow direction. Continuous vortex growth at Reynolds number 9800 contrasted with apparent breakup of the vortices at Reynolds number 16000. R.C.T.

N80-27657# Technische Univ., Berlin (West Germany). Herman-Foettinger-Inst. fuer Thermo und Fluiddynamik.
A DISCUSSION OF PROBE EFFECTS AND IMPROVED MEASURING TECHNIQUES IN THE NEAR-WALL REGION OF AN INCOMPRESSIBLE THREE-DIMENSIONAL TURBULENT BOUNDARY LAYER
J. D. VAGT and H. H. FERNHOLZ *In* AGARD Turbulent Boundary Layers 17 p (SEE N80-27647 18-34) Jan. 1980 refs
Avail: NTIS HC A17/MF A01

Comprehensive measurements of mean and fluctuating velocities and shear stresses are provided. It is shown that measuring techniques for such measurements are improved, especially in the near wall region of a pressure driven three dimensional boundary layer on a curved wall. R.C.T.

N80-27658*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
DEVELOPMENTS IN THE COMPUTATION OF TURBULENT BOUNDARY LAYERS
M. W. RUBESIN *In* AGARD Turbulent Boundary Layers 23 p (SEE N80-27647 18-34) Jan. 1980 refs
Avail: NTIS HC A17/MF A01 CSCL 20D

Two methods of turbulence computation are discussed in terms of their basic similarities. It is shown that the two methods are interrelated and that each can gain from advances in the other. The degree of success of a pair of increasingly complex Reynolds stress models to broaden their range of applicability is examined through comparison with experimental data for a variety of flow conditions. An example of a large eddy simulation is presented, compared with experimental results, and used to evaluate the models for pressure rate of strain correlation and dissipation in the Reynolds averaged equations. R.C.T.

N80-27659*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
A NAVIER-STOKES FAST SOLVER FOR TURBULENCE MODELING APPLICATIONS
J. D. MURPHY and M. W. RUBESIN *In* AGARD Turbulence Boundary Layers 16 p (SEE N80-27647 18-34) Jan. 1980 refs
Avail: NTIS HC A17/MF A01

A computer code for the evaluation and/or optimization of the predicative potential of second order turbulent closure models in simple two dimensional flow configurations is discussed. A procedure for the numerical solution of the steady constant property Navier-Stokes equations are described together with algebraic, one dimensional and two dimensional equations of turbulence closure models. Four turbulence models are compared with several sets of experimental data. The effects of initial conditions and boundary

conditions are also described. The effects of purely numerical parameters, such as mesh size, boundary locations, and convergence criteria are presented R.C.T.

N80-27660*# California Univ., Davis.
REYNOLDS STRESS CLOSURES: STATUS AND PROSPECTS
B. E. LAUNDER *In* AGARD Turbulent Boundary Layers 13 p (SEE N80-27647 18-34) Jan. 1980 refs
(Contract NSG-2256)
Avail: NTIS HC A17/MF A01 CSCL 20D

The basic pattern of Reynolds closures and the reason they look as an attractive type of model for practical shear flow calculations is summarized. The relationship between the organized structures and Reynolds stress closures is discussed. An outline given of fundamental developments that are being introduced to extend the modest reliability of Reynolds stress closures. R.C.T.

N80-27661*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
LARGE EDDY SIMULATION OF TURBULENT CHANNEL FLOW: ILLIAC 5 CALCULATION
J. KIM and P. MOIN *In* AGARD Turbulent Boundary Layers 18 p (SEE N80-27647 18-34) Jan. 1980 refs
Avail: NTIS HC A17/MF A01 CSCL 20D

The capabilities of large eddy simulation in the prediction and analyses of wall-bounded turbulent shear flows are demonstrated. The dynamical equations for large scale field motions are derived. The computational grid network is described and its relation to the observed physical length scales in the flow are discussed. Some aspects of the mechanics and structure of the flow are examined both in the vicinity of the wall and in regions away from the wall. An attempt is made to correlate numerical results with laboratory observations. Other significant observations and conclusions are presented. R.C.T.

N80-27662# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France)
A TURBULENCE CLOSURE OF THE TRANSPORT EQUATION FOR THE PROBABILITY DENSITY OF VELOCITY
M. M. RIBEIRO (CTAMFUL-DTA, Lisbon) *In its* Turbulent Boundary Layers 12 p (SEE N80-27647 18-34) Jan. 1980 refs
Avail: NTIS HC A17/MF A01

A proposal for a first order closure of the hierarchy of transport equations for the probability density of velocity in a turbulent field is presented. The fluid is assumed to be incompressible and Newtonian. The effects of the pressure deviations on the probability density are modelled based on the assumption of homogeneous behavior of the flow field. The closure is shown to be compatible with a well-known Reynolds stresses closure. Particular attention is given to the physical implications of the assumptions embodied in the modelling of the unknown terms that occur in the exact equation R.C.T.

N80-27663# Douglas Aircraft Co., Inc., Long Beach, Calif.
MODELLING REQUIREMENTS FOR THE CALCULATION OF THE TURBULENT FLOW AROUND AIRFOILS, WINGS AND BODIES OF REVOLUTION
T. CEBECI and H. U. MEIR (Deutsche Forschungs- und Versuchsanstalt Fuer Luft- und Raumfahrt, Goettingen, West Germany) *In* AGARD Turbulent Boundary Layers 12 p (SEE N80-27647 18-34) Jan. 1980 refs
(Contract N00019-78-M-0466)
Avail: NTIS HC A17/MF A01

The merits of turbulence models were considered for the calculation of the flow around geometric configurations of relevance to airplane and missile design. Calculated results obtained with three turbulence models were compared to each other and to the boundary layer measurements. Significant results are reported. R.C.T.

N80-27664# Norges Tekniske Hoegskole, Trondheim. Inst. for Mekanikk.
THE TURBULENT BOUNDARY LAYER AND THE CLOSURE PROBLEM
L. N. PERSEN *In* AGARD Turbulent Boundary Layers 5 p (SEE N80-27647 18-34) Jan. 1980 refs
Avail: NTIS HC A17/MF A01

Previous attempts to establish a proper phenomenological relation for turbulent flows are reviewed followed by a suggested approach to the problem in the case of a turbulent boundary layer. An attempt is made at showing the extreme flexibility that such a relation must exhibit if it is to account for effects of outside conditions and pre-history of the flow. By selecting proper 'inner variables' as parameters and properly characterizing the outer flow it is shown how a sufficiently general phenomenological relation can be established and how the closure problem may thus be considered in a different perspective. M.G.

N80-27665# National Aerospace Lab., Amsterdam (Netherlands).
BOUNDARY LAYER MEASUREMENTS ON A TWO-DIMENSIONAL WING WITH FLAP AND A COMPARISON WITH CALCULATIONS
B. VANDENBERG and B. OSKAM *In* AGARD Turbulent Boundary Layers 14 p (SEE N80-27647 18-34) Jan. 1980 refs
Avail: NTIS HC A17/MF A01

Measurements performed on a wing flap configuration which was so designed that flow separations occur nowhere apart fro... a small laminar separation bubble on the wing nose are presented and discussed. The measurements comprise surface pressure measurements, boundary layer and wake traverses at 16 stations, and flow visualization tests to establish the presence of separation bubbles and boundary layer transition regions. The data resolve the various flow phenomena sufficiently well to provide a significant test case for calculation methods for the flow around multielement airfoils. Comparison with such a calculation method showed satisfactory agreement in many respects. A need for improved modelling was found to exist in some regions, particularly for the wing wake above the flap. M.G.

N80-27666# Aix-Marseilles Univ. (France).
THREE-DIMENSIONAL TURBULENT BOUNDARY LAYER: RESTRUCTURATION OF AN AXISYMMETRIC FLOW TO A DISCONTINUITY OF THE WALL PERIPHERAL VELOCITY [COUCHE LIMITE TURBULENTE TRIDIMENSIONNELLE: TRIQUE SOUMIS A UNE DISCONTINUITE DE LA VITESSE DE PAROI]
E. ARZOUMANIAN, L. FULACHIER, J. COUSTEIX (ONERA, Toulouse), and B. AUPOIX (ONERA, Toulouse) *In* AGARD Turbulent Boundary Layers 11 p (SEE N80-27647 18-34) Jan. 1980 refs
Avail: NTIS HC A17/MF A01

The influence of the rotation of a cylinder on the restructuration of a developing three dimensional boundary layer is studied by using the analysis of the mean velocity field. A three dimensional turbulent boundary layer is developed on a circular cylinder the axis of which is parallel to the flow. In the downstream region the boundary layer is fully developed and the rear part of the cylinder rotates about its axis. The peripheral velocity at the wall is practically equal to the external velocity. The model used can account for the inequality of the turbulent shear stress direction and the velocity gradient direction. Emphasis is placed on the study of the buffer layer down to the viscous sublayer. The measurements reveal that the collaterality of the flow is first obtained in a very thin region near the wall and then seems to extend progressively in the boundary layer. In contrast, the calculations indicate a more extended linear portion of the hodograph. M.G.

N80-27667# Max-Planck-Institut fuer Stroemungsforschung, Goettingen (West Germany).
EVIDENCE FOR INSTABILITY-WAVES IN THE VELOCITY-FIELD OF A FULLY DEVELOPED TURBULENT CHANNEL-FLOW
M. HOFBAUER *In* AGARD Turbulent Boundary Layers 5 p (SEE N80-27647 18-34) Jan. 1980 refs
Avail: NTIS HC A17/MF A01

The results from hot film measurements and quantitative visual investigations, performed in the turbulent flow of an oil-channel at

a low Reynolds number (Re 8000), are discussed. The main result of the hot film measurements is the power spectrum of the v-component of the fluctuating velocity. The power spectrum has regular maxima and minima. The frequencies corresponding to the maxima of the power spectrum are plotted as a function of the order n of the maxima. This graph demonstrates that the frequencies of the maxima are the harmonics of a fundamental frequency which are determined to be about 0.15 Hz. An estimation shows that the fundamental frequency is of the same order of magnitude as the roughly calculated unstable Tollmien-Schlichting frequencies of the mean turbulent velocity profile. This fundamental frequency is interpreted as the most excited frequency of Tollmien-Schlichting-like instability waves. The harmonics are believed to be due to a nonlinear amplification of the primarily excited instability waves. The evidence of regular oscillations in the near-wall region of the fully developed turbulent flow from the visual studies is examined. M.G.

N80-27668# Office National d'Etudes et de Recherches Aerospatiales, Toulouse (France).
EXPERIMENTAL RESULTS CONCERNING THE INFLUENCE OF TRANSITION PROCESSES ON THE INITIAL STRUCTURE OF A TURBULENT BOUNDARY LAYER
D. ARNAL and J. C. JUILLEN *In* AGARD Turbulent Boundary Layers 9 p (SEE N80-27647 18-34) Jan. 1980 refs In FRENCH; ENGLISH summary
Avail: NTIS HC A17/MF A01

How the initial structure of the turbulent boundary layer can be influenced by the transition mechanism is examined. In the case of zero pressure gradient the evolution from the laminar to the turbulent regime is characterized by the intermittency phenomenon; the conditional sampling of the hot wire signal shows that the turbulent spots exhibit a structure similar to the classical turbulent boundary layer structure. With a mild positive pressure gradient, it becomes difficult to describe the intermittency. When the transition is beginning downstream from the laminar separation point, the shape parameter decreases but the intermittency appears no longer. Only a progressive deformation of the instability waves is observed; at the end of the transition, the spectrum of the turbulent energy is composed of a series of peaks corresponding to harmonics of the instability waves. M.G.

N80-27669# Scientific and Technical Research Council of Turkey, Ankara.
SOME MEASUREMENTS IN SYNTHETIC TURBULENT BOUNDARY LAYERS
O. SAVAS *In* AGARD Turbulent Boundary Layers 12 p (SEE N80-27647 18-34) Jan. 1980 refs
(Contract NSF ENG-75-03694; NSF ENG-77-23541)
Avail: NTIS HC A17/MF A01

Synthetic turbulent boundary layers are examined which were constructed on a flat plate by generating systematic moving patterns of turbulent spots in a laminar flow. The experiments were carried out in a wind tunnel at a Reynolds number based on plate length of 1,700,000. Spots were generated periodically in space and time near the leading edge to form a regular hexagonal pattern. The disturbance mechanism was a camshaft which displaced small pins momentarily into the laminar flow at frequencies up to 80 Hz. The main instrumentation was a rake of 24 hot wires placed across the flow in a line parallel to the surface. The main measured variable was local intermittency, i.e., the probability of observing turbulent flow at a particular point in space and time. The results are reported in x-t diagrams showing the evolution of various synthetic flows along the plate. The dimensionless celerity or phase velocity of the large eddies is found to be 0.88, independent of eddy scale. All patterns with sufficiently small scales eventually showed loss of coherence as they moved downstream. A novel phenomenon called eddy transposition was observed in several flows which contained appreciable laminar regions. The large eddies shifted in formation to new positions, intermediate to their original ones, while preserving their hexagonal pattern. The present results, together with some empirical properties of a turbulent spot, are used to estimate the best choice of scales for constructing a synthetic boundary layer suitable for detailed study. The values recommended are: spanwise scale/thickness 2.5, streamwise scale/thickness 8 M.G

N80-27670# University of Southern California, Los Angeles. Dept. of Aerospace Engineering.
COHERENT STRUCTURES IN TURBULENT BOUNDARY LAYERS
R. F. BLACKWELL *In* AGARD Turbulent Boundary Layers 7 p (SEE N80-27647 18-34) Jan. 1980 refs
(Contract DAAG29-76-G-0297)
Avail: NTIS HC A17/MF A01

The nature of coherent eddy structures in turbulent boundary layers is examined. The dynamics of turbulent boundary layers are controlled by two different eddy structures. In the intermittent region, the large scale outer structure dominates the flow field and controls the entrainment of nonturbulent fluid. Near the wall, counter-rotating streamwise vortices, with resulting elongated streaks of low speed fluid lying between them, are the predominate eddies. The interaction between these two different eddy structures seems to be the primary means by which turbulent energy is produced. The main features of these characteristic eddies are reviewed and some remaining problems are outlined. M.G.

N80-27671# Cambridge Thermionic Corp., Mass. Dept. of Engineering.
FLOW VISUALIZATION OF TURBULENT BOUNDARY LAYER STRUCTURE
M. R. HEAD and P. BANDYOPADHYAY *In* AGARD Turbulent Boundary Layers 12 p (SEE N80-27647 18-34) Jan. 1980 refs
Avail: NTIS HC A17/MF A01

The results from flow visualization experiments performed using an argon-ion laser to illuminate longitudinal and transverse sections of the smoke filled boundary layer in zero pressure gradient are discussed. Most of the experiments were confined to the range 600 Re sub theta 10,000. Results indicate that the boundary layer consists almost exclusively of vortex loops or hairpins, some of which may extend through the complete boundary layer thickness and all of which are inclined at a more or less constant characteristic angle of approximately 45 deg to the wall. Since the cross-stream dimensions of the hairpins appear to scale roughly with the wall variables U sub tau and nu, while their length is limited only by the boundary layer thickness, there are very large scale effects on the turbulence structure. At high Reynolds numbers (Re sub theta = 10,000) there is little evidence of large-scale coherent motions, other than a slow overturning of random agglomerations of the hairpins just mentioned. M.G.

N80-27672# Adelaide Univ. (Australia). Dept. of Mechanical Engineering.
SOME OBSERVATIONS OF THE STRUCTURE OF THE TURBULENT BOUNDARY LAYER
A. S. W. THOMAS *In* AGARD Turbulent Boundary Layers 11 p (SEE N80-27647 18-34) Jan. 1980 refs
Avail: NTIS HC A02/MF A01

Results are presented to describe some measured features of the organized large structure of a turbulent boundary layer. The spanwise correlation scale, the conditional Reynods stress contribution, and the experimentally determined streamline pattern of the large structure are discussed. Correlation and conditional sampling techniques are employed to examine the influence of this structure at the wall. It is found that increased activity at the wall is associated with curved streamlines. This is to be expected if it is a rotational instability that couples the turbulent bursts to the large structure. Author

N81-23431# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France)
TECHNICAL EVALUATION REPORT ON THE FLUID DYNAMIC PANEL SYMPOSIUM ON SUBSONIC/TRANSONIC CONFIGURATION/AERODYNAMICS
H. KOERNER Jan. 1981 19 p refs
(AGARD-AR-146; ISBN-92-835-1380-0; AD-A096824) Avail NTIS HC A02/MF A01

Papers presented at the various sessions are highlighted. Topics cover prediction methods, weapons carriage, configuration optimization, powered jet interaction, and multicomponent interference. Conclusions from the discussion are considered from the point of view of computational fluid dynamics, interference aspects, and optimization. Recommendations are offered. A.R.H.

N82-13384# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
TECHNICAL EVALUATION REPORT ON THE FLUID DYNAMICS PANEL SYMPOSIUM ON COMPUTATION OF VISCOUS-INVISCID INTERACTIONS
J. C. LEBALLEUR Oct. 1981 21 p refs Partly in ENGLISH; Partly in FRENCH Symp. held at Colorado Springs 29 Sep. - 1 Oct. 1980
(AGARD-AR-171; ISBN-92-835-0300-7; AD-A107753) Avail: NTIS HC A02/MF A01

The status of current research in computational aerodynamics based on methods solving a viscous-inviscid interaction problem is surveyed. In spite of limitation in the models or numerical techniques for shock wave boundary layer interaction or trailing edge problems, the situation is well advanced in unseparated, steady two-dimensional flow, with the potential approximation for the inviscid part. Progress has advanced in the computation of separations, based on strong interaction models. It would be fruitful to make use of the complete Euler equations in transonic flow. Progress toward strong interaction methods is much less advanced in unsteady or three-dimensional flow, but seems likely. The development of strong interaction methods, highly connected with that of Inviscid and Navier-Stokes numerical techniques, appears as mandatory to having access to practical application needs.
Author

N82-19519# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). Fluid Dynamics Panel.
A COMPILATION OF UNSTEADY TURBULENT BOUNDARY LAYER EXPERIMENTAL DATA
L. W. CARR (Army Aeromechanics Lab., Ames Research Center, Calif.) London Nov. 1981 56 p refs
(AGARD-AG-265; ISBN-92-835-1406-8; AD-A111489) Avail: NTIS HC A04/MF A01

A comprehensive literature search was conducted and those experiments related to unsteady turbulent boundary layer behavior were cataloged. In addition, an international survey of industrial, university, and governmental research laboratories was made, in which experimental programs associated with unsteady turbulent boundary layer research were identified. Pertinent references were reviewed and classified based on the technical emphasis of the various experiments. Experiments that include instantaneous or ensemble averaged profiles of boundary layer variables are stressed. Detailed reviews that include descriptions of the experimental apparatus, flow conditions, summaries of acquired data, and significant conclusions are made. The measurements of these experiments that exist in digital form have been stored on magnetic tape, and instructions are presented for accessing these data sets for further analysis.
S.L.

N82-20478# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
A FURTHER COMPILATION OF COMPRESSIBLE BOUNDARY LAYER DATA WITH A SURVEY OF TURBULENCE DATA
H. H. FERNHOLZ (Technische Univ., Berlin), P. J. FINLEY (Imperial Coll. of Science and Technology, London), and V. MIKULLA Nov. 1981 219 p refs
(AGARD-AG-263; ISBN-92-835-1404-1; AD-A111638) Avail: NTIS HC A10/MF A01

Data compiled for nominally two dimensional compressible shock-free flows was supplemented by further data including some shock-boundary-layer-interactions. A review of the available turbulence measurements is presented. The measurements were compared on the basis of inner and outer region similarity relationships. There was little evidence of any quantitative correlation between different experiments. There was also an examination of the breakdown conditions for the Van-Driest-Crocco mean flow temperature-velocity correlation and the associated transformation procedures. The effects of extreme transverse curvature on the mean flow are briefly considered. For individual titles, see N82-20479 through N82-20483.

N82-20479# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
HOT WIRE ANEMOMETRY IN COMPRESSIBLE TURBULENT BOUNDARY LAYERS
In its A Further Compilation of Compressible Boundary Layer Data With a Survey of Turbulence Data 12 p (SEE N82-20478 11-34) Nov. 1981 refs
Avail: NTIS HC A10/MF A01

Hot-wire anemometry in compressible flow was studied. New techniques for the measurement of turbulence in compressible flows with thermal sensors are described. The greatest amount of information about fluctuating flow variables as achieved using the newly developed sensors and techniques in conjunction with the classical hot-wire mode diagram method. It was found that the hot wire has no fundamental handicap for accurate high speed turbulence measurements in non-separated boundary layers outside the immediate wall region. It was also known that extreme overheating of a supported sensors leads to advantages in simplicity and accuracy of measurements of turbulent fluctuations over the full Mach number range.
M.D.K.

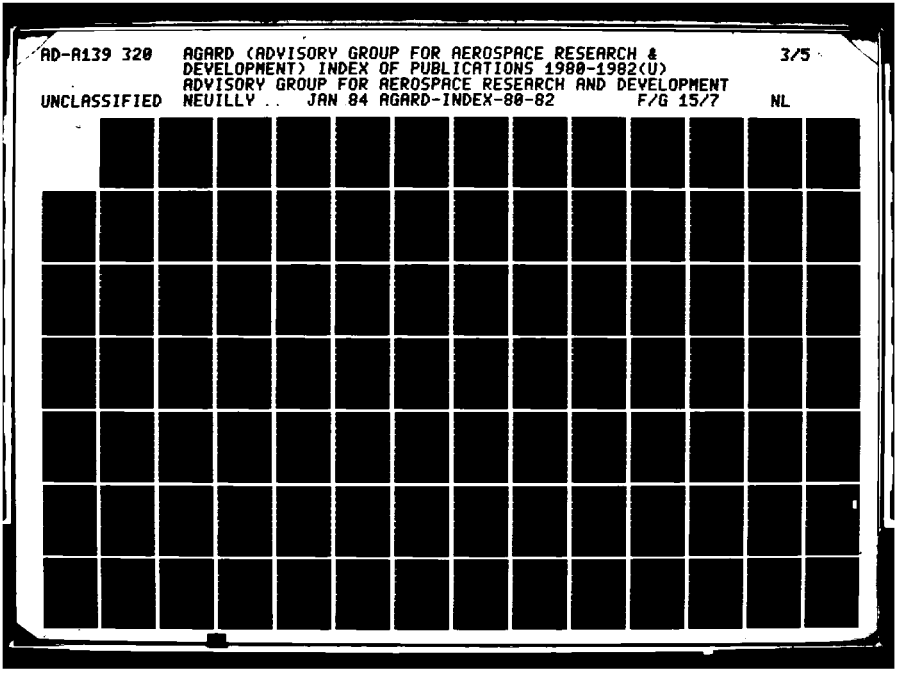
N82-20480# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
TURBULENCE DATA: SINGLE COMPONENTS
In its A Further Compilation of Compressible Boundary Layer Data With a Survey of Turbulence Data 17 p (SEE N82-20478 11-34) Nov. 1981 refs
Avail: NTIS HC A10/MF A01

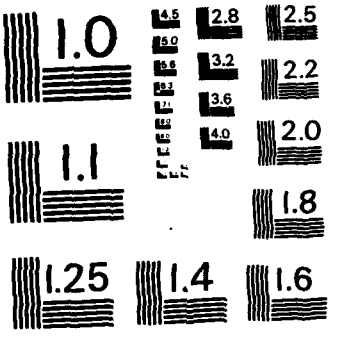
Measurements of three normal stress distributions in subsonic and supersonic boundary layers were made. It was found that the standard reference measurement remains the zero pressure-gradient subsonic boundary layer. The velocity fluctuations, density, temperature and mass flux fluctuations in compressible boundary layers were studied. The turbulence structure changes as a result of effects of compressibility were investigated, in boundary layers both with and without heat transfer. The effect of pressure gradients and shock interactions on the turbulence were studied. The Reynolds number, Mach number, heat transfer normal and tangential shear stresses, and the kinetic energy of the fluctuating motion were studied. The shape and range of the energy spectrum between the subsonic and supersonic boundary layer was also investigated. Tables listing investigations in which measurements of single components fluctuating quantities are presented. It was found that the fluctuating velocities were made dimensionless with one of three velocities, the velocity at the outer edge of the boundary layer, the skin friction velocity or the local mean velocity.
M.D.K.

N82-20481# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
TURBULENCE DATA: TWO COMPONENT TERMS
In its A Further Compilation of Compressible Boundary Layer Data With a Survey of Turbulence Data 19 p (SEE N82-20478 11-34) Nov. 1981 refs
Avail: NTIS HC A10/MF A01

Investigations of the behavior of two-component correlations shear stress component and heat flux, for compressible turbulent boundary layers were made. Important parameters as Mach number, pressure gradient, heat transfer, Reynolds number, free-stream turbulence, wall roughness, such and wall curvature on the turbulence structure and especially on the shear stress distribution of compressible boundary layers were studied. There relatively few two-component correlation measurements. A main emphasis on the Reynolds shear stress [illegible] discussed.

N82-20482# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
MEAN FLOW TOPICS
In its A Further Compilation
With a Survey of Turbulence
Nov. 1981 refs
Avail: NTIS HC A10/MF A01
A [illegible]
for the [illegible]
[illegible]
[illegible]


AD-A139 320 AGARD (ADVISORY GROUP FOR AEROSPACE RESEARCH & DEVELOPMENT) INDEX OF PUBLICATIONS 1980-1982(U) ADVISORY GROUP FOR AEROSPACE RESEARCH AND DEVELOPMENT
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UNCLASSIFIED NEUILLY .. JAN 84 AGARD-INDEX-80-82 F/G 15/7 NL



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

compressible turbulent boundary layers was studied. The boundary layer was formed on the outer surface of one of a number of slender cylinders aligned with the flow. For the subsonic tests two models were used. The first (series 01) consisted of an aluminum tube 3.65 m long and 25.4 mm in diameter. The front end was mounted on the tunnel settling chamber screens so that it extended along the contraction center line into the working section. The second model (series 02) consisted of a steel wire under tension passing through the screens. For the hypersonic test cases, results are presented for two wires and for a composite wire-cylinder model. M.D.K.

N82-20483# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
CLASSIFIED LIST OF SUPPLEMENTARY ENTRIES
In its A Further Compilation of Compressible Boundary Layer Data With a Survey of Turbulence Data 135 p (SEE N82-20478 11-34) Nov. 1981 refs
Avail: NTIS HC A10/MF A01

A compilation of data of turbulence measurements of a compressible boundary layer is presented. Measurements of the characteristics of the compressible turbulent boundary layer included data on: axially symmetric boundary layers, hot wire anemometry, shock-wave-induced pressure gradients, temperature measurements, cold-wall hypersonic turbulent layers, and other wind tunnel data. M.D.K.

N83-10403# National Aerospace Lab., Amsterdam (Netherlands).
EVALUATION REPORT: AGARD FLUID DYNAMICS PANEL SYMPOSIUM ON FLUID DYNAMICS OF JETS WITH APPLICATION TO V/STOL
B. M. SPEE Jul. 1982 11 p refs
(AGARD-AR-187; AD-A119560) Avail: NTIS HC A02/MF/MF A01

Topics covered include: (1) jet interactions with neighboring surfaces; (2) jet structure and development; (3) wind tunnel simulation of flow field, forces moments; (4) injection and thrust augmentation; (5) theoretical models and their assessments; (6) two dimensional wall jets; and (7) the use of a tracer gas method for measuring entrainment of an axisymmetric free jet. Conclusions of a panel on the impact of military applications on rotorcraft and V/STOL aircraft design are summarized. A.R.H.

N83-20076# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). Fluid Dynamics Panel.
FLUID DYNAMICS ASPECTS OF INTERNAL BALLISTICS
1982 61 p refs Meetings Held in St. Louis, France, Shrivenham, England and Colleferro, Italy
(AGARD-AR-172; ISBN-92-835-1439-4) Avail: NTIS HC A04/MF A01

The interior ballistics cycle including the presentation of different models and computer codes used in interior ballistics are discussed. An example of application is given. Furthermore the experimental methods and associated theories are described, which allow the foregoing models to be validated. These methods and theories also yield indispensable input and allow to verification of the computed results. The gaseous outflow from tube launchers, the physical and thermodynamics characteristics of propellant gases are considered. Specific problems encountered in interior ballistics (liquid propellants, behavior of antierosive additives, behavior of solid propellants at high pressures) are given. GRA

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INSTRUMENTATION AND PHOTOGRAPHY

Includes remote sensors; measuring instruments and gages; detectors; cameras and photographic supplies; and holography.

N83-17855# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
GYROSCOPIC INSTRUMENTS AND THEIR APPLICATION TO FLIGHT TESTING
B. STIELER and H. WINTER Sep. 1982 216 p refs
(AGARD-AG-160-VOL-15; ISBN-92-835-1433-5) Avail: NTIS HC A10/MF A01

The use of gyroscopic instruments to support flight testing is discussed. Gyroscopic instruments are used in flight tests to measure the aircraft angular accelerations and rates, attitude and heading and - in combination with accelerometers - the linear acceleration, the ground velocity and the position. The measuring principles, the technical layout and the error behavior of the sensors and systems used for these measurements are described. Gyros, accelerometers, attitude and heading references and inertial navigation systems are included. Integrated and hybrid sensor systems as they are used in modern instrumentation systems are considered. Examples of actual flight instrumentation systems are described and the requirements for the gyroscopic sensors in these systems are discussed for applications in aircraft stability and control flight tests, in performance tests and in airborne and ground systems calibration and testing. S.L.

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MECHANICAL ENGINEERING

Includes auxiliary systems (non-power); machine elements and processes; and mechanical equipment.

N81-17447# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
CENTRIFUGAL COMPRESSORS, FLOW PHENOMENA AND PERFORMANCE
Nov. 1980 342 p refs In ENGLISH; partly in FRENCH Papers presented at the 55th(B) Specialists' Meeting of the Propulsion and Energetics Panel of AGARD, Brussels, 7-9 May 1980
(AGARD-CP-282; AD-A094912) Avail: NTIS HC A15/MF A01

Experimental investigations on flows in impellers and diffusers, theoretical calculations of flows in impellers, interaction between impeller and diffuser, and design experience and performance of advanced centrifugal compressors are discussed. Emphasis is on the inducer, impeller and the diffuser flow field, and on interactions between impeller and diffuser. A comprehensive survey and detailed information on design experience and centrifugal compressor performance are provided. Viscous, transonic, compressible, and three dimensional effects were studied. The influence of nonuniform flow at the rotor outlet on performance and surge margin, namely for high pressure ratio compressors, are discussed. For individual titles, see N81-17448 through N81-17468.

N81-17448# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Cologne (West Germany). Inst. fuer Antriebstechnik.
EXPERIMENTAL AND THEORETICAL INVESTIGATIONS ON THE INTERNAL FLOW IN A CENTRIFUGAL COMPRESSOR DIFFUSER
H. KRAIN *In* AGARD Centrifugal Compressors, Flow Phenomena and Performance 18 p (SEE N81-17447 08-37) Nov. 1980 refs
Avail: NTIS HC A15/MF A01

A two dimensional straight diffuser was designed and tested based on empirical flat diffuser performance maps. First experimental results concerning overall diffuser recovery, diffuser

inlet conditions, and diffuser performance development are presented. A two dimensional finite difference blade-to-blade calculation method was developed taking into account diffuser losses and sidewall blockage. E.D.K.

N81-17449# Cranfield Inst. of Tech., Bedfordshire (England). Fluid Engineering Unit.
FLOW IN CENTRIFUGAL COMPRESSOR IMPELLERS: A THEORETICAL AND EXPERIMENTAL STUDY
A. GOULAS *In* AGARD Centrifugal Compressors, Flow Phenomena and Performance 17 p (SEE N81-17447 08-37) Nov. 1980 refs
Avail: NTIS HC A15/MF A01

The flow field in various centrifugal compressor impellers is studied both theoretically and experimentally in order to improve the understanding of the flow phenomena involved and to develop numerical methods capable of predicting the complex viscous and turbulent flow field. The circumferential and radial components of velocity and the rms of the correspoinding fluctuations in the impeller of a centrifugal compressor were obtained using a laser Doppler anemometer. The results indicate a two unequal vortex arrangement with opposite direction of rotation and with the smaller vortex immediately behind the suction side of each blade. The radial velocity profiles indicate a weak wake at the center of the passage near the shroud as for curvature dominated flows. The study of the published experimental data points to the vorticity being a dominant feature of the flow inside the impeller. Numerical integration of the vorticity equations shows that the production of streamwise vorticity is affected by the diffusion achieved in the inducer and the length of the radial part of the impeller, both major design parameters. The prediction method is a finite difference scheme based on the matrix through flow analysis as was modified to incorporate the effect of viscosity and turbulence on the flow field. E.D.K.

N81-17450# Societe Creusot-Loire, Le Creusot (France).
EXPERIMENTAL FLOW ANALYSIS IN A STAGE OF CENTRIFUGAL MACHINERY
G. BOIS (METRAFLU SARL, Ecully, France), J. M. DUCHEMIN, A. VOUILLARMET (Ecole Centrale de Lyon, France), and K. D. PAPAILIOU (National Technical Univ., Athens) *In* AGARD Centrifugal Compressors, Flow Phenomena and Performance 30 p (SEE N81-17447 08-37) Nov. 1980 refs In FRENCH; ENGLISH summary
Avail: NTIS HC A15/MF A01

Experimental results obtained at the exit of the impellers and in the vaneless diffusers of two centrifugal compressors, with and without a cover plate, are presented. Two measurement methods are compared. The first is conventional and uses directional pressure probes, the second rests on the use of a laser system. An attempt is made at analyzing secondary flows using the results of a quasi-three dimensional meridional calculation. The secondary flow approach uses the results already acquired for axial machines, taking fuller account of the additional terms appearing in the formulation. E.D.K.

N81-17451# Nuovo Pignone S.p.A., Florence (Italy).
INLET FLOW DISTORTIONS ON INDUSTRIAL CENTRIFUGAL COMPRESSOR STAGES. EXPERIMENTAL INVESTIGATIONS AND EVALUATION OF EFFECTS ON PERFORMANCE
E. BENVENUTI, L. BONCIANI, and U. CORRADINI *In* AGARD Centrifugal Compressors, Flow Phenomena and Peformance 16 p (SEE N81-17447 08-37) Nov. 1980 refs
Avail: NTIS HC A15/MF A01

Results are presented of tests carried out on a stage equipped with three different inlet configurations, two with curved de-swirl vanes and straight vanes, and one with no vanes. Test results show the presence of high intensity wakes downstream of both the curved and straight vanes that are not completely mixed out along the path towards the impeller. Wake mixing is associated with a total pressure loss whose magnitude can be well evaluated from the measurements. Stage efficiency is decreased by the presence of both straight and curved vanes, the decrease being almost the same despite the different wake amplitudes produced by the two types of vanes; the strong wakes from the curved de-swirl vanes decrease the impeller's head coefficient somewhat at high flows. The good repetitiveness and consistency of test results are indications of the reliability of the procedures selected for investigating complex flow fields of this kind and assessing their effect on stage performance. E.D.K.

N81-17452# Office National d'Etudes et de Recherches Aerospatiales, Paris (France).
CALCULATING TRANSONIC FLOW IN A CENTRIFUGAL COMPRESSOR USING A PSEUDO-STATIONARY METHOD [CALCUL DE L'ECOULEMENT TRANSSONIQUE DANS UN COMPRESSEUR CENTRIFUGE PAR UNE METHODE PSEUDO-STATIONNAIRE]
R. SOVRAND *In* AGARD Centrifugal Compressors, Flow Phenomena and Performance (date] 10 p (SEE N81-17447 08-37) Nov. 1980 refs In FRENCH; ENGLISH summary
Avail: NTIS HC A15/MF A01

A study of perfect fluid flow through a centrifugal compressor is presented. The calculation of a transonic flow on a blade-to-blade stream surface is emphasized. Based upon the solution of the time dependent Euler equations, the study is directed towards obtaining the steady flow through the blade row. The numerical scheme is a time marching method derived from the MacCormack model, extended at ONERA. This approach, combining an explicit discretization of the equations according to the well known predictor-corrector technique, corresponds to a conservative method, the writing of which is not too difficult. The numerical results are very useful for designing high performance turbomachines. E.D.K.

N81-17453# Numerical Continuum Mechanics, Inc., Woodlawn Hills, Calif.
NUMERICAL ANALYSIS OF THE THREE DIMENSIONAL VISCOUS FLOW FIELD IN A CENTRIFUGAL IMPELLER
L. WALITT *In* AGARD Centrifugal Compressors, Flow Phenomena and Performance 29 p (SEE N81-17447 08-37) Nov. 1980 refs
Avail: NTIS HC A15/MF A01

The steady three dimensional Reynolds averaged Navier-Stokes equation were solved numerically via a successive approximation method. The method is applicable to centrifugal impellers, axial rotors, turbines, and stator cascades. Viscous flow fields were calculated in a radial impeller, two backswept centrifugal impellers, one with a splitter vane, and an axial supersonic compressor cascade. The radial impeller field contained a significant separation region near the trailing edge of the suction surface, while the backswept fields showed significant leading edge separation and some trailing edge separation near the shroud. Kulite recordings of the shroud pressure variation between the blades in the inducer region and in the radial portion of the backswept impeller with the splitter vane, generally agreed with corresponding calculations. Pressure measurements on the blades of the supersonic compressor cascade agreed with corresponding computations.
Author

N81-17454# Vrije Universiteit, Brussels (Belgium).
THREE DIMENSIONAL INVISCID CALCULATIONS IN CENTRIFUGAL COMPRESSORS
C. HIRSCH, C. LACOR, and G. WARZEE (Brussels Univ.) *In* AGARD Centrifugal Compressors, Flow Phenomena and Performance 11 p (SEE N81-17447 08-37) Nov. 1980 refs
Avail: NTIS HC A15/MF A01

An inviscid, rotational, three dimensional flow model in centrifugal compressors is presented. The three dimensional flow is separated into a potential flow part and a rotational part described by a simple additional function. The solution of the potential flow part is described and applied to several centrifugal compressors. Results are compared to experimental data as well as to results of a quasi-three dimensional calculation procedure. E.D.K.

N81-17455# Politecnico di Milano (Italy). Istituto di Macchine.
TRANSONIC FLOW CALCULATION IN CENTRIFUGAL COMPRESSORS BY A TIME DEPENDENT METHOD OF CHARACTERISTICS
C. OSNAGHI, A. PERDICHIZZI, and F. BASSI *In* AGARD Centrifugal Compressors, Flow Phenomena and Performance 14 p (SEE N81-17447 08-37) Nov. 1980 refs
Avail: NTIS HC A15/MF A01

Difficulties in the numerical solution of the flow in advanced centrifugal compressors arise from the transonic nature of the flow. In order to solve this problem, a time dependent method of

characteristics, which takes into account shock waves, boundary layer and wakes, is presented. Separated flow is simulated by simplified models. Such a program is proposed for centrifugal compressors both for impellers and diffusers. Extension of the method to unsteady phenomena is discussed. Results are discussed, and they demonstrate the possibilities of the method at the present state of the art. Author

N81-17456# Virginia Polytechnic Inst., Blacksburg. Dept. of Mechanical Engineering.

THREE-DIMENSIONAL, VISCOUS FLOW CALCULATIONS FOR ASSESSING THE THERMODYNAMIC PERFORMANCE OF CENTRIFUGAL COMPRESSORS: STUDY OF THE ECKARDT COMPRESSOR

J. MOORE and J. G. MOORE *In* AGARD Centrifugal Compressors, Flow Phenomena and Performance 19 p (SEE N81-17447 08-37) Nov. 1980 refs

Avail: NTIS HC A15/MF A01

A calculation procedure for partially parabolic flow is used to calculate flow in the impeller and diffuser of the Eckardt centrifugal compressor. This is a general geometry cascade flow method including the effects of tip leakage and stationary walls. The calculated and experimental results for three dimensional viscous flow and overall thermodynamic performance are compared. Wake flow, resulting from boundary layer accumulation, causes blockage of the impeller passage. Calculated wake development, with and without flow leakage through the tip clearance gap, is compared with measurements. The thermodynamic process in the Eckardt compressor, at the maximum efficiency point at 14000 RPM, is represented on a temperature entropy diagram. Calculated results of the development of mass averaged temperature and entropy through the impeller and diffuser are presented. The work done, the pressure ratios, and the efficiencies of the impeller and compressor are calculated to within 1 or 2%. The influence of the boundary conditions on the compressor flow and performance is discussed. Author

N81-17457# Manchester Coll. of Science and Technology (England). Dept. of Mechanical Engineering.

COMPUTATION OF THREE DIMENSIONAL FLOW THROUGH THE ECKARDT COMPRESSOR IMPELLER

C. BOSMAN *In* AGARD Centrifugal Compressors, Flow Phenomena and Performance 8 p (SEE N81-17447 08-37) Nov. 1980 refs

Avail: NTIS HC A15/MF A01

The inviscid flow through the Eckardt impeller was computed using a time marching technique with primitive variables. Comparison is made at one operating point between the experimental results, computed quasi-three dimensional inviscid results using stream surface techniques, and the computed inviscid three-dimensional results. The computed three dimensional results exhibit the presence of a passage vortex, which is necessarily absent in the quasi-three dimensional solution, and generally show improved agreement with experimental results. The presence of a jet/wake efflux pattern is evident in the three dimensional inviscid solution although its strength is less than that of the experimental result. E.D.K.

N81-17458*# Iowa State Univ. of Science and Technology, Ames. Dept. of Mechanical Engineering.

COMPUTATION OF FLOW IN RADIAL- AND MIXED-FLOW CASCADES BY AN INVISCID-VISCOUS INTERACTION METHOD

G. K. SEROVY and E. C. HANSEN (Florida Univ., Gainesville) *In* AGARD Centrifugal Compressors, Flow Phenomena and Performance 11 p (SEE N81-17447 08-37) Nov. 1980 refs

Avail: NTIS HC A15/MF A01

The use of inviscid-viscous interaction methods for the case of radial or mixed-flow cascade diffusers is discussed. A literature review of investigations considering cascade flow-field prediction by inviscid-viscous iterative computation is given. Cascade aerodynamics in the third blade row of a multiple-row radial cascade diffuser are specifically investigated. M.G.

N81-17459# Von Karman Inst. for Fluid Dynamics, Rhode-Saint-Genese (Belgium).

ROTATING NONUNIFORM FLOW IN RADIAL COMPRESSORS

R. A. VANDENBRAEMBUSSCHE, P. FRIGNE, and M. ROUSTAN (Societe Creusot-Loire, Le Creusot, France) *In* AGARD Centrifugal Compressors, Flow Phenomena and Performance 14 p (SEE N81-17447 08-37) Nov. 1980 refs

Avail: NTIS HC A15/MF A01

The prediction of rotating instabilities in radial vaneless diffusers is examined. The rotating nonuniformities were experimentally measured by means of hot films, in centrifugal compressors of different geometry and at different Reynolds numbers. Results are compared with other available data and theoretical predictions. The rotating instabilities can be explained by Senoo's theory for reverse flow in radial diffusers, if a correction term in function of Reynolds number is added. First inviscid results obtained with a time-evolutive interaction model are presented. M.G.

N81-17460# Creare, Inc., Hanover, N.H. Fluid Machinery Div.

THE INFLUENCE OF DIFFUSER INLET PRESSURE FIELDS ON THE RANGE AND DURABILITY OF CENTRIFUGAL COMPRESSOR STAGES

D. JAPIKSE *In* AGARD Centrifugal Compressors, Flow Phenomena and Performance 11 p (SEE N81-17447 08-37) Nov. 1980 refs

Avail: NTIS HC A15/MF A01

An anomalous range characteristic of two stages differing only in diffuser passage number was investigated. Pressure field data in the diffuser inlet region was examined and a strong shock pressure recovery system was discovered when a low diffuser number is used and a mild shock recovery process resulted when a large diffuser number was employed. When strong shocks were present, it was found that a leading shock set up a subsequent accelerating flow field which stabilized a second shock. In turn, the second shock contributed substantially to the static pressure recovery process in the diffuser inlet region. The combined effect was a highly stabilized flow fields, in agreement with the Kantrowitz shock stabilization criterion. By contrast, the strong shock system contributed to a loss in total pressure of up to 2 deg of the total pressure rise in the stage. Two different stages are discussed where mechanical failure occurred. These cases may be related to the strong shock system of the diffuser inlet region closely coupled to the impeller blade tips. M.G.

N81-17461# Office National d'Etudes et de Recherches Aerospatiales, Paris (France).

THE INFLUENCE OF NONUNIFORM FLOW AT A ROTOR OUTLET ON DIFFUSER PERFORMANCES IN A CENTRIFUGAL COMPRESSOR [INFLUENCE DE L'HETEROGENEITE DE L'ECOULEMENT A LA SORTIE DU ROTOR SUR LES PERFORMANCES DU DIFFUSEUR D'UN COMPRESSEUR CENTRIFUGE]

H. HUS (Hispano Suiza) and C. FRADIN *In* AGARD Centrifugal Compressors, Flow Phenomena and Performance 13 p (SEE N81-17447 08-37) Nov. 1980 refs In FRENCH; ENGLISH summary

Avail: NTIS HC A15/MF A01

The performance of the diffuser of a centrifugal compressor is analyzed when the inlet flow is deliberately more or less nonuniform. The measurement of instantaneous values of pressure and velocity by means of pressure transducers and hot-wire anemometers gives the detailed structure of the flow field. An accurate estimation of the effect of nonuniformities on the performances of the diffuser is derived from the se measurements. They show that the pressure losses are directly related to the nonuniformities. Validation of an overall estimation of diffuser performance from conventional probe measurements is derived from this experiment. M.G.

N81-17462# National Gas Turbine Establishment, Pyestock (England).

DESIGN AND EXPERIMENTAL PERFORMANCE OF SOME HIGH PRESSURE RATIO CENTRIFUGAL COMPRESSORS

P. M. CAME and M. V. HERBERT *In* AGARD Centrifugal Compressors, Flow Phenomena and Performance 31 p (SEE N81-17447 08-37) Nov. 1980 refs

Avail: NTIS HC A15/MF A01

A design procedure for impellers and diffusers of high pressure ratio centrifugal compressors is described. Particular emphasis is

given to a philosophy of design for supersonic inlet, vaned radial diffusers. Test results are presented for several transonic diffusers operating in a 6 1/2 pressure ratio stage. Observations of surge in this and other compressors are used as a basis for a discussion of possible surge mechanisms in centrifugal compressors.
Author

N81-17463# Ruhr Univ., Bochum (West Germany). Lefrstuhl fuer Fluidenergiemaschinen.
A PROCEDURE FOR THE COMPUTER-AIDED CONSTRUCTION OF RADIAL COMPRESSOR IMPELLERS WITH HIGH FLOW COEFFICIENT
W. FISTER and J. EIKELMANN *In* AGARD Centrifugal Compressors, Flow Phenomena and Performance 12 p (SEE N81-17447 08-37) Nov. 1980 refs
Avail: NTIS HC A15/MF A01

A computer-aided procedure for the construction of radial compressor impellers with high flow-coefficient is presented. The procedure consists of an iterative succession of constructional design, recomputation of fluid-flow-mechanical characteristics and specific geometrical correction based upon the given criteria. The significance of the computational procedures and criteria used is verified on the basis of the operating behavior of two compressor stages. M.G.

N81-17464# Societe Generale de Constructions Electriques et Mechaniques Alsthom-Atlantique, La Courneuve (France).
THE WHEEL OF A CENTRIFUGAL COMPRESSOR WITHOUT BLADE FLEXURE [ROUE DE COMPRESSEUR CENTRIFUGE SANS FLEXION DANS LES AILES]
J. POULAIN and G. JANSSENS *In* AGARD Centrifugal Compressors, Flow Phenomena and Performance 10 p (SEE N81-17447 08-37) Nov. 1980 refs In FRENCH; ENGLISH summary
Avail: NTIS HC A15/MF A01

A centrifugal compressor with backward leaned blades is presented. The geometry of the compressor is designed in such a way as to eliminate the bending stresses due to centrifugal forces. The compressor was tested in a Freon loop. Due to a theoretical analysis of the test results, an improved version of the compressor was designed. This compressor seems well suited for a multistage configuration and shows a pressure ratio of 4.8 with a polytropic efficiency of 0.83. In a single stage configuration, without the return duct, its pressure ratio is 5.3 with an efficiency of 0.85. M.G.

N81-17465# Northern Research and Engineering Corp., Woburn, Mass.
IMPROVEMENTS IN SURGE MARGIN FOR CENTRIFUGAL COMPRESSORS
W. JANSEN, A. F. CARTER, and M. C. SWARDEN *In* AGARD Centrifugal Compressors, Flow Phenomena and Performance 17 p (SEE N81-17447 08-37) Nov. 1980 refs
Avail: NTIS HC A15/MF A01

The performance of stall inhibitor concepts for centrifugal compressors is investigated. Three impeller wall treatments and a vaned diffuser treatment are assessed. The impeller wall treatments were tested on compressor stages that produce a medium pressure ratio of three to one at the design point. Both the impeller and diffuser treatments were applied to a stage that produces a six to one pressure ratio. Specific results are discussed. M.G.

N81-17466# Detroit Diesel Allison, Indianapolis, Ind.
MODEL 250-C30/C28B COMPRESSOR DEVELOPMENT
D. C. CHAPMAN *In* AGARD Centrifugal Compressors, Flow Phenomena and Performance 6 p (SEE N81-17447 08-37) Nov. 1980
Avail: NTIS HC A15/MF A01

The performance of advanced versions of the Allison Model 250 engine series in production for the Sikorsky S76 and Bell Long Ranger helicopters is discussed. These engines, designated 250-C30 and -C28B respectively, use a single stage centrifugal compressor matched at 8.7:1 pressure ratio at design speed. The initial design met flow, pressure ratio, and efficiency requirements, but encountered both a localized deficiency in the surge line around 85% speed and excessive impeller blade vibratory stress at high speed. Several potential remedies were tried unsuccessfully and the compressor was redesigned. The redesign featured redistributed impeller blade loading, revised impeller blade thickness, and increased number of diffuser vanes. These changes eliminated the vibratory stress problem. A unique inducer shroud bleed system, requiring no control, resolved the surge line problem and improved high speed flow and efficiency as well. M.G.

N81-17467# Noel Penny Turbines Ltd., Toll Bar End (England).
CENTRIFUGAL COMPRESSORS FOR SMALL AERO AND AUTOMOTIVE GAS TURBINE ENGINES
R. W. CHEVIS and R. J. VARLEY *In* AGARD Centrifugal Compressors, Flow Phenomena and Performance 18 p (SEE N81-17447 08-37) Nov. 1980 refs
Avail: NTIS HC A15/MF A01

Compressor design requirements for three engine types are briefly discussed. These types are the expendable turbojet, the low cost single shaft turbopropeller engine, and the automotive truck gas turbine engine. Technical and test data are presented for representative types of compressors. M.G.

N81-17468# Solar Turbines International, San Diego, Calif.
EFFICIENCY OF CENTRIFUGAL COMPRESSOR IMPELLERS
C. RODGERS *In* AGARD Centrifugal Compressors, Flow Phenomena and Performance 14 p (SEE N81-17447 08-37) Nov. 1980 refs
Avail: NTIS HC A15/MF A01

It is argued that improved efficiency correlation of high and low pressure ratio compressors can be obtained, if the impeller and diffuser performances of centrifugal compressors and pumps can be separated. This allows the impeller performance potential to be correlated separately in terms of peak polytropic efficiency versus specific spped based upon average flowpath density. Test data are presented to support the improved correlation, on several compressor impeller geometries at low and high Mach number and specific speed, together with design charts showing attainable state-of-the-art impeller efficiency levels as dependent upon geometry and operating conditions. M.G.

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STRUCTURAL MECHANICS

Includes structural element design and weight analysis; fatigue; and thermal stress.

N81-20461# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
CRITICALLY LOADED HOLE TECHNOLOGY PILOT COLLABORATIVE TEST PROGRAMME Final Technical Report
T. COOMBE and R. B. URZI Nov. 1980 60 p refs
(AGARD-R-678; ISBN-92-835-1375-4; AD-A097221) Avail: NTIS HC A04/MF A01

The interaction of fastener hole quality and resulting fatigue lives of low load transfer structural joints is investigated while utilizing fatigue rated and nonfatigue rated fastener systems. These fastener systems were primarily loaded in shear. A load level verification was made and it was established that there were few differences, within the range of testing frequencies used in the accuracy of loading or comparability of data between participants. Interference fit fasteners are relatively insensitive to effects of surface finish and hole quality with the exception of dimensional tolerance which is important because it affects interference fit. Interference fit fasteners gave better results than clearance fit.
S.F.

N81-33503# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
MANUAL ON THE FATIGUE OF STRUCTURES. 2: CAUSES AND PREVENTION OF DAMAGE. 7: MECHANICAL SURFACE DAMAGE
W. G. BARROIS (l'Armement (Air), Vanves, France) Jun. 1981 140 p refs
(AGARD-MAN-10(ENG); ISBN-92-835-1389-4) Avail: NTIS HC A07/MF A01

Surface damage to aircraft structures is often the origin of fatigue cracks. Damage arising from decarburization and wheel

grinding; friction and severe wear; rolling fatigue; contact fatigue; fretting fatigue; and erosion by solid and liquid particles and cavitation is examined. Damage in gears, cams, rails, and bearings are discussed as well as to the surface of metals transparent materials, reinforced plastics, and laminates. A.R.H.

N82-10457# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
NON-LINEAR AEROELASTIC ANALYSES AND TESTING
Jul. 1981 43 p refs Partly in ENGLISH; partly in FRENCH Meeting held in Cesme, Turkey, 5-10 Apr. 1981
(AGARD-R-698; AD-A105708) Avail: NTIS HC A03/MF A01

The ground vibration testing of aircraft with active control systems is discussed and a method of performing and interpreting dynamic tests on non-linear systems, such as control surface actuators is presented. For individual titles, see N82-10458 through N82-10459.

N82-10458# Office National d'Etudes et de Recherches Aeronautiques, Paris (France).
IDENTIFICATION OF THE EIGEN MODES OF A STRUCTURE FROM THE RESPONSES TO A NON-APPROPRIATED EXCITATION
R. DAT and P. DUNOYER *In* AGARD Non-linear Aeroelastic Analyses and Testing 18 p (SEE N82-10457 01-39) Jul. 1981 refs In FRENCH; ENGLISH summary
Avail: NTIS HC A03/MF A01

The two methods are presented which use the harmonic responses, at a large number of points on the structure, in order to determine the eigen modes, without necessitating an appropriation of the excitation forces. The first one of the methods, which is more synthetic, determines the set of modal characteristics through the resolution of a set of algebraic equations; the second one, which is more analytic, proceeds to a separation of each mode by combining the harmonic responses of the different points of the structure. The results show that the two methods give a satisfactory modelisation of the structure through the modal representation. Author

N82-10459# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Goettingen (West Germany). Inst. of Aeroelasticity.
NONLINEAR AEROELASTIC ANALYSES TAKING INTO ACCOUNT ACTIVE CONTROL SYSTEMS
R. FREYMANN *In* AGARD Non-linear Aeroelastic Analyses and Testing 19 p (SEE N82-10457 01-39) Jul. 1981 refs
Avail: NTIS HC A03/MF A01

Analytical investigations on aircraft with active control systems can be performed on the basis of an extended formulation of the generalized aeroelastic equations. The structural modal parameters needed for the investigation can be determined in a ground vibration test on the real aircraft structure. A method is presented for determining the transfer functions of the different elements of the control loops in a ground vibration test on the real aircraft and in special tests on the aircraft hydraulic actuation systems. To demonstrate the validity of the procedure, dynamic response calculations based upon the proposed extended formulation of the aeroelastic equations, which take into account both the results of the ground vibration test as well as of the actuator tests, are performed on a model wing structure with a hydraulically driven rudder. Results of the analysis are compared to measured data on the same model structure. A.R.H.

N82-19571# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). Structures and Materials Panel.
PRACTICAL APPLICATIONS OF FRACTURE MECHANICS
H. LIEBOWITZ, ed. (George Washington Univ.) May 1980 425 p refs
(AGARD-AG-257; ISBN-92-835-1359-2; AD-A089049) Avail: NTIS HC A16/MF A01

Practical applications of fracture mechanics for all aspects of aircraft design, manufacture and testing are presented. Although theoretical discussions are included to provide an appreciation of the complexity of the problems involved, the emphasis is on practical examples. Applications to engine components; built-up structures; joints, lugs and fasteners; integral structures and forgings are covered. The effects of stress corrosion and problems of scatter affecting determination of stress concentration factors, fatigue crack propagation and residual strength are discussed. S.L.

N82-19600# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
DURABILITY OF ADHESIVE BONDED STRUCTURES SUBJECTED TO ACOUSTIC LOADS
H. F. WOLFE (AFWAL, Wright-Patterson AFB, Ohio) and I. HOLEHOUSE (Rohr Industries, Chula Vista, Calif.) London Dec. 1981 16 p refs Presented at the 53rd Meeting of the AGARD Struct. and Mater. Panel, Noordwijkerhout, Netherlands, 27 Sep. - 2 Oct. 1981
(AGARD-R-701; ISBN-92-835-1409-2; AD-A111488) Avail: NTIS HC A02/MF A01

Acoustic fatigue prediction techniques for weldbonded aluminum, adhesive bonded aluminum, an adhesive bonded graphite epoxy structures are summarized. Adequate performance under static loading did not guarantee adequate performance under dynamic loading. Some prediction methods were developed for certain failure modes in adhesive bonded aluminum and graphite epoxy bonded skin stiffened structures. Further investigations are needed to adequately predict the acoustic fatigue life of adhesive bonded aircraft structures. N.W.

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GEOSCIENCES (GENERAL)

N81-23507# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
THE PHYSICAL BASIC OF THE IONOSPHERE IN THE SOLAR-TERRESTRIAL SYSTEM
Feb. 1981 384 p refs Presented at the 27th Meeting of the Electromagnetic Wave Propagation Panel, Pozzuoli, Italy, 28-31 Oct. 1980
(AGARD-CP-295; ISBN-92-835-0284-1; AD-A098119) Avail: NTIS HC A17/MF A01

The processes that produce and control the distribution of ionization in the ionosphere as a component of the solar terrestrial system are considered. Several examples of modeling and prediction techniques are given that can be applied by the terrestrial users of the electromagnetic spectrum.

N81-23508*# Air Force Geophysics Lab., Hanscom AFB, Mass.
THE SOLAR ULTRAVIOLET SOURCE FOR THE IONOSPHERE AND ITS VARIATION
H. E. HINTEREGGER *In* AGARD The Phys. Basis of the Ionosphere in the Solar-Terrest. System 11 p (SEE N81-23507 14-42) Feb. 1981 refs
(Contract NASA ORDER S-50030-AG)
Avail: NTIS HC A17/MF A01 CSCL 04A

Ion production in the ionospheric E and F regions is primarily due to solar EUV fluxes at wavelengths below 102.7 nm, where the flux ratios of maximum/minium for the present solar cycle were found to range from values around 3 for the dominant chromospheric emissions to much higher values for coronal emissions, resulting in a factor of about 4 in the integrated flux of the range 14-102.7 nm. The vertical distribution of ion production depends not only on the incident solar EUV fluxes but also on the structure of the absorbing neutral atmosphere (thermosphere). As the latter is strongly affected by solar EUV fluxes above 130 nm (production of atomic oxygen and heating), the observed increase, with ratios ranging from about 1.2 around 175-185 nm to about 2.3 around 140 nm, is at least indirectly important in the solar cycle variation of the ionosphere. The EUV variability models of the ionosphere using non EUV indices such as F sub 10.7, R sub Z or Ca2 plage indices are valuable as a crude guide only, but not for quantitative representations. Author

N81-23509# Fraunhofer Inst., Freiburg (West Germany).
SOLAR RADIATIONS AND THEIR INTERACTIONS WITH THE TERRESTRIAL ENVIRONMENT
G. SCHMIDTKE *In* AGARD The Phys. Basis of the Ionosphere in the Solar-Terrest. System 11 p (SEE N81-23507 14-42) Feb. 1981 refs
Avail: NTIS HC A17/MF A01

The measurement of solar wind parameters as well as solar electromagnetic radiation in different spectral ranges are considered. The variability of the radiations and some aspects of these competing energy sources for the terrestrial atmosphere are discussed. R.C.T.

N81-23510# Imperial Coll. of Science and Technology, London (England). Blackett Lab.
MAGNETOSPHERIC AND IONOSPHERIC FLOW AND THE INTERPLANETARY MAGNETIC FIELD
S. W. H. COWLEY *In* AGARD The Phys. Basis of the Ionosphere in the Solar-Terrest. System 14 p (SEE N81-23507 14-42) Feb. 1981 refs
Avail: NTIS HC A17/MF A01

The flux tube and plasma flow within the Earth's magnetosphere and the resulting flow in the ionosphere are discussed, with particular reference to effects associated with the interplanetary magnetic field (IMF). Whem IMF B sub z less than or is at least not strongly positive, two cell convection occurs at high latitudes with antisunwar flow over the polar cap. The size of the cells depends on IMF, as expected from the Dungey open magnetosphere model, but part of the convection appears to be driven by viscous magnetopause boundary layers. Asymmetries occur in the two cell flow about noon midnight meridian in response to IMF B sub y which form a consistent set with a ready qualitative interpretation in terms of the open model. Sunward tailward shifts in the cells also occur in response to IMF B sub x which may be similarly interpreted. When IMF B sub z is strongly positive a qualitatively different ionospheric flow pattern occurs at high latitudes with sunward flow in at least part of the polar cap. Observations pertaining to this condition are reviewed, together with theoretical interpretations. R.C.T.

N81-23511# Max-Planck-Institut fuer Aeronomie, Katlenburg-Lindau (West Germany).
MAGNETOSPHERIC INFLUENCES ON THE IONOSPHERE
H. KOHL *In* AGARD The Phys. Basis of the Ionosphere in the Solar-Terrest. System 7 p (SEE N81-23507 14-42) Feb. 1981 refs
Avail: NTIS HC A17/MF A01

Particle penetration, electric fields and plasma waves originating in the magnetosphere and propagating downward were investigated with respect to their effect on the ionosphere. A number of problems like the polar cap ionozation, the formation of the trough, the energy from Joule heat, and others are discussed. R.C.T.

N81-23512# Technische Hochschule, Darmstadt (West Germany).
IONOSPHERIC DISTURBANCES OF MAGNETOSPHERIC ORIGIN
H. POEVERLEIN and E. NESKE (Fraunhofer-Inst. fuer Physikalische Messtechnik, Freiburg) *In* AGARD The Phys. Basis of the Ionosphere in the Solar-Terrest. System 11 p (SEE N81-23507 14-42) Feb. 1981 refs
Avail: NTIS HC A17/MF A01

Various types of coupling between magnetosphere and ionosphere are distinguished. Various phenomena occurring in connection with geomagnetic disturbances are discussed which give a clear evidence of magnetosphere ionosphere coupling. The displacement of the midlatitude trough of the ionosphere to lower L values (lower latitudes) with increased geomagnetic activity, corresponds to a similar displacement of the plasmapause. The large scale magnetospheric convection is demonstrated by theoretically derived pictures of streamlines. An expression for the location of the plasmapause in dependence on K sup p is obtained from some crude approximative relationships. R.C.T.

N81-23513*# Lockheed Missiles and Space Co., Palo Alto, Calif.
MAGNETOSPHERE-IONOSPHERE COUPLING THROUGH THE AURORAL ACCELERATION REGION
R. D. SHARP and E. G. SHELLEY *In* AGARD The Phys. Basis of the Ionosphere in the Solar-Terrest. System 13 p (SEE N81-23507 14-42) Feb. 1981 refs
(Contract NAS5-25773; NAS2-3395; NSF ATM-79-11174)
Avail: NTIS HC A17/MF A01 CSCL 04A

An important form of coupling between the magnetosphere and the ionosphere occurs through acceleration mechanisms operative in the high altitude ionosphere on magnetic field lines connecting to the auroral zone. Energetic ion mass spectrometer data from within these auroral acceleration regions are presented to illustrate the characteristics of the mechanisms. Observations of ionospheric plasmas in the ring current, the distant plasma sheet, and the magnetotail lobes are shown illustrating the extent of their circulation and the importance of their contribution to the plasma in each regime. Finally the precipitating plasmas in the auroral region and the extent and peculiar effects of the O(+) component of that precipitation on the ionosphere are illustrated. R.C.T.

N81-23514*# Utah State Univ., Logan. Center for Atmospheric and Space Sciences.
MODELLING THE HIGH-LATITUDE IONOSPHERE
W. J. RAITT, R. W. SCHUNK, and J. J. SOJKA *In* AGARD The Phys. Basis of the Ionosphere in the Solar-Terrest. System 14 p (SEE N81-23507 14-42) Feb. 1981 refs
(Contract NAG2-77; F19628-79-C-0025; NSF ATM-78-10501)
Avail: NTIS HC A17/MF A01 CSCL 04A

Results of an ionospheric model program are presented which demonstrate the extreme variability of the steady state, daytime, ionospheric F region electron density and ion composition due to both neutral atmospheric changes with solar cycle, season and magnetic activity, and to the effects of ionospheric drifts caused by perpendicular electric fields. Consideration is given to the time history of the ionospheric plasma as it undergoes convective motion due to the combined effects of corotation forces and electromagnetic forces which results from the mapping of the magnetospheric cross tail electric field to the rotating ionosphere. A simple model of the convection pattern is described. The model calculates the net effect of the tendency for the plasma to corotate about the geographic pole and the E sub Bar times B sub Bar velocity induced by a perpendicular electric field mapped to a circle centered about a point 5 deg antisunward of the geomagnetic pole and oriented such that the equipotentials are parallel to the noon midnight meridian. This convection pattern shows the generally accepted features of high latitude convection, but because of the offset between the geographic and geomagnetic poles a marked universal time dependence in these features is predicted. R.C.T.

N81-23515# Norwegian Defence Research Establishment, Kjeller.
THE PHYSICS OF RADIO WAVE ABSORPTION
E. V. THRANE *In* AGARD The Phys. Basis of the Ionosphere in the Solar-Terrest. System 15 p (SEE N81-23507 14-42) Feb. 1981 refs
Avail: NTIS HC A17/MF A01

Various aspects of the physical causes of radio wave absorption in the ionosphere are reviewed. The theory for propagation of radio waves through a partially ionized atmosphere is developed. Physical models of the D region and lower E layer that may explain the observed variation of absorption are discussed. R.C.T.

N81-23516# Bonn Univ. (West Germany). Radioastronomical Inst.
ELECTRODYNAMICS OF THE LOWER IONOSPHERE
H. VOLLAND *In* AGARD The Phys. Basis of the Ionosphere in the Solar-Terrest. System 13 p (SEE N81-23507 14-42) Feb. 1981 refs
Avail: NTIS HC A17/MF A01

The electrical conductivities of the ionospheric E and lower F layers (dynamo region) were investigated with respect to their potential to carry electric current systems. The state of the knowledge about electric current systems flowing within the

ionospheric dynamo region as well as their generator mechanisms were reviewed. R.C.T.

N81-23517# Centre National d'Etudes des Telecommunications, Issy-les-Moulineaux (France).
THE EFFECTS OF AURORAL ACTIVITY ON THE MIDLATITUDE IONOSPHERE
M. BLANC *In* AGARD The Phys. Basis of the Ionosphere in the Solar-Terrest. System 11 p (SEE N81-23507 14-42) Feb. 1981 refs
Avail: NTIS HC A17/MF A01

The various physical processes which occur as a result of solar wind energy deposition on the magnetospheric cavity and thus the midlatitude ionosphere are discussed. Particular emphasis is placed on the complexed geometry of the various channels through which solar wind energy is transported within the magnetospheric cavity from the various dissipation regions of the ionosphere. R.C.T.

N81-23518# Auroral Observatory, Tromso (Norway).
CURRENTS IN THE AURORAL ZONE IONOSPHERE
A. BREKKE *In* AGARD The Phys. Basis of the Ionosphere in the Solar-Terrest. System 9 p (SEE N81-23507 14-42) Feb. 1981 refs
Avail: NTIS HC A17/MF A01

A short outline of the evolution of the model current system at polar latitudes is given. The more recent observations of the Birkeland currents together with the ionospheric currents are interpreted in terms of a simplified current model, which is a current induced by the motion of plasma across the magnetic field lines in the magnetosphere. The amount of Joule heating released in the upper auroral atmosphere during strong auroral electrojets is related to the magnetic field perturbations on ground and it is shown that the amount of heat released is larger for a positive magnetic bay than for a negative bay of similar strength. M.G.

N81-23519# Auroral Observatory, Tromso (Norway).
NEUTRAL WINDS IN THE POLAR IONOSPHERE
A. BREKKE *In* AGARD The Phys. Basis of the Ionosphere in the Solar-Terrest. System 7 p (SEE N81-23507 14-42) Feb. 1981 refs
Avail: NTIS HC A17/MF A01

Observations of the neutral air dynamics in the polar ionosphere are presented and a comparison with some of the present models of the neutral air global wind system is also made. The need for more research in this field is stressed. A few measurements do exist of this phenomenon which on one hand indicate the presence of local heat sources in the auroral zone and on the other a strong influence on the ion drag force. It is concluded that a better understanding of the neutral dynamics in the polar ionosphere is needed since it is generally accepted that the polar cap and auroral zone disturbances influence the neutral atmosphere dynamics at lower latitudes on a global scale. Futhermore the neutral dynamics at auroral heights are coupled to the magnetospheric processes and to the interplanetary space via the magnetic field. A better understanding of the sun-earth relationship can be obtained by studying the neutral atmosphere dynamics at high latitudes. M.G.

N81-23520*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md. Lab. for Planetary Atmospheres.
ELECTRICAL COUPLING BETWEEN THE LOWER ATMOSPHERE AND THE IONOSPHERE
R. A. GOLDBERG *In* AGARD The Phys. Basis of the Ionosphere in the Solar-Terrest. System 11 p (SEE N81-23507 14-42) Feb. 1981 refs
Avail: NTIS HC A17/MF A01

The evidence for interactions between the ionosphere and troposphere is reviewed as a first step in establishing the role of electrical coupling between two regions. Upward processes appear to include the transfer of energy through gravity waves, or through the transmittance of VLF radio waves induced by lightning. In each case, the excitation of the upper atmosphere by tropospheric sources can stimulate feedback processes returning to the troposphere. Downward coupling involves changes in the global and local electrical structure of the atmosphere, and is often induced by solar activity. These effects are more direct and may possibly bypass the stratosphere. The responses in the atmospheric circuit to local changes are nearly instantaneous, and therefore are looked on with promise for possible influences on weather systems. Emerging experimental evidence indicates that atmospheric electric fields, especially at high latitudes and in the upper atmosphere, are responsive to solar and geomagnetic phenomena. Corpuscular radiations are known to strongly enhance the local atmospheric electrical conductivity and ionizations at stratospheric and mesospheric altitudes. Theories postulate that the electric field perturbations regulated by solar activity may be responsibile for the observed statistical correlations between solar activity and thunderstorms. M.G.

N81-23521# Max-Planck-Institut fuer Aeronomie, Katlenburg-Lindau (West Germany).
FIRST RESULTS FROM THE TROMSOE IONOSPHERIC MODIFICATION FACILITY
P. STUBBE, H. KOPKA, A. BREKKE, T. HANSEN, O. HOLT, R. L. DOWDEN, T. B. JONES, T. ROBINSON, H. J. LOTZ, and J. WATERMAN *In* AGARD The Phys. Basis of the Ionosphere in the Solar-Terrest. Systems 9 p (SEE N81-23507 14-42) Feb. 1981 refs Prepared in cooperation with Tromsoe Univ., Norway and Otago Univ., Dunedin, New Zealand and Leicester Univ., England and Goettingen Univ., West Germany
Avail: NTIS HC A17/MF A01

Preliminary experiments performed during the construction phase of the heating facility are surveyed. Experimental results relating to D region modification, generation of ELF and VLF waves by polar electrojet modulation, excitation of micropulsations, F region deformation, and anomalous absorption are briefly discussed. M.G.

N81-23522*# Boston Univ., Mass. School of Arts and Sciences.
A SUMMARY OF ROCKET-INDUCED IONOSPHERIC PERTURBATIONS
M. MENDILLO and J. FORBES *In* AGARD The Phys. Basis of the Ionosphere in the Solar-Terrest. System 9 p (SEE N81-23507 14-42) Feb. 1981 refs Prepared in cooperation with Boston Coll., Mass.
(Contract NAS8-32844)
Avail: NTIS HC A17/MF A01 CSCL 04A

Observational evidence for artificially induced ionospheric modifications is briefly reviewed and the scientific and technological interest in induced ionospheric holes is discussed. M.G.

N81-23523*# Utah State Univ., Logan. Center for Atmospheric and Space Sciences.
IONOSPHERIC COMPOSITION: THE SEASONAL ANOMALY EXPLAINED
D. G. TORR, P. G. RICHARDS, and M. R. TORR (National Inst. for Telecommunications Research, Johannesburg, South Africa) *In* AGARD The Phys. Basis of the Ionosphere in the Solar-Terrest. System 15 p (SEE N81-23507 14-42) Feb. 1981 refs
(Contract NAS5-24331; NSF ATM-80-05088)
Avail: NTIS HC A17/MF A01 CSCL 04A

The main photochemical processes of the ionosphere are reanalyzed in the light of laboratory measurements of rate coefficients, using the Atmosphere Explorer data. Major changes to the chemistry include the transfer of nearly all metastable O(+) ions to N2(+) via charge exchange with N2. The N2(+) ions become vibrationally excited by resonant fluorescence of solar near UV and near infrared radiation, leading to a return transfer of N2(+) ionization to O(+) by charge exchange or vibrationally excited N2(+) with atomic oxygen. With this chemistry the seasonal variations in the peak electron densities are then shown to be caused primarily by anomalous seasonal variations in neutral composition. The required neutral composition variations are empirically produced by the MSIS model atmosphere. The circulation derived from recent 3D models of the global thermosphere qualitatively accounts for the seasonal variations in neutral composition predicted by the MSIS model. In addition to the composition effect, vibrationally excited N2 is found to contribute a 20% effect to the anomalous seasonal behavior at solar maximum. M.G.

N81-23524# Centre National d'Etudes des Telecommunications, Issy-les-Moulineaux (France).
THERMOSPHERIC NEUTRAL COMPOSITION CHANGES AND THEIR CAUSES
P. BAUER *In* AGARD The Phys. Basis of the Ionosphere in the Solar-Terrest. System 6 p (SEE N81-23507 14-42) Feb. 1981 refs
Avail: NTIS HC A17/MF A01

The various types of thermospheric composition changes are defined and the mechanisms taking place are analyzed. In addition, the role played by molecular oxygen is shown. It appears clearly that the winter F region anomaly is associated with changes in thermospheric composition. In addition to purely dynamical effects driving an increase in atomic oxygen concentration over the winter hemisphere, it is shown that a large part of the anomaly seems to arise from molecular oxygen concentration changes induced by a combination of dynamical and photochemical effects. M.G.

N81-23525# Institut Royal Meteorologique de Belgique, Brussels.
RELATIONS BETWEEN SOLAR FLUX AND E-REGION PARAMETERS
M. NICOLET and L. BOSSY *In* AGARD The Phys. Basis of the Ionosphere in the Solar-Terrest. System 10 p (SEE N81-23507 14-42) Feb. 1981 refs
Avail: NTIS HC A17/MF A01

A detailed analyis of the behavior of the critical frequency of the E-layer with the variation of the solar flux at 10.7 cm leads to the possibility of an explanation of the simultaneous ionization by ultraviolet radiation (Lyman-Beta) and soft X-rays (30 to 100 A). The ratio of the X-radiation to the UV-radiation varying strongly with solar activity changes the ratio of the principal ions concentrations. Author

N81-23526*# Illinois Univ., Urbana-Champaign. Aeronomy Lab.
ENERGETIC PARTICLE PRECIPITATION AT MIDDLE AND LOW LATITUDES
L. G. SMITH and H. D. VOSS *In* AGARD The Phys. Basis of the Ionosphere in the Terrest. System 6 p (SEE N81-23507 14-42) Feb. 1981 refs
(Contract NGR-14-005-181)
Avail: NTIS HC A17/MF A01 CSCL 04A

The results from rocket observations of the nighttime electron density profile in the upper E region (120 to 200 km) over Wallops Island, Virginia are discussed. The observations demonstrated the importance of atmospheric tides in the formation of the intermediate layer near 150 km. These observations also show that, except perhaps on geomagnetically quiet nights, energetic particles are the dominant ionization source in the layer. Using rocket, satellite, and ground-based observations it is possible to study the global morphology of particle precipitation. It is found that, just as there are northern and southern auroral zones, there are also mid-latitude, low-latitude, and equatorial zones of precipitation. The evidence for these zones and the properties of the precipitating particles are summarized. M.G.

N81-23527*# Utah State Univ., Logan. Center for Atmospheric and Space Sciences.
ENERGETIC 0-POSITIVE PRECIPITATION: A SIGNIFICANT ENERGY
M. R. TORR, D. G. TORR, and R. ROBLE (National Center for Atmospheric Research, Boulder, Colo.) *In* AGARD The Phys. Basis of the Ionosphere in the Solar-Terrest. System 11 p (SEE N81-23507 14-42) Feb. 1981 refs
(Contract NAS8-33992; NAS5-24331)
Avail: NTIS HC A17/MF A01 CSCL 04B

The interaction of 0(+) ions with the thermophere and their subsequent history is described. The large scale effects of this precipitation are examined using a global thermospheric circulation model. A mechanism is suggested by which the energetic 0(+) fluxes may be self-sustaining. M.G.

N81-23528# Institut fuer Astrophysik und Extraterrestrische Forschung, Bonn (West Germany).
ON THE MORPHOLOGY OF THE POLAR THERMOSPHERE
G. W. PROELSS *In* AGARD The Phys. Basis of the Ionosphere in the Solar-Terrest. System 8 p (SEE N81-23507 14-42) Feb. 1981 refs
Avail: NTIS HC A17/MF A01

The latitudinal structure and extension of the thermospheric disturbance zone generated by the solar wind/magnetospheric energy source is investigated using density data obtained by the polar orbiting satellite ESRO 4. A statistical analysis of ESRO 4 data reveals that (1) in the afternoon/evening sector the disturbance boundary coincides with the region of electric current dissipation along the auroral oval; (2) in the midnight/early morning sector dynamical effects extend the disturbance zone to lower latitudes and this expansion is strongly dependent on season and magnetic activity; and (3) in the late morning sector direct heating effects along the auroral oval are superimposed on the residuals of the early morning disturbance. These results are consistent with previous observations and provide boundary conditions for upper atmospheric models. M.G.

N81-23529# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
STRUCTURE OF ELECTRON TEMPERATURE
H. THIEMANN *In its* The Phys. Basis of the Ionosphere in the Solar-Terrest. System 9 p (SEE N81-23507 14-42) Feb. 1981 refs
Avail: NTIS HC A17/MF A01

Electron density and temperature measurements of the retarding potential analyzer on board the AEROS-B satellite are analyzed in an altitude range from about 300 to 700 km for daytime conditions. The average temperature always displays the same qualitative pattern as a function of electron density and latitude for fixed altitudes. A model function describing this behavior is given. By means of this function the temperature response of the corresponding experimental data on seasonal as well as on hemispherical effects is discussed. M.G.

N81-23530*# Illinois Univ., Urbana-Champaign. Aeronomy Lab.
MIDLATITUDE SPORADIC-E LAYERS
L. G. SMITH and K. L. MILLER *In* AGARD The Phys. Basis of the Ionosphere in the Solar-Terrest. System 6 p (SEE N81-23507 14-42) Feb. 1981 refs
(Contract NGR-14-005-181)
Avail: NTIS HC A17/MF A01 CSCL 04A

Rocket borne probes and incoherent scatter radar were demonstrated to be effective methods of studying the structure of midlatitude sporadic E layers. Layers are formed when metal ions are converged vertically in a wind shear to produce a local enhancement of electron density. Rocket and radar observations show that the layers may occassionally have complex structure produced by an unstable wind shear. The partial transparency to radio waves of sporadic E layers is shown to be due to localized regions of high electron density. E.D.K.

N81-23531# Max-Planck-Institut fuer Aeronomie, Katlenburg-Lindau (West Germany).
THE SEASONAL AND GEOGRAPHICAL VARIATION OF EQUATORIAL SPREAD-F IRREGULARITIES INFLUENCED BY ATMOSPHERIC GRAVITY WAVES AND ELECTRIC FIELDS DUE TO THUNDERSTORMS
J. ROETTGER *In* AGARD The Phys. Basis of the Ionosphere in the Solar-Terrest. System 3 p (SEE N81-23507 14-42) Feb. 1981 refs
Avail: NTIS HC A18/MF A01

An empirical model is described which can explain features of large scale equatorial spread F irregularities. A correlation between the diurnal, seasonal, and geographical variation of spread F irregularities and convective thunderstorm activity is found. Originating mechanisms for this correlation are dynamical processes (convection) in the lower atmosphere; the coupling mechanisms are electric fields and atmospheric gravity waves. The empirical model, which bases on worldwide distribution of convective regions and empirical assumptions about ionospheric electric fields, does not claim to be exhaustive but can describe several typical features of the morphology of equatorial spread F irregularities. E.D.K.

N81-23532# Toulouse Univ. (France). Lab. de Sondages Electromagnetiques de l'environnement Terrestre.
PLASMA INSTABILITIES IN THE ELECTROJETS
M. CROCHET *In* AGARD The Phys. Basis of the Ionosphere in the Solar-Terrest. System 11 p (SEE N81-23507 14-42) Feb. 1981 refs In FRENCH; ENGLISH summary
Avail: NTIS HC A17/MF A01

The electron density irregularities embedded in the equatorial and auroral electrojets are associated with plasma instability phenomena (two stream and cross field instabilities). These irregularities extensively investigated using VHF and UHF radars and more recently HF radars, at the equator and in the auroral zone, are often used as tracers of the electron velocity and the electric field in the electrojets. A number of recent experimental results obtained in the equatorial electrojet in Africa with HF radar are presented: long wavelengths measurements and counter electrojet observations. At the light of these experimental results a classification of the electrojet plasma instabilities is proposed. Threshold conditions and saturation of the instabilities are discussed for different equatorial and auroral configurations as the validity of electric field measurements. E.D.K.

N81-23533# Oslo Univ. (Norway).
DYNAMICS OF THE DAYSIDE CUSP AURORA
A. EGELAND, P. E. SANDHOLT, K. HENRIKSEN, C. S. DEEHR, and G. G. SIVJEE *In* AGARD The Phys. Basis of the Ionosphere in the Solar-Terrest. System 8 p (SEE N81-23507 14-42) Feb. 1981 refs Prepared in cooperation with Tromsoe Univ., Norway and Alaska Univ., Fairbanks
Avail: NTIS HC A17/MF A01

A multi national auroral project for investigations of the dayside cusp aurora from Svalbard was begun the winter of 1978/79. The characteristics of the cusp emission were studied and the results are summarized. The occurrence and duration of discrete auroral forms superimposed on the weak permanent 630 nm belt were not previously separated from the clean cusp aurora. Special attention is given to the dynamics of the dayside cusp aurora and the simultaneous occurring aurora in the night sector in relation to the dayside and nightside magnetic activity. The conclusion is that a dayside current system exists and that it is associated with the position of the cusp aurora. The intensity and movements of this current system are correlated with the nightside electrojet. It is suggested that a discontinuity similar to the Harang discontinuity exists in the dayside cusp around magnetic noon. E.D.K.

N81-23534*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
LARGE-SCALE WAVES IN THE IONOSPHERE OBSERVED BY THE AE SATELLITE
S. H. GROSS (Polytechnic Inst. of New York, Farmingdale), C. A. REBER, and F. HUANG (Computer Sciences Corp., Silver Spring, Md.) *In* AGARD The Phys. Basis of the Ionosphere in the Solar-Terrest. System 10 p (SEE N81-23507 14-42) Feb. 1981 refs
Avail: NTIS HC A17/MF A01 CSCL 04A

Atmospheric Explorer (AE) satellite data were used to establish whether coherent waves in the gravity wave range are present in both neutral and ionized media in the thermosphere. The AE-C data in particular are shown. Data consist of the in situ argon, helium, nitrogen, and oxygen densities, plasma density, and ion and electron temperatures. Filtering provides the fluctuation signals for each which are spectrum analyzed for power and cross spectra. The observed frequencies are essentially proportional to the spatial wavenumbers along the satellite track. Scale sizes range from thousands to tens of kilometers. E.D.K.

N81-23535# Leicester Univ. (England). Dept. of Physics.
THE GENERATION AND PROPAGATION OF ATMOSPHERIC GRAVITY WAVES WITH SPECIAL REFERENCE TO RADIO PROPAGATION
T. B. JONES *In* AGARD The Phys. Basis of the Ionosphere in the Solar-Terrest. System 14 p (SEE N81-23507 14-42) Feb. 1981 refs
Avail: NTIS HC A17/MF A01

The characteristics of the propagation of internal gravity waves in the upper atmosphere can be derived from a consideration of the hydrostatic equations. These are shown to be consistent with the wave like disturbances in the ionosphere known as travelling ionospheric disturbances (TIDs). The two main classes of TIDs observed experimentally can be identified with two independent solutions of the gravity wave equations. Possible sources of the gravity waves were considered and the disturbances resulting from a point impulsive source in the atmosphere are consistent with the measured parameters of TIDs. The changes in electron density distributions in the ionosphere during TID activity were described in detail and their influence on radio systems ranging from HF to UHF considered. E.D.K.

N81-23536# University Coll. of Wales, Aberystwyth. Dept. of Physics.
PREDICTION TECHNIQUES FOR FORTHCOMING SOLAR MAXIMA
G. M. BROWN *In* AGARD The Phys. Basis of the Ionosphere in the Solar-Terrest. System 7 p (SEE N81-23507 14-42) Feb. 1981 refs
Avail: NTIS HC A17/MF A01

The various techniques used to predict the magnitude of a forthcoming sunspot maximum are reviewed. Details of individual methods are not considered, but full bibliographical references are given. Most of the techniques are discussed in relation to their applications to the current solar cycle number 21. During the last decade there was substantial improvement in prediction abilities arising from the realization that a solar cycle is being built up for several years prior to its conventional beginning at sunspot minimum. This means that information about the nature and size of an up coming cycle must be contained in both solar and terrestrial data obtained during the declining phase of an old cycle and around the minimum. Various prediction applications of this principle are discussed which show considerable promise. These methods break ground in having a degree of physical backing rather than being purely empirical or dependent on the existence of periodicities in the sunspot number time series. E.D.K.

N81-23537# Science Research Council, Slough (England). Rutherford and Appleton Labs.
IONOSPHERIC PREDICTIONS FOR HF RADIO SYSTEMS: THE FUTURE
P. A. BRADLEY and M. LOCKWOOD *In* AGARD The Phys. Basis of the Ionosphere in the Solar-Terrest. System 13 p (SEE N81-23507 14-42) Feb. 1981 refs
Avail: NTIS HC A17/MF A01

Current prediction procedures are reviewed briefly and the uses for which they are needed are considered. Examples are presented of requirements for long term, short term, and storm propagation predictions. Desirable and likely future improvements in knowlege of ionospheric morphology leading to more accurate predictions are discussed. Specific suggestions are made for extended prediction procedures to aid optimization of communication systems. These involve estimates of additional parameters and improved representations of other factors. In particular, predictions of background interference, signal dispersion and error rates are proposed. E.D.K.

N81-23538*# Pennsylvania State Univ., University Park. ionosphere Research Lab.
ULTIMATE LIMITS TO ERROR PROBABILITIES FOR IONOSPHERIC MODELS BASED ON SOLAR GEOPHYSICAL INDICES AND HOW THESE COMPARE WITH THE STATE OF THE ART
J. S. NISBET and C. G. STEHLE *In* AGARD The Phys. Basis of the Ionosphere in the Solar-Terrest. System 7 p (SEE N81-23507 14-42) Feb. 1981 refs
(Contract NSG-5212; NGL-39-009-003)
Avail: NTIS HC A17/MF A01 CSCL 03B

An ideal model based on a given set of geophysical indices is defined as a model that provides a least squares fit to the data set as a function of the indices considered. Satellite measurements of electron content for three stations at different magnetic latitudes were used to provide such data sets which were each fitted to the geophysical indices. The magnitude of the difference between the measured value and the derived equation for the data set was used to estimate the probability of making an error greater than a given magnitude for such an ideal model. Atmospheric Explorer C data is used to examine the causes of the fluctuations and suggestions are made about how real improvements can be made in ionospheric forecasting ability. Joule heating inputs in the

auroral electrojets are related to the AL and AU magnetic indices. Magnetic indices based on the time integral of the energy deposited in the electrojets are proposed for modeling processes affected by auroral zone heating. E.D.K.

N81-23539# Freiburg Univ. (West Germany).
THE DAY-BY-DAY VARIABILITY OF THE IONOSPHERIC PEAK DENSITY
K. RAWER, E. HARNISCHMACHER, and R. EYFRIG *In* AGARD The Phys. Basis of the Ionosphere in the Solar-Terrest. System 7 p (SEE N81-23507 14-42) Feb. 1981 refs
Avail: NTIS HC A17/MF A01

In order to extend the present monthly ionospheric prediction schedule to daily predictions, different causes of day by day variability are discussed. The effect of lunar tides is shown to be predictable. It is particulaly important at certain hours. E.D.K.

N81-23540# Leicester Univ. (England). Dept. of Physics.
EXPERIMENTAL VALIDATION OF THE ONSOD OMEGA PREDICTION METHOD
T. B. JONES and K. MOWFORTH *In* AGARD The Phys. Basis of the Ionosphere in the Solar-Terrest. System 19 p (SEE N81-23507 14-42) Feb. 1981 refs
Avail: NTIS HC A17/MF A01

A detailed analysis of the experimentally determined performance of the Omega system at three locations within the United Kingdom is presented. The predicted performance of the system was obtained using Omega navigation System Operations detail program. The validity of these line of position (LOP) corrections for the three locations was assessed and their diurnal and seasonal variations quantified. The variation in performance of Omega at the three receiver sites was studied by examining the difference in the measured error of the same LOP at the three locations. E.D.K.

N81-23541# Istituto Nazionale di Geofisica, Rome (Italy). Ionospheric Dept.
SOME CONSIDERATIONS UPON MODELS FOR IONOSPHERIC RADIO COMMUNICATIONS FORECASTING
P. DOMINICI and B. ZOLESI *In* AGARD The Phys. Basis of the Ionosphere in the Solar-Terrest. System 16 p (SEE N81-23507 14-42) Feb. 1981 refs
Avail: NTIS HC A17/MF A01

The ionospheric radio communications exhibit, along with consistent advantages, the well known disadvantage that the essential parameters show large variations which must be forecast. By appropriate models, some of these variations are reconductible to known behaviors of solar and geophysical quantities and are therefore foreseeable with satisfactory statistical accuracy; on the contrary, other variations are completey casual. A brief discussion of the differing points of view concerning ionospheric modelling is included. E.D.K.

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GEOPHYSICS

Includes aeronomy; upper and lower atmosphere studies; ionospheric and magnetospheric physics; and geomagnetism.

N82-19747# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). Fluid Dynamics Panel.
MODELING THE LOWEST 1 KM OF THE ATMOSPHERE
W. S. LEWELLEN (Aeronautical Research Associates of Princeton, Inc.) Nov. 1981 89 p refs
(AGARD-AG-267; ISBN-92-835-1407-6; AD-A111413) Avail: NTIS HC A05/MF A01

The interdependence between the turbulent transport of mass, momentum, and energy through the lower levels of the atmosphere, and the distribution of wind, temperature, and species within this layer were reviewed. Particular emphasis is placed on models, either analytical or numerical, which have a basic theoretical foundation in turbulent transport modeling. The results of example model solutions are used to discuss such micrometeorological problems as: wind shear and turbulence around airports; the prediction of low-level clouds and fog; the dispersion of industrial pollutants; the interaction of electromagnetic radiation with turbulent fluctuations in humidity and temperature; and the evolution of organized features within the boundary layer. T.M.

51

LIFE SCIENCES (GENERAL)

Includes genetics.

N80-29990# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
HIGH-SPEED, LOW-LEVEL FLIGHT: AIRCREW FACTORS
D. H. GLAISTER, ed. (Royal Air Force Inst. of Aviation Medicine) Mar. 1980 321 p refs In ENGLISH and FRENCH Presented at the Aerospace Med. Panel's Meeting, Lisbon, 22-26 Oct. 1979 (AGARD-CP-267; ISBN-92-835-0263-9; AD-A087592) Avail: NTIS HC A14/MF A01

Factors effecting aircrews during high speed, low level flight are addressed. Specific topics include ride quality and the effect of the physical environment; thermal effects; vibration effects; cockpit design and aircrew workload; and escape and survival. Particular attention is paid to ride bumpiness and the influence of airframe design and control strategy, the effects of vibration on vision, and the problems and potential uses of helmet mounted sights and displays. For individual titles, see N80-29991 through N80-30018.

N80-29991# Royal Air Force, Farnborough (England).
RIDE-BUMPINESS AND THE INFLUENCE OF ACTIVE CONTROL SYSTEMS
J. G. JONES *In* AGARD High-Speed, Low-Level Flight 16 p (SEE N80-29990 20-51) Mar. 1980 refs
Avail: NTIS HC A14/MF A01

The influence of aircraft design and control strategy on aircraft disturbances stressful to aircrew in high-speed, low-altitude flight is discussed. Standard methods for assessing ride quality are briefly reviewed. In addition, a technique is described that combines time-plane characteristics of response with frequency-plane features usually defined in terms of power spectra. This method, which has been developed as a tool for assessing the dynamic response of aircraft in turbulence, may provide useful additional information for human factors work. The technique leads in particular to a 'characteristic signature', in the time plane, of the aircraft response to gusts. In determining the dependence on aircraft dynamics of this characteristic energy pattern emphasis is placed on the concept of signal 'increments' or 'differences', in contrast to the sinusoidal components of Fourier analysis. It is perhaps relevant that the role of signal differences in time or space is also stressed in classical work on the mechanisms of human sensory perception. M.G.

N80-29992# Amt fuer Wehrgeophysik, Traben-Trarbach (West Germany).
INFLUENCES OF GEOPHYSICAL FACTORS (METEOROLOGICAL AND TOPOGRAPHICAL) ON THE PILOT-AIRCRAFT-SYSTEM IN HIGH SPEED LOW LEVEL FLIGHT (HSLLF)
K. KRAMES *In* AGARD High-Speed, Low-Level Flight 46 p (SEE N80-29990 20-51) Mar. 1980 refs
Avail: NTIS HC A14/MF A01

The effects of interaction between atmosphere, lithosphere, and biosphere on low level high speed flight are discussed along with particular examinations of visibility, wind, thunderstorms, and sleet and hailstones. Since geophysical hazards are at their maximum in low levels, it follows that an extreme reaction ability of the man-machine system in that domain is an absolute requirement. The primary function of geophysical information consists in assessing those flight routes and flight levels presenting minimum potential hazards to the accomplishment of the individual military mission. The use of terrain data bases offers an optimal approach in achieving a high degree of resolution on the basis of 95-by-150-m-grid. The inclusion of weather, vegetation, and surface data will ensure detailed flight information. M.G.

N80-29993# British Aerospace Aircraft Group, Preston (England).
DEVELOPMENT IN HIGH-SPEED LOW-LEVEL FLIGHT: THE PILOT'S VIEWPOINT
J. J. LEE *In* AGARD High-Speed, Low-Level Flight 3 p (SEE N80-29990 20-51) Mar. 1980
Avail: NTIS HC A14/MF A01

Developments in aviation technology during the last one and a half decades leading to significant benefits to high speed low level flight are briefly reviewed. It is concluded that the human characteristics of sensitiveness to stimuli, reaction time, strength/stamina, and adaptability have remained virtually unchanged in evolution terms and will remain a constant in flight assessment. Given the requirements of the mission and the scenario, the areas where development can be applied to improve mission success still remain firmly in the fields of performance, handling, guidance/navigation and vehicle design characteristics. M.G.

N80-29994# Aerospace Medical Research Labs., Wright-Patterson AFB, Ohio.
BIOTECHNOLOGY CHALLENGES PRESENT IN OPERATIONAL HIGH-SPEED LOW-LEVEL FLIGHT
R. L. DEHART *In* AGARD High-Speed, Low-Level Flight 6 p (SEE N80-29990 20-51) Mar. 1980 refs
Avail: NTIS HC A14/MF A01

Operational stressors in high speed low level flight (HSLL) are identified for the mission scenarios of the B-52, F-111, and the A-10 aircraft. It is concluded that there exists a common technology need requiring contributions from the aerospace medical practitioner which becomes evident in discussing the aircraft in their respective HSLL combat missions. Continued development of automated systems integrating components within the cockpit affecting aircraft controls and weapons delivery systems is required. The specialist in aerospace medicine must ensure that sophisticated systems do in fact offload peripheral tasks of the pilot and increase his performance and ability to successfully accomplish the mission in a high threat combat environment. In addition, it is evident opportunities are available for biotechnology to improve or develop systems providing required information to the aircrew member in a method or format which permits him to remain heads-up and eyes-out-of the cockpit. M.G.

N80-29995# Centre d'Etudes et de Recherches de Medecine Aerospatiale, Paris (France).
THERMIC PROBLEMS PRESENTED BY HIGH-SPEED, LOW-LEVEL FLIGHT [PROBLEMES THERMIQUES POSES PAR LE VOL A GRANDE VITESSE ET A BASSE ALTITUDE]
J. TIMBAL and J. COLIN *In* AGARD High-Speed, Low-Level Flight 7 p (SEE N80-29990 20-51) Mar. 1980 refs In FRENCH
Avail: NTIS HC A14/MF A01

In certain cases, high speed flight at low altitude is likely to create conditions which surpass the tolerance limits of pilots. The physical factors of the environment as well as their effects on performance have been the subject of numerous studies. One method of predicting the period of heat tolerance is presented and discussed. The important part played by the humidity of the air and the physical activity of the pilot is demonstrated. The prevention of climatic inconveniences requires the use of relatively simple means which must be put into effect before flight. During the course of flight, prevention implies that the inconveniences were predicted during the design of the aircraft. The problem of risk associated with thermal loads is discussed under three principles: evaluating thermal ambience, evaluating human tolerance, and increasing the tolerance. Transl. by A.R.H.

N80-29996# Royal Air Force Inst. of Aviation Medicine, Farnborough (England).
EFFECTS ON PERFORMANCE OF THERMAL STRAIN ENCOUNTERED DURING HIGH-SPEED, LOW-LEVEL FLIGHT
T. M. GIBSON, J. R. ALLAN, C. J. LAWSON, and R. G. GREEN *In* AGARD High-Speed, Low-Level Flight 9 p (SEE N80-29990 20-51) Mar. 1980 refs
Avail: NTIS HC A14/MF A01

The effects of thermal strain on pilot performance during high speed, low level flight are examined through flight simulator testing. Each subject carried out two replicate experiments in which he was first heated to a deep body temperature of 37.5 C, then alternately heated and cooled twice between deep body temperature limits of 37.9 and 38.5 C, and finally cooled to 37.5 C. Core temperatures and skin temperatures were monitored. The results demonstrate that differences in performance on the flight simulator can be produced by heating or cooling the skin at the same level of deep body temperature. These differences do not exist at deep body temperatures of 37.5 C, but at core temperatures between 37.9 and 38.5 C, performance during heating is worse than during cooling. Above the critical core temperature (i.e., above 37.5 C), skin temperature is a more important determinant of performance than the absolute level of deep body temperature; it is, however, impossible to exclude [illegible]ssible effects on performance of direction and rate of change c[illegible]core and skin temperatures. It is clear that the thermal strain [illegible]ountered by aircrew in routine high speed, low level flight [illegible]rm conditions could cause a reduction in the operational cap[illegible]y of the aircrew. The situation will be exacerbated by anythin[illegible]t increases the thermal strain such as the wearing of more [illegible]ive protective clothing, higher work rates and repeated sortie[illegible]ted by inadequate time for thermal recovery. M.G.

N80-29997# School of Aerospace Medicine, Brooks AFB, Tex. Crew Technology Div.
AIRCREW HEAT STRESS DURING HIGH-SPEED, LOW-LEVEL FLIGHT
R. F. STRIBLEY and S. A. NUNNELEY *In* AGARD High-Speed, Low-Level Flight 5 p (SEE N80-29990 20-51) Mar. 1980 refs
Avail: NTIS HC A14/MF A01

An overview of the problems related to aircrew heat stress during high speed low level flight is given. Physiological heat exchange mechanisms in the cockpit environment and the performance consequences of heat stress are examined. Current cockpit cooling systems designs are assessed and suggestions are made for the design of man-oriented cockpit cooling. M.G.

N80-29998# Laboratoire Central de Biologie Aerospatiale, Paris (France).
QUANTIFYING THE AGRESSION GENERATED BY LOW FREQUENCY VIBRATIONS [ESSAI DE QUANTIFICATION DE L'AGRESSION ENGENDREE PAR LES VIBRATIONS DE BASSE FREQUENCE]
P. QUANDIEU, P. BORREDON, J. C. ROUHET, and L. PELLIEUX *In* AGARD High-Speed, Low-Level Flight 17 p (SEE N80-29990 20-51) Mar. 1980 refs In FRENCH
Avail: NTIS HC A14/MF A01

From a biomechanical viewpoint, man can be considered as a deformable solid under the effect of mechanical stimulation such that as provoked by flight at high speed and low altitude. A physiological response to physical stimulation results and muscular mass struggles against the deformation imposed. According to the degree of muscle tension, the vibratory response of the subject is a phase displacement in relation to the oscillation which gives birth to movement. The final deformation is the result of mechanical action and physiological reaction. A baboon was used in laboratory tests to demonstrate magnitude of the mechanical capability to account for the behavior of a subject exposed to vibrations. A loads transducer and an accelerometer were placed at the point where force was applied in order to determine the effective mass (the complex relation of dynamic force to the acceleration). With the help of measurements obtained totally outside the body, it was possible to record an eminently variable dynamic behavior the whole length of the same vibration. The importance of the variations obtained on the parameters considered provides hope for using the method to examine the total behavior of man exposed to vibrations. Transl. by A.R.H.

N80-29999# Naval Aerospace Medical Research Lab., New Orleans, La.
A METHOD FOR STUDYING HUMAN BIODYNAMIC RESPONSES TO WHOLE-BODY Z-AXIS
J. C. GUIGNARD, C. L. EWING, G. C. WILLEMS, W. ANDERSON, W. H. MUZZY, III, D. J. THOMAS, and P. L. MAJEWSKI *In* AGARD High-Speed, Low-Level Flight 7 p (SEE N80-29990 20-51) Mar. 1980 refs
Avail: NTIS HC A14/MF A01

The methodology used as well as some illustrative results obtained in current experiments to determine the transmissibility

of mechanical vibration to major axial segments (pelvis, upper torso, head) of the seated human body vibrated in the z-axis are presented. Factors influencing transmissibility are mentioned and the importance of controlling such factors in experimental determinations of the human biodynamic response to vibration is discussed. The methodology described, adapted from established use in human impact studies, includes the use of standardized anatomical coordinate systems for data reference, which is essential to the meaningful comparison of responses measured in different subjects or in different conditions of vibration. R.C.T.

N80-30000# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Bonn (West Germany). Inst. fer Flugmedizin.

HEAD MOVEMENTS INDUCED BY VERTICAL VIBRATIONS

L. VOGT, E. SCHWARTZ, and H. MERTENS *In* AGARD High-Speed, Low-Level Flight 14 p (SEE N80-29990 20-51) Mar. 1980 refs

Avail: NTIS HC A14/MF A01

Eleven subjects were vibrated on a shake-table in the frequency range of 2 Hz to 19 Hz to assess the complex head motion induced by z-axis mechanical vibration. Acceleration amplitude was sinusoidal and held constant at 0.35 g (rms). Each subject was given two trials; one sitting relaxed without a backrest; the other leaning against a backrest with a 12 deg inclination from the vertical. Head motion was recorded with a special television camera (x-y tracker) by pursuing a target painted on the temporal part of the subject's forehead. This instrument continuously records the horizontal and vertical coordinates of the tracked point and gives the output as analogues voltages. For each frequency and experimental condition the vertical and horizontal motion of the tracking target was related to the displacement of the shake-table. The results are given as different transmissibility curves for vertical and horizontal head motion. When relating horizontal to vertical transmissibility it becomes obvious that, without a backrest, at the resonant frequency the horizontal transmissibility is about 75 percent of the vertical transmissibility. When using a backrest horizontal transmissibility is reduced to about 35 percent of the vertical transmissibility. R.C.T.

N80-30001# Royal Aircraft Establishment, Farnborough (England).

THE EFFECT OF RECLINED SEATING ON THE TRANSMISSION OF LINEAR VIBRATION TO THE HEAD

M. E. JOHNSTON *In* AGARD High-Speed, Low-Level Flight 14 p (SEE N80-29990 20-51) Mar. 1980 refs

Avail: NTIS HC A14/MF A01

The transmission of vibration to the heads of subjects seated in a Mk 10B ejection seat exposed to vibration within the frequency range 2-25 Hz was measured. Measurements were made for the seat conventionally mounted (back angle 20 deg to the vertical) and reclined for seat back angles of 30 deg., 45 deg., and 60 deg. to the vertical. The seat was vibrated using a swept sine wave technique in either the vertical or lateral direction. Head motion in each of the three head anatomical orthogonal linear axes (G sub x, G ub y, G sub z) *was measured on a bite bar* fitted with accelerometers. Ten subjects were used, each fitted with a standard Mk 2/3 flying helmet. The results indicate that for a given input, particularly in the lateral axis, head motion increases considerably when the head is in contact with the rest. Also head motion both against and off the rest increases as the seat back angle to the vertical is increased. Such increases in vibration to the head are very uncomfortable and could well lead to a performance decrement for a visual task. R.C.T.

N80-30002# Royal Air Force Inst. of Aviation Medicine, Farnborough (England).

THE EFFECTS OF AIRCRAFT VIBRATION ON VISION

G. R. BARNES *In* AGARD High-Speed, Low-Level Flight 11 p (SEE N80-29990 20-51) Mar. 1980 refs

Avail: NTIS HC A14/MF A01

Movements of the head resulting from aircraft vibration were investigated in terms of their effects on visual performance. Major emphasis was placed on the limitations in the response of the pursuit reflex and the vestibulo-ocular reflex. The following analyses were conducted in order to assess: (1) the frequency characteristics of the vestibulo-ocular and pursuit reflexes; (2) the ability of subjects to suppress reflex vestibular eye movements which become inappropriate when viewing a helmet-mounted display; (3) the effect of relative movement between the eye and the viewed object on visual performance, and (4) *the biodynamic response of the head* during vibration which gives rise to stimulation of the vestibular system. The results are discussed in an attempt to estimate the effects of aircraft vibration on visual performance. R.C.T.

N80-30003# Royal Aircraft Establishment, Farnborough (England).

THE EFFECT OF 3-25 HZ VIBRATION ON THE LEGIBILITY OF NUMERIC LIGHT EMITTING DIODE DISPLAYS

M. E. JOHNSTON and J. H. WHARF *In* AGARD High-Speed, Low-Level Flight 9 p (SEE N80-29990 20-51) Mar. 1980 refs

Avail: NTIS HC A14/MF A01

The effects of 3-25 Hz2 sinusoidal vibration at an rms acceleration level of 2.5 m/s2 in both the vertical and lateral axes on *the performance of a reading task are described.* The task was to read aloud numeric characters presented on a yellow high luminance light emitting diode display which was designed for the military cockpit. Random numbers were presented on the display in sets of four changed every 3 s. The subjects were each fitted with a MK 2/3 flying helmet and strapped into an Mk 10B ejection seat which was mounted on the same vibration platform as the display. Tests were conducted with the subject's head held both against and just off the head rest. The results indicate that reading performance is affected most by lateral vibration, when the head is against *the head rest. Maximum errors* occurred for lateral vibration frequencies of 15-16 Hz which is shown to correspond to the probable onset of overlapping nodal images due to head vibration. R.C.T.

N80-30004# Royal Aircraft Establishment, Farnborough (England). Flight Systems Dept.

THE EFFECT OF TURBULENCE ON HELMET MOUNTED SIGHT AIMING ACCURACIES

N. O. TATHAM *In* AGARD High-Speed, Low-Level Flight 4 p (SEE N80-29990 20-51) Mar. 1980

Avail: NTIS HC A14/MF A01

The effects of the turbulence associated with high speed, low level flight on the accuracies achievable with helmet mounted sighting equipment were assessed. In-flight analysis were conducted during trials in a Canberra aircraft, flying straight and level at 350 km, 250 ft. Laboratory analysis were conducted using a two axis vibration rig driven by vibration data recorded from the same Canberra aircraft to provide simulated turbulence. Aiming accuracies were obtained for collimated targets fixed in space in the simulation, and for both collimated targets fixed to the airframe and ground targets in flight. The results obtained show a good correlation between aiming errors achieved in flight and those obtained from the simulation, and demonstrate that the aiming errors consist mainly of a low frequency random motion which increases with vibration level. In addition, various techniques were investigated to overcome the errors involved in order to enable fine aiming to be performed with the helmet sight. R.C.T.

N80-30005# Naval Aerospace Medical Research Lab., New Orleans, La.

CLINICAL MEDICAL EFFECTS OF HEAD AND NECK RESPONSE DURING BIODYNAMIC STRESS EXPERIMENTS

D. J. THOMAS, C. L. EWING, P. L. MAJEWSKI, and N. S. GILBERT *In* AGARD High-Speed, Low-Level Flight 15 p (SEE N80-29990 20-51) Mar. 1980 refs

Avail: NTIS HC A14/MF A01

Volunteers were subjected to various degrees of impact acceleration. The directions of applied acceleration were -X (front to back), +Y (right to left), and -X + Y (45 degrees between -X and +Y). The major categories of symptoms were neckpain, headache, restraint related musculoskeletal symptoms, and syncope. A few special cases had findings which *required clinical* evaluation and followup. The type, extent, duration, and severity of the symptoms were related in some cases to the direction peak acceleration, and acceleration duration. R.C.T.

N80-30006# Air Force Flight Dynamics Lab., Wright-Patterson AFB, Ohio.
OPERATIONAL ASPECTS OF GUIDANCE AND CONTROL ADVANCES VERSUS PILOT WORKLOAD FOR LOW ALTITUDE, HIGH SPEED FLIGHT
M. A. OSTGAARD *In* AGARD High-Speed, Low-Level Flight 10 p (SEE N80-29990 20-51) Mar. 1980 refs
Avail: NTIS HC A14/MF A01

Some of the characteristics of the human operator and their similarity to guidance and control functions are discussed. It is shown that the operator's characteristics as a controller depend on four kinds of variables: control task variables, which include the system inputs and all the system elements external to the operator; environmental variables such as ambient illumination, temperature, vibration, etc.; operator centered variables such as training, fatigue, motivation; and procedural variables such as instructions, practice, order of presentation relating to a given task. When these variables are essentially time stationary or invariant over an interval of interest, the operator vehicle system can be modeled as a quasilinear system much the same as standard servo loops. R.C.T.

N80-30007# Fraunhofer-Inst. fuer Informations- und Datenverarbeitung, Karlsruhe (West Germany).
TV OPERATOR PERFORMANCE IN REAL TIME AIR-TO-GROUND RECONNAISSANCE MISSIONS UNDER TASK-LOADING CONDITIONS
H. MUTSCHLER *In* AGARD High-Speed, Low-Level Flight 11 p (SEE N80-29990 20-51) Mar. 1980 refs Sponsored by the German Federal Ministry of Defense
Avail: NTIS HC A14/MF A01

The detection performance of a black-and-white-TV operator in real time reconnaissance missions was determined by the parameters of the RPV-system, the scene, and the task. A series of 6 experiments were performed with 19 untrained subjects who had to find military vehicles in static ground scenes displayed on a TV screen. The scenes were presented only shortly, for 1 to 10 secs. This corresponds to a speed of about 50 to 500 km/h at a nonoverlapping frame rate. The subjects pointed to located targets with a light-pen. Analysis of variance indicate that the detection rate is influenced by: (1) scene parameters which consititute the conspicuity of a target in a natural scene, such as global context, contrast and local context; (2) short presentation times of less than 3 secs; (3) system parameters such as resolution and image segmentation; and (4) number of targets. Detection rate decreases if the task is to mark all targets and detection rate increases if the task is only to indicate those scenes which contain at least one target. The false alarm rate decreases with the number of sessions the subjects took part in and was finally at low level. Taking the confidence level expressed into account proved to increase the detection-false alarm ratio remarkably. Search times were nearly equal to presentation times from 1 to 5 secs only. The search times for the 50% detection rate decreased from 4 secs in the first experiment to 2 secs in the last one. R.C.T.

N80-30008# Marconi Avionics Ltd., Rochester (England). Airborne Display Div.
THE INFLUENCE OF THE DESIGN OF DISPLAYS ON COCKPIT WORKLOAD
R. H. HOLMES *In* AGARD High-Speed, Low-Level Flight 10 p (SEE N80-29990 20-51) Mar. 1980
Avail: NTIS HC A14/MF A01

The problems involved in designing display and controls for high speed low level aircraft are discussed with the emphasis on the reduction of cockpit workload. Some modern display techniques are also described. R.C.T.

N80-30009# Marconi Avionics Ltd., Rochester (England). Airborne Display Div.
COLOUR DISPLAYS: THEIR AVAILABILITY, PERFORMANCE AND APPLICATION TO IMPROVED CREW EFFICIENCY
D. W. HUSSEY *In* AGARD High-Speed, Low-Level Flight 12 p (SEE N80-29990 20-51) Mar. 1980 refs
Avail: NTIS HC A14/MF A01

The use of advanced technology in the form of multifunction electronic displays, processors, sophisticated sensors, and other automated pilot aids are discussed. Guidelines are suggested which are to be used in determining how color is used to enhance the presentation of information. R.C.T.

N80-30010# Royal Aircraft Establishment, Farnborough (England) Flight Systems Dept.
HELMET-MOUNTED DEVICES IN LOW-FLYING HIGH-SPEED AIRCRAFT
D. N. JARRETT *In* AGARD High-Speed, Low-Level Flight 9 p (SEE N80-29990 20-51) Mar. 1980 refs
Avail: NTIS HC A14/MF A01

Two separate simulation studies are described. The first assesses the amount of movement occurring between the pilot's helmet and his eyes. The second concerns the legibility of information presented on an experimental LED matrix display. It is concluded that aircraft vibration does not cause significant helmet movement in comparison with natural voluntary head motion, and that the degrading effect of aircraft vibration on the legibility of displayed information could be counteracted using a brighter display. E.D.K.

N80-30011# Naval Air Development Center, Warminster, Pa.
THE ROLE OF HELMET MOUNTED DISPLAYS IN HIGH-SPEED LOW-LEVEL FLIGHT
G. T. CHISUM *In* AGARD High-Speed, Low-Level Flight 5 p (SEE N80-29990 20-51) Mar. 1980 refs
Avail: NTIS HC A14/MF A01

During critical phases of flight operations the requirement for shifts of gaze between the environment outside the cockpit and the interior of the cockpit is a problem which can be eased by the development of an effective helmet mounted display capable of presenting sensor and aircraft position and condition information. In both fixed wing and rotary wing aircraft, a head out of the cockpit attitude is considered to be highly desirable. An effective helmet mounted display is one which is comfortable to use, does not degrade normal visual functioning, can present the required information, and does not increase crew fatigue due to weight and bulk. The general design concerns regarding helmet mounted displays apply to those to be used in a high speed, low level environment. Some of the design parameters take on special significance, however, in high speed low level flight. E.D.K.

N80-30012# Naval Air Systems Command, Washington, D. C.
RESEARCH FOR VISUAL ENHANCEMENT FOR HIGH SPEED LOW LEVEL FLIGHT SPONSORED BY THE NAVAL AIR SYSTEMS COMMAND
H. ROSENWASSER, G. T. CHISUM (NADC, Warminster, Pa.), J. J. KULIK (Naval Training Equipment Center), M. L. WOLBARSHT (Duke Univ.), M. M. COHEN (NADC, Warminster, Pa.), and A. LEWIS (Cornell Univ.) *In* AGARD High-Speed, Low-LevelFlight 11 p (SEE N80-29990 20-51) Mar. 1980 refs
(Contract N00019-78-C-0431; N00019-78-C-3036)
Avail: NTIS HC A14/MF A01

Apart from engineering considerations, the proper emphasis of the various parameters of visual displays in high speed low level flight depends upon the knowledge of the physiological variables in the visual system. Psychophysical tests can best be interpreted in conjunction with a detailed examination of the physiological function of the visual system. A summary of programs is given to show progress in this approach. E.D.K.

N80-30013# Defence and Civil Inst. of Environmental Medicine, Downsview (Ontario).
HUMAN FACTORS IN HIGH-SPEED LOW-LEVEL ACCIDENTS: A 15 YEAR REVIEW
R. C. RUD and D. F. LEBEN *In* AGARD High-Speed, Low-Level Flight 6 p (SEE N80-29990 20-51) Mar. 1980 refs
Avail: NTIS HC A14/MF A01

The Canadian Forces introduced the CF 104G into Squadron Operation in 1963 and since that time these aircraft have operated in the high speed, low level environment in both the strike/reconnaissance and tactical support roles. Fifty seven accidents involving these aircraft are reviewed with regard to cause factors. Marginal weather appears to be the one most significant factor contributing to low level, high speed accidents; however, several human factors such as visual contrast problems, fatigue, stress, reaction time, mission completion syndrome, inattention, and task overload were identified. Aspects of accidents which

typify human factors problems are described. Suggested possible preventive measures are outlined. E.D.K.

N80-30014# Naval Aerospace Medical Research Lab., New Orleans, La.
CREW STATION ASSESSMENT USING THE BIOMAN MODELING SYSTEM
G. D. FRISCH, L. A. DAULERIO, and M. SCHULTZ *In* AGARD High-Speed, Low-Level Flight 16 p (SEE N80-29990 20-51) Mar. 1980 refs Prepared in cooperation with NADC, Warminster, Pa.
Avail: NTIS HC A14/MF A01

The use of the Bioman modeling system in evaluating the physical compatability of crew members with crew stations under emergency egress conditions is demonstrated and the usefulness of this approach as both a design and evaluation criteria is illustrated. Validated results from F-18 aircraft investigations based both on ejection tower and human physiological acceptance tests are presented to demonstrate the evaluation process of a given crew station. Futhermore, these results are contrasted against those obtained from the A-4 and F-14 and the relative propensity of direct impact injuries are discussed. E.D.K.

N80-30015# Bureau of Medicine and Surgery (Navy). Washington, D.C.
NAVAL AVIATION WATER SURVIVAL PROGRAM
W. MCINTOSH *In* AGARD High-Speed, Low-Level Flight 3 p (SEE N80-29990 20-51) Mar. 1980 refs
Avail: NTIS HC A14/MF A01

The very nature of naval aviation requires that the majority of operation flights be conducted overwater. The missions vary from operations in the immediate vicinity of aircraft carriers and shore bases to single aircraft flights hundreds of miles form the nearest land. Each situation presents unique problems in terms of required survival equipment and length of time to rescue. Major revisions to the Naval Aviation Water Survival Program are presently underway. The Training curricula are being standardized and water survival instructors are to be extensively trained to conduct the training. Aviation life support systems are being modified to provide automatic life preserver inflation and parachute divestment. New water training devices are being procured and training is to be conducted in the devices with the same configuration of life support equipment with which the aircrew members fly. E.D.K.

N80-30016# Martin-Baker Aircraft Co. Ltd., Denham (England).
HIGH-SPEED, LOW-LEVEL FLIGHT SURVIVAL ON EJECTION
M. A. A. HOBBS *In* AGARD High-Speed, Low-Level Flight 2 p (SEE N80-29990 20-51) Mar. 1980
Avail: NTIS HC A14/MF A01

The history of work on high speed low level ejection is presented. Current bay practices and a look into the future are also discussed. E.D.K.

N80-30017# Aerospace Medical Research Labs., Wright-Patterson AFB, Ohio.
MINIMIZING THE SEQUENCED DELAY TIME FOR ESCAPE FROM HIGH-SPEED, LOW-LEVEL FLIGHT PROFILES
J. H. RADDIN, JR., L. J. SPECKER, and J. W. BRINKLEY *In* AGARD High-Speed, Low-Level Flight 12 p (SEE N80-29990 20-51) Mar. 1980 refs
Avail: NTIS HC A14/MF A01

The time delay that occurs between the actuation of an escape system and the actual initiation of the ejection catapult acceleration separate the crew from an aircraft is one of the critical factors in the design of escape systems for high speed low level (HSLL) flight conditions. This delay may preclude what could otherwise be a successful escape from certain HSLL profiles. The purpose of this paper is to examine the significance of current operational delay times and describe techniques to minimize the delays. Operational through-the-canopy ejection data are presented to assess the risk of injury incurred in eliminating the delay time altogether. Experimental data from tests with human volunteers are presented to demonstrate the potential for significantly reducing the time required for upper torso retraction. Finally the implications of available aeromedical evidence are elevated in the definition of the most promising approaches to minimize the time required for a HSLL escape sequence. E.D.K.

N80-30018# Naval Air Development Center, Warminster, Pa. Aircraft and Crew Systems Technology Directorate.
LOW LEVEL, ADVERSE ATTITUDE ESCAPE USING A VERTICAL SEEKING EJECTION SEAT
J. J. TYBURSKI, G. D. FRISCH (Naval Aerospace Medical Research Lab., New Orleans, La.), and L. A. DAULERIO *In* AGARD High-Speed, Low-Level Flight 10 p (SEE N80-29990 20-51) Mar. 1980 refs
Avail: NTIS HC A14/MF A01

Recent advances in the development of a maximum performance ejection seat (MPES) with a vertical seeking capability address the need for safe escape from aircraft at low altitude, high speed, and extreme adverse attitude conditions. The performance specifications of this system, as presently envisioned, provide safe egress from an inverted aircraft at airspeeds of 0 through 600 knots and altitudes as low as 50 feet above ground level (AGL). The data base and techniques to be used to predict the occupant response consist of instrumented ejection tests, mathematical simulations, and graphical analysis of tests results. Consideration is also given to the occupant's anthropomorphic properties and physical restrictions such as initial position and seat configuration. The applicability and efficacy of utilizing biodynamic response simulation and other techniques, not only as a design tool in the evaluation of the physical compatibility of man and ejection system, but also in the evaluation of the ejection system performance are demonstrated. E.D.K.

N80-30019# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
OPERATIONAL ROLES, AIRCREW SYSTEMS AND HUMAN FACTORS IN FUTURE HIGH PERFORMANCE AIRCRAFT
P. F. IAMPIETRO, ed. Mar. 1980 97 p refs Partly in ENGLISH and FRENCH Presented at the Aerospace Med. Panels Specialist Meeting, Lisbon, 22-26 Oct. 1979
(AGARD-CP-266; ISBN-92-835-0262-0; AD-A087703) Avail: NTIS HC A05/MF A01

The understanding of the operational characteristics of high performance aircraft in relationship to the operator's physiological, cognitive, psychomotor and perceptual capabilities is investigated. Relationships between man and machine are discussed in order to identify any biotechnology research deficiencies and establish appropriate selection, training, and assignment criteria for future high performance aircraft. For individual titles, see N80-30020 through N80-30028.

N80-30020# Department of the Air Force, Edwards AFB, Calif. F-16 Combined Test Force.
THE OPERATIONAL ROLES OF THE F-16
R. C. ETTINGER *In* AGARD Operational Roles, Aircrew Systems and Human Factors in Future High Performance Aircraft 18 p (SEE N80-30019 20-51) Mar. 1980
Avail: NTIS HC A05/MF A01

The F-16 weapons system is described from its design features to its cockpit displays and controls. The multirole capacity of the F-16 is illustrated by description of the weapons delivery systems, aircraft performance, and weapons carriage capability. Typical operational missions from NATO bases in F-16 European participating countries over Central and Northern Europe are discussed in detail. E.D.K.

N80-30021# French Air Force, Paris. Bureau des Programmes de Materiel
OPERATIONAL MISSIONS AND CONCEPTUAL DESIGN OF THE MIRAGE 2000
J. GUILLOU *In* AGARD Operational Roles, Aircrew Systems and Human Factors in Future High Performance Aircraft 5 p (SEE N80-30019 20-51) Mar. 1980 In FRENCH
Avail: NTIS HC A05/MF A01

The Mirage 2000 program was established to assure the replacement of all versions of the Mirage 2 aircraft. Intended for defense and aerial superiority, the first Mirage 2000 version must have the capability to intercept hostile bodies at very high altitude, to destroy hostile bodies penetrating at low altitude, and to engage in close combat with weapons equal to those on the test pursuit aircraft of its generation. The SNECMA M 53 engine will be used with a delta wing configuration and electric flight controls. The capacity for maneuverability of the Mirage 2000 marks a

fundamental progress in relation to the preceeding aircraft and will lead to new combat techniques. Transl. by A.R.H.

N80-30022# Royal Air Force, London (England).
THE CAPABILITIES AND OPERATIONAL ROLES OF ROYAL AIR FORCE TORNADOES
H. M. ARCHER *In* AGARD Operational Roles, Aircraft Systems and Human Factors in Future High Performance Aircraft 6 p (SEE N80-30019 20-51) Mar. 1980
Avail: NTIS HC A05/MF A01

The concept of producing a multirole aircraft designed to meet the complexities of a number of roles was reached only after extensive computer analysis had shown the way ahead. For the RAF, the air-to-ground task and the air-to-air task calls for differing operating capabilities, but Tornado can meet these requirements. In its IDS version, the aircraft is able to effectively carry out the roles of counter-air, interdiction, close air support, maritime attack, and reconnaissance. Moreover, it is able to do so at very high speed and very low altitude, regardless of weather. The ADV on the other hand uses its powerful long range multitarget radar, advanced avionics with computerized mission planning, and automatic attack features, together with its missile armament, to make it the most effective interceptor available for the air defence of the UK's large strategic area. Backing this very wide range of capabilities, is a comprehensive maintenance system of support, designed from the outset to optimize fault diagnosis, and keep the aircraft ready to fly with the minimum delay. E.D.K.

N80-30023# French Air Force, Bretigny sur Orge. Centre d'Essais en Vol.
WEAPONS SYSTEMS OF *THE* MIRAGE 2000: MAN MACHINE INTERFACE [LE SYSTEME D'ARMES DU MIRAGE 2000 INTERFACE HOMME MACHINE]
G. VARIN *In* AGARD Operational Roles, Aircrew Systems and Human Factors in Future High Performance Aircraft 15 p (SEE N80-30019 20-51) Mar. 1980 In FRENCH
Avail: NTIS HC A05/MF A01

The multipurpose role of the Mirage 2000 aircraft led to the design of a very complex weapon system which includes navigation, automatic pilot, radar, and countermeasures. The use of such a system which already saturates the pilot in combat aircraft actually in service could be still more difficult in the Mirage 2000. In face, considering the maneuverability qualities of the aircraft, which is largely augmented by electric flight control, the Air Army could introduce new combat techniques which would be more trying and more constraining for the pilot. In order to best utilize the capabilities of the Mirage 2000, an important integration effort was made at the cabin level to realize the best compromise in the presentation of parameters and of the controls at the pilot station: displays highly adapted to each flight phase, multiplexed control, and synthetic representation of tactical situations.
Transl. by A.R.H.

N80-30024# Royal Air Force Inst. of Aviation Medicine, Farnborough (England).
TORNADO - AIRCREW SYSTEMS
E. P. BECK (Royal Navy) *In* AGARD Operational Roles, Aircrew Systems and Human Factors in Future High Performance Aircraft 7 p (SEE N80-30019 20-51) Mar. 1980 refs
Avail: NTIS HC A05/MF A01

Aspects of the aircrew equipment assembly (AEA) for Tornado, including the cabin environment, the escape system, personal equipment and associated supply systems, and survival equipment are considered. The size rolls and integration of preproduction standard items comprising the various AEAs are validated, unforseen man/seat/cockpit incompatibilities are identified, limitations to be imposed on the aircrew population acceptable for Tornado on account of critical anthropometric dimensions are defined, and proposed aircrew drills for strapping-in, emergency ground egress, etc., are refined. E.D.K.

N80-30025# Air Force Avionics Lab., Wright-Patterson AFB, Ohio. Reconnaissance and Weapon Delivery Div.
INFORMATION TRANSFER FOR IMPROVED PILOT PERFORMANCE
R. N. LUTTER *In* AGARD Operational Roles, Aircrew Systems and Human Factors in Future High Performance Aircraft 6 p (SEE N80-30019 20-51) Mar. 1980 refs
Avail: NTIS HC A05/MF A01

The missile intercept confidence factor (MICF) concept was developed to provide the pilot with information about the engagement dynamics of an air-to-air missile engagement. It attempts to account for the critical parameter target maneuver by bounding the possible aerodynamic boundaries, by calculating upper and lower boundary limits. A no-escape target maneuver is utilized to establish the lower boundary and the current maneuver is used for the upper boundary. The MICF factor relates the pilot's position relative to these two boundaries and a minimum range boundary. As an interceptor varies its position within the missile launch envelope boundaries, the MICF varies between a value of zero to one and presents the pilot with an indication of the increasing/decreasing goodness of his launch condition. The MICF allows the pilot to be interactive with the fire control system. Through an assessment of the tactical situation, the pilot can determine whether to accept a low confidence launch or to maneuver to a more favorable launch position. E.D.K.

N80-30026# Panavia Aircraft G.m.b.H., Munich (West Germany). Flight Operations.
HUMAN FACTORS ASPECTS IN HIGH SPEED LOW LEVEL FLIGHT
J. L. DELL *In* AGARD Operational Roles, Aircrew Systems and Human Factors in Future High Performance Aircraft 4 p (SEE N80-30019 20-51) Mar. 1980
Avail: NTIS HC A05/MF A01

Human factors aspects of high speed, low level flying are discussed. There is a direct relationship between crew comfort and operational efficiency. The following areas of comfort are discussed: flying clothing; combined harness, arm, leg, and head restraints; helmets; anti-g protection; ejector seats; cockpit conditioning; cockpit layout; noise aspects; and ride comfort. Other topics include workload and workload sharing, physiological and psychological aspects, spatial disorientation, and detachment phenomenon. E.D.K.

N80-30027# Aerospace Medical Research Labs., Wright-Patterson AFB, Ohio.
ADDRESSING HUMAN FACTOR OPTIONS IN CONCEPTUAL DESIGN
P. V. KULWICKI *In* AGARD Operational Roles, Aircrew Systems and Human Factors in Future High Performance Aircraft 15 p (SEE N80-30019 20-51) Mar. 1980 refs
Avail: NTIS HC A05/MF A01

The interplay of human factors technology with systems design disciplines during the conceptual phase of development is discussed. Such design features as a full bubble canopy for unobscured vision, fly by wire primary flight control system, modified ejection seat position for better comfort and G-relief and the hands-on-throttle-and-stick concept for improved subsystem management are examples of the benefits of addressing human factor options in conceptual design. E.D.K.

N80-30028# Laboratoire de Medecine Aerospatiale, Bretigny-sur-Orge (France).
HUMAN FACTORS IN MIRAGE 2000 MISSIONS [FACTEURS HUMAINS DES MISSIONS DU MIRAGE 2000]
H. VIEILLEFOND *In* AGARD Operational Roles, Aircrew Systems and Human Factors in Future High Performance Aircraft 6 p (SEE N80-30019 20-51) Mar. 1980 refs In FRENCH
Avail: NTIS HC A05/MF A01

Like modern aircraft, the Mirage 2000 is characterized essentially by a great degree of controllability, an aptitude to perform at high altitude, and a lessening of the pilot's workload. These three essential characteristics require that the pilot adapt to his aircraft. The great controllability implies very brutal variations of intense accelerations which the pilot must endure. Toleration of repeated accelerations is still poorly understood, especially over a long period, consequently pilot selection must be rigorous. The physiopathological effects of high altitude are better known and

effective protection can be proposed. The chances of mission success are real only if the pilot has at his disposal a comfortable environment, which involves ergonometric studies of the seat, of controls, of protective equipment, and of cabin ventilation.
Transl. by A.R.H.

N83-19421# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
IMPACT INJURY CAUSED BY LINEAR ACCELERATION: MECHANISMS, PREVENTION AND COST
J. L. HALEY, JR., ed. (Army Aeromedical Research Lab.) London Oct. 1982 495 p refs In ENGLISH and FRENCH Conf. held in Cologne, 26-29 Apr. 1982
(AGARD-CP-322; ISBN-92-835-0317-0) Avail: NTIS HC A21/MF A01

Spinal column injuries under compressive, bending, and tensile loads; leg, head, and neck injuries; injury data collection; injury preventing hardware; seat/man models; and crashworthiness are addressed. For individual titles, see N83-19422 through N83-19454.

N83-19422# Purdue Univ., Lafayette, Ind. Dept. of Anatomy.
CHRONIC EFFECTS OF +G SUB Z IMPACT ON THE BABOON SPINE
D. C. VANSICKLE and L. E. KAZARIAN (AFAMRL) *In* AGARD Impact Injury Caused by Linear Acceleration: 3 p (SEE N83-19421 09-51) Oct. 1982 refs
Avail: NTIS HC A21/MF A01

A detailed time lapse anatomical study of degenerative changes very similar to human spondylosis deformans is provided. Traumatic spondylosis deformans was found to occur without radiographically detectable vertebral fracture. In the baboon, radiographic examination on the day of exposure to excessive mechanical stress will reveal no significant radiographic changes, but that the subsequent appearance of spondylosis deformans strongly suggests that the pathological changes are the direct result of trauma. Author

N83-19423# California Univ., San Diego. Medical Center.
MECHANISMS OF HEAD IMPACT INJURY AND MODIFICATION BY HELMET PROTECTION
A. M. NAHUM and C. WARD (Biodynamic/Engineering, Inc.) *In* AGARD Impact Injury Caused by Linear Acceleration: 29 p (SEE N83-19421 09-51) Oct. 1982 refs
Avail: NTIS HC A21/MF A01

Head protection provided by helmets or padding on the impacted cadaver skull surface was examined. Using unembalmed human cadaver subjects, frontal and lateral head impacts were conducted. Head acceleration and intracranial pressures were measured in order to determine the head and brain responses. Brain response was further analyzed with the aid of a finite element brain model; each impact was simulated on the computer to determine brain stresses and displacement during the impact. The degree of protection provided can be quantified by comparing head acceleration and brain pressures for equivalent energy impacts. Author

N83-19424# Heidelberg Univ. (West Germany). Inst. of Forensic Medicine.
DYNAMIC FRONTO-OCCIPITAL HEAD LOADING OF HELMET-PROTECTED CADAVERS
R. MATTERN, F. SCHUELER, and G. SCHMIDT *In* AGARD Impact Injury Caused by Linear Acceleration: 11 p (SEE N83-19421 09-51) Oct 1982 refs Sponsored in part by the European Community and Bundesanstalt fuer Strassenwesen
Avail: NTIS HC A21/MF A01

Eleven dynamic fronto-occipital impact tests on helmet-protected cadavers were conducted with a deceleration trolley to which a quasi-rigid wall was installed. Effective head impact velocity lay between 32 and 45 km/h. The maximum deceleration of the head was on average 136 g in x-direction and 105 g in z-direction. The deceleration of the vertebral column reached values of 146 g for the 1st thoracic vertebra and 77 g for the 12th thoracic vertebra (average value of the maxima). Examination of the vertebral column showed 6 cases of severe compression fractures of the upper and middle thoracic part, signs of strain and flexion could be detected in the form of minor injuries in all cases. Discreet skull injuries were detected in only two cases. Injury to the brain could not be found but cannot be excluded in view of the test object. All the full-faced safety helmets used were of the same type and manufacture. The polycarbonate outer shell did not break in any of the tests. The polystyrol inner liner showed plastic compressions of a maximum of 30% of the thickness of the damping liner at contact point. Author

N83-19425# Biokinetics and Associates Ltd., Ottawa (Ontario). Engineering Dept.
TEMPORAL CHARACTERISTICS OF TRANSLATIONAL ACCELERATION IN THE PREDICTION OF HELMETED HEAD INJURY
J. A. NEWMAN *In* AGARD Impact Injury Caused by Linear Acceleration: 7 p (SEE N83-19421 09-51) Oct. 1982 refs
Avail: NTIS HC A21/MF A01

The significance of time as a parameter in the prediction of head injury likelihood of severity is examined. It is shown that since the temperal characteristics of the acceleration waveform is simply a reflection of the mechanical characteristics of the headform/helmet assembly it bears only a trivial relation to the input forcing function and thus is generally uncorrelatable to head injury severity. It is concluded therefore that upper limits on translational acceleration alone, though not without certain restrictions, constitutes a sufficient criteria for evaluating helmet performance. The use of a time parameter is shown to be unsupportable and can lead to unnecessarily complex criteria and inferior helmet performance. Author

N83-19426# Laboratoire Central de Biologie Aerospatiale, Paris (France). Service de Biomecanique.
STUDY IN THE IMPULSE AND IN VIVO REGIME OF THE TRANSMISSIVITY OF THE INTERVERTEBRAL LUMBAR DISKS OF A PRIMATE [ETUDE EN REGIME IMPULSIONNEL ET 'IN VIVO' DE LA TRANSMISSIBILITE DES DISQUES INTERVERTERBRAUX LOMBAIRES D'UN PRIMATE]
P. QUANDIEU, L. PELLIEUX, B. GARNIER (Soc. MEREAVIB), P. BORREDON, B. VALEZY, *and* B. PIEDECOCQ *In* AGARD Impact Injury Caused by Linear Acceleration: 21 p (SEE N83-19421 09-51) Oct. 1982 refs In FRENCH
Avail: NTIS HC A21/MF A01

By analogy with methods for analyzing the behavior of industrial structures, the hypothesis is presented that the propagation of shock and vibration in the vertebral column can be understood by determining the transfer function of the intervertebral disk. The transfer function is defined and the conditions for its use are reviewed. The method used and the protocol followed are described in the study of the propagation of consecutive vibrations from shock applied directly to the sacrum of a low weight primate (young baboon). The linearity of the vertebral response is examined and the velocity of the group and the phase of propagated waves is calculated. This study complements a previous investigation of the discal behavior, in vivo and in situ, in the vibratory regime in a chronically bioinstrumented animal. Transl. by A.R.H.

N83-19427# Wayne State Univ., Detroit, Mich. Center for Bioengineering.
HUMAN CADAVERIC RESPONSE TO SIMULATED HELICOPTER CRASHES
A. I. KING and R. S. LEVINE *In* AGARD Impact Injury Caused by Linear Acceleration: 8 p (SEE N83-19421 09-51) Oct. 1982 refs
(Contract F33615-79-C-530)
Avail: NTIS HC A21/MF A01

The use of energy absorbers in crew seats of military helicopters has the potential of minimizing spinal injuries during a crash. The determination of human response during such simulated crashes was attempted using a Black Hawk crew seat. A total of 28 impacts with 10 different cadavers were carried out to determine the injury pattern and the biodynamic response. Head and pelvic accelerations were measured along with sled and seat acceleration. Floor board and belt loads were also monitored. High speed film was taken to obtain head and torso kinematics. The predominant mode of failure was the anterior wedge fracture from T8 to L3. Generally, there was only one fracture per spine. One of the disturbing observations is the rolling of the shoulders within the restraint system resulting in hyperflexion of the thoraco-lumbar spine and anterior wedge fractures. An associated potential

problem area is the observed large head excursions which can lead to significant head and neck acceleration injuries. Author

N83-19428# Daimler-Benz A. G., Stuttgart (West Germany).
INJURY MECHANISMS IN FRONTAL COLLISIONS INVOLVING GLANCE-OFF
W. REIDELBACH and F. ZEIDLER *In* AGARD Impact Injury Caused by Linear Acceleration: 4 p (SEE N83-19421 09-51) Oct. 1982 refs
Avail: NTIS HC A21/MF A01

Among frontal car collisions offset impact collisions are three times more frequent than symmetrical ones. In case of small overlap and high collision speed the colliding vehicles glance-off. The definition and application of the energy equivalent speed helps to evaluate crash severity and to distinguish glance-off from non-glance-off collisions. The investigation of frequency and severity of injuries to belted occupants unveils that in case of glance-off, due to he impact-shock syndrome, the injury risk of lower extremities in increased, the injury risk of remaining body regions is reduced when compared to non-glance-off cases. Author

N83-19429# Pennsylvania Univ., Philadelphia. Dept. of Neurosurgery.
ACCELERATION DAMAGE TO THE BRAIN
T. A. GENNARELLI and L. E. THIBAULT *In* AGARD Impact Injury Caused by Linear Acceleration: 9 p (SEE N83-19421 09-51) Oct. 1982 refs
Avail: NTIS HC A21/MF A01

On the basis of 150 primate experiments utilizing controlled head acceleration the authors conclude that a unitary tolerance for head injury is unrealistic. Rather, a series of tolerance criteria exist that define two fundamentally different kinds of mechanically induced intracranial injury vascular and axonal. The mixture of these two injury types is largely determined by the magnitude and the time-history of the loading condition because of differences in the material properties of the vascular and axonal elements. The topographical distribution of the injured elements will be determined by the kinematics of the loading condition because of asymmetries of geometry, anatomy and constitutive behavior of the intracranial contents. In light of these findings the effect of acceleration on the brain is presented for the continuum of diffuse brain injuries and for acute subdural hematoma. Author

N83-19430# Pennsylvania Univ., Philadelphia. Dept. of Bioengineering.
THE DEVELOPMENT OF INTRACRANIAL TISSUE COMPONENT FAILURE CRITERIA AS A CONSEQUENCE OF CONTROLLED INERTIAL LOADING
L. E. THIBAULT and T. A. GENNARELLI *In* AGARD Impact Injury Caused by Linear Acceleration: 10 p (SEE N83-19421 09-51) Oct. 1982 refs
Avail: NTIS HC A21/MF A01

Acute subdural hematoma and diffuse axonal injury have been shown to be responsible for the large majority of deaths and/or disabilities associated with head injuries. In order to develop a set of criteria which describe the tolerance of the head to mechanical loading (and thereby gain better insight into methods of protection) it appears that it is necessary to describe, and to understand discretely the behavior of those components which constitute the intracranial contents. Specifically, the behavior of the vascular and neuronal elements under dynamic loading conditions needs to be further ellucidated. Physical and animal experimental models conducted in conjunction with isolated tissue studies will then permit us to relate the more macroscopic phenomena, such as the input force-time history or kinematical response of the head, to the variation of the field parameters within the intracranial vault and the concomitant changes in neurophysiology and neurohistology. Author

N83-19431# Association Peugeot-Renault, Rueil-Malmaison (France). Lab. de Physiologie et de Biomecanique.
RESPECTIVE INFLUENCES OF ACCELERATION, JERKS, AND THE AMPLITUDE OF FLEXION OF THE NECK ON THE OCCURRENCE OF CEREBRAL LESIONS [INFLUENCES RESPECTIVES DE L'ACCELERATION, DU JERK ET DE L'AMPLITUDE DE LA FLEXION DU COU SUR LA SURVENUE DES LESIONS CEREBRALES]
C. TARRIERE, G. WALFISCH, A. FAYON, C. GOT, F. GUILLON, A. PATEL, and J. HUREAU (Paris Univ.) *In* AGARD Impact Injury Caused by Linear Acceleration: 23 p (SEE N83-19421 09-51) Oct. 1982 refs In FRENCH Prepared in cooperation with Hopital Raymond Poincare
Avail: NTIS HC A21/MF A01

Experimental results obtained on fresh human cadavers whose average vascular pressure was reestabilished before undergoing direct impacts to the head are summarized. The influences of parameters such as linear and angular aceleration, jerk, the amplitude of neck flexure, and shock duration are analyzed and discussed. Drawings show the principle of the frontal and lateral impact tests and the kinematics of the head during these tests. The severity of the cerebral lesions from lateral and frontal impacts; the location of the lesions from parieto-temporal and frontal impacts; impacts from free falls; and automobile accident reconstruction are considered. Measurements made of the head of a dummy and those made at the center of gravity of the heads of human subjects under the same test conditions are compared. Transl. by A.R.H.

N83-19432# Naval Biodynamics Lab., New Orleans, La.
HEAD AND SPINE INJURIES
A. SANCES, JR., J. MYKLEBUST, C. HOUTERMAN, R. WEBER, J. LEPKOWSKI, J. CUSICK, S. LARSON, C. L. EWING, D. J. THOMAS, B. SALTZBERG (Texas Research Inst. of Mental Sciences) et al. *In* AGARD Impact Injury Caused by Linear Acceleration: 35 p (SEE N83-19421 09-51) Oct. 1982 refs Prepared in cooperation with the Medical College of Wisconsin (Contract N00014-77-C-0749)
Avail: NTIS HC A21/MF A01

Neurophysiologic and biomechanical methods were used to evaluate axial tension applied to the cervical spinal cord and brain during impact or inertial loading. Because axial forces are often implicated in military accidents, these studies were designed to evaluate physiologic changes in the brain and spinal cord with cervical axial tension applied to the Rhesus (Macaca mulatta) monkey. Both slowly applied (0.1 to 1 cm/s) and rapidly applied loads (greater than 100 cm/s) were studied in the isolated fresh cadaveric cervical column of the monkey and in the intact living and dead monkey. Similar investigations were conducted on fresh human cadaveric skulls and cervical spinal columns and in the fresh human cadaveric torso. Both axial tension and compression were applied to the human preparations. Thoraco-lumbar sections were also tested for failure in compression. Helmet studies were also conducted to determine the effects with axial loading. A mathematical model was developed using a lumped parameter torso, head and helmet capable of simulating displacement and time dependent applied loads. The model was compared with photographically studied football injuries for validation. Author

N83-19433# Naval Biodynamics Lab., New Orleans, La. Neurophysiology Div.
NEUROPHYSIOLOGICAL EFFECTS OF -X IMPACT ACCELERATION
M. S. WEISS and M. D. BERGER *In* AGARD Impact Injury Caused by Linear Acceleration: 7 p (SEE N83-19421 09-51) Oct. 1982 refs
Avail: NTIS HC A21/MF A01

In 19 experiments, eight unanesthetized Rhesus monkeys, with torsos restrained in a seated position, and with head and neck free to move were subjected to peak sled accelerations in the -X direction ranging from 42 m/sq sec to 963 m/sq sec. Recordings of cortical somatosensory evoked potentials were made using recording electrodes chronically implanted over the somatosensory cortex. Electrical pulse stimuli were delivered at a rate of 5 Hz through spinal electrodes located at L1 - L2. Evoked potentials were recorded prior to impact, through the impact event, and subsequent to impact, then subjected to quantitative analysis procedures which included normalized cross-correlation and

exponential regression. The results of this analysis suggest a neurophysiological effect which holds promise as an indicator of a pre-injurious central nervous system condition. This effect is an immediate increase of 2% to 5% in the latency of the primary surface positive peak of the cortical evoked potential. There appears to be a threshold for these increases in latency at peak sled accelerations in the region of 600 m/sq. sec. This is consistent with previous findings and provides the basis for applying these techniques to human volunteer experiments. Author

N83-19434# Naval Biodynamics Lab., New Orleans, La.
INSTRUMENTATION REQUIREMENTS FOR ASSESSING OCCUPANT RESPONSE TO THREE DIMENSIONAL HIGH ACCELERATION ENVIRONMENTS
G. D. FRISCH and L. A. DAULERIO (NADC) *In* AGARD Impact Injury Caused by Linear Acceleration: 9 p (SEE N83-19421 09-51) Oct. 1982 refs
Avail: NTIS HC A21/MF A01

Instrumentation standardization for ejection and crash testing is addressed, and the effectiveness of the proposed methology in assessing a series of fully instrumented ejections ranging from 0 to 600 KEAS is demonstrated. The effects on seat performance attributable to canopy jettisoning or penetration, rocket ignition, and windblast are analyzed. Author

N83-19435# Naval Biodynamics Lab., New Orleans, La.
EVOKED POTENTIAL STUDIES OF CENTRAL NERVOUS SYSTEM INJURY DUE TO IMPACT ACCELERATION
B. SALTZBERG, W. D. BURTON, JR., N. R. BURCH, C. L. EWING, D. J. THOMAS, M. S. WEISS, M. D. BERGER, A. SANCES, JR., P. R. WALSH, J. MYKLEBUST et al. *In* AGARD Impact Injury Caused by Linear Acceleration: 11 p (SEE N83-19421 09-51) Oct. 1982 Prepared in cooperation with the Medical Coll. of Wisconsin and the Houston State Psychiatric Inst.
(Contract N00014-76-C-0911)
Avail: NTIS HC A21/MF A01

One aspect of a comprehensive program designed to investigate the effects of various levels of impact acceleration on the functional integrity of the nervous system is reported. The results described are based on the measurement of afferent neural transmission in the Rhesus monkey as revealed by latency and amplitude changes in the evoked potential (EP). In order to track the time course of recovery of latency and amplitude with high time resolution, automated methods for detecting peak amplitude and latency of components of the evoked potential were developed. These methods were applied to EP data recorded during impact experiments on Rhesus monkeys. Author

N83-19436# Naval Biodynamics Lab., New Orleans, La.
NEUROPATHOLOGY OF THE RHESUS MONKEY UNDERGOING -GX IMPACT ACCELERATION
F. UNTERHARNSCHEIDT (Neuroscience, Inc.) *In* AGARD Impact Injury Caused by Linear Acceleration: 34 p (SEE N83-19421 09-51) Oct. 1982 refs
(Contract N00014-78-C-0800)
Avail: NTIS HC A21/MF A01

Each vector direction of impact acceleration produces a different and predictable type of injury in regard to quality and distribution. The specific neuropathological injury pattern in -Gx acceleration transmitted indirectly to the head via the vertebral column consists of tissue damage at the zone of maximum stretched at the atlanto-occipatal junction, if the threshold is reached, incomplete and complete traumatic transection of the spinal cord and rupture of both vertebral arteries and concomitant basilar and spinal subarachnoid and subdural hemorrhages. Furthermore at peak sled acceleration levels low enough that neither incomplete nor complete transections occurred, a local indentation of tissue was seen at the ventral fissure, apparently caused by direct impact of the tip of the odontoid process of the axis. In some instances, subdural hemorrhages over both cerebral hemispheres due to ruptured bridging veins were seen, probably as the result of rotational acceleration. As we have demonstrated before, a neurophysiological and neuropathological continuum from no lesions to severe and lethal ones can be demonstrated, described and quantified. The head-neck and brain-cord systems can be described by input-output relationships. Each effective mechanical input to the head and neck corresponds to a predictable and typical morphological end state. Author

N83-19437# Centre d'Essais en Vol, Bretigny-Air (France).
RESEARCH ON PROTECTING THE VERTEBRAL COLUMN FROM EJECTION ACCELERATIONS [RECHERCHE CONCERNANT LA PROTECTION DE LA COLONNE VERTEBRALE]
F. COUSSAU, B. VETTES, and G. BEZAMAT *In* AGARD Impact Injury Caused by Linear Acceleration: 10 p (SEE N83-19421 09-51) Oct. 1982 In FRENCH
Avail: NTIS HC A21/MF A01

A pneumatic solution was used in the design of equipment to relieve the vertebral column of chase pilots during ejection. Inflatable structures called girders were set up, capable of supporting large forces. These girders were used to construct equipment, and to verify the validity of the principles held. Tests on a dummy and a human subject were conducted by the Flight Test Center. The Aerospace Medicine Laboratory demonstrated that such equipment was capable of decreasing 50% of the forces transmitted to the seat by the vertebral column. A useable prototype for the aircraft environment, as well as its inflation at the moment of ejection were studied. Transl. by A.R.H.

N83-19438# Naval Air Development Center, Warminster, Pa.
THE U.S. NAVY APPROACH TO CRASHWORTHY SEATING SYSTEMS
M. SCHULMAN *In* AGARD Impact Injury Caused by Linear Acceleration: 12 p (SEE N83-19421 09-51) Oct. 1982 refs
Avail: NTIS HC A21/MF A01

The U.S. Navy has for the past 22 years been committed to the support of a number of research and development programs to improve seating systems in non-ejection aircraft. This committment has resulted in a family of crashworthy seats which have gone through considerable testing and evaluation to demonstrate their capacity to manage crash loads and to limit those loads transmitted from the aircraft to the crewmembers. The development process has led to crashworthy armored and unarmored pilot/co-pilot, troop, passenger, gunner and specialty seats. However, the demonstration that these seats are effective in increasing the probability of survival *during and after a crash* does not necessarily mean that they will be adopted for military aircraft. New generation helicopters will require crashworthy seating in accordance with the latest military specifications, but retrofitting current operational aircraft with advanced seats is a more difficult undertaking. The acquisition manager must make the final decision and then provide the funding to support the effort. Author

N83-19439# Simula, Inc., Tempe, Ariz.
DEVELOPMENT OF IMPROVED CRITERIA FOR ENERGY-ABSORBING AIRCRAFT SEATS
S. P. DESJARDINS, J. W. COLTMAN, and D. H. LAANANEN *In* AGARD Impact Injury Caused by Linear Acceleration: 19 p (SEE N83-19421 09-51) Oct. 1982 refs
(Contract DAAK51-79-C-0016; DAAK51-79-C-0026; DAMD17-81-C-1175)
Avail: NTIS HC A21/MF A01

Present criteria for the design and evaluation of crashworthy aircraft seats have been in existence since 1971. Their application has enabled greatly improved seating systems to be developed and put into use in modern U.S. Army helicopters. The experience gained during the development and qualification of these production systems has emphasized the need for more comprehensive criteria. An interagency effort was therefore initiated and sponsored by the U.S. Army to accomplish this goal. Several research efforts are presently underway to provide the needed information to develop more rigorous and comprehensive design and evaluation criteria, to more completely understand the complex response of the human occupant and seating system in the crash environment, and to maximize the efficiency of such systems in providing crash protection to the occupant. The efforts now underway include the acquisition of additional information, concerning human tolerance to GA loading, the development of a standardized test dummy, variables testing and a sensitivity analysis to determine the influence of the many variables involved on the seat and occupant response, an investigation of the influence of the test subject considering various anthropomorphic dummies as well as cadavers and of course, the overall synthesis and interpretation of the results of these research efforts. This paper summarizes these projects, reports on their status, and presents preliminary results of the research efforts. Author

N83-19440# Defence and Civil Inst. of Environmental Medicine, Downsview (Ontario).

EFFECT OF REEL-TYPE WEBBING RETRACTORS AND SHOULDER-BELT SLACK ON DUMMY-DYNAMICS DURING SIMULATED FRONTAL VEHICLE IMPACTS

T. J. BOWDEN, J. K. REICHERT, and A. K. NASSIM (Road and Motor Vehicle Traffic Safety) *In* AGARD Impact Injury Caused by Linear Acceleration: 12 p (SEE N83-19421 09-51) Oct. 1982 refs

Avail: NTIS HC A21/MF A01

A Hy-Ge impact simulator was used for determining the performance of motor-vehicle seat belts equipped with retractors during simulated impacts at 13.5 m/n. The occupant of the seat was simulated by a standard anthropometric dummy. The shoulder strap of the seat belt was pulled various distances up to 25 cm away from the dummy chest before impact and the belt was then anchored near the retractor with fragile tape. The results of this study indicate that a retractor-equipped strap behaves less stiffly than a rigidly-anchored strap, allowing greatest forward motion of the body parts restrained by the strap and reducing the peak accelerations of these parts. In a harness in which the retractor is in the lap belt, the head and shoulder trajectories are similar to those when a harness without retractors is used. Author

N83-19441# Research Inst. for Road Vehicles, TNO, Delft (Netherlands).

MADYMO: A CRASH VICTIM SIMULATION COMPUTER PROGRAM FOR BIOMECHANICAL RESEARCH AND OPTIMIZATION OF DESIGNS FOR IMPACT INJURY PREVENTION

J. WISMANS, J. MALTHA, J. J. VANWIJK, and E. G. JANSSEN *In* AGARD Impact Injury Caused by Linear Acceleration: 11 p (SEE N83-19421 09-51) Oct. 1982 refs

Avail: NTIS HC A21/MF A01

A compact general purpose computer program package MADYMO, for two or three dimensional crash victim simulations is discussed. The program predicts the kinematic and dynamic behavior of the victim during the crash, based on data of the victim, the environment, the safety devices and the crash conditions. The package differs from most of the existing CVS programs by its flexibility in choice of number of linkages and number of elements in each linkage. Great flexibility in the modeling of force interactions between elements and environment is assured by the fact that user-defined submodels can readily be incorporated. The package is used for basic biomechanical crash research as well as for the development and optimization of crash safety devices such as seat belts, child seats and vehicle paddings. Some recent applications of this program package, with special emphasis on the validity of the model and computer aided design aspects, are discussed. Author

N83-19442# Daimler-Benz A.G., Sindelfingen (West Germany).

ADVANCED RESTRAINT SYSTEM CONCEPTS

W. REIDELBACH and H. SCHOLZ *In* AGARD Impact Injury Caused by Linear Acceleration: 11 p (SEE N83-19421 09-51) Oct. 1982

Avail: NTIS HC A21/MF A01

Today's lap/shoulder belts with emergency locking retractors provide improvements (automatic belt length adjustment, convenience, and comfort), but also disadvantages (greater webbing elongation and spool-out effect). Compensation of these deficiencies can be achieved by the use of pretensioners, the specifications and possible designs of which are explained. The Mercedes-Benz passive restraint system consists of air bags deployed by means of solid propellant gas generators and knee bolsters. The sensor is designed to detect low and high impact severity levels. In a low level impact one of the passenger side generators is triggered, and the second passenger generator only in case of a higher level impact together with or after the driver side generator. To balance the specific limitations of belt or air bag performances, combined systems were studied, such as an air bag/knee bolster system with supplementary belt or modern lap/shoulder belt systems, supplemented by an air bag in the steering wheel and a pretensioner for the passenger belt, both of which are designed to prevent head/face impact. Author

N83-19443# Institute of Aviation Medicine, Farnborough (England).

RECENT IMPROVEMENTS IN CRASH RESTRAINT IN UK HELICOPTERS

A. P. STEELE-PERKINS *In* AGARD Impact Injury Caused by Linear Acceleration: 9 p (SEE N83-19421 09-51) Oct. 1982 refs

Avail: NTIS HC A21/MF A01

The introduction into the RAF Chinock HCI of crew seats with energy attenuation resulted in a major advance in crashworthiness, and the principles of the seat are outlined. Shortcomings in the quick release facilities in passenger restraint harnesses are discussed briefly together with suggested improvements. A seat rotation mechanism with good crashworthy features which can be incorporated into any existing seat system is described, and finally the problems of providing an efficient harness for mobile aircrew are discussed and solutions offered. Author

N83-19444# Laboratoire de Medecine Aerospatiale, Bretigny-sur-Orge (France).

EVALUATION OF THE EFFICIENCY OF HELICOPTER ANTICRASH SEATS USING A HORIZONTAL ACCELERATION BENCH AND A SIMULATED CRASH [EVALUATION SUR BANC D'ACCELERATION HORIZONTAL ET LORS D'UN CRASH SIMULE DE L'EFFICACITE DE SIEGES ANTICRASH D'HELICOPTERES]

B. VETTES and G. BEZAMAT *In* AGARD Impact Injury Caused by Linear Acceleration: 17 p (SEE N83-19421 09-51) Oct. 1982 refs In FRENCH

Avail: NTIS HC A21/MF A01

A horizontal acceleration bench and a simulated crash of the PUMA SA 330 helicopter were used to qualify a pilot seat, a three-man seat for flying personnel, and a joined seat for passengers, all with disposible energy absorbers. An automatic method for analyzing and interpreting accelerations on the dummy and seat was used to evaluate the intensity, the duration of acceleration, the jolt, and the elastic response of the different corporal masses of the dummy (pelvis-thorax-head). Tests on the horizontal acceleration bench were conducted in the unitary vertical, unitary horizontal, and in combined directions. Despite their severity, the tests verified the good functioning of the energy absorber systems and the attenuation of accelerations transmitted to the dummies. The crash test confirmed that occupants of these such apparatus would be reasonably safe; however, there does exist risk of more or less serious injuries (shock, fracture, confusion) especially in the lower cervical region (C5 to C7).

Transl. by A.R.H.

N83-19445# Middlesex Polytechnic, London (England). Road Safety Engineering Lab.

SOME LIMITATIONS OF ADULT SEAT BELTS WHEN USED TO RESTRAIN CHILD DUMMIES IN SIMULATED FRONTAL IMPACTS

A. P. ROY, K. J. HILL, and G. M. MACKAY (Birmingham Univ., Engl.) *In* AGARD Impact Injury Caused by Linear Acceleration: 12 p (SEE N83-19421 09-51) Oct. 1982 refs

Avail: NTIS HC A21/MF A01

The problem of younger sitting children on auto accidents is approached by reporting the results of a series of simulated crash tests using the KL/Middlesex Polytechnic test sled and comparing them with known U.K. accident performance of child restraints complying with BS.3254 - 1960. The test programme simulated three types of frontal crash pulse with a dummy representing a 50%ile 3 year old restrained in adult lap and diagonal belts and adult lap belts. Initial crash velocities were of the order of 50 km/h with sled input pulses ranging from 11 g to 43 g. The results suggest that the adult lap and diagonal configuration was generally satisfactory but for very severe crash decelerations the diagonal strap may load the neck in a manner which does not occur with conventional child restraints. This neck load can be reduced by using a properly located booster cushion but not by household cushions which slip out and leave the child vulnerable to submarining. The lap belt only configuration allows the dummy to jacknife with a possible risk of abdominal injury and of a head contact with the vehicle fascia. R.J.F.

N83-19446# Aerospace Medical Research Labs., Wright-Patterson AFB, Ohio.
VALIDATION OF A BIODYNAMIC INJURY PREDICTION MODEL OF THE HEAT-SPINE SYSTEM
E. PRIVITZER, R. R. HOSEY (Systems Research Lab., Inc., Dayton, Ohio), and J. E. RYERSON (Systems Research Lab., Inc., Dayton, Ohio) *In* AGARD Impact Injury Caused by Linear Acceleration: 10 p (SEE N83-19421 09-51) Oct. 1982 refs
Avail: NTIS HC A21/MF A01

Mathematical models of the human and baboon head-spine structures are discussed. These models consist of fully three dimensional assemblages of rigid bodies and deformable elements, for which the equations of motion are solved using a large displacement, small deformation dynamic matrix structural analysis program. A validation program for these models is outlined with particular emphasis on the refinement and validation of the baboon head-spine model. Results are described from a series of drop test simulations which were run to study the effects of variations in the degree of spinal curvature on head-spine system dynamic response. Author

N83-19447# Aerospace Medical Research Labs., Wright-Patterson AFB, Ohio.
EVIDENCE FOR THE UTILIZATION OF DYNAMIC PRELOAD IN IMPACT INJURY PREVENTION
B. F. HEARON, J. H. RADDIN, JR., and J. W. BRINKLEY *In* AGARD Impact Injury Caused by Linear Acceleration: 14 p (SEE N83-19421 09-51) Oct. 1982 refs
Avail: NTIS HC A21/MF A01

Dynamic preload is anticipatory acceleration in the same direction as a later impact acceleration. To evaluate the influence of dynamic preload on human impact response, tests with volunteer subjects were conducted. Test data are presented which indicate that the peak forces and body segment accelerations imposed on subjects during impact accelerations are decreased when those impacts are preceded by dynamic preload. The impact response differences were more striking for comparisons between zero and low levels of dynamic preload than for comparisons between low and higher levels of preload. The threshold for these protective effects is apparently below 0.25 G dynamic preload for the test conditions investigated. In addition, the medical and subjective data support the assertion that dynamic preload is protective when applied prior to G(sub x) impact accelerations. Since impacts conducted on decelerator facilities are all influenced by track friction and therefore preceded by dynamic preload, it appears that they are fundamentally different from impacts conducted on accelerator facilities, involving zero dynamic preload. This indicates a need to reassess previous tolerance estimates derived from rocket sled decelerations. Decelerator tests do not appear to predict the more severe results of similar exposures on accelerators. Research efforts are continuing to further delineate the significance and utility of dynamic preload as a technique in impact injury prevention.
R.J.F.

N83-19448# Birmingham Univ. (England). Accident Research Unit.
HEAT PROTECTION FOR ROAD USERS WITH PARTICULAR REFERENCE TO HELMETS FOR MOTORCYCLISTS
J. B. PEDDER, S. B. HAGUES, and G. M. MACKAY *In* AGARD Impact Injury Caused by Linear Acceleration: 14 p (SEE N83-19421 09-51) Oct. 1982 refs
Avail: NTIS HC A21/MF A01

The overall problem of head injuries resulting from road traffic accidents is discussed. The mechanism of head injuries and the development of human tolerance criteria is briefly discussed. An accident sample of fatally and seriously injured two-wheeled motor vehicle riders is examined. Data on the performance of the riders' helmets and the nature of the riders' head injuries are presented. This information is used to assess the protective value of current designs worn by the casualties. A comparison of the two groups of riders highlights the outstanding severity of head injuries sustained by the fatalities. In light of this field data, comments are made on the relevance of existing specifications for protective helmets. R.J.F.

N83-19449# Institute of Aviation Medicine, Farnborough (England).
THE DEVELOPMENT AND INITIAL EVALUATION OF AN OBLIQUE-IMPACT TEST FOR PROTECTIVE HELMETS
D. H. GLAISTER *In* AGARD Impact Injury Caused by Linear Acceleration: 8 p (SEE N83-19421 09-51) Oct. 1982 refs
Avail: NTIS HC A21/MF A01

The development of a novel test device in which angular forces are measured (or derived) following off axis impacts to a helmeted headform is discussed. The ultimate aim is to replace construction requirements by a definitive test. Prototype and second generation rigs are described and evaluated in tests on several types of helmets using a range of impact surfaces. Preliminary tests suggest that the method can differentiate between various shell materials. With a modified anvil, surface irregularities can also be examined. Information can be made available relating to the instantaneous levels of friction developed during impacts, on the torque produced, and on the angular acceleration and terminal angular velocity achieved by the helmeted headform. The technique should provide a useful tool for the investigation and further development of protective helmets. R.J.F.

N83-19450# Army Safety Center, Fort Rucker, Ala. Directorate for Aviation System Management.
ANALYSIS OF US ARMY AVIATION MISHAP INJURY PATTERNS
J. E. HICKS, B. H. ADAMS, and D. F. SHANAHAN (Army Aeromedical Research Lab.) *In* AGARD Impact Injury Caused by Linear Acceleration: 12 p (SEE N83-19421 09-51) Oct. 1982 refs
Avail: NTIS HC A21/MF A01

Recent advances in US Army procedures for the identification and reporting of personnel injuries resulting from aircraft mishaps are reviewed. Mishap injury data requirements based on the needs of retrospective and prospective analyses are discussed. The requirements for these analyses to support engineering management decisions that will implement remedial programs to correct identified crashworthiness deficiencies is discussed. The US Army process for gathering aviation mishap injury data is summarized and modifications to procedures and codes for recording injury data are given. Examples of use of the data resulting in fleet wide improvement programs are discussed.
R.J.F.

N83-19451# Wright State Univ., Dayton, Ohio.
BACKFACE SIGNATURE FROM BODY ARMOR
R. F. ROLSTEN and D. J. KARL *In* AGARD Impact Injury Caused by Linear Acceleration: 10 p (SEE N83-19421 09-51) Oct. 1982 refs
Avail: NTIS HC A21/MF A01

Two types of body armor of light weight were developed that will prevent perforation. The textile armor will defeat the bullet fired from most handguns. The hard armor will defeat the calibre .30AP. A correlation was made between the laboratory and field evaluation results as they relate to backfire surface signature and blunt trauma sustained by the wearer. There is concern that a threat greater than calibre .30AP may provide a prohibitive level of impact energy and subsequent blunt trauma injury. The experimental and clinical techniques established for the flexible body armor may be useful as fiducial points in further development. R.J.F.

N83-19452# International Clinical Labs., Inc., Atlanta, Ga.
COST EFFECTIVENESS OF BODY ARMOR
R. H. HOLMES *In* AGARD Impact Injury Caused by Linear Acceleration: 5 p (SEE N83-19421 09-51) Oct. 1982
Avail: NTIS HC A21/MF A01

Body armor is a common denominator of cost effectiveness. It is the only means we have for further reduction in battlefield mortality and morbidity. Protective devic for material and personnel must be continually upgraded. Present day helmet and body armor should provide significant reduction in killed in action and wounded in action. This reduction in casualties can be translated into savings of billions of dollars. A price cannot be placed on human life, but costs can be projected for lost lives and disabilities incurred. The aftermath of war related expenditures has become so great that societal pressures now challenge the

rationale of payment. Protective armor is not just a wise investment, it is a necessity. R.J.F.

N83-19453# Belgian Air Force, Brussels. Service d'Equetes d'Accidents Aeriens.
TRAUMAS BY IMPACT DURING AIR SERVICE AND FLIGHT FITNESS IN THE BELGIAN AIR FORCE [TRAUMATISMES PAR IMPACT EN SERVICE AERIEN ET APTITUDE AU VOL A LA FORCE AERIENNE BELGE]
A. FLION *In* AGARD Impact Injury Caused by Linear Acceleration: 11 p (SEE N83-19421 09-51) Oct. 1982 In FRENCH
Avail: NTIS HC A21/MF A01

Different impact accidents involving chase pilots over a 10 yr period (1968 through 1977) were analyzed according to the type of impact (landing and takeoff accidents, midair collisions, bird strikes, ejections). In each of these categories, the incidence of type of clothing, the degree of severity of the injuries sustained by the pilot, the relation between the injuries and the circumstances of the accident, and the exact cause of the lesions were determined. The effects of these accidents on the flight fitness of the pilots involved (temporary total unfitness, limited fitness, and final fitness) were also examined. What became of the pilots in the groups of traumatic impacts is discussed. A.R.H.

N83-19454# Institute of Aviation Medicine, Oslo (Norway).
IMPACT INJURIES FROM LINEAR ACCELERATION SUSTAINED BY AN F-5 MAN/MACHINE COLLIDING WITH THE TERRAIN AT 45 KIAS
H. T. ANDERSEN *In* AGARD Impact Injury Caused by Linear Acceleration: 13 p (SEE N83-19421 09-51) Oct. 1982
Avail: NTIS HC A21/MF A01

An accident is given of the impact injuries sustained by a pilot who flew an F-5 aircraft into the terrain during horizontal flight after having passed the target. An autopsy report is given. R.J.F.

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AEROSPACE MEDICINE

Includes physiological factors; biological effects of radiation; and weightlessness.

N81-17698# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
SPATIAL DISORIENTATION IN FLIGHT: CURRENT PROBLEMS
G. PERDRIEL, ed. (French Air Force, Paris) and A. J. BENSON, ed. (RAF, Farnborough, England) Oct. 1980 99 p refs In ENGLISH and FRENCH Proc. of Conf. held in Bodo, Norway, 20-23 May 1980
(AGARD-CP-287; ISBN-92-835-0278-7; AD-A094913) Avail: NTIS HC A05/MF A01

The correlation between spatial disorientation in flight and the occurrance of aircraft accidents is discussed in detail. Particular attention is placed on determining the perceptual errors that characterize spatial disorientation in flight. For individual titles, see N81-17699 through N81-17709.

N81-17699# Centre de Recherches du Service de Sante des Armees, Clamart (France).
PHYSIOLOGICAL MECHANISMS OF SPATIAL DISORIENTATION NOT OF VISUAL ORIGIN [LES MECHANISMS PHYSIOLOGIQUES DE LA DESORIENTATION SPATIALE D'ORIGINE NON VISUELLE]
J. COLIN *In* AGARD Spatial Disorientation in Flight 6 p (SEE N81-17698 08-52) Oct. 1980 refs In FRENCH
Avail: NTIS HC A05/MF A01

Spatial orientation involves the complex integration of data emanating from numerous receptors. In most cases, a disorientation occurs when the visual system, which plays the principle role, can no longer perform its function and the other systems are influenced by a gravito-inertial environment. The reactions thrown out of gear by linear and radial acceleration and then by angular acceleration are reviewed. For a third time the factors modifying the intensity of these reactions are recalled. This permits insisting on the concept of visual dominance and vestibular suppression, which is at the origin of the essential means of preventing spatial disorientation in flight. An aeromedical formation of the crew is particularly important in the visual presentation of information required for piloting, for repeated carry over for flight formation and for flight without visibility. Transl. by A.R.H.

N81-17700# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
AN UPDATE OF FINDINGS REGARDING SPATIAL DISORIENTATION IN FLIGHT: A RECONSIDERATION OF UNDERLYING MECHANISMS
F. H. MONESI *In its* Spatial Disorientation in Flight 6 p (SEE N81-17698 08-52) Oct. 1980 refs
Avail: NTIS HC A05/MF A01

The anatomical foundations, physiological mechanisms and mental functions known to influence spatial orientation on Earth and in flight are reviewed. The effects of flight environment on visual, vestibular and kiaesthetic cues as well as on mental functions able to induce perceptual errors conducive to spatial disorientation are reconsidered with a view of identifying the theories accounting for disorientation incidents and accidents in flight. R.C.T.

N81-17701# Italian Air Force Medical Services, Bari-Palese AFB.
PERCENTUAL ERRORS IN FLIGHT: A SURVEY OF 100 MILITARY PILOTS ON ACTIVE DUTY
P. DEGIOSA *In* AGARD Spatial Disorientation in Flight 7 p (SEE N81-17698 08-52) Oct. 1980 refs
Avail: NTIS HC A05/MF A01

A survey was given to 80 pilots and 20 cadet pilots in flight activity to determine some of the problems associated with perceptive disturbances in flight. The survey consisted of 116 questions, divided into 6 major parts: the first contains biographical data such as age, total hours of flight and the hours of flight activity during 1979, type of aircraft piloted, flight accident if any; the second part is relative to the possible correlation between on the one hand psycho-affective or psycho-social situation and type of mission and on the other hand disturbances if any; the third part refers to the correlation between on the one hand physical conditions, life, habits, the use of drugs and on the other hand possible perceptive alterations they can cause; the fourth part investigates the relations between the type of aircrafts and perceptive alterations; the fifth part deals with different atmospheric conditions in which the flight is possible; with some of the questions we investigate the duration of the disturbances and the time of the disappearance of these perceptive disturbances initially felt; and the last part investigates the perceptive disturbances suffered out of the flight and the quality considered indispensable in avoiding them. R.C.T.

N81-17702# Pennsylvania State Univ., University Park.
THE AMBIENT VISUAL SYSTEM AND SPATIAL ORIENTATION
H. W. LIEBOWITZ and J. DICHGANS (Tuebingen Univ.) *In* AGARD Spatial Disorientation in Flight 4 p (SEE N81-17698 08-52) Oct. 1980 refs
(Contract MH-08061; EY-03276)
Avail: NTIS HC A05/MF A01

Two modes of processing visual information are reviewed with particular emphasis on their independent functions and the role of the ambient visual system in orientation. The multisensory basis of orientation and the central integration of signals are discussed. Disorientation is assumed to result from a mismatch, in comparison with the previous experience of the individual, of these simultaneously occurring signal patterns. It is suggested that disorientation in aircraft under instrument flight conditions may result from the substitution of an unnatural symbolic indicator to replace the visual stimuli normally involved in orientation and the failure of a learned cognitive skill to compensate for mismatched signals R.C.T.

N81-17703# School of Aerospace Medicine, Brooks AFB, Tex. Ophthalmology Branch.

VISUAL ILLUSIONS AS A PROBABLE CAUSE OF AIRCRAFT ACCIDENTS

T. J. TREDICI *In* AGARD Spatial Disorientation in Flight 5 p (SEE N81-17698 08-52) Oct. 1980 refs

Avail: NTIS HC A05/MF A01

Spatial disorientation, visual restrictions, and illusions were examined as the possible causal factors in aircraft accidents. A number of aircraft accidents were analyzed in which visual illusions appear to be a significant or contributing factor in the accident. It is shown that such factors as rain on the windshield, flashblindness by high intensity strobe lights, disorientation by flickering lights, and ground light intensity variations appear to have led to errors in judgement, thus directly contributing to the aircraft accident. It is concluded that a studied awareness of these factors is the pilot's best corrective action available. R.C.T.

N81-17704# Army Air Corps, Stockbridge (England).

DISORIENTATION IN ARMY HELICOPTER OPERATIONS: A GENERAL REVIEW

K. EDGINGTOM and C. J. BOX *In* AGARD Spatial Disorientation in Flight 9 p (SEE N81-17698 08-52) Oct. 1980 refs

Avail: NTIS HC A05/MF A01

Accidents involving aircraft mishandled during takeoff, landing or tactical low flying (or nap of the earth flight) were investigated. Special emphasis was placed on examining those accidents which occurred as a result of flight disorientation. Orientation error rates, the type of accidents as well as influencing factors were reviewed. Significant results are reported. R.C.T.

N81-17705# Centre d'Essais en Vol, Bretigny-sur-Orge (France). Lab. de Medecine Aerospatiale.

ILLUSIONS OF ATTITUDE AND MOVEMENT DURING EARTH-HORIZONTAL ROTATION

A. LEGER, J. P. LANDOLT, and K. E. MONEY *In* AGARD Spatial Disorientation in Flight 19 p (SEE N81-17698 08-52) Oct. 1980 refs In ENGLISH and FRENCH Prepared in cooperation with Defence and Civil Inst. of Environmental Medicine, Downsview, Ontario

Avail: NTIS HC A05/MF A01

Ten voluntary males underwent a sequence of experiments to determine the effect of rotation about the horizontal axis. Each subject underwent nine separate tests of rotation about the horizontal axis. The number of tests was determined by the number of combinations of the three subject axes (X, Y and Z) and three visual conditions (no visual reference, internal visual reference, and external visual reference). In the first condition, the subject was in total darkness (NVR). The internal visual reference (IVR) was produced by lighting the interior of the gondola. Finally, in the external visual reference (EVR) condition, the gondola hatch was left open and the subject could see the surrounding laboratory, with a visual field of about 60 X 50deg. The order of tests for each subject was determined by a nine by nine Latin square. In spite of the strong visual input, convincing illusions of attitude and movement were found in the IVR condition. Similar illusions, of course, were experienced in the NVR condition. Comparable illusions occurred during the X-axis and Y-axis rotations, as well as during the (usually employed) Z-axis rotations. In most subjects, the illusions were absent in the EVR condition, but, in some subjects, there was perceptible illusory movement inspite of clear visual reference to the real motion. R.C.T.

N81-17706# Institute of Aviation Medicine, Fuerstenfeldbruck (West Germany).

ORTHOSTATIC DISORDER. A CONTRIBUTING FACTOR TO MOTION SICKNESS?

G. R. FROEHLICH *In* AGARD Spatial Disorientation in Flight 4 p (SEE N81-17698 08-52) Oct. 1980 refs

Avail: NTIS HC A05/MF A01

Pilot candidates were subjected to the vestibular adroitness test to determine the effects of orthostatic disorders on motion sickness. The test consisted of bending the head once 60 degrees downward and back to the upright position while being rotated at 180 degrees/sec. The test was divided into four categories; each category producing a varying degree of motion sickness symptoms (i.e., mild nausea to severe nausea). Significant results as well as the conclusions are presented in detail. R.C.T.

N81-17707# Defence and Civil Inst. of Environmental Medicine, Downsview (Ontario). Head/Biodynamics Section.

A GENERALIZED TRANSFER FUNCTION FOR DESCRIBING MECHANONEURAL SEMICIRCULAR-CANAL DYNAMICS

J. P. LANDOLT (Texas Univ., Galveston) and M. J. CORREIA *In* AGARD Spatial Disorientation in Flight 10 p (SEE N81-17698 08-52) Oct. 1980 refs

Avail: NTIS HC A05/MF A01

The dynamic response characteristics of the semicircular canal to rotational head movements were determined via a generalized transfer function. The adequacy of the model was tested by recording the neural activity of the primary efferent fibers inervating the semicircular canals as they respond to appropriate stimulation. Specifically the mechanoneural response characteristics of primary afferent, semicircular canal units in the pigeon were studied to determine whether the model could be used in describing the neurodynamics in other species. R.C.T.

N81-17708# Naval Aerospace Medical Research Lab., Pensacola, Fla.

A MULTISTATION SPATIAL DISORIENTATION DEMONSTRATOR

F. E. GUEDRY, JR. *In* AGARD Spatial Disorientation in Flight (P (SEE N81-17698 08-52) Oct. 1980 refs

Avail: NTIS HC A05/MF A01

A disorientation familiarization trainer was designed and constructed for demonstrating a range of visual and acceleratory conditions that induce disorientation. The demonstrator provides students with memorable personal experiences with various classes of disorientating conditions coupled with an introduction to disorientation-error prevention. R.C.T.

N81-17709# Royal Air Force Inst. of Aviation Medicine, Farnborough (England).

THE ROYAL AIR FORCE SPATIAL DISORIENTATION FAMILIARISATION DEVICES (SDFD)

A. J. BENSON *In* AGARD Spatial Disorientation in Flight 10 p (SEE N81-17698 08-52) Oct. 1980 refs

Avail: NTIS HC A05/MF A01

The Spatial Disorientation Familiarization Device (SDFD) was designed to demonstrate to aircrew the fallibility of their senses and the errors of perception that can lead to spatial disorientation in flight. The SDFD is a servocontrolled turntable on which the subject is seated 1 m from the axis of rotation, inside a light-tight cab. Displays within the cab show the subject that his sensations of rotation and attitude are in error, and permit the demonstration of oculogyral, oculogravic, cross coupled (Coriolis) and autokinetic phenomena. Control of the velocity trajectory of the turntable and the illumination of the various displays may be preprogrammed and recorded along with a commentary on magnetic tape. This facility allows an optimized training sequence to be delivered consistently, even by relatively unskilled operators. R.C.T.

N81-24715# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).

SIGNIFICANCE OF CIRCADIAN RHYTHMS IN AEROSPACE OPERATIONS

K. E. KLEIN (DFVLR, Bad Godesberg, West Germany) and H. M. WEGMANN Dec. 1980 64 p refs

(AGARD-AG-247; ISBN-92-835-1378-9; AD-A096568) Avail: NTIS HC A04/MF A01

Reviewing experimental research and results from the pertinent literature, the significance of circadian rhythms is discussed under the following aspects: characteristics and interrelationships of environmental and biological circadian systems; circadian rhythms of mental and physical performance, as well as of susceptibility and resistance; modification of circadian cycling through external and internal factors; disturbance of circadian rhythmicity and sleep-wake cycling in air and space operations and shiftwork; consequences for performance efficiency and health; formulas; models and rest duty regulations; and recommendations for the passenger, crew, and management. The Biorhythm Theory is critically reviewed. T.M

N81-26699# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
THE EFFECT OF LONG TERM THERAPEUTICS, PROPHYLAXIS AND SCREENING TECHNIQUES ON AIRCREW MEDICAL STANDARDS
C. E. SIMPSON, ed. (Ministry of Defense, London) Mar. 1981 147 p refs In ENGLISH and FRENCH Conf. held at Toronto, 15-19 Sep. 1980
(AGARD-CP-310; ISBN-92-835-0288-4; AD-A101018) Avail: NTIS HC A07/MF A01

The effects of high stress missions on flight crew members is surveyed. Medical standards, screening, and selection of aircrews are described, as well as epidemiology and medical treatment.

N81-26700# Institute of Aviation Medicine, Oslo (Norway).
PHYSICAL FITNESS AND CARDIOVASCULAR CAPACITY: AN EPIDEMIOLOGICAL PROGRAM
K. MYHRE, E. ALNAES, and H. T. ANDERSEN *In* AGARD The Effect of Long-Term Therap., Prophylaxis and Screening Tech. on Aircrew Med. Standards 7 p (SEE N81-26699 17-52) Mar. 1981 refs
Avail: NTIS HC A07/MF A01

A longitudinal survey was conducted of the way of living of all personnel with flying status in terms of diet, smoking and drinking habits, and habitual physical activity, in addition to anthropometrical/physiological parameters such as weight, percentage of fat, maximal aerobic power, serum concentrations of triglycerides, total cholesterol and HDL cholesterol. This information is obtained from each subject during his periodical major medical examination at the Institute of Aviation Medicine, which is every sixth year when the subject is below 40 yrs of age, otherwise every third year. This program is discussed. S.F.

N81-26701# Institute of Aviation Medicine, Manching (West Germany).
CHANGES IN PHYSICAL FITNESS DUE TO VARIATIONS IN PHYSICAL ACTIVITY AND DIET
H. T. ANDERSEN and K. MYHRE *In* AGARD The Effect of Long-Term Therap., Prophylaxis and Screening Tech. on Aircrew Med. Standards 4 p (SEE N81-26699 17-52) Mar. 1981 refs
Avail: NTIS HC A07/MF A01

Physical deterioration in 122 young pilots and navigators of the Royal Norwegian Air Force was studied over the 5-year period 1972-1977. A net gain in body weight with no simultaneous increase in aerobic capacity was interpreted as an early, but serious, sign of physical degeneration. S.F.

N81-26702# School of Aerospace Medicine, Brooks AFB, Tex. Crew Technology Div.
PHYSIOLOGICAL CRITERIA RELATED TO G TOLERANCE IN COMBAT AIRCREW
J. E. WHINNERY *In* AGARD The Effect of Long-Term Therap., Prophylaxis and Screening Tech. on Aircrew Med. Standards 14 p (SEE N81-26699 17-52) Mar. 1981 refs
Avail: NTIS HC A07/MF A01

Initial studies measuring the +Gz tolerance of 59 USAF aircrewmen undergoing aeromedical evaluation were made on the USAF School of Aerospace Medicine (USAFSAM) human centrifuge using a specific centrifuge stress medical evaluation protocol. Clinically measurable parameters were found to be associated with +Gz tolerance. In addition, the use of the centrifuge stress medical evaluation protocol to detect medically significant cardiac dysrhythmias was investigated. The types of dysrhythmias and their time of onset give added insight into the physiologic response of man to +Gz stress. S.F.

N81-26703# Laboratoire de Medecine Aerospatiale, Bretigny-sur-Orge (France).
THE EFFECTS OF ACCELERATION ON COMBAT PILOT PERFORMANCE [ACCELERATIONS ET APTITUDE DES PILOTES D'AVIONS DE COMBAT]
B. VETTES, G. LEGUAY (Hospital d'Instruction des Armees), H. VIELLEFOND (Hospital d'Instruction des Armees), A. SEIGNEURIC, and R. AUFFRET *In* AGARD The Effect of Long-Term Therap., Prophylaxis and Screening Tech. on Aircrew Med. Standards 9 p (SEE N81-26699 17-52) Mar. 1981 In FRENCH
Avail: NTIS HC A07/MF A01

The cardiovascular system is the target of the stress factors associated with flight in combat aircraft. Consequently, examination of the heart and vessels receives all the attention of the experts during physical fitness examinations of aircraft pilots on admission, and especially during their review visits. It is often useful to evaluate functional circulatory integrity during a standardized test which is reproductive of the cardiovascular stress undergone by the pilot. During the test, the principal cardiovascular parameters are recorded and the visual field evaluated. Televised observation and recorded conversation sheds light on the general behavior of the subject. Experience with a centrifuge provides indispensible supplementary information to the medical record. A.R.H.

N81-26704# Aerospace Medical Research Labs., Wright-Patterson AFB, Ohio. Biochemical Protection Branch.
EXPERIENCE WITH HIGHLY SELECTIVE SCREENING TECHNIQUES FOR ACCELERATION STRESS DUTY
B. F. HEARON and J. H. RADDIN *In* AGARD The Effect of Long-Term Therap., Prophylaxis and Screening Tech. on Aircrew Med. Standards 8 p (SEE N81-26699 17-52) Mar. 1981 refs
Avail: NTIS HC A07/MF A01

Impact acceleration tests designed to medically screen flight crews for high stress missions were conducted with human volunteers. Facilities included the Vertical Deceleration Tower, the Horizontal Decelerator and the Impulse Accelerator sleds. Disqualifying defects are summarized. S.F.

N81-26705# Royal Air Force, High Wycombe (England).
MANAGEMENT OF UNFIT AIRCREW
M. G. P. FISHER *In* AGARD The Effect of Long-Term Therap., Prophylaxis and Screening Tech. on Aircrew Med. Standards 6 p (SEE N81-26699 17-52) Mar. 1981 refs
Avail: NTIS HC A07/MF A01

The implications of unfitness in aircrew due to illness or injury are examined. A general philosophy of care and management directed towards an early and successful return to flying status is suggested. The role of the Flight Surgeon is highlighted as an intermediary between the clinical specialist and the executive, who is responsible for coordinating the evidence required for a rational assessment of the fitness of the man/women as a whole. Examples are given of an unusual case (chondro sarcoma) and of a common injury (ejection spinal fractures). Conditons which currently pose problems of assessment are discussed; hypertension; peptic ulcer; manic depressive psychosis; and sarcoidosis. S.F.

N81-26706# Letterman Army Inst. of Research, San Francisco, Calif. Div. of Biorheology.
A SOLID-STATE DARK ADAPTOMETER: THE LAIR DARK ADAPTOMETER
H. ZWICK, P. A. OMARA, E. S. BEATRICE, S. L. BIGGS, and C. W. VANSICE *In* AGARD The Effect of Long-Term Therap., Prophylaxis and Screening Tech. on Aircrew Med. Standards 10 p (SEE N81-26699 17-52) Mar. 1981 refs
Avail: NTIS HC A07/MF A01

The eye's ability to adjust from a very bright light to a very dim light environment is known as dark adaptation. A dark adaptometer was developed which is considerably less complicated than other dark adaptometers. Interface with a low cost microcomputer system allows clinical flexibility for routine military screening and research flexibility for investigators studying the role of dark adaptation in military tasks. The data presented validate the use of this device for such applications. S.F.

N81-26707# Institute of Aviation Medicine, Manching (West Germany).
SCREENING FOR NOISE INDUCED HEARING LOSS IN NORWEGIAN AIR FORCE
H. M. BORCHGREVINK *In* AGARD The Effect of Long-Term Therap., Prophylaxis and Screening Tech. on Aircrew and Standards 4 p (SEE N81-26699 17-52) Mar. 1981 refs
Avail: NTIS HC A07/MF A01

A hearing loss prophylaxis program for the Norwegian Armed Forces is detailed. The program includes: (1) a central archive of noise level registrations for civil and military work situations; (2) the publishing and distribution of noise level measurements, risk criteria and recommended prophylactic initiatives to the various work places; and (3) audiometry of personnel. S.F.

N81-26708# Aerospace Medical Research Labs., Wright-Patterson AFB, Ohio. Aviation Vision Lab.
PROPOSED NEW VISION STANDARDS FOR THE 1980'S AND BEYOND: CONTRAST SENSITIVITY
A. P. GINSBURG *In* AGARD The Effect of Long-Term Therap., Prophylaxis and Screening Tech. on Aircrew Med. Standards 15 p (SEE N81-26699 17-52) Mar. 1981 refs
Avail: NTIS HC A07/MF A01

Data are presented that reveal individual differences in contrast sensitivity among normal observers that have definite implications for visual performance in operational environments. Since these differences in visual sensitivity can relate to detection and recognition ranges, these data can then be transformed into time to perform certain tasks and lead naturally towards visual standards being based on task performance under operational conditions. It is suggested that contrast sensitivity data be obtained in parallel with conventional vision tests to begin creating visual standards that relate to observer capability over the full range of operational environments. E.D.K.

N81-26709# School of Aerospace Medicine, Brooks AFB, Tex. Neuropsychiatry Branch.
BIOFEEDBACK REHABILITATION OF AIRSICK AIRCREW
R. A. LEVY, D. R. JONES, and E. H. CARLSON *In* AGARD The Effect of Long-Term Therap., Prophylaxis and Screening Tech. on Aircrew Med. Standards 4 p (SEE N81-26699 17-52) Mar. 1981
Avail: NTIS HC A07/MF A01

The current treatment program for airsickness is reported in detail, describing treatment method and results. This program is based on biofeedback relaxation training and physiological monitoring in a motion stimulus environment. Twenty aircrew disabled by chronic, severe airsickness were treated and followed. Two of this group were subsequently grounded for reasons unrelated to motion sickness, 2 were deleted from UPT due to continued motion sickness, 1 was disqualified from back-of-aircraft radio operator duties due to motion sickness, and 15 were successfully returned to operational flying. E.D.K.

N81-26710# Institute of Aviation Medicine, Fliegehorst (West Germany). Dept. of Aviation Psychology.
PSYCHOLOGICAL THERAPY AND PREVENTION OF STRESS REACTIONS IN GERMAN MILITARY PILOTS
R. W. KEMMLER *In* AGARD The Effect of Long-Term Therap., Prophylaxis and Screening Tech. on Aircrew Med. Standards 11 p (SEE N81-26699 17-52) Mar. 1981 refs
Avail: NTIS HC A07/MF A01

The disturbances of 44 aviators of the German Military are described and documented. The people concerned were pilots and navigators involved in a psychological intervention and counselling program over a period from 1973 to 1979. The aim was flying rehabilitation. The somatic, psychic, and social symptoms are analyzed under the heading of modern stress conceptions. Psychological prevention methods are proposed in order to reach a better stress tolerance. With high probability, these procedures will modify the operational behavior patterns under extreme mission conditions helping to prevent disturbances of health and minimize flight safety risks. E.D.K.

N81-26711# Defence and Civil Inst. of Environmental Medicine, Downsview (Ontario).
DETECTION OF DIAZEPAM AND DETERMINATION OF TIME OF INGESTION IN AIR ACCIDENT/INCIDENT INVESTIGATION
L. J. MCBURNEY *In* AGARD The Effect of Long-Term Therap., Prophylaxis and Screening Tech. on Aircrew Med. Standards 8 p (SEE N81-26699 17-52) Mar. 1981 refs
Avail: NTIS HC A07/MF A01

The temporal excretion patterns of unchanged diazepam metabolites are studied to determine if there was a relationship between metabolite ratios and the time of ingestion. A clinical study was carried out using gas chromatography-mass spectrometry (GC/MS) to verify the presence of and to quantitate diazepam metabolites in the urine of human subjects after a single 10 mg dose. E.D.K.

N81-26712# Institute of Aviation Medicine, Manching (West Germany).
CARDIOVASCULAR RISK FACTORS IN THE PILOT POPULATION: A POLICY DISCUSSION
E. ALNAES and H. T. ANDERSEN *In* AGARD The Effect of Long-Term Therap., Prophylaxis and Screening Tech. on Aircrew Med. Standards 5 p (SEE N81-26699 17-52) Mar. 1981 refs
Avail: NTIS HC A07/MF A01

Several large scale prospective investigations have recently quantified the cardiovascular risk factor pattern in the Scandinavian male population. Since the small population in Norway is biologically and sociologically homogeneous, it is possible to (1) extrapolate from current epidemiological research in Scandinavia to the aircrew population; (2) perform periodic standardized/centralized medical examination and evaluations; and (3) remain in close personal contact with each aircrew member throughout his total career. A risk profile will be established for each aircrew candidate at the point of training entry and monitored annually throughout his career. Among other medical information this will contain family history, cholesterol/HDL ratio, smoking habits, level of physical fitness, etc. Significant changes in any individual's risk factor profile will be a cause for personal counseling and/or minor modifications/restrictions in medical flight status. E.D.K.

N81-26713# Aerospace Medical Div., Brooks AFB, Tex.
DETECTION OF CORONARY ARTERY DISEASE IN ASYMPTOMATIC AIRCREW MEMBERS WITH THALLIUM-201 SCINTIGRAPHY
G. S. UHL, M. A. MONTGOMERY, and G. M. MCGRANAHAN *In* AGARD The Effect of Long Term Therap., Prophylaxis and Screening Tech. on Aircrew Med. Standards 5 p (SEE N81-26699 17-52) Mar. 1981 refs
Avail: NTIS HC A07/MF A01

Thallium-201 exercise myocardial perfusion scintigraphy was accomplished in 130 aircrew members prior to their undergoing coronary angiography. Most were undergoing cardiac catheterization for an abnormal exercise response to treadmill testing. Of these, 22 men had arteriographic evidence of obstructive coronary disease of at least 50% narrowing in a single vessel. All had abnormal myocardial scintigrams. There were 12 other aviators who had minimal degrees of coronary artery disease with lesions less than 50% as the maximum degree of obstruction. Of these, 8 had abnormal thallium scans showing a perfusion defect in the area of the myocardium, presumably supplied by the diseased coronary artery. Of the 96 men with normal angiograms, only 4 had abnormal myocardial scintigraphy. An abnormal myocardial scintigram was often associated with significant obstructive disease. A normal scan accurately ruled out the presence of high grade obstructive lesions and missed only 4 cases of minimal coronary disease. E.D.K.

N81-26714# Hellenic Air Force Aeromedical Center, Athens (Greece).
PILOTS WITH CARDIOLOGICAL PROBLEMS: TEN YEAR FOLLOW UP
G. B. MASDRAKIS, C. E. GIANNOPOULOS, and N. KALOGERAKIS *In* AGARD The Effect of Long Term Therap., Prophylaxis and Screening Tech. on Aircrew Med. Standards 6 p (SEE N81-26699 17-52) Mar. 1981 refs
Avail: NTIS HC A07/MF A01

It is known that a number of flyers with cardiological problems, such as repolarization changes, conduction defects, rhythm

abnormalities or hypertension are maintained on flying status if the successive complete medical evaluation is normal. The follow-up of these flyers for an indefinite period of time is important because it gives the possibility to follow the physical history of cardiac abnormalities in a select group of subjects. The medical files of active airline pilots and Hellenic Air Force Flyers are reviewed in order to determine (1) how many are maintained on flying status although presenting cardiac abnormalities and (2) the evolution of these abnormalities. E.D.K.

N81-26715# Royal Air Force Hospital, Halton (England).
USE OF BETABLOCKADE IN THE TREATMENT OF AIRCREW WITH HYPERTENSION
J. N. C. COOKE *In* AGARD The Effect of Long Term Therap., Prophylaxis and Screening Tech. on Aircrew Med. Standards 5 p (SEE N81-26699 17-52) Mar. 1981 refs
Avail: NTIS HC A07/MF A01

The use of drugs which blockade beta adrenergic recaptors as a treatment for engine and ischaemic heart disease is reviewed. The reasons for using these drugs in the treatment of hypertension in flight crews are summarized. Side effects of betablocking agents are discussed in relation to pilot performance. E.D.K.

N81-26716# Institute of Aviation Medicine, Fuerstenfeldbruck (West Germany).
INFLUENCE OF BETA BLOCKING ATENOLOL AND OTHER MEDICATION ON THE REACTION TIME OF THE VISUAL SYSTEM
D. HARMS, E. PACHALE, and D. NECHVATAL *In* AGARD The Effect of Long Term Therap., Prophylaxis and Screening Tech. on Aircrew Med. Standards 5 p (SEE N81-26699 17-52) Mar. 1981 refs
Avail: NTIS HC A07/MF A01

Visual reaction time as a measure of vigilance and of the psychophysiological condition of subjects was determined after combined physical and mental stress to examine B-blocker influence. Using the technique of electrooculography 40 subjects were measured in a double-blind cross over design after applications of placebo or 50 mg of atenolol (TENORMIN) for 3 days. Visual reaction time was defined as the time between display of a peripheral light signal and the start of the eye movement that shifts the direction of gaze from the reference point to the stimulus. The results of the study show that under these experimental conditions there is a positive effect of beta-blocker medication on vigilance. In order to prove the sensitivity of the test method in a preliminary study, the effects of the well described drugs fenetyllin-hydrochlorid, diazepam, oxazepam, and alcohol on visual reaction time were investigated. E.D.K.

N81-26717# Institute of Aviation Medicine, Fuerstenfeldbruck (West Germany).
CONSIDERATIONS ON LONG TERM THERAPY OF HYPERTONIA, LIPOMETABONIC DISORDERS AND STRUMA IN FLYING PERSONNEL
W. NISSEN and L. GALL *In* AGARD The Effect of Long Term Therap., Prophylaxis and Screening Tech. on Aircrew Med. Standards 9 p (SEE N81-26699 17-52) Mar. 1981 refs
Avail: NTIS HC A07/MF A01

Long term drug therapy in flying personnel is thought to be necessary only in very few instances, as illustrated in cases involving hypertension, hyperlipoproteinemia (HLP) and euthyroid struma in the pilot population. Sound medical advice and guidance in cases of hypertension and HLP are considered more important than drug therapy. Long term treatment of euthyroid struma with thyroid hormones is only practical in rare cases. E.D.K.

N81-27791# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
TOXIC HAZARDS IN AVIATION
Apr. 1981 131 p refs In ENGLISH and FRENCH Proc. of conf. held in Toronto, 15-19 Sep. 1980
(AGARD-CP-309; ISBN-92-835-0291-4; AD-A101019) Avail: NTIS HC A07/MF A01

The aviation environment contains many toxic materials and products. With the evolution of more advanced aircraft propulsion mechanisms, specialized aircraft material development and associated maintenance activities, there is a major increase in the potential toxic hazards associated with these systems. The threat of toxic exposure covers the entire spectrum of low-level continuous or intermittent to high-level brief accidental or unavoidable exposures. However, the protection of the crew and passengers is not the only concern in dealing with the toxic hazards in aviation. Research in the biomedical aspects of occupational health and safety standards, toxic substances, environmental impact criteria and classification of transportation is highlighted. For individual titles, see N81-27792 through N81-27805.

N81-27792# Aerospace Medical Research Labs., Wright-Patterson AFB, Ohio. Toxic Hazards Div.
RAMJET FUEL TOXICOLOGY
K. C. BACK *In* AGARD Toxic Hazards in Aviation 6 p (SEE N81-27791 18-52) Apr. 1981 refs
Avail: NTIS HC A07/MF A01

Fuels containing isomers of perhydromethylcyclopentadiene (RJ4), reduced dimers of bicyclohepadiene (RJ5), a tricyclodecane compound (JP10) and methylcyclohexane were studied for their acute, subacute, and chronic toxicity. The agents are of low order toxicity from acute exposure. Chronic toxicity studies were run on RJ4, and JP10 using rats, mice, dogs and monkeys. Kidney and liver hyperplasia in RJ4 exposed rats and pulmonary irritation in dogs and monkeys exposed to RJ4 and RJ5 emerge as the salient results. Although there is some indication of increased tumor incidence in a small number of mice held for one year after exposure to near saturated RJ5 vapors, there is no clear cut evidence that this compound is carcinogenic. T.M.

N81-27793# Naval Medical Research Inst., Wright-Patterson AFB, Ohio. Toxicology Detachment.
THE TOXICITY OF GRADE JP-5 AVIATION TURBINE FUEL, A COMPARISON BETWEEN PETROLEUM AND SHALE-DERIVED FUELS
M. J. COWAN, JR. and L. J. JENKINS, JR. (Shell Development Co., Houston, Tex.) *In* AGARD Toxic Hazards in Aviation 7 p (SEE N81-27791 18-52) Apr. 1981 refs
Avail: NTIS HC A07/MF A01

In order to assess the suitability of shale-derived JP-5, it is important that its inherent toxicity be identified and that the comparative toxicity of both the shale and petroleum JP-5 be identified. As a liquid acute spill hazard the fuels were examined for ocular and dermal irritation potential and for skin sensitization potential. Since the fuel is a complex mixture of aliphatic and aromatic hydrocarbons each exhibiting different vapor pressures, the nature of any accidental inhalation exposure will be dependent on the concentration of low boiling components in the mixture. The fuels were examined as a vapor inhalation hazard by exposing animals continuously for 90 days to vapors as high as 750 mg/cu m. Groups of animals were examined at 90 days and at the end of their normal expected lifetime. The fuels were examined as a potential oncogen by histopathologic examination of the animals exposed for 90 days and held for a lifetime. T.M.

N81-27794# Ohio State Univ., Columbus. Dept. of Veterinary Pathology.
DIFFERENTIAL EFFECTS OF HYDRAZINE COMPOUNDS ON B- AND T-CELL IMMUNE FUNCTION
M. J. TARR and R. G. OLSEN *In* AGARD Toxic Hazards in Aviation 7 p (SEE N81-27791 18-52) Apr. 1981 refs
(Contract F49620-79-C-0163)
Avail: NTIS HC A07/MF A01

The immunotoxic effects of four hydrazine compounds were evaluated by adding them to lymphocytes in the lymphocyte blast transformation (LBT) assay. 1,1-dimethylhydrazine (UDMH) caused an enhancement of the LBT response of murine splenocytes to the B-cell mitogen lipopolysaccharide (LPS) at concentrations of 10-25 ppm. 1,2-dimethylhydrazine (SDMH) exerted an effect similar to that of UDMH when added to splenocytes in the LBT assay, causing an enhancement of the LBT response to LPS at low concentrations, then a suppression at higher concentrations. The results suggest that UDMH and SDMH abrogate suppressor cell function, and that Hz and MMH suppress T-cell function (cell-mediated immunity) more than B-cell function (humoral immunity). T.M.

N81-27795# California Univ., Irvine. Dept. of Developmental and Cell Biology.
HYDRAZINE EFFECTS ON VERTEBRATE CELLS IN VITRO
A. E. SIEMENS, M. C. KITZES, and M. W. BERNS *In* AGARD Toxic Hazards in Aviation 16 p (SEE N81-27791 18-52) Apr. 1981 refs Submitted for publication
(Contract AF-AFOSR-3136-77)
Avail: NTIS HC A07/MF A01

Cells were exposed to hydrazine in various concentrations (0.001 mM to 10 mM) for varying time periods. The resulting growth and morphological data revealed a possible site of hydrazine action. In all cell lines tested, population growth was depressed by low concentration of hydrazine (0.01 mM to 0.1 nM). Cell growth was initially depressed, but it eventually returned to normal log phase growth even when fresh hydrazine was added to the culture medium. At higher concentrations (0.5 mM to 2.0 mM), hydrazine was lethal. Most cell types first showed population growth depression at 0.01 mM hydrazine, but the lethal concentration varied with the cell type. Cultures treated with hydrazine yielded a significantly higher number of giant, multinucleated cells. Autoradiography studies confirmed that the large, multinucleated cells resulted from cell fusion. T.M.

N81-27796# Aerospace Medical Research Labs., Wright-Patterson AFB, Ohio. Toxic Hazards Div.
THE ONCOGENIC HAZARD FROM CHRONIC INHALATION OF HYDRAZINE
V. L. CARTER, JR., K. C. BACK, and J. D. MACEWEN (California Univ., Irvine) *In* AGARD Toxic Hazards in Aviation 9 p (SEE N81-27791 18-52) Apr. 1981 refs
Avail: NTIS HC A07/MF A01

Studies were therefore conducted to evaluate the long term effects of airborne hydrazine at levels near the present and proposed Threshold Limit Value concentrations. Repeated daily inhalation exposure to 5 parts per million (ppm) hydrazine induced nasal tumors in Fischer 344 male and female rats and in male Golden Syrian hamsters. Repeated exposure to 1 ppm also produced nasal turbinate tumors in rats and pulmonary adenomas in female C57B1/6 mice. The inhalation exposures to the rodents were conducted for 6 hours per day, 5 days per week over a 12 month period. Rats and mice were held 18 months postexposure. The nasal turbinate tumor incidence in rats was dose related. No statistically significant tumorigenic effects occurred after repeated exposure to 0.05 and 0.25 ppm hydrazine concentrations which spanned the American Conference of Governmental Industrial Hygienists recommended Threshold Limit Value. T.M.

N81-27797# Ohio State Univ., Columbus. Dept. of Veterinary Pathobiology.
INHIBITION OF VIRUS TRANSFORMATION BY HIGH ENERGY FUELS AS A CORRELATE OF CARINOGENIC POTENTIAL
J. R. BLAKESLEE, JR. *In* AGARD Toxic Hazards in Aviation 6 p (SEE N81-27791 18-52) Apr. 1981 refs
(Contract F49620-77-C-0110; F49620-77-C-0087)
Avail: NTIS HC A07/MF A01

Hydrazine and naphthylamines and their derivatives were assayed for anti-carcinogenic effects on ST FeSV-directed transformation of human cells. All chemicals tested at non-toxic concentrations showed anti-carcinogenic activity. The temporal relationship of chemical treatment to virus infection was more critical with the hydrazines than with the naphthylamines in that maximum anti-carcinogenic effect occurred when virus-infected cells were exposed to the hydrazines 2 hrs. post-infection, whereas the naphthylamines anti-carcinogenic effect was observed if cells were exposed either pre- or post-infection. The anti-carcinogenic effect, when compared with in vitro chemical transformation and neoplastic transformation, show a high degree of correlation. These data suggest this assay system may lend itself to a rapid screen (9-13 days) of chemicals for carcinogenic potential. Cytotoxic results showed no significant difference in shale oil or petroleum derived JP5 or DFM. Author

N81-27798# Ohio State Univ., Columbus. Dept. of Physiological Chemistry.
INTERTISSUE VARIATION IN BENZO(A)PYRENE METABOLISM BY HUMAN SKIN, LUNG AND LIVER IN VITRO
G. E. MILO, R. W. TREWYN, R. TEJWANI, J. W. OLDHAM, and W. H. J. DOUGLAS (Tufts Univ., Boston) *In* AGARD Toxic Hazards in Aviation 9 p (SEE N81-27791 18-52) Apr. 1981 refs
(Contract F49620-77-C-0110)
Avail: NTIS HC A07/MF A01

Benzo(a)pyrene (B(a)P), an environmental carcinogen, is shown to transform human skin fibroblasts in vitro. This fossil fuel combustion product and other polynuclear hydrocarbons have exhibited a requirement to be biotransformed to their ultimate carcinogenic forms to induce transformation. B(a)P diol-epoxides are the most cited candidates as ultimate carcinogens. Results suggest that either the ultimate form of the carcinogen is different for fibroblasts and epithelial cells or the quantitative generation of hydroxylated metabolites is not required for neoplastic transformation in fibroblast cells. If hydroxylation is required, then the site of hydroxylation may be the significant factor. Present evidence suggests that in B(a)P treated fibroblasts the activation of B(a)P in the cell takes place other than the microsomal P450 complex, presumably in the nucleus. T.M.

N81-27799# Laboratoire Central de Biologie Aerospatiale, Paris (France). Div. de Chimie-Toxicologie.
THE TOXICITY OF GASES FROM THE THERMAL DECOMPOSITION OF COMBUSTIBLE MATERIALS. A TEST CHAMBER PROTOTYPE [TOXICITE DES GAZ DE DECOMPOSITION THERMIQUE DES MATIERES COMBUSTIBLES]
P. E. PICART, J. P. DELCROIX, and M. GUERBET *In* AGARD Toxic Hazards in Aviation 10 p (SEE N81-27791 18-52) Apr. 1981 refs In FRENCH
Avail: NTIS HC A07/MF A01

When fire breaks out in a closed environment, as in an aircraft cabin, evacuation is not immediately possible and thus it is necessary to establish minimum survivable conditions. In this case, toxic gases become a major problem. That is why it is necessary to select materials that present a minimum of toxicity in case of an onboard fire. A test chamber was developed that permits the examination of physical parameters involved with the thermal degradation of aircraft materials, with emphasis on the toxicity of combustion gases. The test chamber is described and the results of tests run on three materials (wood, polyurethane resins, polyvinyl chloride) are presented. T.M.

N81-27800# Defence and Civil Inst. of Environmental Medicine, Downsview (Ontario).
ACUTE CARBON MONOXIDE POISONING
H. D. MADILL and B. J. GILL *In* AGARD Toxic Hazards in Aviation 5 p (SEE N81-27791 18-52) Apr. 1981 refs
Avail: NTIS HC A07/MF A01

The principal toxic action of carbon monoxide is accepted as being due to its combination with hemoglobin to form carboxyhemoglobin (COHb). This has the effect of diminishing the oxygen carrying capability of the blood as well as altering the oxygen dissociation characteristics of the remaining oxyhemoglobin. This fundamental action of carbon monoxide was utilized as an objective measure of the degree of exposure and resulting intoxication based upon the level of COHb produced. The relationship between variable physiological parameters such as diffusivity of the lung, the ventilation rate and the affinity of blood for CO, the CO concentration in inspired air and the exposure time provides a means of predicting COHb formation. T.M.

N81-27801# Laboratoire de Medecine Aerospatiale, Bretigny-sur-Orge (France).
THE INFLUENCE OF ALTITUDE ON THE TOXICITY OF CARBON OXIDES [INFLUENCE DE L'ALTITUDE SUR LA TOXICITE DES OXYDES DE CARBONE]
H. VIEILLEFOND, J. L. POIRER, and H. MAROTTE *In* AGARD Toxic Hazards in Aviation 4 p (SEE N81-27791 18-52) Apr. 1981 refs In FRENCH
Avail: NTIS HC A07/MF A01

The effects of the reduction of partial oxygen pressure on the toxicity of a mixture of carbon dioxide and carbon monoxide were

examined. The degradation of psychomotor performance along with cardiovascular reactions were studied. Standards were established for carbon monoxide concentrations. T.M.

N81-27802# Aeronautical Systems Div., Wright-Patterson AFB, Ohio.
IN-FLIGHT OXYGEN GENERATING EQUIPMENT
J. P. ALLEN *In* AGARD Toxic Hazards in Aviation 12 p (SEE N81-27791 18-52) Apr. 1981 refs
Avail: NTIS HC A07/MF A01

On-board systems produce high oxygen concentrations of physiologically adequate oxygen for the aircrews. The quality of the oxygen is dependent on the quality of the input air and the provisions made for contaminant control. The molecular sieve material provides up to 95% oxygen with contaminant removal and separation from the oxygen product gas mixture. The chlorate candle oxygen generator produces almost 100% oxygen for 30 minutes and has effective adsorbers to remove contaminants from the oxygen produced. The fluomine system provides up to 98% oxygen in the product gas and uses activated carbon and molecular sieve filters for contaminant control. The concept with the greatest potential is the molecular sieve system using a specific type of sieve materials for oxygen concentration and effective contaminant control. Description of the systems are presented. T.M.

N81-27803# School of Aerospace Medicine, Brooks AFB, Tex.
MOLECULAR SIEVE OXYGEN GENERATION SYSTEM: CONTAMINANT STUDIES
K. G. IKELS and J. ERNSTING *In* AGARD Toxic Hazards in Aviation 7 p (SEE N81-27791 18-52) Apr. 1981 refs
Avail: NTIS HC A07/MF A01

The concept of inflight generation of breathing gas is attractive for military aircraft from the standpoint of logistics; safety, and cost. Evaluation and physiological assessment of the molecular sieve system in the laboratory is generally conducted with clean compressed air. In aircraft, however, the molecular sieve generator is supplied with engine bleed air which may not always be totally free of contaminants. Laboratory studies demonstrated that low molecular weight compounds pass through a molecular sieve bed into the breathing gas. The concentrations of the contaminants appearing in the output breathing gas are, however, much lower than that in the supply air and are shown to be directly related to the output demand flow of the oxygen generator. T.M.

N81-27804# Defence and Civil Inst. of Environmental Medicine, Downsview (Ontario).
AIRSCAN: AN ULTRASENSITIVE TRACE AIR IMPURITY ANALYZER FOR USE IN TOXIC AVIATION ENVIRONMENTS
R. LEVESON, N. BARKER, L. KUEHN, and H. D. MADILL *In* AGARD Toxic Hazards in Aviation 12 p (SEE N81-27791 18-52) Apr. 1981 refs Prepared in cooperation with Photovac, Inc., Thornhill, Ontario
Avail: NTIS HC A07/MF A01

An advanced air analyzer is described that is capable of detecting a wide range of pollutants in ambient air at concentrations of well below 1 part-per-billion. The system employs a combination of photoionization detection with gas chromatography using air as the carrier gas, it is fully field portable and accepts a directly introduced sample of air without any need for time-consuming preconcentration procedures. Applications for the instrument include the monitoring of all manner of environments including those within aircraft and spacecraft as well as external environments which may be contaminated during fuelling operations or by accidental emissions from specialized ordinanced. Hydrazine is of particular current relevance. Further applications include the monitoring of human exhaled breath in cases where there has been an unquantified exposure to toxic compounds. Such exposures are difficult to monitor at low levels; however the extreme sensitivity of the system makes it possible to detect breath metabolites in extremely concentrations. T.M.

N81-27805# Rouen Univ. (France). Lab. de Toxicologie.
A LABORATORY MODEL FOR THE EVALUATION OF THE TOXICITY OF COMBUSTION PRODUCTS [MODELE DE LABORATOIRE POUR EVALUER LA TOXICITE DES PRODUITS DE COMBUSTION]
J. M. JOUANY, J. M. PRESLES (DRET, Paris), and J. PRE (Paris XIII Univ., Bobigny) *In* AGARD Toxic Hazards in Aviation 14 p (SEE N81-27791 18-52) Apr. 1981 refs In FRENCH
Avail: NTIS HC A07/MF A01

Criteria are established for the selection of aircraft compartment materials. The toxicity of the materials after undergoing thermal degradation was examined. A screening method is described which compares different biological effects with emphasis on respiration and oxygen metabolism. An index was developed to classify the materials. T.M.

N81-31827# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
SIXTH ADVANCED OPERATIONAL AVIATION MEDICINE COURSE
J. BANDE, ed. May 1981 103 p refs Partly in ENGLISH; partly in FRENCH Course Held at Brussels, Belgium, 24-28 Mar. 1980
(AGARD-R-681; ISBN-92-835-0293-0; AD-A101444) Avail: NTIS HC A06/MF A01

The cardiological problems of selection and screening flying personnel are addressed. The epidemiology and prevention of heart diseases are discussed. Special emphasis is placed on the cardiovascular problems and follow-up of pilots of new generation, high performance aircraft.

N81-31828# Cliniques Univ. Saint-Luc, Brussels (Belgium). Service de Cardiologie.
NON-INVASIVE EVALUATION OF THE CORONARY CIRCULATION
J. M. R. DETRY and J. A. MELIN *In* AGARD 6th Advan. Operational Aviation Med. Course p 1-10 (SEE N81-31827 22-52) May 1981 refs
Avail: NTIS HC A06/MF A01

Coronary artery disease (CAD) is a major medical problem since it is the first cause of mortality and morbidity in the middle aged active population. The early detection of CAD is important since subjects with latent CAD have a much higher incidence of unexpected coronary events as compared to the normal population; as far as occupational medicine is concerned, these subjects should be identified since they may be suddenly incapacitated while on essential duties such as taking off or landing a plane. Among noninvasive diagnostic methods, the role of the history, the value of the exertional ECG and the additional information given by Thallium scintigraphy and radionuclide angiography were examined. T.M.

N81-31829# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
NATO REGULATIONS ON THE CARDIO-VASCULAR SYSTEM
E. E. *In its* 6th Advan. Operational Aviation Med. Course 10 p (SEE N81-31827 22-52) May 1981
Avail: NTIS HC A06/MF A01

The official regulations are the juridical base of all medical decisions concerning fitness for the flying duties. The regulations are presented for each member country in NATO. All the regulations require the circulatory system to be sound, as checked by clinical, radiological, and electrocadiographic examination. The examination procedures and clinical operations were reviewed and examined as to their validity for current NATO requirements. T.M.

N81-31830# Centre Principal d'Expertises Medicales du Personnel Navigant, Paris (France).
THE APPLICATION OF CARDIOGRAMS IN THE VALUATION OF NAVIGATION PERSONNEL [APPORT DES MECANOGRAMMES CARDIAQUES DANS L'EXPERTISE DU PERSONNEL NAVIGANT]
R. CARRE *In* AGARD 6th Advan. Operational Aviation Med. Course 10 p (SEE N81-31827 22-52) May 1981 In FRENCH
Avail: NTIS HC A06/MF A01

Cardiograms provide valuable information for the determination of flight fitness. Several applications of cardiograms are discussed and include: the analysis of the effects of respiration on the

cardiovascular system through phonocardiography; the study of arterial distention with the use of carotidograms; and the creation of an index of chronocardiographic measurement for systolic pressure and blood flow. T.M.

N81-31831# Service de Medecine Aeronautique, Versailles (France).
ECHOCARDIOGRAPHY IN AVIATION MEDICINE [ECHOCARDIOGRAPHIE EN MEDECINE AERONAUTIQUE]
G. LEGUAY and J. DRONIOU (Service de Cardiologie, Paris, France) *In* AGARD 6th Advan. Operational Aviation Med. Course 8 p (SEE N81-31827 22-52) May 1981 In FRENCH
Avail: NTIS HC A06/MF A01

The principles and techniques of echocardiography are discussed. The applications of echocardiography in flight examinations are described and include the early detection of heart disease, diagnosis myocardial infarction, and the examination of the cardiac ventricles. Emphasis is placed on the non-invasive aspect of echocardiography. T.M.

N81-31832# Centre Principal d'Expertises Medicales du Personnel Navigant, Paris (France).
PRINCIPAL ELECTROCARDIOGRAPHIC ANOMALIES IN THE VALUATION OF NAVIGATION PERSONNEL [PRINCIPALES ANOMALIES ELECTROCARDIOGRAPHIQUES DANS L'EXPERTISE DU PERSONNEL NAVIGANT]
R. CARRE *In* AGARD 6th Advan. Operational Aviation Med. Course 8 p (SEE N81-31827 22-52) May 1981 In FRENCH
Avail: NTIS HC A06/MF A01

The pilots of high performance aircraft undergo many extremes in physiological stress. It is essential to flight safety that the cardiovascular system of a pilot be in top working condition. Electrocardiography provides much of the biomedical data necessary for the valuation of flying personnel. Anomalies in electrocardiographic analysis are discussed and their importance in the overall diagnosis of flying personnel is emphasized. The anomalies include: troubles in analyzing rhythmic variations; the Wolff-Parkinson-White syndrome; the incomplete discription of blockage in right branches of the heart; and the effects of turbulence on ventricular function. T.M.

N81-31833# School of Aerospace Medicine, Brooks AFB, Tex.
TREADMILL TESTING FOR THE DETECTION OF ASYMPTOMATIC CORONARY DISEASE IN THE HEALTHY MALE
J. R. HICKMAN, JR. *In* AGARD 6th Advan. Operational Aviation Med. Course 9 p (SEE N81-31827 22-52) May 1981 refs
Avail: NTIS HC A06/MF A01

The poor predictive accuracy of the treadmill test for latent coronary artery disease is discussed. Emphasis is placed on the problem of false positive exercise tests. The treadmill test is regarded as a risk factor and as a part of the total risk factor mosaic rather than as a definitive test for coronary artery disease. Methods that are available for the detection of CAD are presented. T.M.

N81-31834# Service de Sante des Armees, Toulon (France).
CONTINUOUS RECORDING OF THE ECG ACCORDING TO THE HOLTER METHOD [ENREGISTREMENT CONTINU DE L'E.C.G. SELON LA METHODE DE HOLTER]
G. LEGUAY and A. SEIGNEURIC, (Medecin des Hopitaux) *In* AGARD 6th Advan. Operational Aviation Med. Course 9 p (SEE N81-31827 22-52) May 1981 refs In FRENCH
Avail: NTIS HC A06/MF A01

The three parts of continuous electrocardiography are discussed: the recording equipment, the reader, and the information system that is utilized to process the data. Applications of ambulatory electrocardiographic monitoring are described. Special problems are highlighted and include arrhythmias in patients with mitral valve prolapse and ventricular arrhythmias due to exercise or myocadial infarction. T.M.

N81-31835# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). Dept. of Cardiology.
EPIDEMIOLOGICAL BASIS FOR THE PREVENTION OF CORONARY HEART DISEASE
G. DEBACKER (Akademisch Ziekenhuis) *In* AGARD 6th Advan. Operational Aviation Med. Course 7 p (SEE N81-31827 22-52) May 1981 refs
Avail: NTIS HC A06/MF A01

Coronary heart disease (CHD) is an important cause of premature death and disability in the economically active population of most industrialized countries. Therefore there is a great need for measures to control this mass disease. The controversies concerning links between life styles, behavioral factors and the risk of CHD are discussed. Preliminary results of an ongoing controlled preventive trial are presented. T.M.

N81-31836# Militair Hospitaal Brussel (Belgium).
PREVENTION OF CARDIOVASCULAR DISEASES
H. KESTELOOT *In* AGARD 6th Advan. Operational Aviation Med. Course 4 p (SEE N81-31827 22-52) May 1981 refs
Avail: NTIS HC A06/MF A01

Cardiovascular diseases, espcially those caused by coronary heart disease account for 55% of the total death rate in Belgium and are three times more important than cancer. Modern epidemiological research underlined the multifactorial origin of cardiovascular diseases and identified several risk factors. A survey of the most important risk factors influencing cardiovascular mortality is presented. Various recommendations are provided in order to decrease the adverse effects of these risk factors with regard to health and life expectancy. T.M.

N81-31837# Royal Air Force Hospital, Halton (England).
CARDIOVASCULAR PROBLEMS DURING THE PILOTS CAREER
J. N. C. COOKE *In* AGARD 6th Advan. Operational Aviation Med. Course 3 p (SEE N81-31827 22-52) May 1981 refs
Avail: NTIS HC A06/MF A01

In a population which is highly selected at entry and which is generally composed of the younger age groups in the Air Force the pattern of cardiovascular problems tends to depart from that of the general population. In particular congenital heart disease, valvular disease, and hypertensive heart disease consequent upon chronic renal disease are comparatively rare. The effects of repeated regular physical and ECG examinations of aircrew also tend to produce special problems of the elucidation of presymptomatic cardiovascular disease rather than the mangement of symptomatic patients. The following subjects are discussed: essential hypertension; ischaemic heart disease; arrhythmias; and myocarditis, including sarcoidosis. T.M.

N81-31838# School of Aerospace Medicine, Brooks AFB, Tex.
DISPOSITION OF ELECTROCARDIOGRAPHIC ABNORMALITIES IN AVIATION
J. R. HICKMAN, JR. *In* AGARD 6th Advan. Operational Aviation Med. Course 13 p (SEE N81-31827 22-52) May 1981 refs
Avail: NTIS HC A06/MF A01

The present criteria for disposition of electrocardiographic abnormalities in United States Air Force aviators are based upon findings within the flying population and observation of the natural history of specific electrocardiographic findings. The electrocardiogram is a laboratory test requiring a history, physical examination, and other laboratory tests for interpretation. Serial ST and T wave changes, ectopic artrial and ventricular beats, ventricular tachycardia, supraventricular tachcardia, conduction abnormalities such as right and left bundle branch block, Wolff-Parkinson-White electrocardiographic finding, sinus bradycardia, and sinus pauses are discussed. The current aeromedical dispositions for these abnormalities are also discussed. The disposition of certain aeromedical abnormalities will remain flexible and continue to evolve as more experience is gained in dealing with healthy aviators. T.M.

N82-10720# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
PHYSIOPATHOLOGY AND PATHOLOGY OF SPINAL AILMENTS IN AEROSPACE MEDICINE [PHYSIOPATHOLOGIE AT PATHOLOGIE DES AFFECTION DUR RACHIS EN MEDECINE AEROSPATIALE]
R. P. DELAHAYE, R. AUFFRET, P. DOURY, C. KLEITZ, A. LEGER, G. LEGUAY, P. J. METGES, J. L. POIRIER, B. VETTES, and H. VIELLEFOND Apr. 1981 336 p refs In FRENCH
(AGARD-AG-250-FR; ISBN-92-835-2108-0; AD-A101449) Avail: NTIS HC A15/MF A01

Spinal problems in aerospace medicine are reviewed. Opinions are expressed in the areas of etiology, diagnosis and prognosis for lesions in the spinal column, injuries which are activated by piloting rotary wing aircrafts, conventional airplanes, gliders, or by parachute jumping. It is concluded that this information is helpful in aerospace medicine, the medical physiology of flying personnel, and also in the enforcment of flight safety. Transl. by E.A.K.

N82-27972# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
SLEEP AND WAKEFULNESS HANDBOOK FOR FLIGHT MEDICAL OFFICERS
A. N. NICHOLSON (Inst. of Aviation Medicine, Fernborough, England) and B. M. STONE (Inst. of Aviation Medicine, *Fernborough, England) Mar. 1982 89 p*
(AGARD-AG-270(E); ISBN-92-835-1416-5; AD-A115076) Avail: NTIS HC A05/MF A01

Sleep and wakefulness related to aircrew and the aviation environment are discussed. Eight topics are covered: alertness and sleep, sleep, Circadian rhythms, shiftwork, transmeridian flight, air operations and irregularity of work, disorders of sleep and arousal, and hypnotics. N.W.

N82-29870# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
PHYSIOPATHOLOGY AND PATHOLOGY OF SPINAL INJURIES IN AEROSPACE MEDICINE
R. P. DELAHAYE and R. AUFFRET Feb. 1982 338 p refs
(AGARD-AG-250(ENG); ISBN-92-835-1415-7; AD-A115369)
Avail: NTIS HC A15/MF A01

The anatomy and biomechanics of the spine are reviewed and spinal stress in flight is described. The aetiology and pathogenesis of spinal fracture; the clinical examination and radiology of spinal trauma; postural disorders of helicopter and combat aircraft pilots; and flight fitness are considered. Medico-legal aspects of spinal disorders, including intervertebral arthritis, spondylolisthesis, and inflammatory rheumatic conditions are addressed. For individual titles, see N82-29871 through N82-29892.

N82-29871# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
ANATOMY OF THE SPINE
C. KLEITZ and R. P. DELAHAYE *In its* Physiopathol. and Pathol. of Spinal Injuries in Aerospace Med. p 9-28 (SEE N82-29870 20-52) Feb. 1982
Avail: NTIS HC A15/MF A01

The embryology of the spine; general and special regional characteristics of vertebrae; interconnections and articulations, the spine as a whole, and the spine in the seated position are depicted in anatomical drawings and described. A.R.H.

N82-29872# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
BIOMECHANICS OF THE SPINE
C. KLEITZ and R. P. DELAHAYE *In its* Physiopathol. and Pathol. of Spinal Injuries in Aerospace Med. p 29-45 (SEE N82-29870 20-52) Feb. 1982
Avail: NTIS HC A15/MF A01

The spine has at least three basic biomechanical functions: (1) transmit the weight and the flexing movements of the head and the trunk to the pelvis; (2) allow physiological movement between the head, trunk, and pelvis; and (3) protect the spinal cord from trauma caused by forces and movements. The functional biomechanics of the intervertebral disk, the intervertebral ligaments, the vertebrae, and the spinal column are illustrated and discussed. The role of the thoracic cage and muscles is also examined. A.R.H.

N82-29873# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
SPINAL STRESSES IN FLIGHT
R. AUFFRET and H. VIELLEFOND *In its* Physiopathol. and Pathol. of Spinal Injuries in Aerospace Med. p 47-54 (SEE N82-29870 20-52) Feb. 1982
Avail: NTIS HC A15/MF A01

The spine of a pilot is subjected to two types of stresses: those inherent in flight which are of relatively low intensity and are related to the time for which they act; and those which are uncommon but of very high intensity whose effects are related to the mechanical strength of the spinal column and can lead to fractures. The former represent the problem of fatigue of materials; the latter the problem of the strength of materials. The physiological effects of aircraft acceleration and vibration during flight are analyzed. The mechanical effects on the human body of the very high accelerations (impacts) associated with ejection from high performance aircraft at high speed and during crash landings away from prepared runways are examined. A.R.H.

N82-29874# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
THEORIES OF THE PATHOGENESIS OF FRACTURES OF THE SPINE
R. P. DELAHAYE and P. J. METGES *In its* Physiopathol. and Pathol. of Spinal Injuries in Aerospace Med. p 57-59 (SEE N82-29870 20-52) Feb. 1982
Avail: NTIS HC A15/MF A01

The mechanisms of fractures of the thoraco-lumber spine and of the cervical spine are distinguished. The different aetiological circumstances in which traumatic lesions occur (crash, parachuting, ejection, accidents in flight, accidents on centrifuges and sleds) are examined. Clinical studies and practical methods of examination that are often neglected are considered. Radiology must be carried out early, using optimal techniques to yield radiographs that, with the clinical examinations, can facilitate the establishment of an accurate inventory of the lesions. The numerous after-effects of trauma must be detailed, for they produce a very special clinical and radiological picture with which every flight surgeon should be thoroughly familiar. A.R.H.

N82-29875# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
AETIOLOGY AND PATHOGENESIS
R. P. DELAHAYE and R. AUFFRET *In its* Physiopathol. and Pathol. of Spinal Injuries in Aerospace Med. p 60-65 (SEE N82-29870 20-52) Feb. 1982
Avail: NTIS HC A15/MF A01

Records of accident investigations of light civil aircraft, gliders, military aircraft, and civil and military transport aircraft show that the pathogenesis of fractures of the vertebral column and the associated lesions resulting from crashes is almost identical. The localization of spinal fractures in crashes, the forces and accelerations in crashes, and the effect of deceleration when the body is restrained by an abdominal belt are considered. A.R.H.

N82-29876# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
HELICOPTER ACCIDENTS
B. VETTES and R. P. DELAHAYE *In its* Physiopathol. and Pathol. of Spinal Injuries in Aerospace Med. p 66-71 (SEE N82-29870 20-52) Feb. 1982
Avail: NTIS HC A15/MF A01

The uses of helicopters in civil and military operations are reviewed and it is shown that the advantages of maneuverability, vertical take-off and landing, hovering, and the need for unsophisticated ground base contribute to the frequent, often serious accidents of these aircraft. Statistical studies of civil and military helicopters, and the distribution of vertebral fractures in helicopter accidents are discussed. The schematic division of crashes into ground impact in autorotation and crash with loss of control of aircraft corresponds to a distinction between crashes with the possibility of survival and unsurvivable crashes. The pathogenesis of vertebral lesions is discussed for crashes in which the impact is purely vertical (accident in autorotation) and crashes with a significant horizontal impact component (poor chance of survival). Case histories of crash injuries are used to show that

the risk of fatal accidents, which is 0.34 per 10,000 flying hours, must be reduced. A.R.H.

N82-29877# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
EJECTION OF PILOTS FROM COMBAT AIRCRAFT
R. P. DELAHAYE, R. AUFFRET, and B. VETTES *In its* Physiopathol. and Pathol. of Spinal Injuries in Aerospace Med. p 72-96 (SEE N82-29870 20-52) Feb. 1982
Avail: NTIS HC A15/MF A01

The history of scientific studies of pilot escape, especially at high speeds from combat aircraft, is reviewed and the principles of the ejection seat are examined. The different phases of ejection (initiation; seat firing and egress from the aircraft; separation of the seat; landing; survival; and rescue) are described. Normal configurations, abnormal configurations and the extraction (YANKEE system) are discussed as well as the overall results of ejection and the results as a function of in-flight factors. The distribution of ejection lesions, and the pathogenic mechanisms of spinal fractures during ejection are examined. Parachute opening shock and pathological factors associated with landing are also considered. A.R.H.

N82-29878# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
PARACHUTING
A. LEGER and R. P. DELAHAYE *In its* Physiopathol. and Pathol. of Spinal Injuries in Aerospace Med. p 97-121 (SEE N82-29870 20-52) Feb. 1982
Avail: NTIS HC A15/MF A01

The physiopathology and etiology of parachute descents are examined during (1) leaving the aircraft to parachute opening; (2) parachute opening; and (3) descent on the deployed parachute. Military parachuting techniques and training of military parachutists; and fracture and trauma of the spine during parachuting as a means of transport are examined. Other lesions and traumatic sequelae of parachuting are described. General conditions of parachuting as a sport, the equipment used, and spinal trauma in sport parachuting are also covered. Hang gliding and the limits of human tolerance for impacts in free fall are discussed. A.R.H.

N82-29879# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
LIMITS OF HUMAN TOLERANCE FOR IMPACTS IN FREE FALL
In its Physiopathol. and Pathol. of Spinal Injuries in Aerospace Med. p 122-126 (SEE N82-29870 20-52) Feb. 1982
Avail: NTIS HC A15/MF A01

Various techniques used to study the degree of human resistance to impact during an unimpeded fall, jump, or dive from a known point to a know point are described. The physical factors which influence the nature, size, and severity of the lesions received are amplitude, direction of forces, distribution of forces, area of application, and duration. Biological factors (physical condition) are also closely related to impact tolerance. Injuries resulting from impacts into water and at terminal velocity are reported from case histories. A.R.H.

N82-29880# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
FRACTURES OF THE SPINE IN FLIGHT
R. P. DELAHAYE and R. AUFFRET *In its* Physiopathol. and Pathol. of Spinal Injuries in Aerospace Med. p 127-131 (SEE N82-29870 20-52) Feb. 1982
Avail: NTIS HC A15/MF A01

Case histories show that fractures of the spine can occur in the pilot of combat aircraft during rapid vibrational phenomena (induced oscillation) and with inadvertent unlocking of the seat, an event which produces additional accelerations which lead to a sudden compression of the vertebral column. During turbulence, a flight attendant thrown against the wall or the seats of an aircraft sometimes receives a fracture of the spine. More rarely, cervical sprains occur during aerobatics. A.R.H.

N82-29881# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
ACCIDENTS IN CENTRIFUGES AND EXPERIMENTS (EJECTION SEAT TRAINING TOWERS, SLEDS)
R. P. DELAHAYE and R. AUFFRET *In its* Physiopathol. and Pathol. of Spinal Injuries in Aerospace Med. p 132-135 (SEE N82-29870 20-52) Feb. 1982
Avail: NTIS HC A15/MF A01

The performance characteristics of the centrifuge at CEV (Bretigny) are described as well as the protocol used. Results of studies at 6.5 G, 9 G, 11.5 G and 13.5 G are examined to indicate the types of injuries that occurred. Factors responsible for the low incidence of injuries on ejection seat training rigs and rocket sleds are mentioned. A.R.H.

N82-29882# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
CLINICAL EXAMINATION OF SPINAL INJURIES
P. DOURY and G. LEGUAY *In its* Physiopathol. and Pathol. of Spinal Injuries in Aerospace Med. p 136-138 (SEE N82-29870 20-52) Feb. 1982
Avail: NTIS HC A15/MF A01

Manipulation of the subject in the erect, sitting, or lying position occurs following history taking and precedes radiology. In case of severe injury, clinical examination must always be cautious, usually with the patient lying on his back. In the upright position, the patient is examined from the front, back, and side as well as while walking on the toes and heels. Procedures for examining the seated, supine, and prone patient should be followed by neurological and gynecological examination. The identification of thoraco lumbar and cervical fractures is described. It is indicated that simple fractures of the spine are clinically silent in 15% to 20% of cases and that the most searching examination cannot provide sufficient evidence to eliminate with certainty the fracture of the spinal column. A.R.H.

N82-29883# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
RADIOLOGY OF SPINAL TRAUMA IN AVIATION MEDICINE
R. P. DELAHAYE and P. J. METGES *In its* Physiopathol. and Pathol. of Spinal Injuries in Aerospace Med. p 139-186 (SEE N82-29870 20-52) Feb. 1982
Avail: NTIS HC A15/MF A01

Radiological examination of the spine in aerospace medicine is the same as that of any recent spinal trauma, and it obeys the same principles. The examination is carried out as soon as possible after an aviation accident. The entire spine is X-rayed segmentally, with frontal and lateral films. The examination consists of diagnostic radiography and complementary radiological assessment (localized and oblique views, tomography, dynamic films, examinations with the contrast media, scanning). S.L.

N82-29884# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
ANALYTICAL STUDY OF TRAUMATIC LESIONS OF C3-C7
In its Physiopathol. and Pathol. of Spinal Injuries in Aerospace Med. p 187-198 (SEE N82-29870 20-52) Feb. 1982
Avail: NTIS HC A15/MF A01

In a frontal view in a neutral position, the spines are aligned, and the distances between them are more or less equal. Any deviation of the line of the spines is evidence of a unilateral dislocation, and increase in the distance between two spines always indicates a dislocation. In a straight lateral view, the articular processes are superimposed. If they appear are separated at a given level when they are superimposed below, a fracture of the articular processes is sought. The separation indicates a rotation. Traumatic lesions of the cervical spine are often unstable. This instability is not always evident on standard X-rays. It is sometimes necessary to carry out careful dynamic examinations on a second occasion. S.L.

N82-29885# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
RADIOLOGICAL STUDY OF FRACTURES OF C1 AND C2
In its Physiopathol. and Pathol. of Spinal Injuries in Aerospace Med. p 199-210 (SEE N82-29870 20-52) Feb. 1982
Avail: NTIS HC A15/MF A01

Fractures of the axis and atlas of the C1 and C2 area represent 15 to 25% of the fractures of the cervical spine, and preferentially affect the odontoid. The angles from which the X-rays are taken must be strictly controlled. The frontal view can only be interpreted if the spinous process of C2 is projected on the center of the body atlas. In profile, in the normal state, the posterior border of the odontoid should lie on a straight line extended from that of the body. In contrast, the anterior border lies obliquely. The space between the anterior edge of the odontoid and the posterior border of the anterior arch of the atlas should not exceed 3 mm. The state of the soft tissues in front of the spine should always be carefully assessed. S.L.

N82-29886# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
SEQUELAE OF VERTEBRAL FRACTURES AND TRAUMA
R. P. DELAHAYE and P. J. METGES *In its* Physiopathol. and Pathol. of Spinal Injuries in Aerospace Med. p 211-223 (SEE N82-29870 20-52) Feb. 1982
Avail: NTIS HC A15/MF A01

The broad principles of treatment of traumatic lesions and fractures of the spine in aviation medicine are the same as those in general practice. A general scheme in accordance with the different philosophies of various schools of orthopaedic surgery, is presented and the very common thoraco-lumbar fractures of the spine are contrasted with the more severe fractures of the cervical spine. S.L.

N82-29887# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
BACKACHE IN HELICOPTER PILOTS
R. P. DELAHAYE, R. AUFFRET, P. J. METGES, J. L. POIRIER, and B. VETTES *In its* Physiopathol. and Pathol. of Spinal Injuries in Aerospace Med. p 225-260 (SEE N82-29870 20-52) Feb. 1982
Avail: NTIS HC A15/MF A01

Back pains in helicopter pilots are studied. These pains are usually caused by the vibrations of the helicopter. The picture is of a low grade, tiring, heavy ache localized in the lumbar region, or sometimes lower. It extends laterally, often predominantly to one side, and may radiate to the buttocks, the iliac crests or, more rarely, the groin. This discomfort is brought on by flight, aggrevated by lifting effort of by long car journeys, and relieved by lying down and by physiotherapy. S.L.

N82-29888# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
THE CERVICAL COLUMN OF PILOTS OF COMBAT AIRCRAFT
R. P. DELAHAYE and R. AUFFRET *In its* Physiopathol. and Pathol. of Spinal Injuries in Aerospace Med. p 261-263 (SEE N82-29870 20-52) Feb. 1982
Avail: NTIS HC A15/MF A01

The pilots of high performance fighter aircraft sometimes complain of cervical pain during flight at low altitude. The level of vibrations is especially high and the pilot is often leaning forward in a fixed position. The character of the workload, notably in high performance combat aircraft (Mach 2) is considered in studying this problem. S.L.

N82-29889# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
THE SPINE AND FITNESS FOR FLIGHT
R. P. DELAHAYE, R. AUFFRET, G. LEGUAY, P. DOURY, P. J. METGES, and C. KLEITZ *In its* Physiopathol. and Pathol. of Spinal Injuries in Aerospace Med. p 264-289 (SEE N82-29870 20-52) Feb. 1982
Avail: NTIS HC A15/MF A01

The harmful effects of flight factors studied, and the analysis of different sets of statistics confirm that the vertebral column is subjected to a certain number of more or less severe stresses in the course of a flying career. It is necessary to define some criteria of fitness, as far as the spine is concerned, in relation to the type of aircraft. These conditions for fitness are considered from two very distinct aspects: fitness at the time of admission of flying personnel and fitness upon reexamination and after air accidents S.L.

N82-29890# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
VERTEBRAL ARTHRITIS
In its Physiopathol. and Pathol. of Spinal Injuries in Aerospace Med. p 290-295 (SEE N82-29870 20-52) Feb. 1982
Avail: NTIS HC A15/MF A01

Vertebral arthritis is a commonly encountered disorder that rarely affects the fitness of flying personnel. Factors that are considered are the roles in which the flying duties impose a stress upon the spine; these mainly comprise helicopter and combat pilots. The painful functional disturbance unrelated to radiological signs, radiogically, severe involvement of the discs, and therapeutic considerations, which under favorable conditions do not exclude surgery are also emphasized. S.L.

N82-29891# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
ANKYLOSING SPONDYLITIS
In its Physiopathol. and Pathol. of Spinal Injuries in Aerospace Med. p 296-300 (SEE N82-29870 20-52) Feb. 1982
Avail: NTIS HC A15/MF A01

The question of fitness of aircraft pilots in relation to the onset of Anklosing Spohdylitis is discussed. The clinical form of the disease and the nature of its course are considered. Factors emphasized are: specific roles, such as helicopters or combat aircraft, fixed rigidity of the spine and, even more, deformity, extraspinal involvement, severe inflammatory syndromes, the prospect of rapid development, the recognition of a specific aetiology, and the requirements of treatment. S.L.

N82-29892# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
MEDICO-LEGAL ASPECT OF SPINAL DISORDERS IN AVIATION MEDICINE
P. DOURY, R. AUFFRET, and R. P. DELAHAYE *In its* Physiopathol. and Pathol. of Spinal Injuries in Aerospace Med. p 301-307 (SEE N82-29870 20-52) Feb. 1982
Avail: NTIS HC A15/MF A01

Medico-legal aspects of spinal disorders in aviation medicine are discussed. Trauma and intervertebral arthritis, trauma and inflammatory rheumatic conditions, and spondylolisthesis and its association with trauma are considered. S.L.

N82-31930# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
NONINVASINE TECHNIQUES FOR CARDIOVASCULAR EXAMINATION OF INTEREST IN AEROSPACE MEDICINE [TECHNIQUES NON-SANGLANTES DE L'EXPLORATION CARDIO-VASCULAIRE INTERET EN MEDECINE AEROSPATIALE]
R. CARRE May 1982 205 p refs In FRENCH
(AGARD-AG-277(FR); ISBN-92-835-2109-9) Avail: NTIS HC A10/MF A01

In addition to standard electrocardiography and cardiac radiography, other noninvasive cardiological techniques used in the evaluation of pilots include the Holter technique, echocardiography, ultrasonics, and isotopic exploration. Special tests of interest in aerospace medicine are cardiac rheoplethymyopathy with measurement of systolic period intervals, ballistocardiography, tests of lower body negative pressure, and tests using the tilt-table and the centrifuge. For individual titles, see N82-31931 through N82-31943.

N82-31931# Centre Principal d'Expertises Medicales du Personnel Navigant, Paris (France).
PRINCIPAL ELECTROCARDIOGRAPHIC ANOMALIES IN THE EVALUATION OF PILOTS [PRINCIPALES ANOMAIES ELECTROCARDIOGRAPHIQUES DANS L'EXPERTISE DU PERSONNEL NAVIGANT]
R. CARRE, A. DIDIER, and H. ILLE *In* AGARD Noninvasine Tech. for Cardiovascular Exam. of Interest in Aerospace Med. p 1-4 (SEE N82-31930 22-52) May 1982 refs In FRENCH
Avail: NTIS HC A10/MF A01

The cardiovascular system is the sysem most influenced by stress during the flight of high performance aircraft such as the Mirage 2000 or 4000 type. Military regulations covering the physical fitness of pilots requires absolute organic and functional integrity of the circulatory system and an electrocardiogram with six peripheral and precordial derivations is obtained at each evaluation of pilots of such aircraft. Unfitness is easily pronounced for rhythm problems, flutter, auricular fibrillaton, trouble in condition, complete right or complete left bundle branch block, and effects of myocardial infraction. Electrocardiograms are discussed with focus on: (1) rhythm irregularities; (2) incomplete right bundle branch block; (3) left axial deviations and their relation to the left anterior hemiblock concept; the Wolf Parkinson White syndrome; and (5) irregularities of ventricular polarization. Trans. by A.R.H.

N82-31932# Hopital d'Instruction des Armees, Paris (France).
VENTRICULAR PREEXCITATION SYNDROMES [LES SYNDROMES DE PRE-EXCITATION VENTRICLAIRE]
J. DRONIOU *In* AGARD Noninvasine Tech. for Cardiovascular Exam. of Interest in Aerospace Med. p 15-25 (SEE N82-31930 22-52) May 1982 refs In FRENCH
Avail: NTIS HC A10/MF A01

Ventricular preexcitations constitute a group of conduction anomalies involving the premature activation of all or part of the ventricule by normal sine wave excitation. They can be asymptomatic, reduced to their electrocardiograph signatures alone or complicated with arrhythmias, which are often serious. The asymptomatic forms are the source of difficulties in the evaluation of pilots for two reasons: certain electrocargiograph anomaies suggestive of preexcitation do not have an unambiguous signification, and the prognosis is not easily predicted.
Transl. by A.R.H.

N82-31933# Service de Medecine Aeronautique, Versailles (France).
THE EXERCISE ELECTROCARDIOGRAM [ELECTROCARDIOGRAMME D'EFFORT]
G. LEGUAY and A. SEIGNEURIC *In* AGARD Noninvasine Tech. for Cardiovascular Exam. of Interest in Aerospace Med. p 27-66 (SEE N82-31930 22-52) May 1982 refs In FRENCH
Avail: NTIS HC A10/MF A01

The physological basis of exercise electrocardography (EKG) is reviewed with emphasis on muscular contraction, maximum oxygen consumption, pulmonary exchanges, and the adaptation of circulation and of the heart to exercise. Indications and contrdications for the use of stress tests are discussed. The types, placement, and fixation of electrodes are among the basic techniques of exercise EKG described. Modaities of exercise are considered. Normal exercise EKG in coronary insufficiency, the diagnostic value of exercise EKG in cronary insufficiency, the use of the EKG as a criteria in determining severity of coronary insufficiency, and the prognostic value of stress EKG's are examined. Transl. by A.R.H.

N82-31934# Service de Medecine Aeronautique, Versailles (France).
CONTINUOUS ECG REGISTRATION ACCORDING TO THE HOLTER METHOD [ENREGISTREMENT CONTINU DE L'E.C.G. SELON LA METHODE DE HOLTER]
G. LEGUAY and A. SEIGNEURIC *In* AGARD Noninvasine Tech. for Cardiovascular Exam. of Interest in Aerospace Med. p 67-86 (SEE N82-31930 22-52) May 1982 refs In FRENCH
Avail: NTIS HC A10/MF A01

In 1949, Holter implemented a process which allows for the continuous recording of ECG's during ambulation. This process not only permits almost instantaneous knowledge of the electrical activity of the heart but also allows for modification of certain concepts, particularly with regards to arrhythmia. With constant improvement, this method presents two large centers of interest to cardiology: rhythm problems and the supervision of their treatment, and the repolarization problem. The technical modalities of the method are reviewed and implications for cardiology are summarized in order to suggest aspects of interest in aerospace medicine. Transl. by A.R.H.

N82-31935# Centre Principal d'Expertises Medicales du Personnel Navigant, Paris (France).
THE CONTRIBUTION OF STANDARD RADIOGRAPHY IN CARDIOVASCULAR EXPLORATION DURING THE EXAMINATION OF PILOTS [APPORT DE LA RADIOGRAPHIE STANDARD DANS L'EXPLORATION CARDIO-VASCULAIRE AU COURS DE LA VISITE DU PERSONNEL NAVIGANT]
M. PUECH and P. J. METGES (Hopital d'Instruction des Armees) *In* AGARD Noninvasine Tech. for Cardiovascular Exam. of Interest in Aerospace Med. p 87-92 (SEE N82-31930 22-52) May 1982 refs In FRENCH
Avail: NTIS HC A10/MF A01

Teleradiography of the heart and televised radiography are integrated and articulated in complementary cardiologic examinations. Nonbloody radiological techniques and their normal results are described as well as their contribution in a number of pathological situations usually encountered which can pose problems of fitness. Congenital cardiopathy, acquired valvular cardiopathy, and ischemic and obstructive cardiopathies are discussed as well as physiological factors affecting the size and shape of the heart in athletes and Africans. Transl. by A.R.H.

N82-31936# Centre Principal d'Expertises Medicales du Personnel Navigant, Paris (France).
THE CONTRIBUTION OF CARDIAC MECHANOGRAMS IN THE EVALUATION OF PILOTS [APPORT DES MECANOGRAMMES CARDIAQUES DANS L'EXPERTISE DU PERSONNEL NAVIGANT]
R. CARRE, R. AMORETTI, A. DIDIER, and H. ILLE *In* AGARD Noninvasine Tech. for Cardiovascular Exam. of Interest in Aerospace Med. p 93-112 (SEE N82-31930 22-52) May 1982 In FRENCH
Avail: NTIS HC A10/MF A01

The idea of graphically registering carotid pulsations or the apexogram is not recent, having been used in the nineteenth century by Chaveau, Marey, and Maceray. If such recordings were valuable to physiologists, they have been of little value to clinicians and experts on pilots. These nonbloody techniques are easily reproducible at each examination and tracings can be included in the pilot's file for comparison from one examination to another. Cardiac mechanograms provide three classes of information: (1) analysis of the heart murmur indicates the variety of cardiopathology by phonocardiography; (2) the study of arterial distensibility by the carotidogram; and (3) chronocardiographic measure by the study of systolic intervals, permitting determination of the value of myocardial muscle contraction. Transl. by A.R.H.

N82-31937# Hopital d'Instruction des Armees, Paris (France).
ECHOCARDIOGRAPHY IN THE EXAMINATION OF PILOTS [L'ECHOCARDIOGRAPHIE DANS L'EXPERTISE DU PERSONNEL NAVIGANT]
J. DRONIOU and A. COIGNARD *In* AGARD Noninvasine Tech. for Cardiovascular Exam. of Interest in Aerospace Med. p 113-143 (SEE N82-31930 22-52) May 1982 In FRENCH
Avail: NTIS HC A10/MF A01

Echocardiography permits visualization of intracardiac structures thanks to the reflection of an ultrasonic beam by these structures. Introduced into the clinic in the 1950's, this technique has made an extraordinarily rapid advance, to the point of becoming an indispensable requirement in cardiologic examination. Its nonagressive character and its relative simplicity in operation, warrants repetition of the examination at will. Its sensitivity and reliability in experienced hands should give it an important place in the cardiological evaluation of pilots. Transl. by A.R.H.

N82-31938# Hopital d'Instruction des Armees, Versailles (France).
EXAMINING ARTERIAL FUNCTION BY DOPPLER VELOCIMETRY: THE ADVANTAGE IN AEROSPACE MEDICINE [EXPLORATION FONCTIONNELLE ARTERIELLE PAR VELOCIMETRIE DOPPLER INTERET EN MEDECINE AERONAUTIQUE ET SPATIALE]
A. DIDIER, H. ILLE, C. RIBADEAU-DUMAS, P. LANTRADE, and C. HILTENBRAND *In* AGARD Noninvasive Tech. for Cardiovascular Exam. of Interest in Aerospace Med. p 145-158 (SEE N82-31930 22-52) May 1982 refs In FRENCH
Avail: NTIS HC A10/MF A01

Since the work done by Satomura and Kato in Japan in the 1960's, the use of the Doppler effect to measure the rate of blood flow in vessels has developed and met with considerable success, particularly in France. It has become a routine examination in angiology. The precision of the data obtaind and the total innocuousness of this investigative method requires that its place be defined in aeronautica and aerospace medicine for the medical evaluation of pilots as well as for the study of the physiological modification of arterial flow in organisms subjected to actual aeronautical and space constraints. Transl. by A.R.H.

N82-31939# Hopital d'Instruction des Armees, Paris (France).
CONTRIBUTION OF NUCLEAR MEDICINE IN CARDIOLOGY [APPORT DE LA MEDECINE NUCLEAIRE EN CARDIOLOGIE]
J. F. GAILLARD *In* AGARD Noninvasine Tech. for Cardiovascular Exam. of Interest in Aerospace Med. p 159-166 (SEE N82-31930 22-52) May 1982 refs In FRENCH
Avail: NTIS HC A10/MF A01

Isotopic exploration techniques have a practically undeniable place among complementary cardiological examinations. In 1948 a radiocardiogram was introduced which recorded by external detection the dilution curve in cardiac cavities using a radioactive detector. Static scintigraphy appeared in 1964, and in the 1970's, the gamma camera was coupled with a computer to permit rapid dynamic studies with image processing. Benefitting from the same electronic progress and the same image reconstruction algorithm as tomodensitometry, gamma emission tomography obtained results in studies of vascularization and metabolism of the myocardium. Isotopic methods furnish data which, for the most part, were obtained only by bloody radiological explorations using the products of contrast and ultrasonics. Nuclear medicine is interested in the noninvasine functional study of an organ and the possibility of quantifying organ function and of describing it by curves, graphics, and images. To the expert, nuclear medicine is important because of the noninvasive character of most of the techniques used. Those techniques having an invasive character which are excluded in the initial step in pilot evaluation are cited.
Transl. by A.R.H.

N82-31940# Rome Univ. (Italy). Inst. Universitaire de Medecine Aerospatiale.
BALLISTOCARDIOGRAPHY: A NONINTRUSIVE METHOD MOVING TOWARDS CLINICAL APPLICATIONS [LA BALLISTOCARDIOGRAPHIE: UNE METHODE NON-INTRUSIVE AVANCANT VERS DES APPLICATIONS CLINIQUES]
A. DESCANO *In* AGARD Noninvasine Tech. for Cardiovascular Exam. of Interest in Aerospace Med. p 167-181 (SEE N82-31930 22-52) May 1982 refs In FRENCH
Avail: NTIS HC A10/MF A01

Ballistocardiography (BCG) can be defined as a noninvasive experimental method of recording and studying periodic accelerations of the mass of a body due to the reaction of inertial which it represents at each ventricula systole. The typical sequence of waves which constitutes BCG markings differ quantitatively according to the axis of the body (and also according to the state of repose and physical exercise), the age and pathological conditions of the body, and/or the large arterial vessels. The evolution of BCG from work one by J.W. Gordon in 1877 to the present is reviewed. Physiological factors determining the characteristics of the tracings, possible uses in detecting coronary disease and myocardial infaction, and research into three dimensional BCG and applications in microgravity environments are discussed. Transl. by A.R.H.

N82-31941# Centre d'Etudes et de Recherches de Medecine Aerospatiale, Paris (France).
THE ADVANTAGE OF THE TILT TABLE TEST IN EXAMINING CIRCULATORY FUNCTION [INTERET DU TEST A LA TABLE BASCULANTE EN EXPLORATION FONCTIONNELLE CIRCULATOIRE]
J. TIMBAL *In* AGARD Noninvasine Tech. for Cardiovascular Exam. of Interest in Aerospace Med. p 183-190 (SEE N82-31930 22-52) May 1982 refs In FRENCH
Avail: NTIS HC A10/MF A01

Although asking the subject to change position (rise from bed and stand immobile) is the simplest means of evaluate the transition from clinostatism to orthostatism, the results obtained are difficult to standardize because the calling into action of muscles affects the circulatory condition. The tilt table can be used evaluate objectively the rapidity and efficiency of cardiovascular reactions by modidying the application of the force of gravity. Short term effects during the transition from the horizontal to the vertical position are considered with respect to their value in examinations of circulatory function. The use of the tilt table in the selection of astronauts and in determining physical fitness is discussed and possible reasons for not using this method systematically are offered. Transl. by A.R.H.

N82-31942# Laboratoire de Medecine Aerospatiale, Bretigny-sur-Orge (France).
THE ADVANTAGE OF THE LOWER BODY NEGATIVE *PRESSURE TEST IN AEROSPACE MEDICINE* [INTERET DU TEST LOSER BODY NEGATIVE PRESSURE EN MEDECINE AEROSPATIALE]
B. VETTES and H. VIELLEFOND *In* AGARD Noninvasine Tech. for Cardiovascular Exam. of Interest in Aerospace Med. 191-194 (SEE N82-31930 22-52) May 1982 refs In FRENCH
Avail: NTIS HC A10/MF A01

The study of the physiopathological effects of weightlessness is not easy since these effects appear only when the human organism escapes the attractive forces of Earth. It is necessary to resort to simulation to examine the functions of the different physiological systems implicated. Simulation of the incidence of weightlessness on the cardiovascular system shows that physiopathological effects appear very early leading to a new distribution of blood volume. So-called orthostatic tests reveal interesting elements of hemodynamic response. The tests actually provide two classes of blood volume repartition conforming to that observed during prolonged space flght and during the return to Earth. Some tests such as those carried out on a tilt table during long duration bed rest involve modification of the posture of the entire organism. Other tests simulate the difference of ambient pressure between the upper nd lower parts of the body by creating a mobilization of the blood volume in regions where ambient pressure is weakest. Transl. by A.R.H.

N82-31943# Laboratoire de Medecine Aerospatiale, Bretigny-sur-Orge (France).
TECHNIQUES FOR CARDIOVASCULAR EXAMINATION IN HUMAN CENTRIFUGES AND THE PRINCIPAL RESULTS OBTAINED [LES TECHNIQUES D'EXPLORATION CARDIOVASCULAIRE EN CENTRIFUGEUSE HUMAINE ET LES PRINCIPAUX RESULTATS OBTENUS]
B. VETTES and H. VIELLEFOND *In* AGARD Noninvasine Tech. for Cardiovascular Exam. of Interest in Aerospace Med. p 195-203 (SEE N82-31930 22-52) May 1982 refs In FRENCH
Avail: NTIS HC A10/MF A01

Sustained Gz and Gx accelerations have an undeniable effect on the cardiovascular system and consequently the use of a human centrifuge must always be made under strict surveillance of cardiovascular function, preferably using noninvasive techniques. The use of phonocardiography, electroplethysmography, rheoplethysmography, and pneumatic devices to record heart rate, arterial and venous pressure, and cardiac and local debits is described. The number and placement of the electrodes and the tracings obtained in electrocardiography are discussed as well as methods for determining peripheral light loss and central light dim as indications of hemodynamic tolerance as reflected in the visual field. The value of the centrifuge in studying the effectiveness of anti-g suits is also assessed. Transl. by A.R.H.

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MAN/SYSTEM TECHNOLOGY AND LIFE SUPPORT

Includes human engineering; biotechnology; and space suits and protective clothing.

N81-16739# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
TECHNICAL EVALUATION REPORT OF THE AEROSPACE MEDICAL PANEL WORKING GROUP WG-08 ON EVALUATION OF METHODS TO ASSESS WORKLOAD
B. O. HARTMAN (USAF School of Aerospace Medicine, Brooks AFB, Tex.) Nov. 1980 21 p
(AGARD-AR-139; ISBN-92-835-1374-6; AD-A093677) Avail: NTIS HC A02/MF A01

Military aircraft are becoming increasingly complex the associated avionics systems more sophisticaed and the mission profiles more demanding. The problem is to establish if such an increase in aircrew workload has become a limiting factor in the operational employment of some aircraft and to select viable methods to assess it. This companion document to 'Survey of Methods to Assess Workload' sets forth conclusions on workload measurement methodology. S.F.

N81-31849# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
PERSONAL VISUAL AIDS FOR AIRCREW
Jun. 1981 67 p refs Partly in FRENCH and ENGLISH Presented at the AGARD Lecture Series, Paris, 22-23 Jun. 1981 and Fuerstenfeldbruck, West Germany, 25-26 Jun. 1981
(AGARD-LS-115; ISBN-92-835-0292-2; AD-A103707) Avail: NTIS HC A04/MF A01

The various conventional modes of optical correction required either by ametropias or by normal or pathological drops in visual acuity were reviewed. Individual brilliance enhancement systems for night flying conditions are discussed. The harmful effects, on the ocular apparatus, of various radiations are described. The means of protection against these various hazards were examined.

N81-31850# Service de Sante des Armees, Paris (France). Centre Principal d'Expertisde Medicale du Personnel Navigant de l'Aeronautique
CONVENTIONAL OPTICAL CORRECTION OF AMETROPIAS IN AERONAUTICS [CORRECTION OPTIQUE CLASSIQUE DES AMETROPIES EN AERONAUTIQUE]
P. J. MANENT *In* AGARD Personal Visual Aids for Aircrew 4 p (SEE N81-31849 22-54) Jun. 1981 refs In FRENCH
Avail: NTIS HC A04/MF A01

Visual information obtained by the pilot accounts for the majority of inflight decisions and the overall safety of the flight crew. The various types of ametropias are discussed along with their frequencies of occurance among pilots. Correctional methods are discussed and lens design is emphasized. T.M.

N81-31851# Service de Sante pour l'Armee de l'Air, Paris (France).
THE INDICATIONS OF THE USE OF CONTACT LENSES IN AERONAUTICS [LES INDICATIONS DES VERRES DE CONTACT DANS LA PRATIQUE AERONAUTIQUE]
G. F. PERDRIEL *In* AGARD Personal Visual Aids for Aircrew 4 p (SEE N81-31849 22-54) Jun. 1981 refs In FRENCH
Avail: NTIS HC A04/MF A01

Advances in lens design and lens fabrication are discussed. Human tolerance to long term wearing of contact lenses was examined. Examples of successful use of contact lenses in aviation and other activities in high altitude environments are presented. T.M.

N81-31852# Air Force Inst. of Aviation Medicine, Fuerstenfeldbruck (West Germany).
EYE PROTECTION AND TINTED LENSES
In AGARD Personal Visual Aids for Aircrew 6 p (SEE N81-31849 22-54) Jun. 1981 refs
Avail: NTIS HC A04/MF A01

The effects of ultraviolet, infrared, and visible radiation on the eye are discussed individually with specific reference to the concerns of aviation medicine. Several types of protective lenses, including glass filters, plastic filters, polarizing and polychromatic filters, and graduated filters are examined. Also the advantages and disadvantages of colored and neutral lenses are outlined.

N81-31853# National Defence Medical Centre, Ottawa (Ontario). Div. of Ophthalmology.
PROBLEMS ARISING FROM THE WEARING OF HEAD EQUIPMENT
R. E. FORGIE *In* AGARD Personal Visual Aids for Aircrew 7 p (SEE N81-31849 22-54) Jun. 1981 refs
Avail: NTIS HC A04/MF A01

The major problems associated with wearing helmets and oxygen masks are listed. Some of the methods of dealing with the non-optical problems are mentioned. The optical problems are dealt with in more detail and a review of the hypobaric chamber and human centrifuge experiments with soft contact lenses is given together with observations on the use of soft lenses in aircraft. The advantages, disadvantages, complications and limitations of soft contact lenses in military aircrew are discussed briefly with the conclusion that there is a useful if limited role for soft contact lenses in selected military aviators. Author

N81-31854# Royal Air Force Inst. of Aviation Medicine, Farnborough (England).
LASERS AND PROTECTION OF THE EYES
D. H. BRENNAN *In* AGARD Personal Visual Aids for Aircrew 13 p (SEE N81-31849 22-54) Jun. 1981 refs
Avail: NTIS HC A04/MF A01

The applications and characteristics of some of the lasers currently available are discussed and these parameters are related to the ocular tissues at risk. The probable visual consequences of laser induced pathology are considered together with the advantages and disadvantages of protective devices. Accident procedures, codes of conduct, and a hazard related examination protocol are also described. M.G.

N81-31855# Service de Sante pour l'Armee de l'Air, Paris (France). L'Armee de l'Air et du Centre d'Etudes et de Recherches de Medecine Aerospatiale.
PROBLEMS IN AERONAUTICS POSED BY VISUAL DEFICIENCIES [PROBLEMES POSES PAR LES DEFICIENCES VISUELLES EN AERONAUTIQUE]
J. P. CHEVALDERAUD *In* AGARD Personal Visual Aids for Aircrew 5 p (SEE N81-31849 22-54) Jun. 1981 refs In FRENCH
Avail: NTIS HC A04/MF A01

Techniques in screening flying personnel with vision problems were reviewed. The problems that arise in eye examinations are discussed along with the anatomy of the eye. Special emphasis is placed on anatomical anomalies. T.M.

N83-18257# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
ADVANCED AVIONICS AND THE MILITARY AIRCRAFT MAN/MACHINE INTERFACE
Jul. 1982 341 p refs In ENGLISH and FRENCH Meeting held in Blackpool, England, 26-29 Apr. 1982
(AGARD-CP-329; ISBN-92-835-0315-4) Avail: NTIS HC A15/MF A01

The interfacing of air crews of modern military aircrafts with advanced avionics equipment and systems were discussed. Topics include: (1) use of new advanced displays in aircraft, including multicolor displays, displays incorporating optical techniques, and more reliable display systems; (2) use of voice input/output systems for man machine interface, including speech synthesis; (3) complex avionics systems management; and (4) tactile control and their use. For individual titles, see N83-18258 through N83-18286.

N83-18258# Royal Aircraft Establishment, Farnborough (England).
HUMAN FACTORS IMPLICATIONS OF NEW AVIONIC TECHNIQUES
F. G. CUMMING and J. LAYCOCK *In* AGARD Advan. Avionics and the Mil. Aircraft Man/Machine Interface 4 p (SEE N83-18257 08-54) Jul. 1982
Avail: NTIS HC A15/MF A01

Advances in technology particularly in the microelectronics industry which have created a situation where the avionics systems designer has at his disposal a greater number of design options than before, giving him the capability of constructing systems that are more complex than any previously envisaged are discussed. The new techniques available should not only improve on already existing systems but new ideas can be precisely tailored to the pilot's requirements in a way which has not been possible up till now. The pilot will be retained in aircraft of the future because of his unique ability to make decisions in unanticipated situations and for his visual systems capacity to search, detect and recognize visual information present in the outside world. To maximize efficiency the avionic systems should allow unambiguous signals to be passed through his limited capacity channel to produce the minimum number of motor control actions at the output. This may be achieved by: (1) reducing the number of times he is required to close the display/control loop by providing an improved flight control system and a better correlation between the instruments and the outside world; (2) reducing the number of selections of data sources that are required throughout the sortie by introducing automated procedures to take care of plant failures, and providing a more easily operable interface to allow essential interaction with the various systems to be made both fast and accurately. E.A.K.

N83-18259# Direction des Recherches Etudes et Techniques, Paris (France). Delegation Generale pour l'Armement.
THE HUMAN FACTOR IN SYSTEMS HANDLING [LE FACTEUR HUMAIN DANS LE PILOTAGE DES SYSTEMES]
J. C. WANNER *In* AGARD Advan. Avionics and the Mil. Aircraft Man/Machine Interface 12 p (SEE N83-18257 08-54) Jul. 1982 In FRENCH
Avail: NTIS HC A15/MF A01

The rules which allow improvement of flight systems security in human factors are just as useful in human performance in man machine interfaces. The security rules were enforced at the certification of the Concord supersonic airplane and were reviewed after a human behavior study for loopholes in the enforcement of the system. E.A.K.

N83-18260# Royal Aircraft Establishment, Farnborough (England).
HUMAN FACTORS CONSIDERATIONS OF THE PERCEPTION OF COLOUR IN THE AIRBORNE ENVIRONMENT
C. P. GIBSON and J. LAYCOCK *In* AGARD Advan. Avionics and the Mil. Aircraft Man/Machine Interface 9 p (SEE N83-18257 08-54) Jul. 1982 refs
Avail: NTIS HC A15/MF A01

The various CRT technologies in relation to the CIE system of color measurement and the applications and possible pitfalls associated with the use of color as a means of encoding information are discussed. It is suggested that CRTs will become the prime, and certainly the most flexible, display medium in the modern cockpit. The human factors aspects of the use of color are crucial if optimum advantage is to be made of this coding dimension since many areas remain relatively unexplored. The basic mechanisms, and some of the anomalies, of color perception are presented and illustrated. Psychological effects such as the change of perceived hue with luminance, the perceived changes caused by simultaneous color contrast and the effects of chromatic adaptation are outlined. E.A.K.

N83-18261# Centre d'Etudes et de Recherches de Medecine Aerospatiale, Paris (France). Dept. de Physiologie et Ergonomie Aerospatiales.
THE ROLE OF COLOR IN THE SYMBOLS OF AIRCRAFT CONTROL [ROLE DE LA COULEUR DANS LA SYMBOLOGIE DE PILOTAGE DES AERONEFS]
J. P. MENU and G. F. SANTUCCI *In* AGARD Advan. Avionics and the Mil. Aircraft Man/Machine Interface 11 p (SEE N83-18257 08-54) Jul. 1982 refs In FRENCH
Avail: NTIS HC A15/MF A01

The presentation of numerous colors can hinder or confuse the grasp of visual information. Several important rules must be set down for using color on supports integrated in a more general concept of piloting and navigation. The vocabulary of photocolorimetry and available techniques are described with emphasis on the cathode ray tube. The correct use of color and the influence of certain environments on color perception are discussed. Physiological problems associated with the use of cathode ray tubes in aeronautics are examined. A.R.H.

N83-18262# Air Force Wright Aeronautical Labs., Wright-Patterson AFB, Ohio. Flight Dynamics Lab.
COLOR DISPLAY FORMATS: A REVOLUTION IN COCKPIT DESIGN
J. M. REISING and T. J. EMERSON *In* AGARD Advan. Avionics and the Mil. Aircraft Man/Machine Interface 11 p (SEE N83-18257 08-54) Jul. 1982 refs
Avail: NTIS HC A15/MF A01

Pictorial formats that take full advantage of available graphics and color are discussed. These formats enable the pilot to have entirely new views of his situation. Color formats were developed for head up and head down flight, stores management, and engine and systems monitoring, both in the normal and emergency state. By properly designing pictorial formats to give the pilot a more natural, intuitive view of both the outside world and his aircraft systems, he will become convinced of their utility, and the transition into the electro-optical, full color cockpit will be hastened. E.A.K.

N83-18263# Plessey Co. Ltd., Romsey (England). Systems Research Dept.
THE ASSESSMENT OF COLOUR IN LOFARGRAM DISPLAYS
J. METCALFE *In* AGARD Advan. Avionics and the Mil. Aircraft Man/Machine Interface 4 p (SEE N83-18257 08-54) Jul. 1982 refs Sponsored in part by Ministry of Defense of the United Kingdom
Avail: NTIS HC A15/MF A01

The usefulness of multiple colors in CRT displays was assessed. The assessments performed using Lofargram displays are presented. Three phases are reported: (1) the provision of display equipment; (2) an initial pairs comparison assessment; (3) a final operator trial assessment. It is concluded that multiple colors in the type of display under consideration are not more useful in CRT's than monochrome green. E.A.K.

N83-18264# Midwest Systems Research, Inc., Dayton, Ohio.
ADVANCED . DISPLAY FOR COMPLEX FLIGHT TRAJECTORIES
P. B. LOVERING and S. B. BURDESS (RAF Staff College) *In* AGARD Advan. Avionics and the Mil. Aircraft Man/Machine Interface 4 p (SEE N83-18257 08-54) Jul. 1982 refs
Avail: NTIS HC A15/MF A01

Cockpit control and display problems were revealed of complex approach trajectories in support of the Microwave Landing System (MIS) Program. A color graphics display aimed at finding some viable solutions was initiated. The test display format, designed specifically to address orientation and lateral control aspects of the precision approach problem, contained a map display of the approach profile, aircraft attitude, flight direction commands for pitch and a 24 second lateral path predictor. Four colors, green, blue, orange and white were used on a black background for the display elements. Objective performance concerning the desired flight path and pilot opinion on each of the new display features are presented. E.A.K.

N83-18265# Rome Air Development Center, Griffiss AFB, N.Y. Communications Div.

OVERVIEW OF STATE-OF-THE-ART, R&D NATO ACTIVITIES, AND POSSIBLE APPLICATIONS-VOICE PROCESSING TECHNOLOGY

B. BEEK *In* AGARD Advan. Avionics and the Mil. Aircraft Man/Machine Interface 15 p (SEE N83-18257 08-54) Jul. 1982 refs

Avail: NTIS HC A15/MF A01

Voice interactive systems and its role in military applications are discussed. The history and evolution of automatic speech recognition and synthesis is briefly explored and the current state of the art is reviewed. The term voice interactive systems is defined and the advantages and disadvantages of voice interactive systems are highlighted. Previous applications of speech systems to military problems are summarized, the major application areas are described. Important issues to consider when applying voice interactive systems to the aircraft environment are summarized. E.A.K.

N83-18266# Fraunhofer-Inst. fuer Informations- und Datenverarbeitung, Karlsruhe (West Germany).

CHARACTERISTICS OF THE HUMAN INFORMATION CHANNELS AND CONCLUSIONS FOR VOICE INPUT/OUTPUT

H. MUTSCHLER *In* AGARD Advan. Avionics and the Mil. Aircraft Man/Machine Interface 8 p (SEE N83-18257 08-54) Jul. 1982 refs Sponsored in part by German Federal Ministry of Defence

Avail: NTIS HC A15/MF A01

Input and output in man machine communication and the specific characteristics of the human oral and aural channels were considered. The channels' modality represents a relevant factor *in human information processing*, particularly in attention, perception and memory modality specific effects in human infomation processing are presented and applied to the military applications of voice input and output. There is an increase of the human's ability to divide his attention when different modalities are concerned and different subsystems for spatial and verbal informations are involved. Reaction times are generally smaller for auditory than for visual presentation. There is a superior performance of the short term memory for auditorily presented verbal information, if no verbal informations must be handled during the retention period. It is concluded that if modality compatibility between stimulus and response as well as modality coding compatibility is warranted, time consuming transformations can be avoided. E.A.K.

N83-18267# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (West Germany). Military Aircraft Div.

ERGONOMIC REQUIREMENTS FOR VOICE PROCESSING SYSTEMS

R. SEIFERT and P. BUBB *In* AGARD Advan. Avionics and the Mil. Aircraft Man/Machine Interface 13 p (SEE N83-18257 08-54) Jul. 1982 refs

Avail: NTIS HC A15/MF A01

Different voice functions and voice generation methods were examined. Voice functions are verbal warning, verbal threat and guidance information, voice transmission and verbal control of system functions. *The voice functions of the audio interface are* classified as output, output/input, and input functions. Their application and *the methods for voice generation and voice* recognition are discussed. Ergonomic requirements for voice generation, transmission and recognition techniques are discussed which are derived based on the articulation index assessment and other technical data. Information oriented requirements are needed concerning the coding and the organization of the information. These requirements aim at optimizing the demand on man's information perception and processing capabilities, resulting from the use of various voice functions. E.A.K.

N83-18268# Rome Air Development Center, Griffiss AFB, N.Y.

APPLICATION, ASSESSMENT AND ENHANCEMENT OF SPEECH RECOGNITION FOR THE AIRCRAFT ENVIRONMENT

R. VONUSA, E. CUPPLES, S. STEIGERWALD, J. WOODARD, and J. NELSON *In* AGARD Advan. Avionics and the Mil. Aircraft Man/Machine Interface 8 p (SEE N83-18257 08-54) Jul. 1982 refs

Avail: NTIS HC A15/MF A01

Word recognition devices can be used to narrow the bandwidth of voice communication system are discussed. The degree to which the bandwidth can be narrowed is dependent on the vocabulary size and the input word rate, both of which are dependent on the application. Whether these techniques can apply to a particular voice communication system is highly dependent on the communication system's function and on the ability of the automatic speech recognition (ASR) system to operate accurately in the environment. The use of ASR for narrowband communications in the airborne environment is therefore dependent to a large extent on the ability of the ASR device to perform accurately in the harsh airborne environment. The use of ASR for control of airborne functions, to query avionic systems, and for narrowband air-to-air and air-to-ground communications is operationally highly desirable. However, there are several problems associated with the implementation of ASR in the operational environment. One such problem is that of the noisy environment and its effect on ASR performance. The interest in determining if the speech enhancement technology developed for removing noise and interference contained on voice communication channels can be applied to removing the noise encountered in various other environments. A theoretical measurement method based on information theory was presented that may provide a meaningful ASR measure useful for predicting the performance of a particular ASR device. R.J.F.

N83-18269# *Marconi* Avionics Ltd., Rochester (England). Flight Automation Research Lab.

DIRECT VOICE INPUT FOR THE COCKPIT ENVIRONMENT

R. BELL, M. E. BENNETT, and W. E. BROWN *In* AGARD Advan. Avionics and the Mil. Aircraft Man/Machine Interface 7 p (SEE N83-18257 08-54) Jul. 1982 refs Sponsored in part by the United Kingdom Ministry of Defence and the Dept. of Industry

Avail: NTIS HC A15/MF A01

Many aspects of applying speech recognition technology in aircraft cockpits are discussed, particularly the implications of using Direct Voice Input (DVI) in an aircraft, the current capabilities of speech recognition equipment and how DVI will affect pilot activity. Centralized input media of this type affect the structure of the whole avionics suite because of the need for interconnection with many controlled subsystems and the necessity of high integrity operation. The implications of Direct Voice Input (DVI) system integration are discussed. The requirements for a speech recognition system applicable to the cockpit environment are discussed; in particular the problem of noise is discussed and the need for flight trials highlighted. Any equipment used in the cockpit relies on its acceptability to the pilot for success. The pilot interface question is discussed. R.J.F.

N83-18270# General Dynamics Corp., Fort Worth, Tex.

VOICE INTERACTIVE SYSTEM DEVELOPMENT PROGRAM

J. C. RUTH, A. M. GODWIN, and E. B. WERKOWITZ (AFFLD) *In* AGARD Advan. Avionics and the Mil. Aircraft Man/Machine Interface 10 p (SEE N83-18257 08-54) Jul. 1982

Avail: NTIS HC A15/MF A01

The use of Voice Interactive Systems (VIS) (based on computer recognition and voice synthesis technologies) as a method of achieving an enhanced interaction between the pilot and the weapon systems is discussed. The use of VIS as a viable alternative to the more traditional methods is discussed. Functions which best lend themselves to this approach and offer the highest payoff in terms of overall weapon system performance are discussed. The question of whether the voice recognition technology base can be extended sufficiently to provide reliable operation in the stringent combat aircraft environment is addressed. R.J.F.

N83-18271# Army Avionics Research and Development Activity, Fort Monmouth, N. J.
VOICE INTERACTIVE SYSTEMS TECHNOLOGY AVIONICS (VISTA) PROGRAM
L. W. REED *In* AGARD Advan. Avionics and the Mil. Aircraft Man/Machine Interface 14 p (SEE N83-18257 08-54) Jul. 1982 Presented at the Army Sci. Conf., 15-18 Jun. 1982 Previously announced as N82-33383
Avail: NTIS HC A15/MF A01

The Avionics Research and Development Activity's (AVRADA) program to introduce voice recognition and response into the Army aircraft environment is discussed. Program structure and preliminary testing results are discussed. Software development, computer installation, algorithm development, and voice recognizer testing techniques are discussed. The signal-to-noise ratio was found to be a key factor in recognition accuracy. Another problem arises because of the automatic gain controls (AGC) found in most aircraft intercom systems. When there is no voicing for a period of time, the AGC increases the intercom sensitivity. If the first utterance spoken is intended for the recognizer it will likely be rejected because of the distortion caused by the AGC adjusting the gain during the utterance. This is demonstrated in the test results of all test subjects. No attempt was made to set the AGC before beginning the test; as a result, 90% of the first utterances were rejected which resulted in the lowering of the accuracy score by approximately 4%. The AGC has a release time of 10 seconds and the prompts are issued every second; therefore, after the first utterance the AGC has little effect. Some side tests were performed by making an utterance before signaling the computer to begin the test, and in each case the accuracy of the first test word increased to a point comparable to the other vocabulary words. R.J.F.

N83-18272# Crouzet Aerospace and Systems, Valence (France).
THE USE OF VOCAL TECHNIQUES IN A COMBAT AIRCRAFT: FIRST INSTRUCTION [UTILISATION DES TECHNIQUES VOCALES DANS UN AVION DE COMBAT: PREMIERS ENSEIGNEMENTS]
J. R. COSTET and J. M. MALTERRE (Centre d'Essais en Vol) *In* AGARD Advan. Avionics and the Mil. Aircraft Man/Machine Interface 8 p (SEE N83-18257 08-54) Jul. 1982
Avail: NTIS HC A15/MF A01

The definition of a cockpit with reduced available frontal surface because of the inclination of the pilot's seat is among the several reasons given for growing interest in speech recognition and synthesis for future combat aircraft. Techniques used and problems encountered in a program designed to study and experiment with vocal dialog on such aircraft are described. The program aims to validate the recognition techniques in a military environment, supply data to a data base for defining how, according to what criteria, and what types of functions of vocal dialog can be applied. An ergonometric experiment in a simulator seeks to study the insertion of vocal dialog into a phase of flight corresponding to a realistic workload known in advance. Flight tests are planned to attempt to synthesize on board the aircraft, a modern weapon system with functional dialog and operational functions.
Transl. by A.R.H.

N83-18273# Royal Air Force Inst. of Aviation Medicine, Farnborough (England).
PERFORMANCE DECREMENTS ASSOCIATED WITH REACTION TO VOICE WARNING MESSAGES
J. WHEALE *In* AGARD Advan. Avionics and the Mil. Aircraft Man/Machine Interface 12 p (SEE N83-18257 08-54) Jul. 1982 refs
Avail: NTIS HC A15/MF A01

Voice warning messages are being adopted as an alternative to audio warnings because they can be readily understood, generate fast reaction times and supposedly allow a smooth transition from message to action. The effectiveness of synthesized voice message using measures of performance decrement and response time in the context of a central warning system with audio, voice and visual indicators was evaluated. The subject's task was to maintain accuracy on a psychomotor tracking task while responding to warnings. The results show that the various combinations of warning types could not be differentiated with respect to performance decrement on the primary task. The data for reaction time show that audio warnings produce the fastest responses, followed by voice warnings, with central warning panel indicators producing the slowest responses. The implications of the results for the role of synthesized voice warning messages in central warning systems are discussed. R.J.F.

N83-18274# Marconi Co. Ltd., Basildon (England). Airadio Products Div.
COMMUNICATIONS MANAGEMENT: A VITAL LINK
W. E. BRIERLEY *In* AGARD Advan. Avionics and the Mil. Aircraft Man/Machine Interface 19 p (SEE N83-18257 08-54) Jul. 1982
Avail: NTIS HC A15/MF A01

A method by which additional radio equipment can be fitted to light helicopters, preferably by reduction in the already allocated panel area, together with increased control facilities is investigated. A unit is being designed which will provide the required facilities within a panel area only 35% of that required for the controllers it replaces, whilst still providing all the functions required. The proposed Communications Management System control panel provides in one unit the facilities for two pilots to: select control, and display any one of six transmitter-receivers; monitor and/or independently change the frequency or pre-set channel of the selected radio; transmit/receive on the selected radio; select and adjust any or all in any combination eight radio receiver outputs and other audios; monitor and adjust pre-set channels on the left hand display whilst maintaining normal opertion on the right hand station; and direct emergency selection of guard channels for UHF, VHF, TAC VHF in the event of system failure. The system is organised to ensure that when a radio is selected, the only frequencies that can be selected are within the particular radio band, or if a pre-set channel is selected, only channels applicable to the selected radio are available. R.J.F.

N83-18275# Royal Aircraft Establishment, Farnborough (England). Human Factors Group.
FACTORS AFFECTING THE ALLOCATION OF ATTENTION AND PERFORMANCE IN CROSSMONITORING FLIGHT INFORMATION DISPLAYS
V. P. SCHMIT *In* AGARD Advan. Avionics and the Mil. Aircraft Man/Machine Interface 6 p (SEE N83-18257 08-54) Jul. 1982 refs Originally announced as 83X-71276
Avail: NTIS HC A15/MF A01

Experiments on rapid and continuous visual attention switching between spatially separated aircraft cockpit displays are discussed. It was concluded that reversion to a head-up display (HUD) format imposes a significant time cost (in this experiment 3.5 to 4 seconds) before full appreciation of aircraft status is restored. The HUD format gave more accurate flying performance than the head down instrument (HDI) format. This performance was reduced at reversion, even when reversion was to another HUD format, indicating disruption. Reverting from a HDI format to a HUD format improved performance due to the inherently better display of information on the HUD for the type of flying imposed in this experiment. Reversion from a HDI format took longer when this display had been used for periods longer than 60 seconds - this may be interpreted as the time necessary to establish a scanning pattern and the interference resulting from its disturbance. The results taken as a whole suggest that any reversionary flight display should exhibit: minimum scanning requirements; display integrality; and the minimum readjustment required from the pilot at reversion. R.J.F.

N83-18276# British Aerospace Aircraft Group, Brough (England).
THE HEAD UP HANDS BACK CONTROL CONCEPT
G. ROE *In* AGARD Advan. Avionics and the Mil. Aircraft Man/Machine Interface 12 p (SEE N83-18257 08-54) Jul. 1982 refs
Avail: NTIS HC A15/MF A01

The rationale for a new aircraft control concept is developed by reviewing how current systems are controlled and what operational problems are experienced. Based on discussions of the potential offered by digital data transmission, of intelligent subsystems and a definition of the fundamental human factors requirements, a control concept is presented which requires little, if any head down activities. Results from human factors experiments reveal a consistent trend towards reduced times to complete

various complex switch sequences while related errors are reduced. R.J.F.

N83-18277# Thomson-CSF, Issy les Moulineaux (France). Dept. AVG

A MORE EXTENDED INTEGRATION FOR COMBAT AIRCRAFT VISUALIZATIONS [UNE INTEGRATION DE PLUS EN PLUS POUSSEE POUR LES VISUALISATIONS DES AVIONS DE COMBAT]

C. MAUREAU *In* AGARD Advan. Avionics and the Mil. Aircraft Man/Machine Interface 6 p (SEE N83-18257 08-54) Jul. 1982 In FRENCH

Avail: NTIS HC A15/MF A01

Attempts to determine what can be done to significantly improve flight control on combat aircraft practically always result in revealing the need or further extending systems integration. This end is most often obtained by using technological progress particularly information visualization and means at the pilots disposal for exploiting this information. Certain modern equipment in the cabin of the Mirage 2000 aircraft just entering service is reviewed. An analog examination follows on projects for equipping the cabin of a next generation combat aircraft. These projects are elaborated by a working group of equipment suppliers and aircraft designers that was established to integrate systems for future aircraft with the pilots who will use them. Transl. by A.R.H.

N83-18278# Royal Air Force Inst. of Aviation Medicine, Farnborough (England).

HUMAN FACTORS IN AIRCRAFT KEYBOARD DESIGN: STANDARDS, ISSUES AND FURTHER EVIDENCE RELATING TO GLOVES AND KEY CHARACTERISTICS

R. M. TAYLOR and J. V. F. BERMAN *In* AGARD Advan. Avionics and the Mil. Aircraft Man/Machine Interface 17 p (SEE N83-18257 08-54) Jul. 1982 refs

Avail: NTIS HC A15/MF A01

The aircraft pilot is increasingly required to interact with complex digital avionics systems. These systems often require data to be input in digital form. Keyboards provide a logical and convenient interface for performing this task. Surveys of the literature reveal some human factors evidence relevant to aircraft keyboard design, but most of the work is based on the requirements of ground applications, and this is not readily generalized to aircraft environments. Keyboard factors affecting data entry performance include keyboard positioning and layout, key size, actuation force, pre- and post-actuation travel, visual and tactile feedback, key separation and barriers. Other factors include the effects of aircrew gloves on manipulative ability, tactility and hand/finger dimensions, operator comfort, fatigue and aircraft vibration, the level of skill of the operator, the cognitive and physical components of the data entry task and the interference between keyboard data entry and other tasks performed concurrently in the cockpit. The current status of human factors knowledge in these areas are reviewed and the results of recent experiments conducted at the RAF Institute of Aviation Medicine are discussed in relation to keyboard standardization agreements and aircrew training. B.W.

N83-18279# Systems Research Labs., Inc., Dayton, Ohio.

PILOT-MACHINE INTERFACE CONSIDERATIONS FOR ADVANCED AIRCRAFT AVIONICS SYSTEMS

G. L. CALHOUN and E. L. HERRON (General Dynamics) *In* AGARD Advan. Avionics and the Mil. Aircraft Man/Machine Interface 7 p (SEE N83-18257 08-54) Jul. 1982 refs

(Contract F33615-73-C-0391; F33615-76-C-0013; F33615-79-C-0503)

Avail: NTIS HC A15/MF A01

Aircrew acceptance of computer-driven controls depends largely on the successful establishment of the pilot-machine interface. Research was conducted to determine pilot acceptability and usability of one type of interface device--a multifunction control which integrates many aircraft functions onto a single, easily reached control panel. In each study, pilots completed communications, navigation, and weapons tasks on the control while flying simulated missions. This paper discusses some of the design guidelines identified during the studies as critical to the design of the interface. Topics addressed include how to identify functions to implement on a multifunction control, maximize accessibility of frequently used functions, optimize switch/function assignment, label switches, verify selections, and minimize hand motion and errors. B.W.

N83-18280# Twente Univ. of Technology, Enschede (Netherlands).

LIMITING PERFORMANCE OF THE EYE/DISPLAY SYSTEM

D. BOSMAN and F. W. UMBACH *In* AGARD Advan. Avionics and the Mil. Aircraft Man/Machine Interface 15 p (SEE N83-18257 08-54) Jul. 1982 refs

Avail: NTIS HC A15/MF A01

The performance and its limits of the CRT as used in both the recreational sector and professional applications such as aircraft displays, have been extensively researched and described. The new generation of flat panel display devices have image generation properties which are sufficiently different from those of the CRT to require additional ergonomic investigations. In particular, the structural information (spatial domain) does not allow such operations as analogue low pass filtering based on partial overlap of pixels: the image remains tesselated because of the display technology involved, wherein pixels are formed by recticulation of the light modulating or emitting display surface. Also a wide dimming range is necessary to ensure good legibility over the whole ambient luminance range as encountered in cockpit environments. These aspects will be given attention with the human visual characteristics as a reference; recommended display specifications are derived. B.W.

N83-18281# Elliott-Automation Space and Advanced Military Systems Ltd., Frimley (England).

ARCHITECTURE FOR HIGH INTEGRITY DISPLAY SYSTEMS IN FUTURE COMBAT AIRCRAFT

J. A. GRICE *In* AGARD Advan. Avionics and the Mil. Aircraft Man/Machine Interface 13 p (SEE N83-18257 08-54) Jul. 1982 refs

Avail: NTIS HC A15/MF A01

Present indications are that the next generation of combat aircraft will require both Air Defence and Ground Attack capabilities leading to a complex Avionic system. Three different System Architectures have been considered for this complex system with a trend towards a hierarchical system. A Mil-Std-1553B Data Bus has been assumed as the interface standard for the Avionics Bus. Problems of Bus traffic loading, reversionary capability and software location have been investigated. Particular attention has been paid to the Display requirements in terms of number and type of display surfaces and the different display formats are suggested. Some of the implications of giving the pilot flexibility to allocate display formats to different displays are increases in Bus traffic, bus control logic and software. The reliability of the different displays configurations is discussed. Author

N83-18282# Aerospace Medical Research Labs., Wright-Patterson AFB, Ohio.

ELECTROLUMINESCENT LIGHTING AND OTHER TECHNIQUES FOR IMPROVING NIGHT VISION GOGGLES COMPATIBILITY WITH COCKPIT DISPLAYS

H. L. TASK and L. L. GRIFFIN *In* AGARD Advan. Avionics and Mil. Aircraft Man/Machine Interface 6 p (SEE N83-18257 08-54) Jul. 1982 refs

Avail: NTIS HC A15/MF A01

Standard night lighting for most aircraft cockpits results in a lighting configuration that is not compatible with the use of night vision goggles. One specific example discussed in this paper is the US Air Force PAVE LOW III helicopter; a modified version of the HH-53H. Both wavelength and geometric light control techniques were developed and applied to this cockpit to make it compatible with the night vision goggles. A combination of light control film (3-M micro-louvre), color filters, infra-red blocking filters, electroluminescent light and anti-flare baffles were used to successfully retrofit the cockpit for night vision goggle use. In addition, some of the techniques are applicable to reducing windscreen reflection, thus, improving unaided night vision through the windscreen. Author

N83-18283# Aerospace Medical Research Labs., Wright-Patterson AFB, Ohio. Crew Systems Effectiveness Branch.
THE HELMET-MOUNTED HUD: A CHANGE IN DESIGN AND APPLICATIONS APPROACH FOR HELMET-MOUNTED DISPLAYS
J. BRIDENBAUGH, W. KAMA, and H. L. TASK *In* AGARD Advan. Avionics and the Mil. Aircraft Man/Machine Interface 6 p (SEE N83-18257 08-54) Jul. 1982 refs
Avail: NTIS HC A15/MF A01

Recent studies at the USAF Aerospace Medical Research Laboratory (AFAMRL) have been directed at the introduction of a flexible fiber optics bundle (FFOB) to relay alphanumber/symbolic information from a Cathode Ray Tube (CRT) located off the helmet in order to provide Head-Up Display (HUD) equivalent display information. This approach results in less weight and size, the potential for increased brightness and the removal of high voltage from the helmet. In addition to these improved hardware characteristics several visual problems are avoided by this simple configuration. This paper will examine the rationale for such a design approach as well as present results of laboratory studies to assess the effect of FFOB fiber density on symbol legibility for a Helmet-Mounted Head-Up Display (HMHUD). Author

N83-18284# Pilkington P.E. Ltd., St. Asaph (England).
DIFFRACTIVE OPTICS FOR AVIONIC DISPLAYS
D. W. SWIFT *In* AGARD Advan. Avionics and the Mil. Aircraft Man/Machine Interface 8 p (SEE N83-18257 08-54) Jul. 1982
Avail: NTIS HC A15/MF A01

The paper describes what diffractive optical elements are, how they work, and how they are made. It explains in broad terms how the properties of one special class of these elements (conformal holograms) are being used to design Head Up Displays with larger instantaneous fields of view than the current generation and with improved photometric performance, but notes some of the attendant problems. Author

N83-18285# Royal Aircraft Establishment, Farnborough (England). Flight Systems Dept.
WIDE FIELD OF VIEW HEAD-UP DISPLAYS
J. R. BANBURY *In* AGARD Advan. Avionics and the Mil. Aircraft Man/Machine Interface 11 p (SEE N83-18257 08-54) Jul. 1982 refs
Avail: NTIS HC A15/MF A01

The head-up displays currently fitted to production aircraft have a restricted field of view caused by the relatively small diameter of the collimating optics. There is a growing interest in alternative designs which make a greater field of view available to the pilot. Several possible design options for achieving a wide field are outlined. The new methods usually rely on the properties of diffractive optical elements to achieve a satisfactory performance with respect to accuracy, photometric efficiency and sunlight rejection. Some advantages arising from the particular characteristics of diffractive elements are considered. As wide field of view displays become more readily available it is important to establish whether the additional cost and bulk of the equipment is justified by gains in operational efficiency. The paper concludes outlining some possible uses of the larger field. B.W.

N83-18286# Ferranti Ltd., Edinburgh (Scotland).
THE F18 HORIZONTAL INDICATOR OPTICAL SYSTEM
A. BOOT *In* AGARD Advan. Avionics and the Mil. Aircraft Man/Machine Interface 7 p (SEE N83-18257 08-54) Jul. 1982 refs
Avail: NTIS HC A15/MF A01

The design of cockpit displays which are both visible in sunlight, and which whilst visible at night do not significantly interfere with the pilot's normal night time operation present the designer with a significant challenge. Such a display outlines the operational environment and the optical performance requirements of the F18 HI, and the technical solutions which have been adopted in order to satisfy these requirements. In particular, the means of combining the Map and CRT images and achieving intrinsically high brightness, contrast and resolution figures are discussed, as is the mechanism for generating the accurately controlled exit pupil which impacts significantly on both the high and low ambient illumination performance. The use of lightweight fresnel lenses and the associated problems which have been encountered are also highlighted. In conclusion, a comparison is drawn between the achievable performance with this and alternative display systems. Author

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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; AD-A082012) 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
R. G. SARGENT *In* AGARD Modeling and Simulation of Avionics Systems and Command, Control and Commun. 4 p (SEE N80-19809 10-59) Jan. 1980 refs
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
R. G. SARGENT *In* AGARD Modeling and Simulation of Avionics Systems and Command, Control and Commun. 13 p (SEE N80-19809 10-59) Jan. 1980 refs Presented at the ACM 1976 Symp. on the Simulation of Computer Systems
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
H. M. FRANKE *In* AGARD Modeling and Simulation of Avionics Systems and Command, Control and Commun. 27 p (SEE N80-19809 10-59) Jan. 1980 refs
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
D. K. LEEDOM *In* AGARD Modeling and Simulation of Avionics Systems and Command, Control and Commun. 15 p (SEE N80-19809 10-59) Jan. 1980 refs
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
S. H. SAIB *In* AGARD Modeling and Simulation of Avionics Systems and Command, Control and Commun. 6 p (SEE N80-19809 10-59) Jan. 1980
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
HOLLINDE *In* AGARD Modeling and Simulation of Avionics Systems and Command, Control and Commun. 10 p (SEE N80-19809 10-59) Jan. 1980 refs
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
R. HUTTER *In* AGARD Modeling and Simulation of Avionics Systems and Command, Control and Commun. 15 p (SEE N80-19809 10-59) Jan. 1980 refs
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 ENS-C3): AN APPROACH TO THEATER AIR DEFENSE MODEL/METHODOLOGY DEVELOPMENT
U. H. D. LYNCH *In* AGARD Modeling and Simulation of Avionics Systems and Command, Control and Commun. 13 p (SEE N80-19809 10-59) Jan. 1980
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. 20 p (SEE N80-19809 10-59) Jan. 1980
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
H. J. WUNSCHMANN *In* AGARD Modeling and Simulation of Avionics Systems and Command, Control and Commun. 14 p (SEE N80-19809 10-59) Jan. 1980
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. D. HOPKIN and A. J. MCCLUMPHA *In* AGARD Modeling and Simulation of Avionics Systems and Command, Control and Commun. 6 p (SEE N80-19809 10-59) Jan. 1980 refs
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
F. HERZMANN and H. SANDERS *In* AGARD Modelling and Simulation of Avionics Systems and Command, Control and Commun. 13 p (SEE N80-19809 10-59) Jan. 1980 refs
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. 8 p (SEE N80-19809 10-59) Jan. 1980
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. 14 p (SEE N80-19809 10-59) Jan. 1980
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
R. D. HEALY and S. NEWMAN *In* AGARD Modeling and Simulation of Avionics Systems and Command, Control and Commun. 8 p (SEE N80-19809 10-59) Jan. 1980 refs Prepared in cooperation with NADC, Warminster, Pa.
(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
J. G. TAYLOR *In* AGARD Modeling and Simulation of Avionics Systems and Command, Control and Commun. 13 p (SEE N80-19809 10-59) Jan. 1980 refs
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. 6 p (SEE N80-19809 10-59) Jan. 1980
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. 21 p (SEE N80-19809 10-59) Jan. 1980
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
C. FIELDS and S. LEVIN *In* AGARD Modeling and Simulation of Avionics Systems and Command, Control and Commun. 2 p (SEE N80-19809 10-59) Jan. 1980 Prepared in cooperation with Interactive Television Co., Arlington, Va.
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 - SOUEH]
J. MASCLE, G. CATANI, M. SELLIER, and J. LETOUZEY *In* AGARD Modeling and Simulation of Avionics Systems and Command, Control and Commun. 13 p (SEE N80-19809 10-59) Jan. 1980 In FRENCH
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
J. ORLANSKY and J. STRING *In* AGARD Modeling and Simulation of Avionics Systems and Command, Control and Commun. 13 p (SEE N80-19809 10-59) Jan. 1980 refs
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]
M. G. DREYFUS *In* AGARD Modeling and Simulation of Avionics Systems and Command, Control and Commun. 7 p (SEE N80-19809 10-59) Jan. 1980 In FRENCH; ENGLISH summary
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. 24 p (SEE N80-19809 10-59) Jan. 1980
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. 20 p (SEE N80-19809 10-59) Jan. 1980 refs
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
G. WUNDERLICH and R. BRAUN *In* AGARD Modeling and Simulation of Avionics Systems and Command, Control and Commun. 14 p (SEE N80-19809 10-59) Jan. 1980
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)
J. M. RUDDY *In* AGARD Modeling and Simulation of Avionics Systems and Command, Control and Commun. 22 p (SEE N80-19809 10-59) Jan. 1980
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. 22 p (SEE N80-19809 10-59) Jan. 1980 refs In FRENCH; ENGLISH
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. 14 p (SEE N80-19809 10-59) Jan. 1980 refs
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
D. WELP, K. ALMQUIST, and L. RAINEY *In* AGARD Modeling and Simulation of Avionics Systems and Command, Control and Commun. 4 p (SEE N80-19809 10-59) Jan. 1980 Prepared in cooperation with AFAL, Wright-Patterson AFB, Ohio
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. 11 p (SEE N80-19809 10-59) Jan. 1980 refs
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
J. C. OSTGAARD *In* AGARD Modeling and Simulation of Avionics Systems and Command, Control and Commun. 11 p (SEE N80-19809 10-59) Jan. 1980 refs
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
H. W. PONGRATZ *In* AGARD Modeling and Simulation of Avionics Systems and Command, Control and Commun. 13 p (SEE N80-19809 10-59) Jan. 1980
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. 11 p (SEE N80-19809 10-59) Jan. 1980 In FRENCH
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
G. T. SCHMIDT and R. H. SETTERLUND *In* AGARD Modeling and Simulation of Avionics Systems and Command, Control and Commun. 10 p (SEE N80-19809 10-59) Jan. 1980 refs
(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. 18 p (SEE N80-19809 10-59) Jan. 1980 refs
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. 16 p (SEE N80-19809 10-59) Jan. 1980 Prepared in cooperation with Rome Univ., Italy
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
N. E. LANE, M. I. STRIEB (Analytics, Inc., Willow Grove, Pa.), and W. LEYLAND *In* AGARD Modeling and Simulation of Avionics Systems and Command, Control and Commun. 13 p (SEE N80-19809 10-59) Jan. 1980 refs
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
P. M. LINTON and W. F. CLEMENT *In* AGARD Modeling and Simulation of Avionics Systems and Command, Control and Commun. 17 p (SEE N80-19809 10-59) Jan. 1980 refs Prepared in cooperation with Systems Technology, Inc., Mountain View, Calif.
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.

N83-18295# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
DISTRIBUTED MICRO-PROCESSOR APPLICATIONS TO GUIDANCE AND CONTROL SYSTEMS
L. J. URBAN, ed. (Aeronautical Systems Div.) Jul. 1982 113 p (AGARD-AR-178; ISBN-92-835-1428-9) Avail: NTIS HC A06/MF A01

Microprocessor technology is described. Guidance and control architecture is detailed. A lexicon of terminology is provided. Standardization is highlighted. For individual titles, see N83-18296 through N83-18299.

N83-18296# Milco International, Inc., Huntington Beach, Calif.
MICROPROCESSOR TECHNOLOGY
R. K. SMYTH *In* AGARD Distributed Micro-Process. Appl. to Guidance and Control Systems p 1-60 (SEE N83-18295 08-60) Jul. 1982
Avail: NTIS HC A06/MF A01

The current microprocessor technology state-of-the-art is examined, and important technology trends are identified. An overview of the current technology is provided. Author

N83-18297# Boeing Military Airplane Development, Seattle, Wash.
MICROPROCESSOR APPLICATIONS TO GUIDANCE AND CONTROL ARCHITECTURES
R. F. BOUSLEY *In* AGARD Distributed Micro-Process. Appl. to Guidance and Control Systems p 61-84 (SEE N83-18295 08-60) Jul. 1982
Avail: NTIS HC A06/MF A01

A sample of techniques now being examined for use of microprocessor hardware and software in future military G&C systems is presented. Some current and proposed architectures are discussed. The structure of the basic types of architectures is examined. Computational considerations are presented as well as software and fault tolerance considerations for each type of architecture. These architectures are applied to integrated G&C systems for generic types of aircraft. A comparison of benefits through the use of each of these types of architecture made possible through the use of microprocessors is presented. Author

N83-18298# Honeywell, Inc., Minneapolis, Minn.
MICROPROCESSOR AND DIGITAL SYSTEMS TERMINOLOGY AND NOMENCLATURE
T. B. CUNNINGHAM *In* AGARD Distributed Micro-Process. Appl. to Guidance and Control Systems p 85-100 (SEE N83-18295 08-60) Jul. 1982
Avail: NTIS HC A06/MF A01
A list of computer terminology is provided. N.W.

N83-18299# Cranfield Inst. of Tech., Bedfordshire (England). School of Electronic System Design.
OPTIONS AND OPPORTUNITIES FOR STANDARDS
J. T. SHEPHERD *In* AGARD Distributed Micro-Process. Appl. to Guidance and Control Systems (SEE N83-18295 08-60) Jul. 1982
Avail: NTIS HC A06/MF A01
Microprocessor standards are discussed. N.W.

61

COMPUTER PROGRAMMING AND SOFTWARE

Includes computer programs, routines, and algorithms.

N80-32125# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
GUIDANCE AND CONTROL SOFTWARE
L. J. URBAN, ed. (Aeronautical Systems Div.) May 1980 221 p refs In ENGLISH and FRENCH
(AGARD-AG-258; ISBN-92-835-0267-1) Avail: NTIS HC A10/MF A01
Software design and management are discussed with respect to avionics applcations. Particular attention is given to guidance and control systems, communication systems, and weapon systems. For individual titles, see N80-32126 through N80-32142.

N80-32126# British Aerospace Aircraft Group, Preston (England).
AN APPROACH TO THE DERIVATION AND VALIDATION OF REQUIREMENTS
A. O. WARD *In* AGARD Guidance and Control Software 24 p (SEE N80-32125 22-61) May 1980 refs
Avail: NTIS HC A10/MF A01
The problems associated with the development of requirements for guidance and control software are discussed. Ideas are suggested that will overcome these problems and a specific application of those ideas are described in terms of a methodology and associated tools. The position and contribution of requirements definition in the perspective of the overall product life cycle are examined. Two relevant viewpoints are considered: the resources needed to produce requirements; and the quality of requirements and its impact on budget. R.C.T.

N80-32127# Dornier-Werke G.m.b.H., Friedrichshafen (West Germany).
TRENDS IN THE DEVELOPMENT OF SOFTWARE FOR GUIDANCE AND CONTROL
P. ELZER *In* AGARD Guidance and Control Software 10 p (SEE N80-32125 22-61) May 1980 refs
Avail: NTIS HC A10/MF A01
An attempt is made to classify the steps of the development process for computer programs in guidance and control systems. Possible methologies are identified as well as support tools for development on each level. Several existing methods are described. R.C.T.

N80-32128# Naval Air Development Center, Warminster, Pa. Advanced Software Technology Div.
A MODERN FACILITY FOR SOFTWARE PRODUCTION AND MAINTENANCE
H. G. STUEBING *In* AGARD Guidance and Control Software 14 p (SEE N80-32125 22-61) May 1980 refs
Avail: NTIS HC A10/MF A01
A facility was designed, developed, and used for the life cycle support of weapon system software. This facility consists of a software system which runs on a commercial multicomputer configuration. The approach features increased management visibility of the software development process, increased programmer productivity through automation, reducing the cost of change during maintenance, and the use of automated regression testing to improve software quality. R.C.T.

N80-32129# Dornier-Werke G.m.b.H., Friedrichshafen (West Germany).
LOGIC STRUCTURE FOR TESTABILITY AND FAILURE DETECTION
U. SCHULZ and A. ROELKER *In* AGARD Guidance and Control Software 8 p (SEE N80-32125 22-61) May 1980
Avail: NTIS HC A10/MF A01
A concept of the logic structure for testability and failure detection of digital, modular, onboard data acquisition and control units within avionics systems were investigated. The concept was developed according to the maintenance levels within the German Air Force. The tests and failure detection were performed during operation as well as during pre- and post-flight tests without additional external special to type test equipments. The tests were totally integrated into the avionic system. R.C.T.

N80-32130# Office of the Under Secretary of Defense for Research and Engineering, Washington, D. C.
THE UNITED STATES DEPARTMENT OF DEFENSE COMMON HIGH ORDER LANGUAGE
D. A. FISHER *In* AGARD Guidance and Control Software 9 p (SEE N80-32125 22-61) May 1980 refs
Avail: NTIS HC A10/MF A01
The design, development, aquisition, management, and operational support and maintenance of computer software are discussed with respect to avionics applications. Specific emphasis is given to major weapon systems, communications systems, and command control systems. R.C.T.

N80-32131# Softech, Inc., Waltham, Mass.
COMPILER WRITING TECHNIQUES FOR AVIONICS APPLICATIONS
R. J. RUBEY and B. L. WOLMAN *In* AGARD Guidance and Control Software 8 p (SEE N80-32125 22-61) May 1980 refs
Avail: NTIS HC A10/MF A01
Some of the options in compiler construction for avionics applications are reveiwed and the structure of a typical compiler is described. Major emphasis is placed on the significant differences which exist between compilers for avionics applications and compilers used in general purpose applications. R.C.T.

N80-32132# Software Management Consultants, Torrance, Calif.
SOFTWARE VERIFICATION AND VALIDATION
D. J. REIFER *In* AGARD Guidance and Control Software 13 p (SEE N80-32125 22-61) May 1980 refs
Avail: NTIS HC A10/MF A01
The terms verification and validation are described and detailed guidance for their conduct is given. For each activity, the responsibilities of the participating organizations are identified and applicable concepts, methods, products and problems are discussed. R.C.T.

N80-32133# Naval Air Development Center, Warminster, Pa.
SOFTWARE MAINTENANCE MANAGEMENT PROCESS
W. R. BOGDAN *In* AGARD Guidance and Control Software 9 p (SEE N80-32125 22-61) May 1980
Avail: NTIS HC A10/MF A01
The management concepts utilized in developing a maintenance capability to support fleet tactical software are addressed. The tactical software being maintained is described and the kind of management planning that is essential to fleet software maintenance is presented. Software design factors are discussed that will reduce maintenance costs by making the initial software development more amenable to subsequent modification. The methodology the Navy uses to control changes to a software configuration baseline is addressed and how the Navy insures reliability of the software prior to fleet release is included. Also provided is an overview for the work breakdown structure and the organization of resources for work accomplishment. Estimating

procedures are described for determining software maintenance cost. R.C.T.

N80-32134# National Aerospace Lab., Amsterdam (Netherlands). IRAS Mission Operations.
DATA SYSTEM FOR THE INFRA-RED ASTRONOMICAL SATELLITE (IRAS)
R. C. VANHOLTZ *In* AGARD Guidance and Control Software 21 p (SEE N80-32125 22-61) May 1980
Avail: NTIS HC A10/MF A01

The data system that is being developed for the Infra-Red Astronomical Satellite (IRAS) is discussed. After introducing the satellite and its objectives, the setup of the on board and the ground data system is described. The subsystem responsible for the control of the satellite, called IRAS Ground Operations, is then exposed in more detail. The tasks of this subsystem include orbit determination and prediction, real time operations, spacecraft performance evaluation and maintenance, and data pre-processing, distribution, and filing. Finally, the data system configuration control mechanism which was devised to meet the complexity and multinational setup of the system is portrayed. M.G.

N80-32135# General Dynamics Corp., Fort Worth, Tex.
ADVANCED DESIGN CONCEPTS AND PRACTICES IN THE F-16 MISSION COMPUTER SOFTWARE
J. A. EDWARDS *In* AGARD Guidance and Control Software 15 p (SEE N80-32125 22-61) May 1980 refs
Avail: NTIS HC A10/MF A01

Developments in the design of the F-16 mission computer software are discussed. Improved system performance resulted from several broad-scope software design decisions that were applied to the mission computer for the F-16 avionics system. These design decisions were made in the areas of the control and scheduling functions. The selected control concepts relied upon a table-driven system that employed only positive logic and a simplified executive. The Multicomputer configuration was a loosely coupled in an asynchronous network. Communications in the network were implemented via a standard 16-bit protocol. Data consistency was addressed in the basic interface specification as well as the detailed implementation. In general, the timing and hardware design features were hidden from the algorithms through system control approaches. In all, the flexibility and optimizations that resulted from the implementation concept have been well established through two block updates and several demonstration and research programs. M.G.

N80-32136# Ministry of Defence, London (England).
MAIN COMPUTER SOFTWARE FOR THE MRCA TORNADO
K. SANDERSON *In* AGARD Guidance and Control Software 16 p (SEE N80-32125 22-61) May 1980
Avail: NTIS HC A10/MF A01

The main computer software for the tri-national requirement Tornado (Panavia 200 MRCA Tornado) is discussed. Particular reference is made to the role of the national avionic system companies in the participating nations and the organization provided by them for the design and development of the avionic system, including the software. The specification of the top level avionic design requirements and a description of the computing hardware and data transmission arrangements provide an introduction to the specific software development topics. These cover the specification of the software requirements, the development of the Operational Flight Program, the software structure and documentation, hardware-software integration and testing facilities, documentation for the control and reporting of the testing, configuration control aspects, and production software modification control. M.G.

N80-32137# Societe Nationale Industrielle Aerospatiale, Toulouse (France).
THE LOGIC OF THE ELECTRIC FLIGHT CONTROL SYSTEM EXPERIMENT ON THE CONCORDE [LOGICIEL DU SYSTEME DE COMMANDE DE VOL ELECTRIQUE EXPERIMENTE SUR CONCORDE]
Y. NEGRE and J. RAULLET *In* AGARD Guidance and Control Software 11 p (SEE N80-32125 22-61) May 1980 In FRENCH
Avail: NTIS HC A10/MF A01

An experiment using a numerical electric flight control system to control low speed longitudinal instability on the Concorde is described. The security and performance objectives which influenced the system definition are outlined with particular emphasis on problems related to the definition, installation and experimentation with the logic used. Conclusions are drawn principally regarding the level of security which can be expected for onboard logical elements. Transl. by A.R.H.

N80-32138# Smiths Industries Ltd., Bishops Cleeve (England). Electronic Displays Branch.
DESIGN AND DEVELOPMENT OF SOFTWARE FOR SEA HARRIER HUDWAC
E. P. JONES and S. HOWISON *In* AGARD Guidance and Control Software 12 p (SEE N80-32125 22-61) May 1980
Avail: NTIS HC A10/MF A01

The development of the airborne software for the Sea Harrier Head-Up Display and Weapon Aiming Computer System is described. The system requirements are outlined and include the symbology generation for both head-up and head-down display systems; weapon aiming computations; flight path guidance for both target interception and aircraft to ship recovery; pointing and control commands for radar and guided weapons; first line avionic system test and fault identification; and extensive operational self test and failure tolerance. The hardware configuration, software design, and software writing utilizing the CORAL programming language are discussed. M.G.

N80-32139# Dornier-Werke G.m.b.H., Friedrichshafen (West Germany).
SOFTWARE FOR AN INTEGRATED FLIGHT CONTROL AND NIGHT VISION SYSTEM FOR MILITARY HELICOPTERS
P. ELZER, F. FIGEL, and W. HOFFMAN *In* AGARD Guidance and Control Software 8 p (SEE N80-32125 22-61) May 1980 refs Sponsored by the German Federal Ministry of Defense
Avail: NTIS HC A10/MF A01

The functions and structure of an integrated digital flight control and night vision system for military helicopters is described. Its partially redundant components are connected via a serial bus. This resulted in a system with distributed processors. The software had to be structured according to the distributed character of the system and had to take into account the master-terminal principle of the bus architecture. It comprises the algorithms for flight control and handling of the night vision equipment as well as management functions for the bus, the displays, input commands, and error handling. Development of the software and integration of the system were supported by appropriate hardware aids. A special device was developed to facilitate integration of the distributed system. For this the same modular electronic components were used as for the control system. M.G.

N80-32140# IBM Federal Systems Div., Owego, N. Y.
SPACE SHUTTLE APPLICATIONS. PART 1: REDUNDANT COMPUTER OPERATION. PART 2: REDUNDANT COMPUTER SOFTWARE DESIGN AND TEST
R. E. POUPARD and C. T. SHERIDAN *In* AGARD Guidance and Control Software 9 p (SEE N80-32125 22-61) May 1980
Avail: NTIS HC A10/MF A01

The operational characteristics of the space shuttle redundant data processing system are defined. The system was designed to meet the fail operational/fail safe requirements of the space shuttle mission and is comprised of a redundant set of four IBM AP-101 general purpose computers programmed to produce identical, simultaneous output commands. Particular emphasis is given to the design testing of the system software. Additional design characteristics, namely the incorporation of asynchronous interrupts and multiple asynchronous priority levels, are examined and techniques utilized for ensuring data integrity are reviewed. M.G.

N80-32141# Naval Air Development Center, Warminster, Pa. Combat Systems Software Div.
SOFTWARE APPLICATIONS AS DEMONSTRATED IN THE P-3C AVIONICS SYSTEM
J. W. HEAP *In* AGARD Guidance and Control Software 15 p (SEE N80-32125 22-61) May 1980 refs
Avail: NTIS HC A10/MF A01

The software management methodology developed for generation of the P-3C system software for the three UPDATE versions of the avionics system is covered. Emphasis is placed on the software development flow process depicting control points

and deliverables, standards and objectives set for the software functions and design, the contracting strategy, and tool and facilities employed. M.G.

N80-32142# Boeing Military Airplane Development, Seattle, Wash.
EXECUTIVE SOFTWARE REUSABILITY FOR DISTRIBUTED AVIONICS ARCHITECTURES
R. F. BOUSLEY *In* AGARD Guidance and Control Software 12 p (SEE N80-32125 22-61) May 1980 refs
Avail: NTIS HC A10/MF A01

The impact of distributed microprocessor-based systems integrated (mission-oriented) avionics software is addressed. An overview is given of hardware networks and bus control mechanization issues in distributed architectures. Executive software considerations are emphasized. It appears that a functional decomposition of the executive software will help to maximize the reusability of this software since only those functional modules changed. A modularized executive, along with a firm executive/applications software interface, will allow maximum reusability of the applications software. This will minimze the impact on the integration task during mission software development. M.G.

64

NUMERICAL ANALYSIS

Includes iteration, difference equations, and numerical approximation.

N82-29989# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
ADVANCES IN THE TECHNIQUES AND TECHNOLOGY OF THE APPLICATION OF NONLINEAR FILTERS AND KALMAN FILTERS
C. T. LEONDES, ed. Mar. 1982 531 p refs
(AGARD-AG-256; ISBN-92-835-1418-1; AD-A117090) Avail: NTIS HC A23/MF A01

The general theory of filtering is discussed in terms of its historical development. An overview of discrete time and continuous time Kalman filters is presented. Filters in nonlinear dynamic systems are discussed in detail. Various computational techniques in nonlinear and linear filters are presented. Applications and methodologies for nonlinear and Kalman filters are given. Topics covered includes: navigation systems; tracking systems; and target recognition. For individual titles, see N82-29990 through N82-30007.

N82-29990# Bodenseewerk Geraetetechnik G.m.b.H., Ueberlingen (West Germany).
NONLINEAR FILTERING THEORY
V. KREBS *In* AGARD Advan. in the Tech. and Technol. of the Appl. of Nonlinear Filters and Kalman Filters 26 p (SEE N82-29989 20-64) Mar. 1982 refs
Avail: NTIS HC A23/MF A01

An introduction to nonlinear filtering theory is presented by means of a deductive approach. The so-called general estimation problem is defined which is concerned with the extraction of useful information from noisy measurements. The exact mathematical solution of the general estimation problem is outlined which yields the Kushner-Stratonovich equation respectively the Bayesian recursive estimator. From these equations the practical nonlinear filter approxmations are derived in a deductive way. Most important are the local approximate filters of first order (type: extended Kalman Filter) and second order filters. In addition, there are global approximate filters (Bayes-law calculators) available. Several approximation methods for these estimators, such as orthogonal series expansion, Gaussian sums, point masses and splines are briefly discussed. B.W.

N82-29991# Defence Research Establishment, Ottawa. (Ontario). Electromagnetic Section.
EXACT AND APPROXIMATE NONLINEAR ESTIMATION TECHNIQUES
D. F. LIANG *In* AGARD Advan. in the Tech. and Technol. of the Appl. of Nonlinear Filters and Kalman Filter 21 p (SEE N82-29989 20-64) Mar. 1982 refs
Avail: NTIS HC A23/MF A01

In the case of continuous systems, filtering algorithms are derived for nonlinear systems without delays, imbedded in white noise, correlated noise and noise free processes. The filtering equations obtained for nonlinear systems with white noise processes are exact, but for non-white noise processes the results obtained are approximate. In the case of discrete-time systems, nonlinear estimation algorithms, that directly yield the fixed-lag, fixed-point and fixed-interval smoothing and the filtering algorithms, are derived for nonlinear delayed systems wtih measurements corrupted by white noise and correlated noise processes. The derivation is straightforward and clearly indicates the close links between three different classification of smoothers and the filtering estimator. For systems with polynomial, product-type or state-dependent sinusoidal nonlinearities, the proposed algorithms can be practically realized without the need of approximation under the assumption that the estimator errors are Gaussian. Such an assumption is significantly different from the most commonly used assumption that the state is Gaussian. Author

N82-29992# Naval Air Development Center, Warminster, Pa.
THE THEORY AND TECHNIQUES OF DISCRETE-TIME DECENTRALIZED FILTERS
T. H. KERR (Intermetrics, Inc.) and L. CHIN *In* AGARD Advan. in the Tech. and Technol. of the Appl. of Nonlinear Filters and Kalman Filters 39 p (SEE N82-29989 20-64) Mar. 1982 refs (Contract N6116972-D-0301)
Avail: NTIS HC A23/MF A01

An overview of the alternative decentralized filtering techniques that have evolved over the last decade and the current status of each approach is presented. This aspect is important as a preliminary step in performing engineering by allowing the selection of the approach that best fits the constraints imposed by the specific application. Several contributions that are provided herein advance the state-of-the-art for two decentralized filtering approaches (viz., SLU and SPA) as formulated here in discrete-time by specifying and summarizing mechanization equations (with rationale), by analytically establishing stability of these estimation algorithms, and by providing tables that allow quantification of the computer burden upon implementation in terms of required memory allotment and algorithm cycle times. Thus a complete veiw of these two approaches to decentralized filtering is provided. Current applications and likely future application areas for decentralized filtering are identified. B.W.

N82-29993# Naval Air Development Center, Warminster, Pa.
ADVANCES IN COMPUTATIONAL EFFICIENCIES OF LINEAR FILTERING
L. CHIN *In* AGARD Advan. in the Tech. and Technol. of the Appl. of Nonlinear Filters and Kalman Filters 29 p (SEE N82-29989 20-64) Mar. 1982 refs
Avail: NTIS HC A23/MF A01

A broad overview of various discrete-time linear filtering techniques including the Square-Root and variations of Square-Root, Factorized, Chandrasekhar, Partitioning and Decentralized algorithms as well as the basic Covariance and Information filters are presented. Computer burdens of these well-known filtering algorithms are examined and compared from practical operation point of view. B.W.

N82-29994# Texas Instruments. Inc., Lewisville.
DESIGN OF REAL-TIME ESTIMATION ALGORITHMS FOR IMPLEMENTATION IN MICROPROCESSOR AND DISTRIBUTED PROCESSOR SYSTEMS
V. B. GYLYS *In* AGARD Advan. in the Tech. and Technol. of the Appl. of Nonlinear Filters and Kalman Filters 34 p (SEE N82-29989 20-64) Mar. 1982 refs
Avail: NTIS HC A23/MF A01

The use of multiprogrammed processing as a suitable processing environment for real-time estimators is proposed. Concurrent processing is presented as the basic technique for

overcoming the hardware limitations and for meeting the real-time constraints of the estimation problem. Design of a decentralized real-time operating system for controlling multiprogrammed execution of processes in a distributed sytem is outlined. This operating system consists of autonomous, local real-time executives, which operate under fixed allocation of resources. Process scheduling and communications are discussed. The established structure of real-time software and process control can then be utilized to mechanize estimation algorithms as concurrent processes. Several known schemes for decomposing a Kalman filter into concurrent processes are illustrated. B.W.

N82-29995# Hughes Aircraft Co., El Segundo, Calif.
GLOBAL APPROXIMATION FOR NONLINEAR FILTERING WITH APPLICATION TO SPREAD SPECTRUM RANGING
W. M. BOWLES and J. A. CARTELLI (ESL, Synnyvale, Calif.) *In* AGARD Advan. in the Tech. and Technol. of the Appl. of Nonlinear Filters and Kalman Filters 30 p (SEE N82-29989 20-64) Mar. 1982 refs
Avail: NTIS HC A23/MF A01

Some global approximation procedures for nonlinear filtering are described. These procedures yield algorithms for recovering a signal from a measurement containing signal plus noise. The celebrated Kalman filter solves problems in which the signal evolves as the solution to a linear differential equation driven by white Gaussian noise with Gaussian initial condition and where the signal enters linearly into a measurement corrupted by white Gaussian noise. For problems where these linear Gaussian conditions are weakly violated, the Kalman filter serves as a good approximation. In many interesting are weakly violated, the Kalman filter serves as a good approximation. In many interesting problems, however, these conditions are not satisfied. For example, one of the random variables may have a multimodal density function or the signal may enter nonlinearly into the measurement. The techniques discussed here give the designer some tools to use when the Kalman filter is no longer a reasonable approximate solution.
B.W.

N82-29996# Systems Control, Inc., Palo Alto, Calif.
SYSTEM IDENTIFICATION OF NONLINEAR AERODYNAMIC MODELS
T. L. TRANKLE, J. H. VINCENT, and S. N. FRANKLIN *In* AGARD Advan. in the Tech. and Technol. of the Appl. of Nonlinear Filters and Kalman Filters 26 p (SEE N82-29989 20-64) Mar. 1982 refs
Avail: NTIS HC A23/MF A01

System identification, a technology for determining a mathematical model of a dynamic system from observations of its response to inputs is discussed. Identification technology is used for the determination of nonlinear aerodynamic models for aircraft maneuvering at high angles of attack. The method outlined here (equation error, output error, and maximum likelihood algorithms) can directly nonlinear aerodynamic coefficients in table look-up or multivariable spline formats. For application to nonlinear problems, the basic algorithms are enhanced by recent techniques for evaluation of partial derivatives of the likelihood function, calculation of parameter estimation uncertainties, and by the use of multidimensional splines as a generic model structure. An example application of these methods to the identification of F-4S fighter aircraft high angle of attack aerodynamics is illustrated. B.W.

N82-29997# Elektronik-System G.m.b.H., Munich (West Germany).
TECHNIQUES AND METHODOLOGIES FOR THE ESTIMATION OF COVARIANCES, POWER SPECTRA AND FILTER-STATE AUGMENTATION
V. HELD *In* AGARD Advan. in the Tech. and Technol. of the Appl. of Nonlinear Filters and Kalman Filters 10 p (SEE N82-29989 20-64) Mar. 1982 refs
Avail: NTIS HC A23/MF A01

A technique for the the estimation of stationary stochastic noise data from real measurements is discussed. This data contains the noise as well as non-observable deterministic values. The separation is accomplished by a specific smoothing procedure. The stochastic behavior of the data is proven by a Gaussian probability distribution test. Then, based on conventional stochastic relations the covariance and the spectral density are evaluated. Shaping filters are determined from the power spectral density to model colored noise. The filter structure is selected and the filter parameters are optimally identified by a least squares procedure. Finally the filter state is augmented by the degree of the shaping filter. B.W.

N82-29998# Air Force Inst. of Tech., Wright-Patterson AFB, Ohio. Dept. of Electrical Engineering.
REDUCED ORDER KALMAN FILTER DESIGN AND PERFORMANCE ANALYSIS
P. S. MAYBECK *In* AGARD Advan. in the Tech. and Technol. of the Appl. of Nonlinear Filters and Kalman Filters 16 p (SEE N82-29989 20-64) Mar. 1982 refs
Avail: NTIS HC A23/MF A01

The design of an effective operational Kalman filter is discussed. The crux of such a design effort is establishing an adequate model upon which to base the filter: a model describing system dynamics, measurement device characteristics, and statistical properties of uncertainties associated with this structure, all of which becomes embodied in the filter algorithm. Using physical insights, order reduction and model simplification techniques, numerous prospective filters are proposed for a given application. A systematic design procedure is described that exploits these stochastic modeling and performance analysis capabilities, and an example is used to emphasize some important aspects of the design approach. B.W.

N82-29999# Air Force Inst. of Tech., Wright-Patterson AFB, Ohio. Dept. of Electrical Engineering.
DESIGN AND PERFORMANCE ANALYSIS OF AN ADAPTIVE EXTENDED KALMAN FILTER FOR TARGET IMAGE TRACKING
P. S. MAYBECK *In* AGARD Advan. in the Tech. and Technol. of the Appl. of Nonlinear Filters and Kalman Filters 15 p (SEE N82-29989 20-64) Mar. 1982 refs
Avail: NTIS HC A23/MF A01

A simple extended Kalman filter is designed to track targets using outputs from a forward-looking infrared sensor as measurements. It exploits knowledge unused by current correlation trackers - size, shape, and motion characteristics of the target, atmospheric jitter spectral description, and background and sensor noise characteristics - to yield enhanced performance. Monte Carlo performance analyses indicate that the ability of a nonadaptive four-state filter to track a realistic distant point source target with an error standard deviation of 0.2 picture elements under expected tracking conditions surpasses the correlation trackers' abilities by an order of magnitude. Although very accurate tracking performance is achieved under nominally assumed conditions, robustness studies portray a significant degradation when the filter's internal model does not depict the target's intensity profile or motion characteristics well. Background noise properties are shown to be of secondary importance at expected signal-to-noise ratios. These studies emphasize the need for good models and adaptivity within the filter structure. In order to track air-to-air missiles at close range, an eight-state filter incorporates a modified target dynamics model as well as online adaptation to target shape effects, changing target motion characteristics, and maximum signal intensity. It is shown to possess considerable performance potential for highly maneuverable targets despite background clutter.
R.J.F.

N82-30000# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick (West Germany). Inst. fuer Flugfuehrung.
TECHNIQUES FOR THE DEVELOPMENT OF ERROR MODELS FOR AIDED STRAPDOWN NAVIGATION SYSTEMS
W. LECHNER *In* AGARD Advan. in the Tech. and Technol. of the Appl. of Nonlinear Filters and Kalman Filters 28 p (SEE N82-29989 20-64) Mar. 1982 refs
Avail: NTIS HC A23/MF A01

An account is given of how adaptive low order error models were developed and adaptive filtering applied. The results were checked by using measured and simulated strapdown systems (SDS) data. In order to increase the accuracy levels of the inertial navigation systems (INS) additiona external measurements were used. The combination of the different data is often carried out by using the methods of Kalman filtering, which need sufficiently exact error models especially for the INS. As far as strapdown systems are concerned, the development of mathematical

descriptions of the error behavior leads to high order models, because the dynamic environment of the SDS has to be taken into account. However, for real time navigational computations it is necessary to provide low order error models. An error model that conforms to the real SDS error behavior for all possible cases will thus generally lead to an unacceptably sophisticated error model with regard to the real time computations or numerical problems involved. The attempt is made to solve the problem by using adaptive error models and adaptive filtering, thereby avoiding some of the drawbacks of SDS. As an example measured and simulated strapdown data were used to demonstrate and to check the methods suggested. R.J.F.

N82-30001# Analytic Sciences Corp., Reading, Mass.
USE OF FILTERING AND SMOOTHING ALGORITHMS IN THE ANALYSIS OF MISSILE SYSTEM TEST DATA
E. M. DUIVEN, C. L. MEDLER, and J. F. KASPER, JR. *In* AGARD Advan. in the Tech. and Technol. of the Appl. of Nonlinear Filters and Kalman Filters 48 p (SEE N82-29989 20-64) Mar. 1982 refs
Avail: NTIS HC A23/MF A01

Advanced techniques for the processing of missile system test data is discussed. Data from multiple references are used in a post flight analyzer that is based in large part on a smoothing algorithm. The objectives of the processing are to obtain the best estimate of overall system accuracy and to recover the maximum information about individual guidance system error contributors. A procedure for validating the models used in filtering and smoothing algorithms is presented. The procedure checks model validity using daa from multiple system tests. It employs well known statistical hypothesis testing methods in an innovative manner. Minuteman III flight test program data are discussed. In particular, the use of external reference information to enable determination of specific error characteristics which make up the model for the missile guidance system is discussed. It is shown that the ability to identify elements of the model is strongly influenced by the nature of the available reference systems and the chosen test plan. An algorithm bsed on a generalized likelihood ratio test is seen to be effective in isolating certain nonlinear error phenomena, provided that adequate reference data are available. Validation of the models for multiple phases in the operation of a ballistic missile system is discussed. A procedure based on statistical hypothesis testing methods is presented. The procedure can be used to determine whether a proposed test program is capable of isolating bias error phenomena. Alternatively, when data from multiple tests have been collected, the procedure provides a statistical assessment of the presence of bias error phenomena in the system being tested. R.J.F.

N82-30002# Litton Industries, Woodland Hills, Calif. Guidance and Control Systems Div.
INERTIAL NAVIGATION SYSTEM ERROR MODEL CONSIDERATIONS IN KALMAN FILTER APPLICATIONS
J. R. HUDDLE *In* AGARD Advan. in the Tech. and Technol. of the Appl. of Nonlinear Filters and Kalman Filters 9 p (SEE N82-29989 20-64) Mar. 1982 refs
Avail: NTIS HC A23/MF A01

The full linear model describing the propagation of error for inertial navigation systems employing the local level, wander azimuth mechanization equations is developed. The model applies to Schuler tuned, space stable or strapdown inertial system instrumentations. For this model, alternative approximate linear models are developed which in different operational applications proved adequate as 'design models' for the application of Kalman estimation theory. R.J.F.

N82-30003# Singer-Kearfott, Little Falls, N. J.
SEPARATED BIAS ESTIMATION AND SOME APPLICATIONS
B. FRIEDLAND *In* AGARD Advan. in the Tech. and Technol. of the Appl. of Nonlinear Filters and Kalman Filters 13 p (SEE N82-29989 20-64) Mar. 1982 refs
Avail: NTIS HC A23/MF A01

The general theory of separating the estimation of the bias vector from the estimation of the dynamic state vector in applications of Kalman filtering is reviewed using a new derivation. Some of the extensions that various investigators contributed during the past decade are discussed. Several applications, including calibration and failure detection and identification, are discussed. R.J.F.

N82-30004# Defence Research Establishment, Ottawa. (Ontario). Electromagnetics Section.
COMPARISONS OF NONLINEAR FILTERS FOR SYSTEMS WITH NONNEGLIGIBLE NONLINEARITIES
D. F. LIANG *In* AGARD Advan. in the Tech. and Technol. of the Appl. of Nonlinear Filters and Kalman Filters 34 p (SEE N82-29989 20-64) Mar. 1982 refs
Avail: NTIS HC A23/MF A01

The structural differences and performance characteristics of several distinct estimation algorithms, as applied to some practical continuous and discrete time state estimation problems are discussed. The extensive simulation results presented, indicate that when noise inputs are not too small and appropriate a priori estimates are available, the extended Kalman filter can be expected to perform satisfactorily. When nonlinear effects are significant, the realizable minimum variance filter is remarkably superior to any other filter investigated. When the level of noise inputs are large enough to effectively cover the effects of nonlinearities, no particular filter can be consistently superior to any other filter. R.J.F.

N82-30005# Technische Hogeschool, Delft (Netherlands). Dept. of Aerospace Engineering.
KALMAN FILTER SATELLITE ORBIT IMPROVEMENT USING LASER RANGING MEASUREMENTS FROM A SINGLE TRACKING STATION
K. F. WAKKER and B. A. C. AMBROSIUS *In* AGARD Advan. in the Tech. and Technol. of the Appl. of Nonlinear Filters and Kalman Filters 16 p (SEE N82-29989 20-64) Mar. 1982 refs
Avail: NTIS HC A23/MF A01

A study to investigate the possibilities of using the laser range observations acquired at only one tracking station to provide real time position prediction updates during a pass, and also better predictions for subsequent passes over that station is presented. A computer program, called SORKA, was developed, which is based on an extended Kalman filter scheme. The computational approach adopted in SORKA is described in some datail. In particular the methods to compute the state transition matrix and the state noise covariance matrix are emphasized. Typical divergence phenomena arising from processing accurate range only measurements are discussed and the effectiveness of techniques to reduce these instabilities is demonstrated. Laser range measurements acquired during 8 successive passes of GEOS-1 over the Kootwijk groundstation were processed and some results are presented. R.J.F.

N82-30006# Nichols Research Corp., Huntsville, Ala.
STATE ESTIMATION OF BALLISTIC TRAJECTORIES WITH ANGLE ONLY MEASUREMENTS
M. R. SALAZAR *In* AGARD Advan. in the Tech. and Technol. of the Appl. of Nonlinear Filters and Kalman Filters 29 p (SEE N82-29989 20-64) Mar. 1982 refs
Avail: NTIS HC A23/MF A01

The problem of state estimation of ballistic trajectories with angle only measurements is discussed. This type of problem becomes difficult when the observer is free falling and more difficult if the observer is then located in the plane of the observed trajectory. The methods described in this report are very effective against this most difficult case, and superior to existing angle only tracking filters in terms of stability, computational requirements, and tracking performance. The first method described herein utilizes the methods of Marquardt matrix conditioning and explicit Jacobian in determining the weighted least squares state estimate for the nonlinear, time varying, dynamic system of a ballistic trajectory with nonlinear noisy measurements. In this case both the equations of motion and the angle observations are nonlinear functions of the state. This Marquardt least squares (MLS) technique is a nonrecursive or batch process in that all the observations must be processed each time a state estimate is made. The method of incorporating a priori knowledge of the total energy into the MLS algorithm to assist in poor observability problems is also discussed. The second method takes the explicit Jacobian technique developed for the MLS algorithm and applies it to the recursive Kalman filter equations. This improved Jacobian-Kalman filter

formulation together with the MLS for initialization form the complete angle only tracking algorithm. R.J.F.

N82-30007# California Univ., Los Angeles. School of Engineering and Applied Science.
NEW SMOOTHING ALGORITHMS FOR DYNAMIC SYSTEMS WITH OR WITHOUT INTERFERENCE
K. DEMIRBAS *In* AGARD Advan. in the Tech. and Technol. of the Appl. of Nonlinear Filters and Kalman Filters 66 p (SEE N82-29989 20-64) Mar. 1982 refs
Avail: NTIS HC A23/MF A01

The problem of state estimation for discrete models with or without interference is discussed. Three new smoothing algorithms are presented. The main idea for these smoothing algorithms is that of quantizing the states of the models to a finite set of states. This approach reduces the smoothing problem to a multiple (composite) hypothesis testing problem. Further, using three decoding techniques of information theory, the smoothing algorithms are developed. The first smoothing algorithm is referred to as optimum decoding based smoothing algorithm, which uses the Viterbi decoding algorithm. The second smoothing algorithm is referred to as stack sequential decoding based smoothing algorithm, which uses a stack sequential decoding algorithm. The third one is referred to as suboptimum decoding based smoothing algorithm, which uses a suboptimum decoding algorithm. R.J.F.

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SYSTEMS ANALYSIS

Includes mathematical modeling; network analysis; and operations research.

N83-18390# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
PRECISION GUIDED MUNITIONS. TECHNOLOGY AND OPERATIONAL ASPECTS
Sep. 1982 104 p refs Symp. held in Norway, 4-7 May 1982 (AGARD-CP-320; ISBN-92-835-1434-3) Avail: NTIS HC A06/MF A01

Precision guided projectiles and missile control systems are discussed. Emphasis is upon high kill probability weapons directed against ground forces in combat situations in Europe. For individual titles, see N83-18391 through N83-18398.

N83-18391# Army Materiel Systems Analysis Activity, Aberdeen Proving Ground, Md.
ANALYSIS OF THE INPACT OF BATTLEFIELD SCENARIOS ON PRECISION MUNITIONS
D. L. FREDERICK *In* AGARD Precision Guided Spacecraft. Technol. and Operational Aspects 14 p (SEE N83-18390 08-66) Sep. 1982 refs
Avail: NTIS HC A06/MF A01

The computer methodology called the Scenario Analysis Model (SAM) is discussed. This model was developed to analyze the effects of terrain and battlefield induced obscuration on potential Precision Guided Munition (PGM) capabilities from various weapon/designator positions. The model inputs which include digitized terrain, digitized paths, obscurant data, target data, and position coordinates are discussed. Currently, four scenarios located in Germany are available for analysis. Summaries of the scenarios are included. The output of the SAM is useful in understanding the impact of scenario dependent factors on overall PGM utility. Some of the SAM output statistics are discussed. In particular, the degradation effects of obscuration on line-of-sight duration times, distributions of path segment lengths, and ranges to the target are presented for forward observer positions in the four scenarios. In addition, the degradation effects of obscuration on tanks, tow vehicles, and helicopter line of sight duration times for one scenario are presented R.J.F.

N83-18392# Mitre Corp., Bedford, Mass.
APPLICATION OF AN AIRBORNE ENGAGEMENT SYSTEM TO BATTLEFIELD SURVEILLANCE AND ATTACK CONTROL
D. D. NEUMAN *In* AGARD Precision Guided Spacecraft. Technol and Operational Aspects 9 p (SEE N83-18390 08-66) Sep. 1982
Avail: NTIS HC A06/MF A01

The airborne engagement system is a surveillance and attack control system designed to detect, locate, track, and control weapons against time sensitive targets, moving and stationary, located up to 150 km or more beyond the forward line of its own troops. The airborne sensor broadcasts its target location data in real time for reception at multiple ground receiver locations including command, intelligence, and mission execution elements. Simultaneously with performing its surveillance and attack planning functions, the system provides target positioning data to inflight surface and air launched missiles and direct attack aircraft to an accuracy that supports the dispense of anti-armor submunitions as well as other conventional ordnance against fixed and moving targets. Given the proper weapon systems, data provided to direct attack aircraft allow low altitude ingress and egress, and blind weapon delivery (no pop-up) without overflight of the objective area. Data provided to the inflight missile allow for missile flight correction and adjustment of munition dispense in both time and location to compensate for target motion and missile navigation uncertanties. R.J.F.

N83-18393# General Dynamics Corp., Pomona, Calif. Technology Programs Dept.
PRECISION GUIDED MUNITION SEEKER TECHNOLOGY
T. G. HAME *In* AGARD Precision Guided Spacecraft. Technol. and Operational Aspects 11 p (SEE N83-18390 08-66) Sep. 1982
Avail: NTIS HC A06/MF A01

Recent seeker technology developments for application to autonomous target acquisition munitions is discussed. First, basic design approaches for infrared seekers are discussed and the use of two colors to achieve countermeasures and non-target discrimination is introduced. Experimental field test results show the degree of autonomous performance achieved under a variety of battlefield conditions. Next, millimeter wave seekers suitable for use on small diameter missiles, munitions and remotely piloted vehicles are described and the results of experimental hardware operating at 35 GHz and 140 GHz are shown. Finally, in view of the unpredictability of battlefield conditions, two concepts for multi-mode terminal guidance are introduced and explored experimentally. A common aperture millimeter wave/two-color infrared seeker is described which combines a 140 GHz sensor with a two-color mid-infrared sensor for optimum battlefield performance. For air defense suppression applications, an experimental passive microwave/infrared seeker is discussed. R.J.F.

N83-18394# Marconi Space and Defence System Ltd., Stanmore (England). Guided Weapon Div.
RADAR SEEKERS FOR PRECISION GUIDED MUNITIONS
D. A. RAMSAY *In* AGARD Precision Guided Spacecraft. Technol. and Operational Aspects 15 p (SEE N83-18390 08-66) Sep. 1982 Sponsored in part by the UK Ministry of Defence
Avail: NTIS HC A06/MF A01

A general perspective is given on the evolution of radar guidance, utilizing the astonishing current advances in electronic technology, so as to overcome past disadvantages of radar guidance and to solve the problems of battlefield targets. Missile control, radar homing missiles, infrared detectors, and several types of missile systems are discussed. R.J.F.

N83-18395# Singer-Kearfott, Wayne, N. J.
ADVANCED IMAGING TECHNIQUES FOR HIERARCHIES OF INTELLIGENT PGMS
C. R. GIARDINA *In* AGARD Precision Guided Spacecraft. Technol. and Operational Aspects 12 p (SEE N83-18390 08-66) Sep. 1982 refs Prepared in cooperation with Stevens Inst. of Technology
Avail: NTIS HC A06/MF A01

Levels of intelligence in precision guided missiles (PGM) are determined as a functional involving false alarm probabilities and non target detection error probabilities. For an apriori specified

mission a minimal PGM IQ is needed; to help guarantee this minimal value, advanced image processing techniques were developed. It is assumed that the munition is fitted with a strapdown navigation and guidance system and a necessary imaging sensor such as infrared. Baseline imaging procedures are described common to all intelligence levels with additional methods given for PGMs with larger IQ's. A recently developed imaging algebra is applied to PGM systems; here operators are employed for image enhancement, restoration, segmentation, classification, and registration. Many of these new operators are based on counterparts in classical mathematical disciplines such as topology, linear and abstract algebra, and functional analysis. The operators described, along with stochastic procedures, help render the desired intelligence level. Preliminary algorithm design shall be conducted for real time digital process implementation. This will go hand-in-hand with computer architecture determination. R.J.F.

N83-18396# Army Missile Command, Redstone Arsenal, Ala. Guidance and Control Directorate.
DEVELOPMENT OF LOW COST MULTIFUNCTION SENSORS FOR LIGHTWEIGHT FIRE AND FORGET ANTITANK WEAPON SYSTEM
J. S. HUNTER and J. C. HUNG (Tennessee Univ.) *In* AGARD Precision Guided Spacecraft. Technol. and Operational Aspects 17 p (SEE N83-18390 08-66) Sep. 1982
Avail: NTIS HC A06/MF A01

The design description, operation, and preliminary evaluation of a multifunction sensing device that is capable of measuring two axes of angular rate and two axes of linear acceleration from a single instrument are discussed. The equations for obtaining three axes of angular rate and three axes of linear acceleration from a single instrument are also developed. Test data is presented that illustrates state-of-the-art performance on available multifunction sensors. Finally, methods of improving the performance of multifunction sensors are discussed. R.J.F.

N83-18397# Naval Surface Weapons Center, Dahlgren, Va.
A GUIDANCE LAW FOR GENERAL SURFACE TARGETS
W. R. CHADWICK and C. M. ROSE *In* AGARD Precision Guided Spacecraft. Technol. and Operational Aspects 10 p (SEE N83-18390 08-66) Sep. 1982 refs Previously announced as X82-75611
Avail: NTIS HC A06/MF A01

A guidance law is proposed for low-cost tactical missiles. Analysis of this law is carried out for fast-moving surface targets and stationary targets in the presence of gravity. The law is simple to implement using the velocity-vane pursuit-guidance seeker and for the above targets is as accurate as proportional navigation. R.J.F.

N83-18398# Army Materiel Systems Analysis Activity, Aberdeen Proving Ground, Md.
OPERATIONAL AND EFFECTIVENESS CONSIDERATIONS FOR A TERMINALLY GUIDED WARHEAD (TGW) CONCEPT FOR THE MULTIPLE LAUNCH ROCKET SYSTEM (MLRS)
R. CHANDLER, E. PANUSKA, and M. STARKS *In* AGARD Precision Guided Spacecraft. Technol. and Operational Aspects 7 p (SEE N83-18390 08-66) Sep. 1982
Avail: NTIS HC A06/MF A01

An effectiveness analysis of a terminally guided warheat (TGW)/multiple launch rocket system (MLRS) concept is discussed. The objective was to examine the effectiveness of this concept under a spectrum of anticipated battlefield weather environments in a European setting. MLRS/TGW effectiveness estimates against several typical Warsaw Pact targets are developed. Additionally, the sensitivity of effectiveness to parameters expected to critically affect system performance, such as response time and target vehicle signature, are examined. R.J.F.

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PHYSICS (GENERAL)

N81-20803# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
IMAGE AND SENSOR DATA PROCESSING FOR TARGET ACQUISITION AND RECOGNITION
Nov. 1980 263 p refs In ENGLISH and FRENCH Proceedings of the 40th Tech. Meeting of the Avionics Panel of AGARD, Aalborg, Denmark, 8-12 Sep. 1980
(AGARD-CP-290; ISBN-92-835-0280-9; AD-A096493) Avail: NTIS HC A12/MF A01

Efforts to enhance the visibility of targets to be detected and identified are examined as well as limitations to the solutions proposed. Topics covered include: target backgrounds and visibility; man machine interactions; image processing, target tracking; and tag target classification and identification. For individual titles, see N81-20804 through N81-20825.

N81-20804# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Oberpfaffenhofen (West Germany). Inst. fuer Physik der Atmosphere.
THE OPTICAL CONTRAST OF LAND AND SEA TARGETS
H. E. HOFFMAN *In* AGARD Image and Sensor Data Process. for Target Acquisition and Recognition 10 p (SEE N81-20803 11-70) Nov. 1980 refs
Avail: NTIS HC A12/MF A01

In the last years the DFVLR has carried out field experiments for determining the visibility ranges maximum detection range, maximum recognition range or maximum identification range when observing ground to air or air to ground with different observation devices. During visibility tests in Northern Germany in summer and autumn 1977 the inherent contrast of a 1.5 t lorry and a minesweeper-type test boat belonging to the Bundeswehr were also measured. The measurements were taken using a photopic adapted photometer installed in a Bell UH 1D helicopter. Some of these measurement results are presented in diagrams and give information on the influence of the following parameters on the inherent contrast of both the land respectively sea targets: background illumination of target area, angle of elevation, time of day, parts of target, degree of cloud cover, angle of azimuth.
Author

N81-20805# Naval Air Development Center, Warminster, Pa.
AN APPROACH TO AIRBORNE INFRARED SEARCH SET PERFORMANCE MODELING
N. E. MACMEEKIN *In* AGARD Image and Sensor Data Process. for Target Acquisition and Recognition 10 p (SEE N81-20803 11-70) Nov. 1980 refs
Avail: NTIS HC A12/MF A01

An airborne search set mathematical model is described which predicts sensor performance in terms of probabilities of detection and false alarm in addition to calculating signals available for processing by the sensor. Inputs and submodels which describe and/or calculate target signatures, backgrounds, atmospheric effects and sensor design are discussed. Sensor performance is illustrated for several atmospheric conditions. Author

N81-20806# Etablissement Technique Central de l'Armement, Arcueil (France).
TARGET DETECTION AND CLASSIFICATION IN INFRARED IMAGERY [DETECTION ET CLASSIFICATION DE CIBLES EN IMAGERIE INFRA-ROUGE]
J. LOUCHET *In* AGARD Image and Sensor Data Process. for Target Acquisition and Recognition 11 p (SEE N81-20803 11-70) Nov. 1980 In FRENCH
Avail: NTIS HC A12/MF A01

A sequence is defined for automatically processing infrared images in order to detect and classify land targets. The nonuniformity of the background and the possible multiplicity of targets in these images require relatively complex processing which ends in the extraction of silhouettes. Methods for classifying the targets are considered. Transl. by A.R.H.

N81-20807# Philips Research Labs., Redhill (England).
REAL-TIME GREY-LEVEL HISTOGRAM MANIPULATION
L. H. GUILDFORD *In* AGARD Image and Sensor Data Process. for Target Acquisition and Recognition 12 p (SEE N81-20803 11-70) Nov. 1980 refs
Avail: NTIS HC A12/MF A01

The problem of how best to match the characteristics of a video signal of high dynamic range to those of a display is addressed with emphasis on adequately depicting small, but often important contrast changes within regions of widely differing mean brightness levels. A solution to the problem is proposed, which involves the application of real-time histogram modification techniques to a selected sub-area (Keyhole) within the image, combined with overall 2-D edge enhancement. The ACE microprocessor which permits implementation of this algorithm in order to investigate the subjective effects of real-time operation is described and some pictorial results are presented. This operator gives promising results especially where the next result is a local adaptive contrast stretch. A.R.H.

N81-20808# Vereinigte Flugtechnische Werke G.m.b.H., Bremen (West Germany).
TEAMWORK IN TARGET ACQUISITION
D. DEY, N. NINZ, and H. MUTSCHLER (Fraunhofer-Inst. fuer Informations- und Datenverarbeitung, Karlsruhe) *In* AGARD Image and Sensor Data Process. for Target Acquisition and Recognition 16 p (SEE N81-20803 11-70) Nov. 1980 refs
Avail: NTIS HC A12/MF A01

The performance in target acquisition or real-time reconnaissance can be improved by a team of observers. Different possible team organizations and their characteristics are described. In experiments with forward looking TV-films shot from a low level flying aircraft, different pseudo-team algorithms of one to four operators are considered. The acquisition performances are measured with different criteria and a cost function is evaluated which weights the success and confidence of the acquisition and *the time expense.* Author

N81-20809# National Aerospace Lab., Amsterdam (Netherlands).
IMAGE PROCESSING TECHNIQUES USING SPLINE APPROXIMATION
W. C. HUISMAN and J. VANKASTEEL *In* AGARD Image and Sensor Process. for Target Acquisition and Recognition 14 p (SEE N81-20803 11-70) Nov. 1980 refs
Avail: NTIS HC A12/MF A01

A two dimensional data compression method is described which is based on a least square image approximation with use of splines. This process is analyzed and in the frequency domain the feasibility of some candidate realizations of the real-time operating hardware is considered. The image reconstruction from the compressed data set consists of an off line computation of a modified compressed data set followed by a real-time replay interpolation process. In order to achieve a better image reconstruction, a flexible edge enhancement algorithm was developed. A.R.H.

N81-20810# Forschungsinstitut fuer Informationsverarbeitung, Karlsruhe (West Germany).
A FLEXIBLE IMAGE PROCESSING SYSTEM
P. GEMMAR, H. ISCHEN, and K. LUETJEN *In* AGARD Image and Sensor Data Process. for Target Acquisition and Recognition 10 p (SEE N81-20803 11-70) Nov. 1980 refs
Avail: NTIS HC A12/MF A01

Design principles and implementation techniques to realize high performance capabilities in a multiprocessor system are described in terms of simultaneous processing, structural flexibility, and data input/output. The flexible image processing system (FLIP) which operates in conjunction with a host computer and can perform up to 64 MIPS (million instructions per second) can be considered as a multi-pipeline-processor comprising 16 individual processors and a high speed data input/output processor. Structural flexibility is achieved by individual processors which can be arranged by programming in nearly any manner to adapt the hardware to an optimal processing structure of the function to be processed. A special data exchange processor provides convenient and rapid access to image data especially for all kinds of homogeneously performed window operations. Experimental results show that FLIP reduces image processing times by factors between 10 to 100 compared with conventional techniques (e.g., using a 1 MIPS general purpose computer). A.R.H.

N81-20811# Etablissement Technique Central de l'Armement, Arcueil (France). Lab. de Traitement d'Images.
ASSISTANCE IN INTERPRETING SATELLITE MULTISPECTRAL IMAGERY [AIDE A L'INTERPRETATION EN IMAGERIE SATELLITE MULTISPECTRALE]
M. REBUFFET *In* AGARD Image and Sensor Data Process. for Target Acquisition and Recognition 13 p (SEE N81-20803 11-70) Nov. 1980 In FRENCH
Avail: NTIS HC A12/MF A01

Serval aspects of the help that image processing by computers can bring to the extraction of information contained in images obtained by satellite are examined. This extraction seeks to establish a cartography and define a planimetry. It helps photointerpreters which must be limited to the number of documents that they can consult and facilitates the man machine interface. The three aspects discussed are: (1) enhancement of a multispectral image and reduction of redundancy; (2) correction of the geometry of an image by relation to a reference; and (3) interactive extraction of information of a graphic nature.
Transl. by A.R.H.

N81-20812# British Aerospace Dynamics Group, Hatfield (England). Infra-Red Equipment Div.
RESEARCH INTO METHODS OF IMAGE PROCESSING FOR TARGET ENHANCEMENT AND DETECTION
D. B. DUKE, A. J. FRYER, and P. A. BIRD *In* AGARD Image and Sensor Data Process. for Target Acquisition and Recognition 17 p (SEE N81-20803 11-70) Nov. 1980 refs
Avail: NTIS HC A12/MF A01

Methods of enhancing targets with respect to their backgrounds for ease of detection and recognition are discussed with emphasis on sensitivity enhancement and spatial resolution enhancement. The use of these methods for improving image interpretability and automatic target detection are discussed. A.R.H.

N81-20813# Norwegian Defence Research Establishment, Kjeller.
IMAGE ENHANCEMENT IN REAL TIME
H. YNDESTAD *In* AGARD Image and Sensor Data Process. for Target Acquisition and Recognition 5 p (SEE N81-20803 11-70) Nov. 1980 refs
Avail: NTIS HC A12/MF A01

An algorithm and a planned computer architecture for image enhancement in real time are presented. The algorithm reduces dynamic range and enhances contrast in an image by homomorphic filtering. The filter function is separable in column- and in line-direction, and the filter is implemented as a linear phase frequency sampling filter. Two dimensional filtering can then be achieved by filtering a picture first line by line and then column by column in a recursive filter. Dynamic range reduction and contrast enhancement are controlled by two parameters. The algorithm needs 32 arithmetic operations. The image processor is a set of processing elements, each having a specific task. One such task can be the described algorithm for homomorphic filtering. The processing element is built up by a microprocessor for local control, a bit slice processor for data transfer control and a specialized arithmetic unit for signal processing. Data transfer between processing elements is *carried out in a high speed ring network.*
Author

N81-20814# Forschungsinstitut fuer Informationsverarbeitung, Karlsruhe (West Germany)
SEMI-AUTOMATIC AND AUTOMATIC EXTRACTION OF OBJECTS FROM AERIAL IMAGES
W. KESTNER and M. STIES *In* AGARD Image and Sensor Data Process. for Target Acquisition and Recognition 13 p (SEE N81-20803 11-70) Nov 1980 refs
Avail: NTIS HC A12/MF A01

Different methods for the extraction of objects from aerial images are presented. Unlike other methods which process the complete image systematically, object guided methods were developed which are applied only to those parts of the image where objects or parts of objects have already been detected, i.e., where a continuation of an object is probable. Basic principles as well as details of the extraction methods are explained. The

methods differ with respect to the local precision of the results, the applicability to different object types and the required image quality. Local operators are described which evaluate grey level diagrams in order to detect object continuations. The methods were implemented on a computer DEC PDP 11/70. Results are presented. A.R.H.

N81-20815# Royal Signals and Radar Establishment, Malvern (England).
A DETECTION AND PROCESSING SCHEME FOR MOVING TARGET DETECTION USING A PASSIVE SENSOR
C. M. HENDERSON *In* AGARD Image and Sensor Data Process. for Target Acquisition and Recognition 11 p (SEE N81-20803 11-70) Nov. 1980
Avail: NTIS HC A12/MF A01

An adaptive spatial filter was implemented in digital hardware and a number of subsequent processing steps were developed including static clutter cancellation and tracking. The hardware is part of an experimental ground based infrared system for low level air surveillance. The spatial filter algorithm is based on using the intensities recorded in a small window to detect locally significant peaks. The effect of noise, quantization, and mismatch between channels is discussed. Variation in target subtense, target registration, and interchannel gaps affect detection probability and this was also explored by computer simulation. The filter produces multiple detections on a single peak and therefore an additional processing stage was devised to reduce multiple detections to single detections. Stationary alarms are removed by a process of static clutter cancellation and remaining alarms are handled by track forming using a microprocessor. Angular rate limits are applied to tracks and established tracks formed within rate limits are confirmed as moving targets. E.D.K.

N81-20816# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Wesseling (West Germany). Inst. fuer Dynamik der Flugsysteme.
A TV-TRACKING SYSTEM BASED ON COMPUTER INTELLIGENCE
G. HIRZINGER and K. LANDZETTEL *In* AGARD Image and Sensor Data Process. for Target Acquisition and Recognition 7 p (SEE N81-20803 11-70) Nov. 1980 refs
Avail: NTIS HC A12/MF A01

An operational system is described which tracks moving objects in an image and servoes a camera platform to continue tracking. The system uses a fast hardware contrast evaluation logic supplying contour coordinates to a supervisory control computer for further processing. Contrast evaluation is restricted to within a rectangular window, which is adapted to the object size automatically. The minicomputer being free from contour finding has enough time during one frame (20 msec) to process the contour data from the preceding frame. Essential criteria in treating problem situations are the changes in contour from the present frame to past frames after isolating the object motion from the superimposed camera motion. They are processed in a kind of heuristic truth tables. Improvements of the tracker are achieved merely by software refinements, that is by application of more elaborate algorithms. Originally the tracker was designed for ground to air tracking, meanwhile however ground to ground tracking was demonstrated for realistic situations too. E.D.K.

N81-20817# Etablissement Technique Central de l'Armement, Arcueil (France).
NUMERICAL TARGET TRACKING [POURSUITE NUMERIQUE DE CIBLES]
M. GIRARD *In* AGARD Image and Sensor Data Process. for Target Acquisition and Recognition 8 p (SEE N81-20803 11-70) Nov. 1980 In FRENCH
Avail: NTIS HC A12/MF A01

A method of logical correlation of images is applied to the tracking of targets on disturbed backgrounds. A target formed of several dozens of pixels can be characterized by points situated at angles to important density boundaries. The majority of these points are present in successive images and have the same vector of translation. They are then differentiated from the background. By this method, correlation is rapid and efficient, even for a disturbed background. It is also 'intelligent' because the evolution of a number of points often permits knowledge of the cause, and the algorithm best adapted for trying to avoid an uncoupling of the tracking can be chosen. Transl. by A.R.H.

N81-20818# EMI Electronics Ltd., Feltham (England).
TARGET TRACKING USING AREA CORRELATION
R. M. B. JACKSON *In* AGARD Image and Sensor Data Process. for Target Acquisition and Recognition 8 p (SEE N81-20803 11-70) Nov. 1980
Avail: NTIS HC A12/MF A01

The tracking system described based on the area correlator technique can provide a stable and accurate track of targets for use in airborne systems in conjunction with FLIR or TV imagers. It is a small size and can be built into standard format packages for installation in military aircraft. The main advantages of this technique are: (1) it can handle targets with a wide range of characteristics; (2) it can track background features to provide a ground reference; (3) it does not require that the edges of the target are within the tracking patches and it can handle targets which completely fill the field of view; (4) it can adapt automatically to magnification and target aspect changes; and (5) it provides highly tenacious tracking in low signal to noise conditions. E.D.K.

N81-20819# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (West Germany).
A REAL-TIME VIDEO TRACKING SYSTEM BASED ON BAYES RULE
W. WEIMER, W. LAIER, and E. KELLER *In* AGARD Image and Sensor Data Process. for Target Acquisition and Recognition 11 p (SEE N81-20803 11-70) Nov. 1980 refs
Avail: NTIS HC A12/MF A01

Essentially based on the distinction between two processes (target and scenery), tracking is broken down into three parts; signal acquisition and reduction, signal classification with respect to target and scenery, and determination of the target coordinates with the aid of the classified signals. It is shown that the Bayes' decision rule works optimally in a statistical sense. The target coordinates are determined by calculating the center of gravity using the probability of presence of the object pixels. In addition the target coordinates are filtered by means of a Kalman filter. This complete procedure is recursive and exhibits an adaptive, learning behavior. Similar algorithms were used in other applications and are known as unsupervised learning procedures. E.D.K.

N81-20820# Forschungsinstitut fuer Informationsverarbeitung, Karlsruhe (West Germany).
TARGET TRACKING AND TARGET DETECTION IN TV- AND FLIR-IMAGERY
M. BOHNER *In* AGARD Image and Sensor Data Process. for Target Acquisition and Recognition 17 p (SEE N81-20803 11-70) Nov. 1980 refs
Avail: NTIS HC A12/MF A01

Procedures for the detection of moving or stationary objects in single images and in image sequences and taken from a moving or stationary sensor are described. The objects are primarily located on the ground in their natural environment so that simple detection procedures cannot be applied. For those situations a tracking system was designed, simulated on a digital computer, and tested with an equipment for real time applications. The scale is determined separately and normalized by the location of object parts. The basic shortcomings of a correlation tracker system were eliminated in a system where in addition to the evaluation of the correlation function objects in the foreground or background are detected based on features like contrast, image differences, contour lines, shape, and relative speed of the objects. E.D.K.

N81-20821# Elektronik-System G.m.b.H., Munich (West Germany).
TARGET IDENTIFICATION OF AIRCRAFT USING IR/TV-SENSOR-IMAGES
D. MEYER, M. MUELLER, and A. WEIMANN *In* AGARD Image and Sensor Data Process. for Target Acquisition and Recognition 18 p (SEE N81-20803 11-70) Nov. 1980 refs
Avail: NTIS HC A12/MF A01

A procedure for noncooperative target identification of aircrafts by pattern recognition applied to TV/IR sensor images is presented. By a multi sensor tracking of high accuracy the position of an aircraft is well known. An imaging sensor with a narrow field of

view is pointed to the aircraft if it is in range. The image is then processed for significant parameters. The contours are extracted by adequate methods of image processing and evaluated for geometric relations which are independent of the projection angle and specific for individual types of aircrafts. The application to typical aircraft contours shows that the ensemble of the extracted parameters can identify different types of aircraft with some significance. An algorithm based on momentum invariants is proposed. The algorithm was implemented and tested on a digital computer by means of simulated noisy images. Some examples of identification results are presented and discussed. E.D.K.

N81-20822# Honeywell Systems and Research Center, Minneapolis, Minn.
AUTONOMOUS TARGET SCREENERS
R. K. AGGARWAL, M. GEOKEZAS, and D. E. SOLAND *In* AGARD Image and Sensor Data Process. for Target Acquisition and Recognition 14 p (SEE N81-20803 11-70) Nov. 1980 refs
Avail: NTIS HC A12/MF A01

The basic functions of an autonomous target screener are: segmentation, feature generation, classification (detection/recognition), and symbol generation. Image segmentation is the function by which the image is segmented in background and objects of interest. The image information within these objects of interest is processed to generate a set of features which characterize the targets of interest. The classification function utilizes statistical/syntactic classifier for detection (target vs. clutter decision) and recognition (truck, tank, APC, etc.). A symbol indicating the position and type of target is displayed on the monitor for cueing purposes. E.D.K.

N81-20823# Army Night Vision Lab., Fort Belvoir, Va.
EVALUATION OF A REALTIME PROTOTYPE AUTOMATIC TARGET CUER
T. L. JONES *In* AGARD Image and Sensor Data Process. for Target Acquisition and Recognition 7 p (SEE N81-20803 11-70) Nov. 1980
Avail: NTIS HC A12/MF A01

The procedures used and problems encountered in the preliminary evaluation of a prototype automatic target cuer which operates on video imagery are presented. Performance measures are defined and their use and limitations described. An overview is given of the operation, training, and field test scenario used to test this target cuer. Results of cuer performance are presented as examples of cuer evaluation procedures. E.D.K.

N81-20824# Rome Air Development Center, Griffiss AFB, N.Y.
DIGITAL IMAGE PROCESSING FOR GROUND TARGET DETECTION, IDENTIFICATION AND LOCATION
G. R. HUGHES *In* AGARD Image and Sensor Data Process. for Target Acquisition and Recognition 7 p (SEE N81-20803 11-70) Nov. 1980
Avail: NTIS HC A12/MF A01

Technology intensive efforts are categorized under each of the exploitation elements: target detection, identification and precision location. Research and development in the area of target detection consists of exploratory and advanced development work units in automated target correlation, automatic change detection, and pipeline image processing for screening probable target areas. Target identification research and developments presented includes automatic techniques for pattern recognition as well as semiautomated techniques for aiding an analyst by correlating various sensor and intelligence inputs to permit target identification. Near real time precision target location techniques include techniques for locating imagery targets in a predefined precision photographic data base as well as techniques for performing location simultaneously with target identification. E.D.K.

N81-20825# Air Force Wright Aeronautical Labs., Wright-Patterson AFB, Ohio. Avionics Lab.
A SYSTEM LOOK AT REAL TIME PROCESSING FOR TARGET ACQUISITION AND CLASSIFICATION
H. LAPP *In* AGARD Image and Sesor Data Process. for Target Acquisition and Recognition 9 p (SEE N81-20803 11-70) Nov. 1980 refs
Avail: NTIS HC A12/MF A01

The target acquisition through classification tasks are analyzed and the machine processing and data screening techniques that are applicable are discussed. The data handling capabilities of an onboard operator and ground based image interpreter are compared. A philosophy of processing data to get information as early as possible in the data handling chain is examined in the context of ground exploitation and dissimenation needs. Examples of how the various real time sensors (screeners and processors) could fit into this data handling scenario are discussed. E.D.K.

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OPTICS

Includes light phenomena.

N81-33982# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
SPECIAL TOPICS IN OPTICAL PROPAGATION
P. HALLEY, ed. Jul. 1981 415 p refs In ENGLISH and FRENCH Conf. held at Monterey, Calif., 6-10 Apr. 1981 (AGARD-CP-300; ISBN-92-835-0295-7; AD-A105193) Avail: NTIS HC A18/MF A01

The elements of knowledge which are technically utilizable, and the elements of development in the field of propagation and optical devices, which have a direct military application to communication and reconnaissance are assessed. The reconnaissance of sea traffic from surveillance satellites, strategic communications and communications with submerged submarines, which depend on propagation, and instruments, laser sources, and special filters are included.

N81-33983# Naval Ocean Systems Center, San Diego, Calif.
OVER-THE-HORIZON OPTICAL SCATTER PROPAGATION IN THE MARINE BOUNDARY LAYER
G. C. MOORADIAN and M. GELLER *In* AGARD Spec. Topics in Opt. Propagation 4 p (SEE N81-33982 24-74) Jul. 1981 refs
Avail: NTIS HC A18/MF A01

Measurements of the scattering properties from normal marine atmospheric aerosols for an over-the-horizon (OTH) optical propagation channel were made for two links. The first link involves an overwater range of 63 km with 19 km and 40 km horizons; the second involves an overwater range of 128 km with a 19 km horizon. Pathloss measurements as a function of transmitter-receiver azimuth and elevation angles for a 0.51 micron Ar-ion CW laser, and a 1.06 micron and 0.53 micron frequency doubled pulsed Nd:YAG laser are reported. Examples of atmospheric ducting are shown with an accompanying large increase of signal and severe scintillations. Two theoretical models are presented, one based on particulate single scatter and the other based on particulate multiple scatter. Comparison between models and the experimental results are made. J.M.S.

N81-33984# Tetra Tech, Inc., Pasadena, Calif.
MULTIPLE SCATTER OF COLLIMATED IRRADIANCE
W. H. WELLS, J. HARRIS, and H. C. LIN *In* AGARD Spec. Topics in Opt. Propagation 9 p (SEE N81-33982 24-74) Jul. 1981 refs Sponsored in part by the Navy
Avail: NTIS HC A18/MF A01

Multiple scattering of incoherent light (or other particles) in an optically thick medium with a plane surface is investigated using the method of spherical harmonics. Techniques that are particularly useful when scattered radiance has a forward peak that generates harmonics of very high degree are described. Convergence of computations hinges mainly on the small number of harmonics in the backscatter and not so much on the large number in the incident and forward scattered light. The method uses annihilation operators to improve the solution by removing eigenfunctions that propagate the wrong way. Backscattered radiance at the surface may be calculated without solving for interior radiance. J.M.S.

N81-33985# Pacific-Sierra Research Corp., Santa Monica, Calif.
GREEN'S FUNCTION CALCULATION OF THE EFFECTS OF THE AIR/WATER INTERFACE ON OPTICAL PROPAGATION
R. F. LUTOMIRSKI and D. E. SNEAD *In* AGARD Spec. Topics in Opt. Propagation 8 p (SEE N81-33982 24-74) Jul. 1981 refs
Avail: NTIS HC A18/MF A01

A Green's function formulation was developed for the propagation of radiance in forward scattering media. The method is used to compute the underwater downwelling radiance and irradiance distributions from a laser source impinging on the ocean surface from above. Calculating the second moment of the irradiance generates an analytic expression for the underwater scintillation in terms of the wave curvature statistics at the surface. J.M.S.

N81-33986# Washington Univ., Seattle. Dept. of Electrical Engineering.
MULTIPLE SCATTERING EFFECTS ON OPTICAL PROPAGATION IN TURBULENCE AND PARTICLES
A. ISHIMARU *In* AGARD Spec. Topics in Opt. Propagation 12 p (SEE N81-33982 24-74) Jul. 1981 refs
Avail: NTIS HC A18/MF A01

The propagation and scattering characteristics of optical beams in fog and clouds are examined. In contrast with the turbulence, the droplet sizes of fog and clouds are comparable to a wavelength and the scattering is spread over wide angles. Therefore, the wave transmission and scattering exhibit different characteristics depending upon whether the particle sizes are smaller or larger than a wavelength. Three solutions and their limitations are discussed. The forward scatter approximation is used for large particles, while the diffusion approximation is used for small particles. The radiative transfer can be used for all sizes. However, solutions are availale only for special wave types and medium geometries. J.M.S.

N81-33987# German Military Geophysical Office, Traben-Trarbach (West Germany).
INVESTIGATIONS FOR THE DEVELOPMENT OF A FORECAST SYSTEM FOR UNDERWATER-VISIBILITY IN THE HELIGOLAND BIGHT
E. R. KUESTERS *In* AGARD Spec. Topics in Opt. Propagation 6 p (SEE N81-33982 24-74) Jul. 1981 refs
Avail: NTIS HC A18/MF A01

In the Heligoland Bight, a shallow part of the North Sea, correlations between meteorological/oceanographic parameters and turbidity are investigated. There are two components that influence underwater visibility: inorganic material and plankton. During most of the year a reduction of the visibility is caused by sediment particles stirred up by strong winds. In summer, however, especially in August, plankton can reach such densities that its influence is greater than that of inorganic material. The vertical extension of the layer rich in plankton is limited by salinity stratifications. During calm periods internal tides make the salinity boundary layer oscillate up and down. The drastic reduction in transparency by sediment particles normally lasts until the third day after the end of a storm, then a pronounced improvement can be noticed. J.M.S.

N81-33988# Naval Postgraduate School, Monterey, Calif.
METEOROLOGICAL DESCRIPTIONS FOR OPTICAL PROPERTIES
K. L. DAVIDSON, G. E. SCHACHER, and C. W. FAIRALL (BDM Corp., Monterey, Calif.) *In* AGARD Spec. Topics in Opt. Propagation 9 p (SEE N81-33982 24-74) Jul. 1981 refs
Avail: NTIS HC A18/MF A01

Observational experiments on turbulent intensities and aerosol distributions in the marine atmospheric boundary layer were performed to relate optical properties to bulk meteorological parameters. Parameters which define the surface fluxes of momentum, heat, and moisture, the processes at the inversion, and the profiles within the intervening convectively mixed layer were examined. Results indicate that optical turbulence (C sub n sq) can be accurately estimated from measured values of wind, temperature, and humidity. A bulk model for estimating optical turbulences was evaluated on the basis of optically determined values with good agreement. Good agreement was observed between extinction values obtained from transmission measurements and those obtained from measured aerosol distributions. However, an existing empirical expression to relate the latter to wind speed and relative humidity appears to be inadequate. J.M.S.

N81-33989# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Wesseling (West Germany). Inst. fuer Physik der Atmosphaere.
DEPENDENCE OF AIR TO GROUND (LAND AND SEA) VISIBILITY RANGES ON LOW FLIGHT ALTITUDES IN CONJUNCTION WITH METEOROLOGICAL PARAMETERS
H. E. HOFFMANN *In* AGARD Spec. Topics in Opt. Propagation 6 p (SEE N81-33982 24-74) Jul. 1981 refs
Avail: NTIS HC A18/MF A01

In outdoor tests the influence of different observation and environmental parameters on the visibility of objects observed from a helicopter was determined. During these tests it was also researched how distances for detection, recognition, and identification change for observations with the naked eye, when these observations are made from different altitudes in the lower atmosphere. In one case it showed up that an increase of the flight altitude by 100 m caused a decrease of the maximum identification range from 2 to 0.8 km, and of the maximum detection range from 15 to 13 km. This might be explained by layers of increased aerosol extinction within the range of temperature inversion or below the cumulus condensation level. J.M.S.

N81-33990# Centre de Recherches de la Compagine Generale d'Electricite, Marcoussis (France).
DETERMINING THE PERFORMANCE OF A COAT SYSTEM IN THE TRACKING PHASE [DETERMINATION DES PERFORMANCES D'UN SYSTEME COAT EN REGIME DE POURSUITE]
G. ROGER *In* AGARD Spec. Topics in Opt. Propagation 10 p (SEE N81-33982 24-74) Jul. 1981 refs In FRENCH; ENGLISH summary
Avail: NTIS HC A18/MF A01

The performance of a COAT system the phase tracking is operating is computed. Phase errors are detected by dithering so the system uses two deformable mirrors of any type, one for correction, one for modulation. It is assumed that the phase errors which must be corrected, the characteristics of the mirrors, the noise spectral density of the receiver, and the gain matrix are known. An expression which represents the gain loss due to the phase errors is determined and a vector space of surfaces with an inner product such that the loss appears as the squared norm of a vector in that space is defined. Changing the basis of the vector space permits the shape of the wave front to be expressed as a combination of simple shapes, which may guide the choice of the mirror structure. The minimal loss corresponding to the correcting mirror, then the loss corresponding to the combination of the correcting mirror and the modulating mirror are computed. The gain matrix is introduced and the general loop equation of the complete system is obtained. J.M.S.

N81-33991# Physics Lab. NDRO-TNO, The Hague (Netherlands).
ATMOSPHERIC MEASUREMENTS IN A COASTAL ENVIRONMENT
T. BAKKER *In* AGARD Spec. Topics in Opt. Propagation 11 p (SEE N81-33982 24-74) Jul. 1981 refs
Avail: NTIS HC A18/MF A01

The results of measurement projects concerning atmospheric limitations for the application of electro-optical equipment are reviewed. Results of simultaneous transmission measurements along close parallel tracks in the visible and the infrared as well as the mm wave (94GHz) region are compared. Long range (5 km) laser transmission measurement results are given. Remote measurement techniques as well as aerosol counters were applied in order to determine the relevant atmospheric characteristics. The measurements were carried out in a coastal environment and on the North Sea. In order to study mutual relationships meteorological measurements were done simultaneously J.M.S.

N81-33992# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Wesseling (West Germany). Inst. of Optoelectronics.

MEASUREMENTS OF CLOUD DEPOLARIZATION AND MULTIPLE SCATTERING

C. WERNER and E. WOLFF *In* AGARD Spec. Topics in Opt. Propagation 12 p (SEE N81-33982 24-74) Jul. 1981 refs

Avail: NTIS HC A18/MF A01

A calibrated lidar system is used to obtain values of backscatter coefficients, depolarization rations, and multiple scattering effects. Measurements of cloud polarization and multiple scattering effects on different cloud types are reported. An anisotropy of the depolarization with the axmuth angle was determined. This anisotropy depends on the size of the cloud droplets. J.M.S.

N81-33993# Laboratoire d'Optique Appliquee, Palaiseau (France).

APPLICATION OF LASERS TO THE MEASUREMENT OF ATMOSPHERIC GASES FROM A A DISTANCE: THE USE OF RESONANT RAMAN DIFFUSION [APPLICATION DES LASERS A LA MESURE A DISTANCE DES GAZ ATMOSPHERIQUES: UTILISATION DE LA DIFFUSION RAMAN RESONNANTE]

J. C. POURNY and H. ELNABYSALAH *In* AGARD Spec. Topics in Opt. Propagation 11 p (SEE N81-33982 24-74) Jul. 1981 refs In FRENCH

Avail: NTIS HC A18/MF A01

The use of lasers for remotely detecting gaseous compounds in the atmospheric was developed in different lidar techniques involving several types of interactions of monochromatic laser light with atmospheric molecules. Measurement by absorption, particularly in the infrared, permits sensitivities on the order of ppb, on a measurement path of some hundreds of meters. Differential absorption, which is less sensitive, affords the possibility of exploring in all directions with a distance resolution. Lidar measurement based on Raman diffusion permits sounding numerous molecular constituents with a single laser ray. Its use is always limited to highly concentrated compounds. Tunable lasers are beneficial in the case of resonance where the Raman diffusion section increases strongly. Cross sections for NO2, SO2, and O3 are examined. It is shown that the method is of interest in detecting dispersed constituents in clouds. Transl. by A.R.H.

N81-33994# Naval Postgraduate School, Monterey, Calif. Dept. of Physics and Chemistry.

MULTIWAVELENGTH EXTINCTION AND INDEX FLUCTUATION MEASUREMENTS

E. C. CRITTENDEN, JR., E. A. MILNE, A. W. COOPER, G. W. RODEBACK, and S. H. KALMBACH *In* AGARD Spec. Topics in Opt. Propagation 7 p (SEE N81-33982 24-74) Jul. 1981 refs

Avail: NTIS HC A18/MF A01

The effects of aerosols and turbulence on optical propagation through the atmosphere were measured with double ended systems. Path lengths up to 15 km were utilized. For horizontal paths, the length is limited by the curvature of the Earth. Both band-filtered grey body and laser sources are used for extinction measurements at 16 wavelengths from 0.4 to 10 micrometers. A chopped beam is used with synchronous detection, to improve signal-to-noise ratio. Detection and digitization of the received signal are triggered by means of a small-divergence pulsed pilot laser beam, located at the center of the main beam. The effects of turbulence on the index of refraction were determined using scintilation and optical transfer function. Equipment was developed to make optical transfer function measurements with a pulsed source on an aircraft during of fly-over. A.R.H.

N81-33995# Scripps Institution of Oceanography, San Diego, Calif. Visibility Lab.

MEASUREMENTS OF OPTICAL ATMOSPHERIC QUANTITIES IN EUROPE AND THEIR APPLICATION TO MODELING VISIBLE SPECTRUM TRANSMITTANCE

R. W. JOHNSON and W. S. HERING *In* AGARD Spec. Topics in Opt. Propagation 12 p (SEE N81-33982 24-74) Jul. 1981 refs

(Contract F19628-78-C-0200)

Avail: NTIS HC A18/MF A01

A series of data flights to obtain simultaneous optical and meteorological measurements betwen ground levels and an altitude of 6 km was conducted during each of five separate two month periods selected to be representative of each of the four temporal seasons. Illustrative data representing altitude profiles of visible spectrum scattering characteristics are presented, as are the simultaneous measurements of ambient and dewpoint temperature. Several contemporaneous sets of multi-spectral directional volume scattering function measurements at scattering angles of 30 and 150 degrees are included. The use of these data as a basic for the development of a technique for estimating atmospheric path radiance and contrast transmittance is discussed. A computer model for the estimation of these atmospheric properties that is relatively fast and easy to apply is described with examples of its performance. The model predicts the directional path radiance and contrast transmittance of any slant atmospheric path as a function of wavelength. A.R.H.

N81-33996# Naval Ocean Systems Center, San Diego, Calif.

COMPARISON OF UNDERWATER RADIANCE MEASUREMENTS WITH VARIOUS ANALYTICAL TREATMENTS OF THE RADIATIVE TRANSFER EQUATIONS

R. ANDERSON and L. STOTTS *In* AGARD Spec. Topics in Opt. Propagation 16 p (SEE N81-33982 24-74) Jul. 1981 refs

Avail: NTIS HC A18/MF A01

In situ experimental data are presented on the off-axis radiance produced by a pulsed underwater laser operating at a wavelength of 520 nanometers. Path lengths in homogeneous seawater range up to 50 meters with separations of up to more than 6 meters from the path. Absorption and scattering lengths in the water are about 6 and 4 meters, respectively. These results are compared with the predictions provided by popular models derived from radiative energy theory. Limitations are clearly shown on the accuracy of the radiance predicted by these models. Author

N81-33997# GTE Sylvania, Inc., Mountain View, Calif. Systems Group.

DOWNLINK LASER CLOUD PROPAGATION EXPERIMENT

G. R. HOSTETTER and P. J. TITTERTON *In* AGARD Spec. Topics in Opt. Propagation 10 p (SEE N81-33982 24-74) Jul. 1981 refs

Avail: NTIS HC A18/MF A01

An experiment was designed to obtain the first measurements of laser pulse stretching resulting from downward vertical propagation through a cloud. For the nonuniform clouds that were present over Kauai, pulse stretching was found to be less than was expected from propagation thoery. The clouds were characterized by an aircraft-borne Knollenberg particle counter and by attenuation of moonlight passing through the cloud layer. For cloud geometric thickness of 4,000 to 8,600 feet and optical thickness of 19 to 86, the received pulsewidths range from 1 to 7 microseconds. These received pulsewidths were from 0.05 to 0.2 of the theoretically predicted values. Typically, to received pulse were composed of a fast and a slow component, indicating at least two different propagation modes through the clouds. The widths of the slow components were approximately equal to the theoretical values predicted for the entire pulse. A.R.H.

N81-33998# York Univ., Downsview (Ontario). Dept. of Physics.

LABORATORY MEASUREMENTS OF LIGHT PROPAGATION IN TURBID MEDIA

A. I. CARSWELL *In* AGARD Spec. Topics in Opt. Propagation 9 p (SEE N81-33982 24-74) Jul. 1981 refs

Avail: NTIS HC A18/MF A01

The propagation and scattering of laser beams in turbid media were investigated experimentally. Water droplet clouds and liquid water suspensions of scatterers were studied. A major area of interest was the use of polarization information to measure multiple scattering. In the forward direction the effects of multiple scattering on the extinction coefficient and on the beam shape were measured. It was found that the incident beam characteristics (width, polarization, coherence) are strongly preserved in the forward direction even at extinction coefficients as high as 5 m/1. In the backward direction, measurements of cloud reflectance were made. The polarization of the reflected signal is found to be spatially anisotropic and to depend strongly on the size parameter of the scatterers. Applications of the findings for diagnostics of turbid situations in the atmosphere are discussed. A.R.H.

N81-33999*# Scripps Institution of Oceanography, La Jolla, Calif. Visibility Lab.
REMOTE SENSING OF THE DIFFUSE ATTENUATION COEFFICIENT OF OCEAN WATER
R. W. AUSTIN *In* AGARD Spec. Topics in Opt. Propagation 9 p (SEE N81-33982 24-74) Jul. 1981 refs
(Contract NAS5-26249; N00014-78-C-0566; NOAA-04-6-158-44033; NOAA-NA80AA-D-00007)
Avail: NTIS HC A18/MF A01 CSCL 20F

A technique was devised which uses remotely sensed spectral radiances from the sea to assess the optical diffuse attenuation coefficient, K (lambda) of near-surface ocean water. With spectral image data from a sensor such as the coastal zone color scanner (CZCS) carried on NIMBUS-7, it is possible to rapidly compute the K (lambda) fields for large ocean areas and obtain K 'images' which show synoptic, spatial distribution of this attenuation coefficient. The technique utilizes a relationship that has been determined between the value of K and the ratio of the upwelling radiances leaving the sea surface at two wavelengths. The relationship was developed to provide an algorithm for inferring K from the radiance images obtained by the CZCS, thus the wavelengths were selected from those used by this sensor, viz., 443, 520, 550 and 670 nm. The majority of the radiance arriving at the spacecraft is the result of scattering in the atmospheric and is unrelated to the radiance signal generated by the water. A necessary step in the processing of the data received by the sensor is, therefore, the effective removal of these atmospheric path radiance signals before the K algorithm is applied. Examples of the efficacy of these removal techniques are given together with examples of the spatial distributions of K in several ocean areas. A.R.H.

N81-34000# Air Force Geophysics Lab., Hanscom AFB, Mass. Optical Physics. Div.
RECENT AUROROL AND AIRGLOW MEASUREMENTS IN THE INFRARED
A. T. STAIR, JR., R. NADILE, J. C. ULWICK, K. D. BAKER, and D. J. BAKER *In* AGARD Spec. Topics in Opt. Propagation 6 p (SEE N81-33982 24-74) Jul. 1981 refs Prepared in cooperation with Utah State Univ., Logan
Avail: NTIS HC A18/MF A01

Specialized cryogenic infrared instrumentation was developed for measuring the aurora, airglow, and upper atmospheric emissions for aircraft, rockets, and satellite platforms. Starting in 1972, a series of some 30 rockets have been launched from Poker Flat, Alaska. The highlights, of these measurements, the first auroral enhancements at wavelengths longer than 2 micrometers and the first upper atmospheric radiation observed from 70 to 150 km in the wavelength region 2 to 2 micrometers are reviewed. In addition, more recent data obtained by a rocketborne cryogenic telescoped spectrometer which scanned the earthlimb and observed infrared (1.5 to 17 micrometers) emissions from 20 km to 200 km tangent altitudes are discussed. A.R.H.

N81-34001# Air Force Geophysics Lab., Hanscom AFB, Mass.
BACKGROUND MEASUREMENTS FROM A BALLOON-BORNE STARING SENSOR
R. E. MURPHY, F. H. COOK, and B. K. YAP (Yap Analytics, Inc., Lexington, Mass.) *In* AGARD Spec. Topics in Opt. Propagation 11 p (SEE N81-33982 24-74) Jul. 1981 refs
Avail: NTIS HC A18/MF A01

Several hours of data were gathered on three successful data flights conducted as part of the balloon altitude mosaic measurements (BAMM) program which was designed to collect spectral, spatial, and temporal statistics on the infrared Earth/atmospheric backgrounds. Two of these flights collected data on a wide range of infrared backgrounds characteristics of the Southwestern United States. A third mission provided statistics of the Gulf Coast region as well as solar specular reflections off land, water, and clouds. Measurements were made with a two-color SWIR radiometer and with a Michelson interferometer spectrometer covering the 2.5 to 5.5 micron region from float altitudes of 70,000 to 100,000 ft. Both instruments were spatially co-aligned such that their 4x4 mosaic focal planes projected over-lapping footprints on the ground simultaneously. Data collected on these flights were reduced and relevant statistics were compiled. Samples of the data and results are presented. A.R.H.

N81-34002# Nice Univ. (France). Dept. d'Astrophysique.
OPTICAL C SUB N SQ REMOTE SENSING IN THE UPPER ATMOSPHERIC BY MULTIDIMENSIONAL ANALYSIS OF STELLAR SCINTILLATION
J. VERNIN and M. AZOUIT *In* AGARD Spec. Topics in Opt. Propagation 9 p (SEE N81-33982 24-74) Jul. 1981 refs
Avail: NTIS HC A18/MF A01

Multidimensional statistical analysis of stellar scintialltion, the motion of the various atmospheric turbulent layers can be determined both in magnitude and direction, in addition to their turbulent strength (as measured by square (sub n or square C sub to) as a function of altitude. A system which consists of a very light-sensitive image receiver (television camera), followed by a specialized numerical computer (two-dimensional correlator) which utilizes in real time the spatial distribution of the irradiance of a large telescope entrance pupil was developed. This apparatus allows identification of fast temporal variations of the vertical profiles of turbulence strength, using sounding only 10 sec apart. By tracking the double star gamma Virginis, a vertical resolution of about 1.7 km was achieved. Temporal evolution of the reflective index at a given altitude shows that the turbulence remains for several hours but it concentrates in small patches of a few kilometers length. A statistical study of these variations shows that it is possible to modelize the intermittency of the atmospheric turbulence by a this lag power law such as tau to the 0.31 power. A.R.H.

N81-34003# Visidyne, Inc., Burlington, Mass.
INFRARED RADIANCE MODEL OF THE UPPER ATMOSPHERE
T. C. DEGGES and H. J. P. SMITH *In* AGARD Spec. Topics in Opt. Propagation 14 p (SEE N81-33982 24-74) Jul. 1981 refs
Avail: NTIS HC A18/MF A01

A physical model to predict infrared emission was implemented in a computer program that computes infrared radiances for an Earth's limb viewing geometry. The nominal spectral region covered lies between 2.5 and 25 micrometers and emphasis is placed on radiation originating at altitudes between 50 and 300 km. The basic result from the model is the calculation of the populations of vibrational states of the important infrared emitters such as carbon dioxide, water vapor, ozone and nitric oxide. In the troposphere and lower stratosphere, molecular collisions are rapid enough to maintain vibrational populations in kinetic equilibrium. At higher altitudes, radiative de-excitation may be faster than collisional or radiative excitation, and a nonequilibrium vibrational population results. The model uses collisional excitation and de-excitation rates obtained from published data when possible and balances collisional processes with absorption and emission of infrared radiation. The equations of radiative transfer are solved at each level to include absorption of radiation from the Earth's surface, all other atmospheric levels and the Sun. R.C.T.

N81-34004# Atmospheric Radiation Consultants, Acton, Mass.
MINIMUM DETECTABLE QUANTITIES OF TRACE GASES USING HIGH RESOLUTION SPECTROSCOPY
A. S. ZACHOR, B. BARTCHI (Utah State Univ., Logan), and F. P. DELGRECO (AFGL) *In* AGARD Spec. Topics in Opt. Progagation 6 p (SEE N81-33982 24-74) Jul. 1981 refs
(Contract F19628-77-C-0203)
Avail: NTIS HC A18/MF A01

Studies that define the capability of a Fourier spectrometer (FTS) system to remotely detect and characterize particular gaseous emissions by ground-level stationary sources are summarized. The principal result was a tabulation of predicted minimum detectable quantities (MDQ's) for 14 trace gases including DF, HF and N2O. The detectable (observable) quantity of the target gas was essentially the product of the molecular column thickness of the gas in the line of sight and the Planck spectral radiance difference between the target gas and background averaged over the detection band. The MDQ's are the values of this quantity which correspond to approximately 95 percent probability of detection and one percent probability of false detection. Although derived for a particular baseline system and measurement geometry, the results can be scaled to other conditions. The baseline FTS systems modelled in the studies employ mosaic focal planes together with optical designs or data processing techniques that perform background subtraction to obtain the target background spectral radiance contrast. Detection and quantification of the target gases are based on the degree of

correlation of the observed target spectral contrast with predicted target spectral contrast signatures. R.C.T.

N81-34005# Massachusetts Inst. of Tech., Cambridge. Dept. of Electrical Engineering and Computer Science.
LINE-OF-SIGHT OPTICAL COMMUNICATION THROUGH LOW-VISIBILITY WEATHER
J. H. SHAPIRO *In* AGARD Spec. Topics in Opt. Propagation 9 p (SEE N81-33982 24-74) Jul. 1981 refs
(Contract NSF ENG-78-78216)
Avail: NTIS HC A18/MF A01

The multiple forward scatter propagation model for a line of sight optical link operating in low visibility weather is summarized. Digital communication performance for diffraction limited and wide field of view receivers are compared. It is shown that background light suppression is the key to extended link operability in the daytime. Three techniques for achieving this suppression are: use of a wide angle narrowband optical filter at the receiver; operation at mid ultraviolet wavelength; and use of adaptive phase compensation at the receiver. The promise and drawbacks of these approaches are briefly discussed. R.C.T.

N81-34006# Naval Ocean Systems Center, San Diego, Calif.
MERCURIC BROMIDE DISSOCATION LASERS
E. SCHIMITSCHEK *In* AGARD Spec. Topics in Opt. Propagation 11 p (SEE N81-33982 24-74) Jul. 1981 refs
Avail: NTIS HC A18/MF A01

The principal features of HgBr2/HgBr dissociation lasers are reviewed. Particular attention is given to their performance status and potential applications for underwater communication systems. R.C.T.

N81-34007# General Electric Co., Philadelphia, Pa.
COPPER VAPOR LASERS: A REVIEW
T. W. KARRAS *In* AGARD Spec. Topics in Opt. Propagation 9 p (SEE N81-33982 24-74) Jul. 1981 refs
Avail: NTIS HC A18/MF A01

Typical operation for two discharge configurations were investigated. Emphasis was placed on an immature transverse discharge mode and a more developed longitudinal discharge mode. Both were demonstrated at average powers exceeding 50 watts. Master oscillator power amplifier operation was used to extend the power of nominal 15 watt modules to over 100 watts. This device also showed great flexibility in its various output parameters. Repetition rate was varied from a single pulse to over 100 kilohertz. Pulse width was changed from 5 to 185 nanoseconds. Its volume was greatly increased while maintaining constant specific output. R.C.T.

N81-34008# General Electric Co., Schenectady, N. Y. Corporate Research and Development Div.
RECENT DEVELOPMENT OF HIGH-POWER VISIBLE LASER SOURCES EMPLOYING SOLID-STATE SLAB LASERS AND NONLINEAR HARMONIC CONVERSION TECHNIQUES
Y. S. LIU, W. B. JONES, and J. P. CHERNOCH *In* AGARD Spec. Topics in Opt. Propagation 8 p (SEE N81-33982 24-74) Jul. 1981 refs
Avail: NTIS HC A18/MF A01

Developments of high power solid state slab laser technology in both Yd:YAG and Nd:glass are reported. High power nonlinear frequency conversion, employing second harmonic generation in various nonlinear crystals is discussed. Nonlinear phase matching properties critical to efficient frequency conversion in LiIO3, LiNbO3, CDA, KDP, and recently developed KTP (KTiOPO4) are presented. Efficient frequency conversion in the average power range exceeding 10 W imposes severe constraints in both fundamental beam properties and the nonlinear processes in various media. R.C.T.

N81-34009# Naval Research Lab., Washington, D. C.
DOWN-CONVERSION OF RARE GAS HALIDE LASERS FOR BLUE-GREEN APPLICATIONS
R. BURNHAM, N. DJEU, and B. L. WEXLER *In* AGARD Spec. Topics in Opt. Propagation 6 p (SEE N81-33982 24-74) Jul. 1981 refs
Avail: NTIS HC A18/MF A01

The down conversion of rare gas lasers to the blue-green region was investigated with respect to its scalability and efficiency for applications in blue-green communications systems. Attention was also given to progress in Raman conversion of the XeCl laser output in atomic and molecular media. R.C.T.

N81-34010# Lockheed Missiles and Space Co., Palo Alto, Calif.
NARROW BANDPASS LARGE FIELD OF VIEW OPTICAL FILTERS
W. J. ROSENBERG and A. M. TITLE *In* AGARD Spec. Topics in Opt. Propagation 12 p (SEE N81-33982 24-74) Jul. 1981 refs
(Contract N00014-78-C-0526)
Avail: NTIS HC A18/MF A01

The types and capabilities of birefringent filters are reviewed. The general operating principles of Lyot (perfect polarizers), partial polarizing, and Solc (no internal polarizers) filters are introduced. Appropriate techniques for tuning each filter type are presented. Field of view of birefringent filters is discussed and is compared to Fabry-Perot and interference filters. The transmission and throughput advantage of birefringent filters are shown. The state of the art in practical filters is also reviewed. R.C.T.

N81-34011# McDonnell-Douglas Astronautics Co., St. Louis, Mo.
OPTICAL RECEIVERS FOR UNDERWATER COMMUNICATION
J. E. JACKSON, G. M. LEE, and C. M. CIANY *In* AGARD Spec. Topics in Opt. Propagation 16 p (SEE N81-33982 24-74) Jul. 1981 refs
Avail: NTIS HC A18/MF A01

The tradeoffs which must be considered to develop an optimum overall receiver design are discussed. The available choices for a receiver filter are presented and an overall receiver configurat n is developed. R.C.T.

N81-34012# Standard Elektrik Lorenz A.G., Stuttgart (West Germany).
OPTICAL FIBER COMMUNICATION AT DIFFERENT TRANSMISSION WAVELENGTHS
K. HESS and H. HAUPT *In* AGARD Spec. Topics in Opt. Propagation 7 p (SEE N81-33982 24-74) Jul. 1981 refs
Avail: NTIS HC A18/MF A01

The development of 34 Mbit/s optical transmission systems operated at 850 nm and 1200 nm and using graded index multimode fibers are reported and compared. The results of a field trial are presented which illustrate that fiber optic transmission is well suited for real applications. R.C.T.

N81-34013# Hughes Research Labs., Malibu, Calif.
NONLINEAR ADAPTIVE OPTICS
C. R. GIULIANO *In* AGARD Spec. Topics in Opt. Propagation 13 p (SEE N81-33982 24-74) Jul. 1981 refs
Avail: NTIS HC A18/MF A01

A brief history of the activity in the field of nonlinear optical phase conjugation is presented. The principle for utilizing a nonlinear conjugation in adaptive optics is also discussed. Several examples of potential applications for optical phase conjugation are given. R.C.T.

N81-34014# Laboratoire Central de Recherches Thomson-CSF, Orsay (France).
PHASE CONJUGATION AND DEGENERATE FOUR WAVE MIXING IN PHOTOREFRACTIVE BI12SIO20 CRYSTAL
J. P. HUIGNARD and J. P. HERRIAU *In* AGARD Spec. Topics in Opt. Propagation 6 p (SEE N81-33982 24-74) Jul. 1981 refs
Avail: NTIS HC A18/MF A01

Generation of phase conjugate wavefronts by using real time holography and degenerate four wave mixing in Bi12SiO20 crystals (BSO) is described. Removal of phase distortions by allowing the time reversed phase conjugate wavefront to travel back through the phase disturbing medium is demonstrated. The spatial frequency dependence of wavefront reflectivity is considered. The use of BSO for real time interferometry is described. Degenerate four wave mixing in BSO crystals with a pulsed Nd YAG laser is demonstrated. Applications of the crystal for coherent image processing, optical computing high speed adaptive optics, hand coherent optical processing are considered. J.D.H.

N81-34015# Istituto Superiore delle Poste e delle Telecomunicazioni, Rome (Italy).
THEORY OF NONLINEAR PROPAGATION IN MULTIMODE OPTICAL FIBERS
B. CROSIGNANI, P. DIPORTO, and C. H. PAPAS (California Inst. of Technology, Pasadena) *In* AGARD Spec. Topics in Opt. Propagation 6 p (SEE N81-33982 24-74) Jul. 1981 refs
Avail: NTIS HC A18/MF A01

A set of equations which describes pulse propagation in multimode optical fibers in the presence of an intensity dependent refractive index is derived by taking advantage of the coupled mode theory usually employed for describing the influence of fiber imperfections on linear propagation. The role of the waveguide structure in terms of the propagation constants and the spatial configurations of the propagating modes is considered. The conditions under which envelope soliton transmission in the presence of many modes taken place are discussed. The way in which these conditions are modified by the possible presence of carrier fluctuations is considered. J.D.H.

N81-34016# City Coll. of the City Univ. of New York. Dept. of Physics.
THEORY OF NONLINEAR PULSE PROPAGATION IN INHOMOGENEOUS DISPERSIVE MEDIA: APPLICATION TO OPTICAL WAVEGUIDES
N. TZOAR, B. BENDOW (RADC, Hanscom AFB, Mass.), and P. D. GIANINO (RADC, Hanscom AFB, Mass.) *In* AGARD Spec. Topics in Opt. Propagation 6 p (SEE N81-33982 24-74) Jul. 1981 refs
Avail: NTIS HC A18/MF A01

Nonlinear pulse propagation in longitudinally uniform and nonuniform optical waveguides is analyzed. The approximate analysis employed takes account of various physical effects associated with transverse confinement, dispersion and nonlinearity. It is concluded that both bright and dark solitons may be supported in typical fiberguides under a variety of conditions. This is in marked contrast to the unbounded medium case, where bright silitons exist only under conditions of anomolous dispersion. In the presence of weak longitudinal inhomogeneity, solitons continue to propagate without a change of shape, but their group velocity becomes time dependent. J.D.H.

N81-34017# Massachusetts Inst. of Tech., Cambridge. Dept. of Electrical Engineering and Computer Science.
HOW TO TAP A FIBER OPTIC LINK AND ELUDE DETECTION: WHAT'S NEW IN QUANTUM COMMUNICATION
J. H. SHAPIRO *In* AGARD Spec. Topics in Opt. Propagation 5 p (SEE N81-33982 24-74) Jul. 1981 refs
Avail: NTIS HC A18/MF A01

The conditional Poisson process statistical model for direct detection, from which the signal plus additive white Gaussian noise statistical models for heterodyne and homodyne detection may be derived is examined. The relationship between these results and recently derived quantum mechanical photodetection formulas is reviewed. It is shown that the two coincide only when the radiation field incident on the detector is in a Glauber coherent state or a random mixture of such states. The two photon coherent states, which are not of this class, are described. They have novel quantum noise characteristics that permit noise reduction to be realized in homodyne detection. In particular, use of two photon coherent state light makes possible high signal to noise ratio detection from a directional coupler that is very weakly linked to an information bearing optical waveguide. Accordingly, a low loss waveguide tap may permit an unauthorized party to obtain information from an optical data bus in a virtually undetectable manner. This result as well as other mysteries and applications of two photon coherent states are explained. J.D.H.

N81-34018# Laboratoire Central de Recherches Thomson-CSF, Orsay (France).
USE OF A REMOTELY CONTROLLED INTEGRATED DIRECTIONAL COUPLER SWITCH IN AN OPTICAL FIBER LINK
P. PAPUCHON, C. PUECH, and A. SCHNAPPER *In* AGARD Spec. Topics in Opt. Propagation 9 p (SEE N81-33982 24-74) Jul. 1981 refs
Avail: NTIS HC A18/MF A01

The observation of optical bistability with bulk or integrated modulators or switches, and without a Fabry Perot cavity, is demonstrated. In their output light intensity versus incident light intensity behavior, such devices exhibit hysteresis and can be used as optical limiters, pulse shapers, optical transistors, and bistable switches. The remote control of a bistable directional coupler switch is described. It is shown that the output light from the directional coupler can be switched from one channel to the other via switching informations contained in the incident light itself. J.D.H.

N81-34019# Consiglio Nazionale delle Ricerche, Florence (Italy). Inst. of Ricerca sulle onde Elettromagnetiche.
RESOLVING POWER EVALUATION OF OPTICAL ADAPTIVE SYSTEMS THROUGH THE ATMOSPHERE
A. CONSORTINI *In* AGARD Spec. Topics in Opt. Propagation 4 p (SEE N81-33982 24-74) Jul. 1981 refs
Avail: NTIS HC A18/MF A01

The resolving power of coherent optical adaptive systems in the turbulent atmosphere is evaluated. General formulas are given for two systems which produce different kinds of partial corrections of phase and amplitude fluctuations. Numerical results are presented in the case of a modified Karman model. It is concluded that even a partial correction can allow one to overcome the limit of the aperture diameter imposed by the turbulence. J.D.H.

N81-34020# Optical Sciences Co., Placentia, Calif.
ANISOPLANATISM IN ADAPTIVE OPTICS
D. L. FRIED *In* AGARD Spec. Topics in Opt. Propagation 12 p (SEE N81-33982 24-74) Jul. 1981
(Contract F30602-80-C-0305)
Avail: NTIS HC A18/MF A01

The consequences for an adaptive optics system of the fact that the turbulence induced wavefront distortion for two propagation paths with slightly different propagation directions can be significantly different is examined. The results are presented in terms of the average optical transfer function of a compensated imaging system, and in terms of the average antenna gain of an adaptive optics laser transmitter. Each is expressed as a function of the angular separation between the propagation path along which the reference signal arrives, and the propagation path along which the adaptive optics system is to provide performance. A performance reduction factor representing an asymptotic limit for very high spatial frequencies and for very large transmitter diameters is presented. Numerical results are presented. J.D.H.

N81-34021# Rome Air Development Center, Griffiss AFB, N.Y.
REDUCTION OF ANISOPLANATIC ERRORS
D. W. HANSON and N. SCHWARTZ (Syracuse Univ., N.Y.) *In* AGARD Spec. Topics in Opt. Propagation 10 p (SEE N81-33982 24-74) Jul. 1981
Avail: NTIS HC A18/MF A01

An optimum linear estimator for the phase at the point ahead angle is developed for the case where the optical line of sight slews through the turbulent atmosphere faster than the turbulence is transported by the ambient winds. Difficulties encountered when using the standard approach to optimum linear estimation are discussed. The optimum linear estimate is developed in terms of the structure and hyperstructure functions, rather than the correlation function, since the correlation function for the phase aberrations is difficult to observe. The relaxation in station keeping requirements which can be achieved through the use of the optimum linear estimator is derived and found to be on the order of 15%. Author

N81-34022# Arizona Univ., Tucson. Optical Sciences Center.
PHASE MEASUREMENT SYSTEMS FOR ADAPTIVE OPTICS
J. C. WYANT and C. L. KOLIOPOULOS *In* AGARD Spec. Topics in Opt. Propagation 12 p (SEE N81-33982 24-74) Jul. 1981 refs
Avail: NTIS HC A18/MF A01

Sensors that measure the wavefront directly and slope measurement sensors are described and compared. Both self referencing and nonself referencing wavefront sensors are discussed and interferometric and geometric slope sensors are compared. The conclusion is reached that of the phase measurement systems studied to the lateral shear interferometer and the nutating Hartmann sensor are of the most general use due to their high efficiency and simplicity. J.D.H.

N81-34023# Itek Corp., Lexington, Mass. Optical Systems.
ADAPTIVE OPTICAL SYSTEMS USING DISCRETE COMPONENTS
J. W. HARDY *In* AGARD Spec. Topics in Opt. Propagation 14 p (SEE N81-33982 24-74) Jul. 1981 refs
Avail: NTIS HC A18/MF A01

The state of development of adaptive optical systems in which the major functions of wavefront sensing, computation, and wavefront correction are performed by discrete components is discussed. The operating principles and performance of the most important adaptive optical devices developed during the last few years are described, including wavefront sensors, detector arrays, electronic data processors, and deformable mirrors. Typical system configurations for compensated imaging and laser beam control are described. Limitations of discrete technology at the device and system level are reviewed. The directions in which adaptive optical systems may evolve are assessed. J.D.H.

N83-20758# Twente Univ. of Technology, Enschede (Netherlands).
MODERN DISPLAY TECHNOLOGIES AND APPLICATIONS
D. BOSMAN, ed. Neuilly-Sur-Seine, France AGARD Oct. 1982 219 p refs
(AGARD-AR-169; ISBN-92-835-1438-6) Avail: NTIS HC A10/MF A01

Analysis of both current and anticipated requirements for information displays in military avionics; identification of display applications where new technologies in visual displays have the greatest impact on military avionics; and survey the present status and potential for further development of a wide range of modern *display technologies are presented. An engineering view on vision* and displays explained the technical factors affecting the perception of displayed data, sampling and addressing, the human factors affecting display design and use, and the use of color in displays. A description of technologies included the cathode ray tube, vacuum fluorescent tubes, liquid crystal displays, light emitting diodes, electro-luminescent displays, electrochemical displays and other display technologies. The application of display technologies to military avionics was examined in the areas of classifications, head up displays, head down displays, helmet mounted systems, keyboard displays, and alphanumeric modules. An assessment is made of modern display technology potential. Author

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ADMINISTRATION AND MANAGEMENT

Includes management planning and research.

N81-11902# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
DESIGN TO COST AND LIFE CYCLE COST
Jul. 1980 333 p refs In ENGLISH and FRENCH Symp. held in Amsterdam, 19-22 May 1980
(AGARD-CP-289; ISBN-92-835-0268-X; AD-A090098) Avail: NTIS HC A15/MF A01

Life cycle costs (LCC) methodology and its relation to specifications and requirements are discussed. Other topics include the impact of LCC analysis on total system design, cost control of operations and support, and LCC of subsystems and components. For individual titles, see N81-11903 through N81-11928.

N81-11903# British Aerospace Aircraft Group, Preston (England).
LIFE CYCLE COST ANALYSIS (LCCA) IN MILITARY AIRCRAFT PROCUREMENT
R. CHISHOLM *In* AGARD Design to Cost and Life Cycle Cost 8 p (SEE N81-11902 02-81) Jul. 1980 refs
Avail: NTIS HC A15/MF A01

The changing economic environment and the developing requirement to put increased emphasis on downstream activities in the early phases of a weapon system program are discussed. A possible approach to calculating the magnitude and spread of cost reducing investments is considered and applications of life cycle cost analysis in strategic decision making, the design process, and as a sales aid are mentioned. E.D.K.

N81-11904# Naval Air Systems Command, Washington, D. C.
O AND S COST VISIBILITY IN EARLY DESIGN
R. E. HOUTS *In* AGARD Design to Cost and Life Cycle Cost 12 p (SEE N81-11902 02-81) Jul. 1980
Avail: NTIS HC A15/MF A01

Maintenance support costs and related cost data and techniques currently employed by the Naval Air Systems Command (NAVAIR) are discussed. The operating and support (O&S) cost definitions including the NAVAIR O&S cost breakdown structure, data bases, and cost estimating techniques that allow the analyst to employ engineering oriented cost analysis techniques in early design are presented. E.D.K.

N81-11905# Army Aviation Research and Development Command, St. Louis, Mo.
US ARMY DESIGN-TO-COST EXPERIENCE
R. B. LEWIS, II, E. P. LAUGHLIN, and F. E. SPRING *In* AGARD Design to Cost and Life Cycle Cost 11 p (SEE N81-11902 02-81) Jul. 1980
Avail: NTIS HC A15/MF A01

Design-to-Cost procedures were included in all major U.S. Army aviation procurements since 1972. Experience was gained during design, development, procurement and initial fielding of several major systems. The ownership cost of this equipment is considered during development. Production and operational phases and techniques for cost control are discussed. Lessons learned as a result of joint Government-Industry Design-To-Unit-Production Cost programs are presented. Techniques which were effective in cost management on utility and attack helicopters and turbine engine programs are listed. Producibility engineering planning, initial production tooling, and facilitization to reduce production costs are discussed. The role of warranties in controlling operating and support costs is illustrated. It is concluded that Design-To-Unit-Production-Cost techniques were effective in achieving lower production costs, but that additional work is necessary to better control operating and support costs and thereby achieve optimal life cycle costs. E.D.K.

N81-11906# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
A REVIEW AND ASSESSMENT OF SYSTEM COST REDUCTION ACTIVITIES
W. E. LAMAR *In its* Design to Cost and Life Cycle Cost 38 p (SEE N81-11902 02-81) Jul. 1980 refs
Avail: NTIS HC A15/MF A01

A review of the evolution of cost reduction concepts over the past decade to current design to life cycle cost (DTLCC) efforts is presented. Emphasis is given to progress achieved and basic problems and issues which have confronted successful application of these concepts. The review addresses the importance of top management action, consideration of costs in the early phase, and a credible data base. Progress in developing cost prediction and analysis methods, technologies to reduce development, acquisition, operations and support costs, the institutionalization of design to cost and design to life cycle cost methods, and remaining challenges are discussed E.D.K.

N81-11907# Boeing Aerospace Co., Seattle, Wash.
DESIGN TO LIFE CYCLE COST RESEARCH
F. T. CARLSON *In* AGARD Design to Cost and Life Cycle Cost 15 p (SEE N81-11902 02-81) Jul. 1980
Avail: NTIS HC A15/MF A01

Design to life cycle cost research applied to the area of logistics systems is discussed with a look at history data for typical aircraft systems. Deficiencies in systems operations and support are identified and described. Methods of assessing the cost, risk, and program application are discussed. Areas of emphasis, cost drivers, and their impacts are shown. It is determined that many deficiencies in the ownership of systems do not relate to program plans. Resolution by future technology advances must be aimed toward elimination of manpower, material, and program causative factors through research of logistics subsystems, i.e., inspections, material distribution, people use, and logistics networks. E.D.K.

N81-11908# Dornier-Werke G.m.b.H., Friedrichshafen (West Germany).
IMPACT ON SYSTEM DESIGN OF COST ANALYSIS OF SPECIFICATIONS AND REQUIREMENTS
H. GREISER *In* AGARD Design to Cost and Life Cycle Cost 10 p (SEE N81-11902 02-81) Jul. 1980
Avail: NTIS HC A15/MF A01

Four categories of requirements are to be considered: (1) technical requirements; (2) operational requirements; (3) program-specific requirements; and (4) budget requirements. Their impact on cost is to be identified and quantified for each phase of a weapon system's life cycle. E.D.K.

N81-11909# British Aerospace Aircraft Group, Preston (England).
EVOLUTION OF TECHNIQUES FOR LCC ANALYSIS
J. M. JONES *In* AGARD Design to Cost and Life Cycle Cost 13 p (SEE N81-11902 02-81) Jul. 1980
Avail: NTIS HC A15/MF A01

The need to control aircraft operating and support costs starting with a coordinated approach to life cycle cost (LCC) analysis during the conceptual design stage is identified. Experiences in the development and use of LCC models are discussed. The limitations of existing systems together with examples of current work on this subject are presented. E.D.K.

N81-11910# McDonnell Aircraft Co., St. Louis, Mo.
THE HORNET PROGRAM: A DESIGN TO LIFE CYCLE COST CASE STUDY
R. D. DIGHTON *In* AGARD Design to Cost and Life Cycle Cost 12 p (SEE N81-11902 02-81) Jul. 1980
Avail: NTIS HC A15/MF A01

A primary requirement of the Hornet program is significant reduction in life cycle cost (LCC). The design and management techniques used to develop a new fighter/attack system at an affordable LCC are described. The designer must consider key elements of LCC such as reliability, maintainability, unit production cost, and logistics support cost elements in parallel with traditional concerns of weight and performance when designing life cycle costs. Examples of trade studies resulting in relatively large LCC avoidances are summarized. E.D.K.

N81-11911# General Dynamics/Fort Worth, Tex. F-16 Systems Engineering Management.
DESIGN TO COST AND THE F-16 MULTIROLE FIGHTER
W. M. ROWELL *In* AGARD Design to Cost and Life Cycle Cost 14 p (SEE N81-11902 02-81) Jul. 1980 refs
Avail: NTIS HC A15/MF A01

The low cost of the F-16 Fighter Aircraft is the result of a selected balance of innovative technologies, available low cost material and equipment, and cost reducing configuration options. This was implemented through the application of design to cost concepts from the beginning of the program. The F-16 full scale development contract contained several clauses which provided downstream cost control including control of both acquisition and operations. A key part of this plan was the identification and close tracking of a few cost drivers which comprise over 50% of the air vehicle cost. A number of specific contract provisions are aimed at control of operating and support costs. These provisions provide financial incentives and penalties for consideration of reliability and other logistic support parameters. Other control provisions require cost considerations in trade studies, engineering change proposals, and in vendor selections. E.D.K.

N81-11912# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (West Germany). Aircraft Div.
STRUCTURAL INTEGRATION AS A MEANS OF COST REDUCTION
P. E. SIEBERT *In* AGARD Design to Cost and Life Cycle Cost 17 p (SEE N81-11902 02-81) Jul. 1980
Avail: NTIS HC A15/MF A01

Through some components of the Tornado fighter aircraft it is demonstrated how costs can be reduced by structural integration. The components are two flat panels, the wing carry through box and the Taileron. Cost savings could be achieved from 15% to a maximum of 68%. E.D.K.

N81-11913# Avions Marcel Dassault, Saint-Cloud (France).
DESIGN-TO-COST AND NEW TECHNOLOGIES [DESIGN-TO-COST ET TECHNOLOGIES NOUVELLES]
F. CORDIE *In* AGARD Design to Cost and Life Cycle Cost 8 p (SEE N81-11902 02-81) Jul. 1980 In FRENCH
Avail: NTIS HC A15/MF A01

Modern combat aircraft design can no longer be undertaken without giving equal consideration to mission cost and performance when making compromises which lead to the choice of an aircraft formula. These compromises are based on technologies which can be used from the beginning of production. Usually they are new technologies which have passed the laboratory stage and applied to existing aircraft before being integrated into the design on a large scale. With respect to structures, carbon-epoxy composite technology is one of the most remarkable. Its introduction at the design stage results in reduction of mass and cost, first on the elements to which it is applied, and then by the amplifying effect on the assembly of the structure and the rest of the aircraft: engine, equipment, and fuel. Such a process supposes that the technology to be applied has attained a degree of maturation which permits prediction of performance and cost with certitude. Transl. by A.R.H.

N81-11914# Societe Nationale Industrielle Aerospatiale, Paris (France). Aircraft Div.
ORGANIZING A DESIGN-TO-COST PROGRAM
R. TASSINARI *In* AGARD Design to Cost and Life Cycle Cost 14 p (SEE N81-11902 02-81) Jul. 1980
Avail: NTIS HC A15/MF A01

Total cost control at all development and production stages is a prerequisite to any significant design-to-cost (DTC) program. Design to life cycle cost (DTLCC) methods further require intimate knowledge of operational and maintenance costs. Specialists in this cost management method are aware of these two principles. Less obvious, perhaps are the great advantages to be derived through an organization specifically trained in the application of DTC and DTLC principles. A specialized organization and methods for integrating costs into all phases of new programs was created much in the way that weights were calculated into programs in the past. To keep pace with this reorganization in development, emphasis was placed on training personnel in value analysis and DTC methods. Results of these efforts first became apparent in 1977, during development of the A 200. Today, the same principles are being applied in development of the A 310. E.D.K.

N81-11915# American Airlines, Inc., Tulsa, Okla.
A NEW METHOD FOR ESTIMATING TRANSPORT AIRCRAFT DIRECT OPERATING COSTS
K. GRAYSON *In* AGARD Design to Cost and Life Cycle Cost 20 p (SEE N81-11902 02-81) Jul. 1980 refs
Avail: NTIS HC A15/MF A01

A means of estimating aircraft direct operating costs for comparative purposes was developed which was able to recognize and include the potential benefits to be gained from technology and design innovation when applied to commercial transport aircraft. The work performed on this subject is reviewed. The validity of the developed methods and how they can be used in the evaluation of aircraft for an airline's fleet is also demonstrated. E.D.K

N81-11916# Societe Nationale Industrielle Aerospatiale, Marignane (France.)
DESIGN-TO-COST APPLIED TO THE AS350 HELICOPTER [LE DESIGN TO COST APPLIQUE A L'HELICOPTERE AS350]
R. MOUILLE *In* AGARD Design to Cost and Life Cycle Cost 18 p (SEE N81-11902 02-81) Jul. 1980 In FRENCH
Avail: NTIS HC A15/MF A01

In order to remain competitive on the international market, cost reduction studies were undertaken a Aerospatiale and were concretized in the design of the AS350 helicopter after two years' effort by a small experimental research group. The development of this helicopter, which is definitely more economical than the Alouette 2 or the Gazelle, has followed the same cost reduction spirit as was used in its design. The method is classic and is based on (1) analysis of the value of functions and of the parts assuring these functions; (2) criticism of the solution; (3) search for new solutions; and (4) choice of compromises. The experience of the participants permitted rapid elimination of the most expensive choice as well as those with least performance. The benefits to be obtained from proceeding correctly from the design stage can be very important with regards to both acquisition and utilization costs. This is of interest to both civil and military users.
Transl. by A.R.H.

N81-11917# United Air Lines, Inc., San Francisco, Calif.
RELIABILITY-CENTERED MAINTENANCE
F. S. NOWLAN *In* AGARD Design to Cost and Life Cycle Cost 13 p (SEE N81-11902 02-81) Jul. 1980 refs
Avail: NTIS HC A15/MF A01

The use of reliability centered maintenance principles are discussed with respect to aircraft component life cycle costs. The following inherent reliability characteristics are emphasized: failure consequences, judged by the effect of loss of function on safety, mission capability and operational readiness; failure modes which lead to an item's loss of function; exposure to secondary damage that results from certain failure modes; visibility of the failure process and a mechanic's ability to discover potential failures and thereby prevent functional failures; evidence by which the operating crew can realize that a functional failure has occurred; exposure to the consequences of multiple failures; and failure rates.
R.C.T.

N81-11918# British Aerospace Aircraft Group, Preston (England).
SOME ENGINEERING ASPECTS OF LIFE CYCLE COSTING
G. W. BLEASDALE *In* AGARD Design to Cost and Life Cycle Cost 9 p (SEE N81-11902 02-81) Jul. 1980 refs
Avail: NTIS HC A15/MF A01

The constituents that are common to most life cycle cost methods are identified. Ways in which some of the engineering costs can be minimized are discussed. It is shown that the extra cost of better engineering design may increase the acquisition cost but this will be more than offset by the large reduction in support costs complemented by the increase in reliability and aircraft availability. Examples are given showing typical contributions to high support costs of mechanical components. R.C.T.

N81-11919# Northrop Corp., Hawthorne, Calif. Aircraft Group.
BALANCED DESIGN: MINIMUM COST SOLUTION
E. HUIE and H. F. HARRIS *In* AGARD Design to Cost and Life Cycle Cost 8 p (SEE N81-11902 02-81) Jul. 1980
Avail: NTIS HC A15/MF A01

The application of life cycle cost analysis is discussed and the techniques used to assessed life cycle cost's during the different phases of weapon system development are described. An illustrative case study showing the benefits of the application of life cycle costing on availability, sustained sorties, and requirements are presented. R.C.T.

N81-11920# Industrieanlagen-Betriebsgesellschaft m.b.H., Ottobrunn (West Germany).
DESIGN TO COST AND SYSTEMS, LCC
K. WICKEL *In* AGARD Design to Cost and Life Cycle Cost 9 p (SEE N81-11902 02-81) Jul. 1980
Avail: NTIS HC A15/MF A01

Different aspects of the design to costs approach are addressed with special attention given to their operational and maintenance cost and methodological implications. Three major subtasks of the design to cost task are examined: design to financial feasibility, design to personnel feasibility; and design to system's life cycle costs. It is shown that design to cost is indisputably an absolutely essential approach to tackling the cost problems as long as the objective does not degenerate to mere design to financial feasibility. R.C.T.

N81-11921# British Aerospace Aircraft Group, Preston (England).
IMPACT OF MAINTAINABILITY OF LIFE CYCLE COSTS
G. R. THORNBER *In* AGARD Design to Cost and Life Cycle Cost 11 p (SEE N81-11902 02-81) Jul. 1980
Avail: NTIS HC A15/MF A01

The interpretation of the definitions of the varied parameters used in assessing maintainability with respect to their significant effect on the quantification of the effect on life cycle cost. One possible interpretation is considered and the results obtained using this are indicated. Methods of assessing maintainability as applied to two international collaborative military aircraft are considered and some of the lessons and problems encountered are addressed. R.C.T.

N81-11922# Vereinigte Flugtechnische Werke G.m.b.H., Bremen (West Germany).
ESTIMATION OF RELATIVE TOTAL COST FOR AIRCRAFT SYSTEMS
J. BOLLMANN and H. LANKENAU *In* AGARD Design to Cost and Life Cycle Cost 9 p (SEE N81-11902 02-81) Jul. 1980 refs
Avail: NTIS HC A15/MF A01

A suitable method for determining the relative total costs (fixed and operating costs) is described. It is shown that during the operating phase a clear statistical comparison must continuously be accomplished between the target and the actual values in order to ensure that any deviations and the causes of such deviations can be detected and eliminated. The need to have an agreed procedure between operator, aircraft manufacturer and equipment supplier is emphasized. R.C.T.

N81-11923# Messier-Hispano-Bugatti S.A., Montrouge (France).
USING COST REDUCTION CONCEPTS AT MESSIER-HISPANO-BUGATTI [MISE EN OEVRE DES CONCEPTS DE REDUCTION DES COUTS CHEZ MESSIER-HISPANO-BUGATTI]
M. ESLINGER *In* AGARD Design to Cost and Life Cycle Cost 11 p (SEE N81-11902 02-81) Jul. 1980 In FRENCH
Avail: NTIS HC A15/MF A01

Industrialization, value analysis, production cost objective, and life cycle cost objective are four concepts used at M-H-B to reduce the cost of products such as landing gear, hydraulic equipment, wheels, and brakes. Each of these concepts is examined, and the means necessary for their implementation are indicated. Results of using these techniques are described. Transl. by A.R.H.

N81-11924# Gabelman (Irving J.) Technical Associates, Rome, N.Y.
SUMMARY OF AGARD LECTURE SERIES 100: METHODOLOGY FOR CONTROL OF LIFE CYCLE COSTS FOR AVIONICS SYSTEMS
I. J. GABELMAN *In* AGARD Design to Cost and Life Cycle Cost 8 p (SEE N81-11902 02-81) Jul. 1980 Lecture held in Bonn, 7-8 May 1979 and in Athens, 10-11 May 1979
Avail: NTIS HC A15/MF A01

The continually increasing cost of avionics and weapons systems between aquisition and their lifetime operation are discussed. Specific emphasis is given to the following: elements of life cycle costs; parametric cost analysis; and life cycle cost methodology. R.T.

N81-11925# Marconi Avionics Ltd., Rochester (England).
DESIGN TO COST VIEWED AGAINST THE ACHIEVEMENT OF OPTIMUM SYSTEM CAPABILITY
R. G. ROSE *In* AGARD Design to Cost and Life Cycle Cost 6 p (SEE N81-11902 02-81) Jul. 1980
Avail: NTIS HC A15/MF A01

The criteria for defining the cost of avionics systems are discussed. Two types of costs are specifically described: one time costs and recurring costs. One time costs include design and

development, manufacture, training, documentation and facilities. Recurring costs include retraining where necessary, post design improvement studies, operating and maintenance costs and transportation and handling. These two groups are interactive in as much as poor design usually results in heavy maintenance costs and design for the reduction of operating and maintenance costs will usually result in higher design and development costs for the achievement of the results required. There is another point in product design that must be considered as part of assets management, and that is the required availability or state of readiness of the equipment to perform the tasks for which it was developed. R.C.T.

N81-11926# Ministry of Defence, London (England).
SUMMARY OF AGARD LECTURE SERIES 107: THE APPLICATION OF DESIGN TO COST AND LIFE CYCLE COST TO AIRCRAFT ENGINES
E. J. JONES *In* AGARD Design to Cost and Life Cycle Cost 5 p (SEE N81-11902 02-81) Jul. 1980 Lecture held in Saint Louis, France 12-13 May 1980 and in London, 15-16 May 1980
Avail: NTIS HC A15/MF A01

The latest methodologies of cost/performance comparison and trade offs for aircraft engines are examined. Information includes data collection, analysis, modelling and estimating all development and operations costs. R.C.T.

N81-11927# Air Force Wright Aeronautical Labs., Wright-Patterson AFB, Ohio. Aero Propulsion Lab.
THE ROLE OF ADVANCED TECHNOLCGY OF TURBINE ENGINE LIFE CYCLE COST
R. F. PANELLA, M. A. BARGA, and R. G. MCNALLY *In* AGARD Design to Cost and Life Cycle Cost 13 p (SEE N81-11902 02-81) Jul. 1980 refs
Avail: NTIS HC A15/MF A01

The advanced technology of the turbine engine and its impact on life cycle costs (LCC) is addressed. To adequately assess this advanced technology, LCC techniques are to be developed which are sensitive to performance, structural design, manufacturing processes, reliability and maintainability. These techniques are then used to determine the performance/life/cost trade-offs of the advanced technology. An overview of current efforts in LCC techniques, and trade-offs is given. R.C.T.

N81-11928# Lucas Aerospace Ltd., Birmingham (England). Engine Management Div.
COST CONSIDERATIONS OF ENGINE FUEL CONTROL SYSTEMS
A. J. ECCLESTON *In* AGARD Design to Cost and Life Cycle Cost 14 p (SEE N81-11902 02-81) Jul. 1980
Avail: NTIS HC A15/MF A01

The manufacture of hydromechanical systems is discussed. It is shown that by applying well tried principles a value engineering team can identify considerable potential savings, particularly in the case of new designs. While lower life cycle costs are frequently only achieved at the expense of increased first cost this is not invariably so. R.C.T.

N81-29023# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). Flight Mechanics Panel.
DESIGN TO COST AND LIFE CYCLE COST
W. E. LAMAR May 1981 30 p Report previously announced as N81-11902
(AGARD-AR-165; ISBN-92-835-1387-8; AD-A101447) Avail: NTIS HC A03/MF A01

Summaries of the papers delivered at the symposium, an account of the closing round table discussion, and an extensive listing of conclusions and recommendations in the area of design to cost and life cycle costing are presented. The sessions covered (1) life cycle methodology and its relation to relation to specifications and requirements, (2) impact of life cycle costs analyses on total system design, (3) cost control of operations and support, and (4) life cycle cost of subsystems and components. The papers delivered at each session are listed. A.R.H.

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DOCUMENTATION AND INFORMATION SCIENCE

Includes information storage and retrieval technology; micrography; and library science.

N80-32283# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
INTERNATIONAL ACCESS TO AEROSPACE INFORMATION
Apr. 1980 105 p refs in ENGLISH and FRENCH Meeting held in Athens, 17-18 Oct. 1979
(AGARD-CP-279; ISBN-92-835-0264-7; AD-A075132) Avail: NTIS HC A06/MF A01 CSCL 05B

A review of the status of Greek organization and facilities with respect to access to aerospace information is presented. The state of European cooperation in the field and the nature of NASA's contribution is considered. Requirements and tools for international cooperation and data exchange are discussed, as well as problems in the utilization of aerospace literature and nonliterature data in aerospace research and development. For individual titles, see N80-32284 through N80-32294.

N80-32284# Scientific Research and Technology Agency, (Greece).
ACCESS TO AEROSPACE INFORMATION: THE GREEK SITUATION
K. N. KOUROGENIS *In* AGARD Intern. Access to Aerospace Inform. 4 p (SEE N80-32283 22-82) Apr. 1980 refs
Avail: NTIS HC A06/MF A01

The establishment of the Greek National Information Program in the form of the National Documentation Center (NDC) is described. The role of the NDC is to create and coordinate a national network of scientific and technical data and information in accordance with international standards and to disseminate processed information to those interested with a view to the economic development of the country. Bibliographies, reprographic services and translation and terminology services are to be provided by the NDC. E.D.K.

N80-32285# European Space Agency, Frascati (Italy). Information Retrieval Service.
EUROPEAN COOPERATION IN FIELD OF AEROSPACE INFORMATION
W. A. MARTIN *In* AGARD Intern. Access to Aerospace Inform. 10 p (SEE N80-32283 22-82) Apr. 1980 refs
Avail: NTIS HC A06/MF A01

Agreements reached in the early 1960's leading to the establishment of the ESRO/ELDO Space Documentation Service are reviewed. European cooperation in both the input of aerospace information and its utilization is described. Details of ESA-IRS activities in support of the NASA information system are given. The development of the use of aerospace information in Europe as evidenced by the growth of IRS networking is examined. Research into aerospace information handling is outlined. The relationship between ESA and the CEC is explained in the context of EURONET. E.D.K.

N80-32286*# National Aeronautics and Space Administration, Washington, D. C.
THE ROLE OF NASA FOR AEROSPACE INFORMATION
G. P. CHANDLER, JR. *In* AGARD Intern. Access to Aerospace Inform. 4 p (SEE N80-32283 22-82) Apr. 1980
Avail: NTIS HC A06/MF A01 CSCL 05B

The NASA Scientific and Technical Information Program operations are performed by two contractor operated facilities. The NASA STI Facility, located near Baltimore, Maryland, employs about 210 people who process report literature, operate the computer complex, and provide support for software maintenance and developments. A second contractor, the Technical Information Services of the American Institute of Aeronautics and Astronautics, employs approximately 80 people in New York City and processes the open literature such as journals, magazines, and books. Features of these programs include online access via RECON announcement services, and international document exchange. E.D.K.

N80-32287# British Library, London (England) International Centre for Bibliographic Descriptions.
STATE-OF-THE-ART OF STANDARDIZATION OF BIBLIOGRAPHIC DATA ELEMENTS
H. DIERICKY *In* AGARD Intern. Access to Aerospace Inform 7 p (SEE N80-32283 22-82) Apr. 1980 refs
Avail: NTIS HC A06/MF A01

The current situation with regard to standardization of data elements in bibliographic records is summarized. The following areas are considered: headings, bibliographic description proper, other areas or particular attributes of the bibliographic record. International and national rules and standards of international significance are dealt with. Although the difficulty for standardization efforts to suit the different requirements of various user groups is recognized, the conclusion reached is that standardization of form and presentation of bibliographic data elements is an essential prerequisite to achieve international compatibility of bibliographic records, particularly in an automated environment. Author

N80-32288# Netherlands School of Business, Breukelen.
STATE-OF-THE-ART OF DATA EXCHANGE: PROBLEMS OF FORMATS AND STANDARDS
J. S. MACKENZIEOWEN In AGARD Intern. Access to Aerospace Inform. 5 p (SEE N80-32283 22-82) Apr. 1980 refs
Avail: NTIS HC A06/MF A01

The vast growth of bibliographic data services over recent years has produced many problems in the field of compatibility for data exchange. It is beginning to be understood that there exists a major gap between the library community on the one side, and the abstracting and indexing services on the other side. It is also becoming clear that any standardized format for bibliographic data exchange should be flexible enough to incorporate the diverse needs of many different users. An effort is being undertaken by UNESCO to solve these problems. The present situation, problems, and future developments in this field are described. E.D.K.

N80-32289# *Institut fuer Flugmechanik, Brunswick (West Germany).*
THE USE OF MULTILINGUAL REFERENCE TOOLS IN THE PRODUCTION AND TRANSFER OF TECHNICAL INFORMATION
G. ROSENAU *In* AGARD Intern. Access to Aerospace Inform. 18 p (SEE N80-32283 22-82) Apr. 1980 refs
Avail: NTIS HC A06/MF A01

A survey of the problems of expressing technical information in one language is given. The discussion of the additional problems encountered in producing the information in more than one or in a foreign language leads to the description of the different types of multilingual reference tools, of their advantages, and of their deficiencies. Based on the experience gained during the revision of the AGARD Multilingual Aeronautical Dictionary criteria developed for a future multilingual reference system are presented. E.D.K.

N80-32290# Lucas Group Services Ltd., Solihull (England).
KINDS OF ACCESS TO UNCLASSIFIED LITERATURE
C. P. AUGER *In* AGARD Intern. Access to Aerospace Inform. 4 p (SEE N80-32283 22-82) Apr. 1980 refs
Avail: NTIS HC A06/MF A01

The nature of unclassified literature is reviewed and the categories available and their organization are examined. The preponderance of reports literature is noted and current awareness and on line services receive particular attention. Consideration is given to the great variety of users seeking access for one reason or another and the different routes open to them. Finally attention is turned to some of the problems which need to be overcome if access is to be improved. E.D.K.

N80-32291# Centre de Documentation de l'Armement, Paris (France). Div. Information
THE MANAGEMENT OF DOCUMENTS HAVING A RESTRICTED CHARACTER [LA QUESTION DES DOCUMENTS AYANT UN CARACTERE DE RESTRICTION]
J. H. KLOPP *In* AGARD Intern. Access to Aerospace Inform. 5 p (SEE N80-32283 22-82) Apr. 1980 refs In FRENCH
Avail: NTIS HC A06/MF A01

Documents containing military or industrial secrets or information reserved to the needs of the State are best managed in a manner analogous to that used for open documents, but with important security regulations imposed by a documentation center. It is preferable for a defense documentation center to create a chain of use parallel to the classic chain of use for open documents, rather than to intermingle documents. The most important advantage of the decision to create a special center for processing classified documents is an uncontested control of the stamping, stocking, and dissemination of these documents. The importance of declassification is discussed and a table is provided showing the markings used by NATO and 14 of its member nations for the various classifications of restricted documents.
Transl. by A.R.H.

N80-32292# Atomic Energy Research Establishment, Harwell (England). Computer Science Div.
FULL TEXT HANDLING: A CRITICAL REVIEW
R. P. L. JONES *In* AGARD Intern. Access to Aerosp. Inform. 10 p (SEE N80-32283 22-82) Apr. 1980
Avail: NTIS HC A06/MF A01

The wide capabilities of full text information retrieval systems are demonstrated. The basic capabilities of such systems are described including the strengths and weaknesses that seem to be inherent in the techniques that are in use. The wider application of such systems is also described. Emphasis is placed on their capability to form a nucleus for integrated information management systems which are flexible in use and do not require programming skills to exploit them. E.D.K.

N80-32293# Max-Planck-Institut fuer Aeronomie, Katlenburg-Lindau (West Germany).
THE NUMERIC AEROSPACE DATA: PROBLEMS OF EVALUATION, HANDLING AND DISSEMINATION
G. K. HARTMANN *In* AGARD Intern. Access to Aerospace Inform. 10 p (SEE N80-32283 22-82) Apr. 1980 refs
Avail: NTIS HC A06/MF A01

In context with dissemination and handling procedures the problems being faced are to distinguish between small, medium, and large information systems. Due to the fact that most of the numeric aerospace data are nonreproducible time series data (often also space dependent) with tremendous growth rates it is becoming extremely difficult and time consuming for any scientist and information system not actively working in the specific field to evaluate, disseminate, and handle those data with a high degree of efficiency and reliability. Thus it is very likely that also in the future, numeric aerospace data exchange activities will by far dominate the pure handling activities despite any technical progress. E.D.K.

N80-32294*# Lunar and Planetary Inst., Houston, Tex.
THE ROLE OF WORLD DATA CENTERS AND THE LUNAR AND PLANETARY INSTITUTE IN THE INTERNATIONAL EXCHANGE OF LUNAR AND PLANETARY DATA
F. B. WARANIUS *In* AGARD Intern. Access to Aerospace Inform. 8 p (SEE N80-32283 22-82) Apr. 1980 refs
(Contract NSR-09-051-001)
(LPI CONTRIB-382) Avail: NTIS HC A06/MF A01 CSCL 05B

The success of many lunar and planetary investigations has resulted in the accumulation of a mass of data in a myriad of formats and medias. The application of these data to comparative planetology, origin of the solar system, and potential industrial applications of space has made it necessary for scientists from many disciplines to have access to the data. The collections of these data are so diverse that it is often difficult to select what is needed based on catalog information alone. The Lunar and Planetary Institute (LPI) proposes to bring the user and the data together. As a research support organization operated by the Universities Space Research Association, the LPI through its active Visiting Scientist Program, a balanced program of study workshops and topical conferences, and organized and supervised data collections has assisted scientists, educators, and students to review, study, and obtain the data necessary to the pursuit of their research. E.D.K.

N81-11941# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
PATENTS: AN INFORMATION RESOURCE
Sep. 1980 144 p refs Lecture held at Munich, 13-14 Oct 1980 and at Delft, Netherlands, 16-17 Oct. 1980
(AGARD-LS-112; AD-A090310) Avail: NTIS HC A07/MF A01

Patents, an important part of the total spectrum of scientific and technical information, are often overlooked by the information community and the scientific and technical community. These communities must be more aware of the importance of patents to the research, development, and engineering efforts in each country. The wide range of applications for information from patents and the methods that can be used for acquiring that information are emphasized. Methods used for indexing and classifying are discussed, the various available abstracting services are compared, and techniques for searching including automated systems are described. For individual titles, see N81-11942 through N81-11951.

N81-11942# British Library, London (England).
THE PLACE OF PATENTS IN THE FIELD OF SCIENTIFIC AND TECHNICAL INFORMATION
M. W. HILL *In* AGARD Patents: An Inform. Resource 6 p (SEE N81-11941 02-82) Sep. 1980 refs
Avail: NTIS HC A07/MF A01

The history of patents for inventions and printed patent specifications is briefly sketched. The usefulness of patent information to research and development, industry, and commerce is indicated. The ways and means of storing and retrieving such information is also discussed. E.D.K.

N81-11943# Commissariat a l'Energie Atomique, Gif-sur-Yvette (France).
THE CASE FOR USING PATENT DOCUMENTATION (ITS UNIQUE CONTENT, ILLUSTRATIONS OF ITS APPLICATION)
M. G. LENOIR *In* AGARD Patents: An Inform. Resource 22 p (SEE N81-11941 02-82) Sep. 1980 refs In ENGLISH and FRENCH
Avail: NTIS HC A07/MF A01

The information contained in patents is largely exclusive and yet, also offers qualities and characteristics enabling one to reach conclusions and make decisions which the usual technical documentation material does not always permit. The advantages users are likely to derive from this type of information is outlined. E.D.K.

N81-11944# General Electric Co., Philadelphia, Pa.
CORPORATE MANAGEMENT OF PATENTS: ROLE OF THE INDUSTRIAL LIBRARIAN
L. CHASEN *In* AGARD Patents: An Inform. Resource 21 p (SEE N81-11941 02-82) Sep. 1980 refs
Avail: NTIS HC A07/MF A01

The librarian, who is seldom the direct user of patents, should become knowledgeable in the rich resources of patent data. Technology transfer can be accomplished by the engineer and scientist having the complete picture which the librarian offers in response to a search request. Major library schools were questioned on whether courses in patent information are part of the curriculum requirements of a special librarian. The other survey is directed to several dozen major industrial libraries in the United States on patent handling and management. The results of these surveys are given. Although there are over 30 patent depositories in the United States, the average research librarian does not make complete use of these depositories. In some cases, the survey indicated they were unaware of these data sources. Several key patents supported by library research are described. On line retrieval systems where patent license data is offered by NASA and DTIC are an example of sources available to the aerospace librarian. A forecast of how libraries and special libraries will retrieve patents and patent applications before the next century commences is presented. E.D.K.

N81-11945# Patent and Trademark Office, Washington, D. C.
TECHNOLOGY ASSESSMENT: A TOOL FOR EXPLOITING PATENTS
A. C. MARMOR *In* AGARD Patents: An Inform. Resource 25 p (SEE N81-11941 02-82) Sep. 1980 refs
Avail: NTIS HC A07/MF A01

Patent document collections, chronologically arranged and technically categorized, represent unique records of technological change. Continuously generated and catalogued, patent literature can be drawn upon as valuable input to technology assessment processes, both from a current and a historical perspective. Comprehensive patent information packages can be developed and tailored to benefit corporate strategists, policy analysts, educators, entrepreneurs, future innovators and the like. The recently established Technology Assessment and Forecast Program has helped, through computerized manipulation of patent bibliographic and classification data, to expand and facilitate the use of patent information in this way. They can profile the patent-active corporations and government organizations in the field, and identify national origin of the technology. Patenting by selected corporations may be reviewed to explore the depth and range of their technological activity. E.D.K.

N81-11946# Naval Material Command, Washington, D. C.
TECHNOLOGY TRANSFER: LICENSING GOVERNMENT INVENTIONS TO INDUSTRY
S. GEE *In* AGARD Patents: An Inform. Resource 14 p (SEE N81-11941 02-82) Sep. 1980 refs
Avail: NTIS HC A07/MF A01

Invention technology constitutes a sizeable portion of the science and technology base in the United States, but in the public domain it is underutilized. Only a small fraction of government inventions are licensed by industry. In order to stimulate greater utilization and licensing of government inventions, government agencies are becoming more disposed towards granting exclusive licenses under certain conditions. In order to develop better insight into government efforts to promote private sector licensing of government inventions, the licensing activities of the Department of the Navy and the National Technical Information Service are highlighted. More licensing of government inventions by industry expedites the flow of technology from the public to private sector. Close cooperation between the licensing and technology transfer communities is desired to help accelerate the rate of government inventions licensing and to improve the chances for technology transfer success. E.D.K.

N81-11947# British Library, London (England).
LIBRARY NETWORKS IN WESTERN EUROPE AND NORTH AMERICA
M. W. HILL *In* AGARD Patents: An Inform. Resource 6 p (SEE N81-11941 02-82) Sep. 1980 refs
Avail: NTIS HC A07/MF A01

In most, if not all, the member countries of NATO, the National Patent Office is the most obvious place to go to when wishing to use patent documents for information purposes. In the Search Room, or the Library, or in a combination of the two - arrangements vary from one country to another - facilities are provided for members of the public (meaning anyone other than a Patent Office Official) to conduct searches for themselves. In several countries, however, there are also in some major towns and cities libraries which hold collections of patent literature and which also are open to anyone who cares to use them. A summary of the available library resources in Denmark, France, Germany, the United Kingdon, and the United States of America is included. E.D.K.

N81-11948# Deutsches Patentamt, Munich (West Germany)
DISSEMINATION OF PATENT INFORMATION THROUGH OFFICIAL SERVICES AND CORRESPONDING RESOURCES IN EUROPE (SEEN THROUGH THE EYES OF A PATENT OFFICE OFFICIAL)
R. SCHIFFELS *In* AGARD Patents: An Inform. Resource 8 p (SEE N81-11941 02-82) Sep. 1980
Avail: NTIS HC A07/MF A01

Reasons for dissemination needs of patent information are discussed. The different means of disseminating patent information are by making patent documentations available, through additional consulting services for researchers, and by additional search aids. The different kinds of users of such information are analyzed.

including existing and potential users. The role of official services in patent information dissemination is described. E.D.K.

N81-11949# Centre for Scientific and Technical Information and Documentation TNO, Delft (Netherlands).
THE ROLE AND POSSIBLE ROLE OF OFFICIAL SERVICES IN THE DISSEMINATION OF PATENT INFORMATION
J. W. PLEVIER *In* AGARD Patents: An Inform. Resource 6 p (SEE N81-11941 02-82) Sep. 1980 refs
Avail: NTIS HC A07/MF A01

Patent offices are considered as organizations which have available a source of well organized information and a large staff of highly specialized technical people with a high level of experience in dealing with information and information retrieval systems. These human and material resources are taken as a starting point for a discussion of a number of activities which might meet some of the information needs of society at large and industry in particular. Some of the items discussed are: study of the performance of retrieval systems; patent statistics and trend analysis; scouting activities; and making available patent information in a comprehensible form for nonpatent specialists. E.D.K.

N81-11950# British Library, London (England).
COMMERCIAL ABSTRACTING AND INDEXING SERVICES, PRINTED AND ON-LINE
D. GREENWOOD and M. W. HILL *In* AGARD Patents: An Inform. Resource 11 p (SEE N81-11941 02-82) Sep. 1980
Avail: NTIS HC A07/MF A01

On-line computer systems provide a simple and versatile method for fulfilling the needs of people working in the patent information field. Access to commercial files held in various computers in the US and Europe can now be obtained relatively easily through international communications networks, and there is no doubt that the number of available files will increase. Information workers are nowadays quite used to this technology: it has become a common-place and those who wish to search for patents information can find a number of data bases designed to meet their needs. E.D.K.

N81-11951# British Library, London (England).
PATENT INFORMATION: LOOKING AHEAD
M. W. HILL *In* AGARD Patents: An Inform. Resource 4 p (SEE N81-11941 02-82) Sep. 1980 refs
Avail: NTIS HC A07/MF A01

A great deal of progress was made due to the work of ICIREPAT and WIPO. Commercial operations provide a wealth of detailed abstracting services covering most of the important subject areas. Methods of dealing with patent information were strengthened, and a number of other on-line and printed services are now available. E.D.K.

N81-12935# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
AGARD INDEX OF PUBLICATIONS 1977-1979
Aug. 1980 428 p
(AGARD-INDEX-77-79; ISBN-92-835-1369-X) Avail: NTIS HC A19/MF A01

A bibliography containing approximately 4,300 entries addressing various topics in aerospace engineering and related areas is given. Subjects include aircraft design, instrumentation, and propulsion; aerodynamics; communications; missile control; aerospace medicine; and quality control. M.G.

N81-17950# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
MANUAL OF DOCUMENTATION PRACTICES APPLICABLE TO DEFENCE-AEROSPACE SCIENTIFIC AND TECHNICAL INFORMATION, VOLUME 3
S. C. SCHULER, ed. Oct. 1980 191 p refs 4 Vol.
(AGARD-AG-235-VOL-3; ISBN-92-835-1373-8; AD-A095032)
Avail: NTIS HC A09/MF A01

Various aspects of information retrieval are described including the principles of post coordinate indexing, examples of feature and edge punched card systems, the use of computers to produce various types of indexes, and the role of dial up on-line systems. Information dissemination practices are outlined and a survey of procedures used by a number of international technical information centers is given. The preparation and reproduction of research and development publications in both paper and microfilm media are described. The factors involved in setting up production facilities are discussed. For individual titles, see N81-17951 through N81-17953.

N81-17951# Royal Aircraft Establishment, Farnborough (England).
INFORMATION RETRIEVAL
T. NORTON *In* AGARD Manual of Doc. Pract. Appl. to Defence-Aerospace Sci. and Tech. Inform. Vol. 3 42 p (SEE N81-17950 08-82) Oct. 1980 refs
Avail: NTIS HC A09/MF A01

After a brief historical overview of information retrieval (IR), a model of an IR system is presented and described. The characteristics of conventional indexing systems are reviewed and shortcomings noted. The principles of postcoordinate indexing systems and examples of feature card and edge punched card systems with suggested applications are described. Problems of vocabulary control are discussed and suggestions on thesaurus construction and presentation are given. The use of computers to produce various types of indexes (KWIC, KWOC, and SLIC) is briefly described. The features of computerized dial up on-line information systems are discussed: equipment, telecommunications, file organization, search preparation and strategy, staff training, advantages and limitations of such systems, and future developments. An appendix outlines the principal features of specialized information centers. Author

N81-17952# Rome Air Development Center, Griffiss AFB, N.Y.
DISSEMINATION PRACTICES
F. S. DYER *In* AGARD Manual of Doc. Pract. Appl. to Defence-Aerospace Sci. and Tech. Inform., Vol. 3 72 p (SEE N81-17950 08-82) Oct. 1980
Avail: NTIS HC A09/MF A01

The dissemination of scientific and technical (S&T) information to the scientific user community is discussed. An overview of the area is presented followed by discussions of initial and secondary distribution. The need for automated support of the processes is described. Included as an appendix are the results of survey responses from a number of national and international technical information centers. These responses detail charters, data bases, practices, and operations of the responding S&T information centers. Most of the S&T information points surveyed are concerned with unclassified, unrestricted material. The exceptions were usually those which interfaced with a well defined user community readily subject to registration and control, and able to demonstrate a need to know such as contractors working on defense contracts. E.D.K.

N81-17953# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
MICROFORM SYSTEMS AND REPROGRAPHY
P. ROLLS *In its* Manual of Doc. Pract. Appl. to Defence-Aerospace Sci. and Tech. Inform., Vol. 3 72 p (SEE N81-17950 08-82) Oct. 1980 refs
Avail: NTIS HC A09/MF A01

The preparation and reproduction of research and development publications are discussed. Technical details of reprographic and microfilm processes are outlined in order to show the main factors involved in setting up publication facilities. The requirements for equipment and staff resources are discussed and cost elements are identified in broad terms. The application of computer output on microfilm is outlined and a review of the practical aspects of quality control for publications in both paper and microfilm media is included. E.D.K.

N81-23955# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
INFORMATION SERVICES: THEIR ORGANIZATION, CONTROL AND USE
Jan. 1981 79 p refs Partly in ENGLISH and FRENCH Papers presented at the Tech. Inform. Panel Specialists' Meeting, Lisbon, 5-6 Nov. 1980
(AGARD-CP-294; ISBN-92-835-0285-X; AD-A097019) Avail: NTIS HC A05/MF A01

The Portuguese scientific and technical information scene was reviewed as was the context of the European information environment. Special emphasis was placed on Euronet and its

interlinking with other networks. The subject of external information services, both national and international, are discussed, as are information retrieval and document delivery problems. In-house information services are also discussed.

N81-23956# Gesellschaft fuer Information und Dokumentation, Heidelberg (West Germany).
INFORMATION TRANSFER: BARRIERS AND TRENDS
W. KUNZ *In* AGARD Inform. Serv.: Their Organ., Control and Use 4 p (SEE N81-23955 14-82) Jan. 1981 refs
Avail: NTIS HC A05/MF A01

Based on a model of knowledge a concept of information as knowledge alteration is outlined. Problems of transfer of knowledge into new areas of application are described. Strategies for designing 'friendlier' information systems for innovation processes are discussed. Author

N81-23957# Centro de Documentacao Cientifica e Tecnica, Lisbon (Portugal).
PORTUGUESE SCIENTIFIC AND TECHNICAL INFORMATION SCENE: PRESENT STATUS AND FUTURE PROSPECTS
C. PULIDO *In* AGARD Inform. Serv.: Their Organ., Control and Use 5 p (SEE N81-23955 14-82) Jan. 1981 refs
Avail: NTIS HC A05/MF A01

A definition of an information policy is presented. The existing on-line systems were examined and promotional activities to demonstrate the potential uses of these systems are described. T.M.

N81-23958# National Center for Scientific and Technical Documentation, Brussels (Belgium).
EURONET AND ITS INTERLINKING TO OTHER NETWORKS
G. M. VANAUTRYVE *In* AGARD Inform. Serv.: Their Organ., Control and Use 7 p (SEE N81-23955 14-82) Jan. 1981 refs
Avail: NTIS HC A05/MF A01

The multidisciplinary data networks for America are compared to the Euronet telecommunications network. User requirements for the network are outlined. The technology selection for the implemention of Euronet is the electronic packet switching technology. The actual network configuration has four packet switching exchanges, established in Frankfurt, London, Paris, and Rome. Remote access facilities are located in Amsterdam, Brussels, Copenhagen, Dublin, and Luxemburg. T.M.

N81-23959# Fachinformationszentrum fuer Energie, Physik, Mathematik G.m.b.H., Eggenstein-Leopoldshafen (West Germany).
NATIONAL INFORMATION SERVICES WITH INTERNATIONAL ORIENTATION
W. RITTBERGER *In* AGARD Inform. Serv.: Their Organ., Control and Use 5 p (SEE N81-23955 14-82) Jan. 1981 refs
Avail: NTIS HC A05/MF A01

The information policy of the Federal Republic of Germany is presented and a few examples from other countries illustrated. Besides cooperation in international information systems there is bi- or multilateral cooperation. This kind of cooperation is illustrated by the examples of several data bases. Principles of information policies, economic and legal aspects as well as the experience gained so far are discussed. The problems of information distribution are also briefly dealt with. From the experience gained so far, criteria for national information services with international orientation are outlined. T.M.

N81-23960# Royal Aircraft Establishment, Farnborough (England)
USE OF EXTERNAL INFORMATION SERVICES
T. NORTON *In* AGARD Inform. Serv.: Their Organ., Control and Use 6 p (SEE N81-23955 14-82) Jan. 1981 refs Revised
Avail: NTIS HC A05/MF A01

Services which would be of use to defense-aerospace organization in the U.K. are examined. Sources for report literature, serial publications, translations, and conference proceedings are discussed and the differences between the various sources were examined. Attempts to improve the detection, identification, and collection of nonconventional or 'grey' literature are described. Reasons for continuing to subscribe to printed indexes and abstracts covering fields of major importance to an organization, even when on-line equivalents are available, are discussed. The importance of informal contacts (the 'old boy' network) in making effective use of external information services is emphasized. T.M.

N81-23961# Institut Technique du Batiment et des Travaux Publics, Paris (France). Centre d'Assistance Technique et de Documentation.
ARIANE: BUILDING DATA BANK
J. DEVOGE *In* AGARD Inform. Serv.: Their Organ., Control and Use 9 p (SEE N81-23955 14-82) Jan. 1981 In ENGLISH and in FRENCH
Avail: NTIS HC A05/MF A01

The data bank, computerized since 1972, collects all information required by the building professionals (i.e., engineers, foremen, architects,...). The following fields are covered in the data bank: building technology and tools; technical regulations concerning building in France; and building products. The design and use of the ARIANE data bank are described. T.M.

N81-23962# Technology Reports Centre, Orpington (England).
INTRODUCTION OF ON-LINE SEARCHING IN INFORMATION SERVICES
B. A. KINGSMILL *In* AGARD Inform. Serv.: Their Organ., Control and Use 7 p (SEE N81-23955 14-82) Jan. 1981 refs
Avail: NTIS HC A05/MF A01

The knowledge and techniques that need to be acquired for effective on-line searching, including operation of the terminal, command languages, system responses, how data bases are implemented, and general search strategy were examined. The various aids available such as manuals, training courses at different levels and different degrees of specialization, and help desks are discussed. The searcher's interaction with the end user of the information was examined. T.M.

N81-23963# Trondheim Univ. (Norway).
SURVEY OF SOLUTIONS TO THE DELIVERY PROBLEMS. GROWTH CONTROL OF LIBRARY COLLECTIONS
S. F. VEDI *In* AGARD Inform. Serv.: Their Organ., Control and uUse 2 p (SEE N81-23955 14-82) Jan. 1981
Avail: NTIS HC A05/MF A01

Two major solutions are discussed: the concentration of interlending to a few libraries in each country, and planned decentralization. Concentration may be suitable for small countries where there already are substantial collections concentrated in two or three libraries. This is much more cost effective than establishing central loan collections from scratch. Decentralization requires provision of material allocated among libraries on systematic basis, including a cooperative acquisition scheme. T.M.

N81-23964# Atomic Weapons Research Establishment, Aldermaston (England).
LIBRARY RECORDS: IN-HOUSE FILE CREATION VERSUS EXTERNAL SERVICES
D. V. WILSON *In* AGARD Inform. Serv.: Their Organ., Control and Use 5 p (SEE N81-23955 14-82) Jan. 1981 refs
Avail: NTIS HC A05/MF A01

A large percentage of the material required in special libraries in the defense field is not recorded in central files. Solutions to this problem are discussed and the use of computers for the creation of files of bibliographical information was reviewed. The transfer of data from an on-line data preparation file to a main off-line book file is outlined. T.M.

N81-23965# Congressional Research Service, Washington, D.C.
INFORMATION SERVICES FOR LEGISLATIVE POLICY MAKING
R. L. CHARTRAND *In* AGARD Inform. Serv.: Their Organ., Control and Use 11 p (SEE N81-23955 14-82) Jan. 1981 refs
Avail: NTIS HC A05/MF A01

Both legislative and executive decision makers in the United States have become committed to the use of information technology computers, telecommunications, microforms, word processing, audio and video devices which affects virtually every facet of governmental and societal activity. The United States Congress has undertaken to improve the efficiency of its functioning through the creation of new legislative entities and mechanisms which would provide a broad spectrum of responsive information

resources and services. The steps by which Congress determined its information needs, defined priorities in terms of files required and specific products or services created, and utilized public and private sector resources to provide the narrative, graphic, or statistical information required for policy making are described.
T.M.

N81-27972# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France)
MANUAL OF DOCUMENTATION PRACTICES APPLICABLE TO DEFENCE-AEROSPACE SCIENTIFIC AND TECHNICAL INFORMATION, VOLUME 4
S. C. SCHULER, ed. Mar. 1981 124 p refs
(AGARD-AG-235-VOL-4; ISBN-92-835-1382-7; AD-A102269)
Avail: NTIS HC A06/MF A01

Several aspects of technical information services are considered. Security requirements, the management of documentation centers, and national and interntional information networks are discussed. For individual titles, see N81-27973 through N81-27975.

N81-27973# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
STORAGE AND SECURITY CONTROL, SECTION 10
M. G. SIMS (Sims, (Michael G.), England) *In its* Manual of Doc. Pract. Appl. to Defence-Aerospace Sci. and Tech. Inform., Vol. 4 p 5-31 (SEE N81-27972 18-82) Mar. 1981 refs
Avail: NTIS HC A06/MF A0

The organization and administration of the security arrangements in a documentation center are described. The problems raised by the need for physical and personnel security are discussed. Document security requirements are considered from publication stage, through to issuing, dissemination, release, filing, storage, handling, circulation control, downgrading, and final disposal. The security grading of document is described. Access to sensitive documents by onsite users and external borrowers is considered. The differing requirements for security of items in various formats are discussed. The protection required in peripheral areas such as reprographic and computer rooms is considered.
J.D.H.

N81-27974# Manchester Univ. (England).
ORGANIZATION AND MANAGEMENT, SECTION 11
D. M. LEICH *In* AGARD Manual of Doc. Pract. Appl. to Defence-Aerospace Sci. and Tech. Inform., Vol. 4 p 33-92 (SEE N81-27972 18-82) Mar. 1981 refs
Avail: NTIS HC A06/MF A01

The establishment of a technical information center and its aims and objectives are discussed. The identification and fulfillment of user requirements are shown to be vital to its success and the way in which these can be achieved by good management is emphasized. Careful planning is essential at all stages and many aspects of planning are escribed. The role of the staff, in particular that of the information manager, is defined and the effectiveness of the information center is shown to be highly dependent on their contribution to it. Budget management and stock control are discussed and the impact of mechanization is considered. Active promotion of the services of the center is necessary and ways of achieving this are outlined. Author

N81-27975*# NASA Scientific and Technical Information Facility, Baltimore/Washington International Airport, Md. 21240
NETWORKS AND EXTERNAL SOURCES OF INFORMATION, SECTION 12
P. F. ECKERT, H. G. WYNNE, W. A. MARTIN (ESA, Rome), and A. BODINI (ESA, Rome) *In* AGARD Manual of Doc. Pract. Appl. to Defence-Aerospace Sci. and Tech. Inform., Vol. 4 p 93-110 (SEE N81-27972 18-82) Mar. 1981 refs Sponsored by NASA
Avail: NTIS HC A06/MF A01 CSCL 05B

The basic functional aspects of telecommunications, text searching, and networking are reviewed. Some of the information services, both commercial and noncommercial, which are operational in the United States and Europe are described. The ARPANET, TELENET, TYMET, and EURONET packet networks are described. External online bibliographic data bases and factual data banks are reviewed. Details of services offered, specific topics available, and contact points are given for (in the United States) the NASA-RECON, DOE/RECON, Defense RDT and E, Lockheed Information System (DIALOG), SDC ORBIT, and the bibliograhic Retrieval systems; and (in Europe), ESA/IRS, the International Atomic Energy Agency, TELESYSTEMS, SPIDEL, INKA DIMDI DATA-STAR, BLAISE, and PERGAMON-INFOLINE systems
J.D.H

N82-21099# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). Flight Mechanics Panel.
AGARD FLIGHT TEST INSTRUMENTATION SERIES. VOLUME 14: THE ANALYSIS OF RANDOM DATA
D. A. WILLIAMS (Cranfield Inst. of Technology), A. POOL, ed., and K. C. SANDERSON, ed. Nov. 1981 168 p refs
(AGARD-AG-160-VOL-14; ISBN-92-835-1405-X; AD-A111412)
Avail: NTIS HC A08/MF A01

The availability of powerful computing facilities, both on-line and off-line, for processing experimental data is addressed. It is shown that the flight test engineer has great flexibility in choosing the dividing line between 'hard wired' and 'soft' signal conditioning equipment. Further, the techniques described are used increasingly to extract meaningful information in situations where more conventional test and analysis techniques are inappropriate. For individual titles, see N82-21100 through N82-21107.
M.D.K.

N82-21100# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
PRE-PROCESSING
In its AGARD Flight Test Instr. Ser., Vol. 14 p 1-43 (SEE N82-21099 11-82) Nov. 1981
Avail: NTIS HC A08/MF A01

The specific requirements for an instrumentation system suitable for gathering random data are discussed. The answer to this question will depend upon the application. Random signals as a result of navigation errors, ILS approach path errors, structural loads resulting from take off and landing or flight in atmospheric turbulence, excitation by turbulent boundary layers or power plant exhausts, through to radio frequency interference were considered in terms of the design of a flight vehicle and demands of an instrumentation system. Questions which need answering before an adequate instrumentation system can be defined are delineated and discussed. Matters which may be looked upon as forming the interface between the raw measurements and the analysis proper are discussed. M.D.K.

N82-21101# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
ANALYSIS TECHNIQUES
In its AGARD Flight Test Instr. Ser., Vol. 14 p 44-83 (SEE N82-21099 11-82) Nov. 1981
Avail: NTIS HC A08/MF A01

Techniques more commonly encountered when analyzing random data from flight trials are introduced and discussed. The techniques are explained at a heuristic level and, where possible, the mathematical specifications of the techniques are developed from this explanation. Mathematical development of the specifications from statistical principles is provided. Expressions which allow estimates to be made of the reliability of results obtained from each technique are also included. The properties of random signals and, in general terms, the implications of those properties are also discussed. M.D.K.

N82-21102# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France)
SOME APPLICATIONS OF RANDOM DATA ANALYSIS
In its AGARD Flight Test Instr. Ser., Vol. 14 p 84-114 (SEE N82-21099 11-82) Nov. 1981 refs
Avail: NTIS HC A08/MF A01

Examples and results which may be obtained from power and cross spectral analysis of random data results from flight trials are presented. Characteristics of the data, decisions of the engineer making the analysis, the details to be extracted from the data and the reliability of that detail were considered. Some examples of applications of random data analysis discussed include measurements of atmospheric turbulence, analysis of records from flight flutter trials evaluation of aircraft ride and handling qualities, and reduction of random measurements to a form suitable for certification trials. Relationships intended to assist engineers in

making the choice of analyzer bandwidth appropriate for a given length of record were also considered. Results extracted from analyses of two types of signal are presented to provide a 'feel' for the consequences of choosing any particular combination of analyser bandwidth and averaging time. The signals used for the analysis were a 'white' noise source band limited at 1 KHz., and a narrow band signal. Results which demonstrate the effect of 'Hanning' each block of data prior to analysis are also included.
M.D.K

N82-21103# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
THE FOURIER SERIES AND FOURIER TRANSFORM
In its AGARD Flight Test Instr. Ser., Vol. 14 p 115-127 (SEE N82-21099 11-82) Nov. 1981
Avail: NTIS HC A08/MF A01

A good working knowledge of the principles of the Fourier series and Fourier transform is essential for developing routines for analyzing random data and for understanding fully the results produced by such routines. In recognition of this fact, an appendix containing an outline of the principles of both the Fourier series and the Fourier transform is presented. The strong relationship between the two when they are applied to sampled time sequences is demonstrated, and a list of properties is included which may be useful to the analyst who is engaged in applying the techniques to specific tasks.
Author

N82-21104# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
THE FAST FOURIER TRANSFORM
In its AGARD Flight Test Instr. Ser., Vol. 14 p 128-135 (SEE N82-21099 11-82) Nov. 1981 refs
Avail: NTIS HC A08/MF A01

A variety of FFT algorithms were devised to attain a maximum of efficiency under particular circumstances, for example to make best use of the attributes of a particular type of computer. All such algorithms make assumptions regarding the length of the data sequence to be transformed. It is generally assumed that the length of the sequence is equal to some power of an integer number. There is evidence to suggest that the most efficient algorithm assumes a length which is equal to a power of eight. However, the majority of algorithms are based upon binary or 'power of two' lengths, i.e., N = 2p. The reasons for this accord are that binary algorithms are relatively simple to understand and encode, the resulting algorithms are compact, and they offer the user the greatest choice of N for a given size of computer store. Two specific binary algorithms are developed for an Appendix. The Cooley-Tukey algorithm was the first to be published in modern times, the second, known as the Sande-Tukey algorithm is a logical development of the first which be preferred in particular circumstances.
Author

N82-21105# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
SOME PROCEDURES WHICH MAKE USE OF THE DFT
In its AGARD Flight Test Instr. Ser., Vol. 14 p 136-143 (SEE N82-21099 11-82) Nov. 1981
Avail: NTIS HC A08/MF A01

An Appendix containing procedures for computing estimates of PSD and CSD from arrays of sampled data, and estimates of auto and cross correlation functions from estimates of PSD and CSD using the DFT as a filtering element is presented. The procedures were presented in a formal high level language. ALGOL 60 was adopted as the language for the Appendix. Procedures were designed to present the various steps in a logical manner and with a degree of clarity. It is worth noting that the procedures would translate into grossly inefficient code if they were to be compiled exactly as they were presented.
M.D.K

N82-21106# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France)
PROBABILITY MEASURES
In its AGARD Flight Test Instr. Ser., Vol. 14 p 144-154 (SEE N82-21099 11-82) Nov. 1981
Avail: NTIS HC A08/MF A01

Random processes yield data whose values cannot be predicted with any certainty. The best that can be hoped for is a description which permits an estimate of the probability that a nominated event will occur using, as the basis for the estimate, averages obtained from data produced by the process at some time in the past. The concept of probability is therefore of primary importance in the study of random processes and the techniques used for describing data produced by such processes. An introduction to those probability measures which are most frequently encountered when analysing random data is provided in the Appendix presented.
Author

N82-21107# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France)
ERROR ANALYSIS
In its AGARD Flight Test Instr. Ser., Vol. 14 p 155-160 (SEE N82-21099 11-82) Nov. 1981
Avail: NTIS HC A08/MF A01

The results obtained from an analysis of random data are never exact. Thus two selections extracted from a recording made under nominally steady conditions will always yield different results. The magnitude and the character of the differences, or likely differences, between two such analyses are just as important as the results themselves if the results are to be interpreted with any degree of confidence. An outline of the method by which the errors associated with the analysis of random data may be estimated are contained in the appendix presented. The method is applied to the task of estimating the errors for several of the more familiar analysis techniques.
M.D.K

N82-23049# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
WHAT SHOULD USERS EXPECT FROM INFORMATION STORAGE AND RETRIEVAL SYSTEMS OF THE 1980'S?
Dec. 1981 117 p refs Proceedings of Conf. held in Munich, 9-10 Sep. 1981
(AGARD-CP-304; ISBN-32-835-0305-8; AD-A111846) Avail: NTIS HC A06/MF A01

Developments in the aerospace and defense information field and the information science field in general, are discussed. Unresolved problems, user and supplier related, in automatic indexing, fact retrieval, and input standardization are reviewed. The impact of technical and sociological changes on information services, now and in the future, is also addressed. For individual titles, see N82-23050 through N82-23060.

N82-23050# Canada Inst. for Scientific and Technical Information, Ottawa (Ontario).
CHANGING INFORMATION SCENE: FROM THE TIP SPECIALISTS' MEETING 1968 IN MUNICH TO THE EIGHTIERS
R. K. H. BREE *In* AGARD What Should Users Expect from Inform. Storage and Retrieval Systems of the 1980's 5 p (SEE N82-23049 13-82) Dec. 1981
Avail: NTIS HC A06/MF A01

The changing information scene, specifically storage and retrieval methods, is evaluated. On-line dialogue and interconnecting data bases are considered in terms of user needs. Constraints on the user by the various communication processes and responsibilities on the suppliers side are also considered. The need for and importance of information brokers in handling user demands is discussed. Broader standardization of rules and regulations for the use of offered services are recommended.
M.D.K

N82-23051# Canada Inst. for Scientific and Technical Information, Ottawa (Ontario).
MAJOR DEVELOPMENTS IN MODERN INFORMATION SERVICES: THE CANADIAN EXPERIENCE
G. EMBER *In* AGARD What Should Users Expect from Inform. Storage and Retrieval Systems of the 1980's 4 p (SEE N82-23049 13-82) Dec. 1981
Avail: NTIS HC A06/MF A01

Major developments in modern information services were studied with primary focus on the user related operational nature of services. Computer design and automation, improvements in telecommunication, and the union of computer and telecommunication technologies were evaluated. The importance of data banks in providing access to critically evaluated numeric data and research results and in bringing people together to solve problems is also discussed. The role of on-line document ordering and delivery was also considered in the study.
M.D.K

N82-23052# Siemens A.G., Munich (West Germany). DV System DB/DC.

MAJOR DEVELOPMENTS IN HARDWARE, SOFTWARE AND TELECOMMUNICATIONS IN THE FIELDS OF INFORMATION STORAGE AND RETRIEVAL

D. MORGENSTERN *In* AGARD What Should Users Expect from Inform. Storage and Retrieval Systems of the 1980's 5 p (SEE N82-23049 13-82) Dec. 1981 refs

Avail: NTIS HC A06/MF A01

Recent progress in information storage and retrieval systems and related advances in the information industry are discussed. Developments in hardware architecture and software and in telecommunications and data networks are emphasized. Two main trends in the future development of data base technology are cited, the implementation of extremely large data base systems and data base decentralization. M.D.K.

N82-23053# Centre de Documentation de l'Armement, Paris (France). Office of Scientific and Technical Information.

NONTECHNICAL FACTORS INFLUENCING INFORMATION SYSTEMS

M. A. YANEZ *In* AGARD What Should Users Expect from Inform. Storage and Retrieval Systems of the 1980's 21 p (SEE N82-23049 13-82) Dec. 1981 refs

Avail: NTIS HC A06/MF A01

Some effects of nontechnical and organizational factors on information systems are presented. The organizational, political, economic, legal and human factors involved are discussed in terms of vendor or host computer functions and user requirements, specifically requirements of scientists and engineers. M.D.K.

N82-23054# Centre de Documentation de l'Armement, Paris (France). Sektion fuer Technik.

AUTOMATED INDEXING AND THE FREE TEXT METHOD

W. MEDER *In* AGARD What Should Users Expect from Inform. Storage and Retrieval Systems in the 1980's 4 p (SEE N82-23049 13-82) Dec. 1981 refs

Avail: NTIS HC A06/MF A01

The method of automated indexing for document content analysis as a method to supplement or supersede the knowledge and experience of a human analyst is presented. Problems of automated indexing, free text retrieval, comparison of both, and suggestions for further development and a synthesis of both methods are discussed. A.D.K.

N82-23055# California Univ., Livermore. Lawrence Livermore Lab. Technology Information System Dept.

FACT RETRIEVAL IN THE 1980'S

V. E. HAMPEL *In* AGARD What Should Users Expect from Inform. Storage and Retrieval Systems of the 1980's 36 p (SEE N82-23049 13-82) Dec. 1981 refs

(Contract W-7405-ENG-48)

Avail: NTIS HC A06/MF A01

Prevailing methodologies of fact retrieval in science and technology are reviewed. Numeric databases are shown to overtake in size and number the large bibliographic collections. The availability of low-cost intelligent computer terminals, micro- and minicomputers, is shown to make aggregation and post-processing of retrieval information from different sources readily possible. The user community is seen to shift from expert information specialists to the end-users of information. Techniques of tabular and graphical fact retrieval are examined. The prospects of fact retrieval by voice, touch screens, and videotext are discussed. The potential of two unusual three-dimensional display techniques, the computer-generated time-resolved integral hologram and the projection of virtual data images into space, are discussed.

Author

N82-23056# Trondheim Univ. (Norway). Dept. of Documentation

USER REQUIREMENTS IN HANDLING ONLINE SYSTEMS AND NETWORKS

A. LAMVIK *In* AGARD What Should Users Expect from Inform. Storage and Retrieval Systems of the 1980's 5 p (SEE N82-23049 13-82) Dec. 1981 refs

Avail: NTIS HC A06/MF A01

Online systems and networks used by Norwegian searchers are outlined. The Nordic information network SCANNET is described. User problems and needs are presented in the light of the work in online user groups. Author

N82-23057# National Library of Medicine, Bethesda, Md. National Center for Biomedical Communications.

OPTICAL DISC TECHNOLOGY AND ITS IMPLICATIONS FOR INFORMATION STORAGE AND RETRIEVAL IN THE EIGHTIES

C. M. GOLDSTEIN *In* AGARD What Should Users Expect from Inform. Storage and Retrieval Systems of the 1980's 8 p (SEE N82-23049 13-82) Dec. 1981 refs

Avail: NTIS HC A06/MF A01

Optical disc technology includes the storage and retrieval of random access graphics on videodiscs as well as the storage of digital information. Optical digital discs for computer mass storage are currently under development by many firms. In addition, efforts are underway to allow the encoding of digital information on videodiscs. The latter is desireable as an inexpensive publication medium for machine readable data as well as a means of obtaining both video and digital information on one disc. Potential applications of this technology include inexpensive online storage, random access graphics to complement online information systems, hybrid network architectures, office automation systems, and archival storage. Author

N82-23058# Institute for Perception RVO-TNO, Soesterberg (Netherlands).

USERS REQUIREMENTS FOR TERMINALS: SELECTION, USE AND ECONOMIC FACTS

H. J. LEEBEEK *In* AGARD What Should Users Expect from Inform. Storage and Retrieval Systems of the 1980's 6 p (SEE N82-23049 13-82) Dec. 1981

Avail: NTIS HC A06/MF A01

In many process-control situations a computer is used to assist the man operating the system. The various tasks can be allocated between man and machine; the machine, or the computer, to undertake the dull, repetitious or fatiguing tasks; the human operator to undertake the supervisory and decision-making tasks. The elements of the tasks thus designed and assigned to the human operator are the perception of the machine output signals and the initiation of a desired state through control actions. Author

N82-23059# Ashford (J. H.) Associates Ltd., Maidenhead (England).

THE USE OF SMALL COMPUTERS IN INFORMATION RETRIEVAL FROM TEXTURAL AND FREE-STRUCTURED DATA-BASES

J. H. ASHFORD *In* AGARD What Should Users Expect from Inform. Storage and Retrieval Systems of the 1980's 6 p (SEE N82-23049 13-82) Dec. 1981 refs

Avail: NTIS HC A06/MF A01

Minicomputer systems are well established for the storage and retrieval of bibliographic records and the full text of documents. Examples are given of a range of applications including the handling of numeric and experimental data. The relationship between free text and structured records is examined, and the appearance of hybrid data forms is noted. Author

N82-23060# Commission of the European Communities, Luxembourg.

ONE YEAR OF EURONET DIANE EXPERIENCE AND EXPECTATIONS

B. MAHON *In* AGARD What Should Users Expect from Inform. Storage and Retrieval Systems of the 1980's 3 p (SEE N82-23049 13-82) Dec. 1981

Avail: NTIS HC A06/MF A01

The telecommunications network in particular the relationship between the European Commission and the consortium of eleven PTT's who provide the technical facilities are described. The evolution of Euronet into a public packet switched network for all the European Community Member States and also for countries outside the Communities, is also described. Concerning the information services, collectively referred to as DIANE, the expansion that has taken place in files available since commercial opening is described and the progressive shift in emphasis from purely bibliographic services to a mix of factual data banks and bibliographic data bases is analyzed. The ancillary facilities, referral, document ordering and delivery, etc., either operational or under development are also described in particular the activities of the

European Communities in developing the common command language and the program of work designed to overcome the language barrier. Experience of the Commission and the Member States in the development of new information services, the integration of new forms of interactive information services (Viewdata) and the contribution that Euronet DIANE had made towards the evolving 'telematique' society, are discussed. Author

N82-23061# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). Technical Information Panel.

MANUAL OF DOCUMENTATION PRACTICES APPLICABLE TO DEFENCE AEROSPACE SCIENTIFIC AND TECHNICAL INFORMATION. VOLUME 5: INDEX

T. NORTON (Royal Aircraft Establishment, Farnborough, England)) Feb. 1982 83 p

(AGARD-AG-235-VOL-5; ISBN-92-835-1414-9; AD-A112916)

Avail: NTIS HC A05/MF A01

A manual was written describing the basic documentation practices involved in the initial setting up and operation of an information-library organization to provide defense aerospace information services. The index to that manual is presented. S.L.

N82-23065# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).

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R. J. MILLEN Jan. 1982 32 p refs

(AGARD-AR-176; ISBN-92-835-1411-4; AD-A111749) Avail: NTIS HC A03/MF A01

Developments since 1970 are described. Concentrating on the situation in the United States of America and the United Kingdom, but including comments on the position in the NATO member nations and several other countries. The emphasis is on photocopying in libraries and of other matters which directly affect information transfer, such as software and database protection. Some of the current international developments are mentioned, including the effects of the EEC and the accession of the Soviet Union to the Universal Copyright Convention. Author

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GENERAL

N81-12993# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France)

TESTING AND MEASUREMENT TECHNIQUES IN HEAT TRANSFER AND COMBUSTION

Sep 1980 281 p refs Presented at the 55th(A) Specialist Meeting of the AGARD Propulsion and Energetics Panel, Brussels, 5-7 May 1980

(AGARD-CP-281; ISBN-92-835-0272-8; AD-A092953) Avail: NTIS HC A13/MF A01

Recent advances in temperature measurements, flow measurements, composition, and chemical measurements were discussed in order to furnish a comprehensive survey of modern test rigs and measurement techniques to development engineers for combustors and other high temperature components and to provide research scientists in these areas with recently developed techniques. Topics include: engine related measuring techniques; heat transfer for measurement techniques, optical velocity measurement techniques in flames, and optical techniques for temperature and composition measurements. For individual titles, see N81-12994 through N81-13015.

N81-12994# Pratt and Whitney Aircraft Group, East Hartford, Conn. Commercial Products Div.

PROBLEM IN THE MEASUREMENT OF METAL TEMPERATURE, GAS TEMPERATURE, HEAT FLUX AND STRAIN IN COMBUSTORS AND TURBINES

W. G. ALWANG *In* AGARD Testing and Meas. Tech. in Heat Transfer and Combust. 9 p (SEE N81-12993 03-99) Sep. 1980 refs

Avail: NTIS HC A13/MF A01

The verification of a gas turbine engine design requires that all critical design parameters be measured as directly and accurately as possible during development testing. The hot section of the engine poses some particularly difficult measurement problems. The limitations of current instrumentation used in the combustor and turbine are described and work in progress to overcome these limitations is reviewed. Among the topics to be covered are: limitations on the use of advanced dual spectral range optical pyrometers for metal surface temperature measurement, use of sputtered thin film thermocouples, problems in measuring gas temperature distributions and burner pattern factor, particularly above 3000 F, problems in measuring static strain and strain range in hot section hardware, and problems in the measurement of radiative and total heat flux. E.D.K.

N81-12995# Motoren- und Turbinen-Union Muenchen G.m.b.H. (West Germany).

TECHNICAL SUPPOSITIONS DEVELOPED FOR SMOKE MEASUREMENTS DURING HIGH PRESSURE FULL ANNULAR COMBUSTOR TESTS AND ENGINE TRIALS

G. KAPPLER, J. SEYBOTH, and G. HUSTER *In* AGARD Testing and Meas. Tech. in Heat Transfer and Combust. 13 p (SEE N81-12993 03-99) Sep. 1980 refs

Avail: NTIS HC A13/MF A01

The knowledge of smoke emissions from jet engines is of interest for civil as well as for military engine applications. Smoke emission measurements are a necessary and reliable tool for low emission combustor development. Two measuring techniques were designed: one for reliable cross correlations and basic calibrations using stained filter paper and another for fast continuous measurements based on an optical extinction method. The measuring systems are described and cross correlation data with a sucked Hartridge smoke meter is presented. Also covered are the sampling probes developed. Analysis of results of smoke emission measurements from three combustors with different smoke suppression methods showed good accuracy and reproducibility of the incorporated measuring systems. E.D.K.

N81-12996# Societe Nationale d'Etudes et de Construction de Moteurs d'Aviation, Moissy-Cramayel (France).

STUDYING THE EXHAUST GAS FROM A POST COMBUSTION TURBOJET ENGINE [ETUDE DES GAZ DECHAPPEMENT DUN TURBOREACTERUR EN RECHAUFFE]

P. GASTEBOIS and S. ROPARS *In* AGARD Testing and Meas. Tech. in Heat Transfer and Combust. 12 p (SEE N81-12993 03-99) Sep. 1980 In FRENCH Prepared in cooperation with Centre d'Essaisdes Propulseurs, Saclay, France

Avail: NTIS HC A13/MF A01

Knowledge of local temperatures and of the concentrations of pollutant species in the jet of a turbojet engine is useful for optimizing post combustion efficiency and for evaluating the importance of the air pollution created by the engine. A means is presented for analyzing gas removed by separator from the blast pipe of an OLYMPUS engine both on the ground and in simulated altitude. Results obtained show the difficulty of fixing the composition of gas taken before analysis and the necessity of improving techniques for measuring high temperature exhaust gases. A.R.H

N81-12997# Cornell Univ., Ithaca, N. Y. Sibley School of Mechanical and Aerospace Engineering.
PROBE MEASUREMENTS IN MULTI-DIMENSIONAL REACTING FLOWS
F. C. GOULDIN *In* AGARD Testing and Meas. Tech. in Heat Transfer and Combust. 14 p (SEE N81-12993 03-99) Sep. 1980 refs
(Contract NSG-3019)
Avail: NTIS HC A13/MF A01

The time mean response of pressure and sampling probes to pressure, density, and velocity fluctuations in turbulent reacting flows is examined by averaging over the instantaneous probe response. Corrections for fluctuation effects are found to be necessary if data obtained by these probes are to be used to find mean velocity and concentration information. Correction terms for pressure probe readings are well founded and of general applicability, while sampling probe correction terms are well founded only if the sample flow is choked at the probe inlet, a state which may be difficult to achieve in practice. Also, probe induced flow field perturbations are discussed for measurements in swirling flow. It is recommended that to avoid perturbations the smallest possible probes be used and that combustion conditions be monitored, e.g., with wall pressure taps, during probe insertion in order to detect perturbations should they occur. E.D.K.

N81-12998# Kraftwerk Union A.G., Mulheim (West Germany).
APPLICATION OF MODEL LAWS WHEN DETERMINING THE HEAT TRANSFER COEFFICIENTS BY EXPERIMENTS ON COOLED TURBINE BLADES
O. A. VONSCHWERDTNER and H. G. HOSENFELD *In* AGARD Testing and Meas. Tech. in Heat Transfer and Combust. 13 p (SEE N81-12993 03-99) Sep. 1980 refs
Avail: NTIS HC A13/MF A01

Model laws were fulfilled for geometry, aerodynamics, and heat transfer by reducing temperature and pressure of the operational and cooling fluids as opposed to the conditions in the turbine. The conception of a cascade wind tunnel with closed circuit enables the independent variation of influence values, e.g., Mach no. and Reynolds no., degree of turbulence and temperature ratio operating fluid/cooling fluid. Two measuring methods used were: (1) determining the local heat transfer coefficients by calorimetric means when cooling the blade surface with water in sections and (2) distribution of the cooling efficiency on the profile contour with the original cooling process. E.D.K.

N81-12999# Von Karman Inst. for Fluid Dynamics, Rhode-Saint-Genese (Belgium).
HEAT TRANSFER MEASUREMENTS RELATED TO HOT TURBINE COMPONENTS IN THE VON KARMAN INSTITUTE HOT CASCADE TUNNEL
B. E. RICHARDS *In* AGARD Testing and Meas. Tech. in Heat Transfer and Combust. 13 p (SEE N81-12993 03-99) Sep. 1980 refs
Avail: NTIS HC A13/MF A01

The hot cascade tunnel developed to extend turbine research to heat transfer studies is described. It is based on a free piston compressor of 1 meter in diameter and 5 meters in length with a test section of 100 mm x 250 mm compatible with an existing ambient temperature blowdown cascade tunnel. Some typical results on heat transfer and film cooling from the first 1200 tests are described. E.D.K.

N81-13000# Oxford Univ. (England). Dept. of Engineering Science.
HEAT TRANSFER RATE AND FILM COOLING EFFECTIVENESS MEASUREMENTS IN A TRANSIENT CASCADE
D. L. SCHULTZ, M. L. G. OLDFIELD, and T. V. JONES *In* AGARD Testing and Meas. Tech. in Heat Transfer and Combust. 9 p (SEE N81-12993 03-99) Sep. 1980 refs
Avail: NTIS HC A13/MF A01

A transient cascade useful for heat transfer rate measurements is briefly described. The facility employs a free piston which compresses the test gas to temperatures around 450 K and pressures of about 3.5 to 7.5 Atm. The model is initially at room temperature and it is necessary to attain the correct gas to wall temperature ratio. The exit Mach number is set by the inlet total pressure and the pressure in the exit dump tank. Thin film heat transfer gauges are used for the measurement of heat transfer rate, deposited on machineable glass ceramic blades. The inherently fast response of these transducers makes them useful for the investigation of boundary layer transition on blade surfaces and some typical results are included. E.D.K.

N81-13001# Sussex Univ., Brighton (England). Dept of Mechanical Engineering.
STUDIES OF TURBULENCE CHARACTERISTICS AND THEIR EFFECTS UPON THE DISTRIBUTION OF HEAT TRANSFER TO TURBINE BLADING
F. J. BAYLEY and W. J. PRIDDY *In* AGARD Testing and Meas. Tech. in Heat Transfer and Combust. 15 p (SEE N81-12993 03-99) Sep. 1980 refs
Avail: NTIS HC A13/MF A01

Two techniques are used to determine the distribution of heat transfer coefficient around turbine blade sections. Data are reported from cascade tests with a steady mainstream and then from tests in which the turbulence intensity and frequency were systematically varied. A provisional correlation of the data is described. E.D.K.

N81-13002# Karlsruhe Univ. (West Germany). Engler-Bunte-Institut.
CORRELATION MEASUREMENT OF VELOCITY AND TEMPERATURE FLUCTUATIONS IN A FREE JET DIFFUSION FLAME
V. WITTMER and R. GUENTHER *In* AGARD Testing and Meas. Tech. in Heat Transfer and Combust. 8 p (SEE N81-12993 03-99) Sep. 1980 refs
Avail: NTIS HC A13/MF A01

A free jet diffusion flame was studied. The measurement techniques used were the laser Doppler anemometry (LDA) and a compensated thermocouple. With LDA the fields of both the mean axial and radial velocities and their fluctuations were measured. The local mean and fluctuating temperature were measured after determining the frequency response. The time constant was measured assuming the transfer function of the thermocouple to be a first order lag. The results of the temperature measurement show that the maximum of the temperature fluctuations is outside of the reaction zone. In a transverse plane, the correlation of the fluctuating axial and radial velocities has the maximum at the location of the highest gradient of the axial velocity. The correlation of fluctuating velocity and temperature becomes zero in the reaction zone. E.D.K.

N81-13003# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Cologne (West Germany). Inst. fuer Antriebstechnik.
VELOCITY AND TURBULENCE MEASUREMENTS IN TURBULENT FLAMES USING THE L2F TECHNIQUE
H. EICKHOFF and R. SCHODL *In* AGARD Testing and Meas. Tech. in Heat Transfer and Combust. 12 p (SEE N81-12993 03-99) Sep. 1980 refs
Avail: NTIS HC A13/MF A01

The flow properties within turbulent diffusion flames were measured using an L2F velocimeter. Considering the problem of seeding, some basic investigations were carried out within a round free jet. The optically measured mean velocity and turbulence intensities were compared with pitot tube and hot wire data respectively. The results which are presented and discussed indicate the capability of the L2F velocimeter when it is applied to highly turbulent flows. Mean velocity and turbulence were measured in hydrogen air and propane air diffusion flames under different initial conditions. The results are discussed with regard to the influence of combustion on the turbulent flow field. E.D.K.

N81-13004# Von Karman Inst. for Fluid Dynamics, Rhode-Saint-Genese (Belgium).
VELOCITY MEASUREMENT TECHNIQUES IN LIQUID SPRAYS USING LASER DOPPLER VELOCIMETRY
M. L. RIETHMULLER and J. M. BUCHLIN *In* AGARD Testing and Meas. Tech. in Heat Transfer and Combust. 7 p (SEE N81-12993 03-99) Sep. 1980 refs
Avail: NTIS HC A13/MF A01

In many applications, there exists a velocity lag between droplets and a surrounding gas. The measurement of gas velocity must therefore be performed separately from the measurement of droplet velocity. This is the objective of a technique implemented in order to measure gas velocity, in the presence of droplets. A

laser velocimeter adjusted for reference beam mode was used in a water spray. Satisfactory results are obtained and it is shown that, providing the gas flow is correctly seeded with small particles, a velocity measurement of gas velocity is yielded even with a large number of droplets. E.D.K.

N81-13005# Office National d'Etudes et de Recherches Aeronautiques, Paris (France).
A METHOD FOR MEASURING SHORT TIME RESPONSE BY DETERMINING VELOCITY AND TEMPERATURE VARIATIONS IN HIGH TEMPERATURE FLOWS [METHODES DE MESURE A COURT TEMPS DE RESPONSE POUR LA DETERMINATION DES FLUCTUATIONS DE VITESSE ET TEMPERATURE DANS LES ECOULEMENTS A TEMPERATURE ELEVEE]
M. CHARDENEL, Y. LEBOT, P. MAGRE, J. LABBE, and P. MOREAU *In* AGARD Testing and Meas. Tech. in Heat Transfer and Combust. 13 p (SEE N81-12993 03-99) Sep. 1980 refs In FRENCH; ENGLISH summary
Avail: NTIS HC A13/MF A01

An optical device using an infrared simultaneous emission and absorption method for measurements of instantaneous gas temperatures, and total pressure probes with a short response time in order to measure the turbulence level were developed to characterize the unsteadiness of high temperature flows. These two experimental techniques are described and the results obtained on hot turbulent flows are analyzed and compared with more classical indications given by laser velocimetry. The further application of these techniques to obtain the turbulence spectra and to determine the integral scale by the optical method of crossed beams is also examined. Author

N81-13006# Imperial Coll. of Science and Technology, London (England).
VELOCITY AND TEMPERATURE MEASUREMENTS IN A PREMIXED FLAME WITHIN AN AXISYMMETRIC COMBUSTOR
A. M. K. P. TAYLOR and J. H. WHITELAW *In* AGARD Testing and Meas. Tech. in Heat Transfer and Combust. 11 p (SEE N81-12993 03-99) Sep. 1980 refs
Avail: NTIS HC A13/MF A01

Measurements of velocity, temperature, and noise characteristics are reported for a premixed natural gas, air flame stabilized on a disc baffle located on the axis of a round pipe and for a corresponding isothermal flow. The stability limits of the flame are identified, and measurements of mean axial velocity, the variance of the corresponding fluctuations, and noise intensity are provided for equivalence ratios in the range 0.7 to 1.6. Center line distributions of mean axial velocity, the variance of the corresponding fluctuations, and mean temperature are reported and an analysis presented of the uncertainties of the laser anemometer instrumentation and bare wire thermocouple measurements. It is shown that: the range of equivalence ratios which allow stable combustion is comparatively small; that the maximum and minimum mean velocities and the length of the recirculation region are increased by combustion; and that the center line distribution of mean temperature is comparatively uniform for more than 3 baffle diameters downstream. E.D.K.

N81-13007# Sussex Univ., Brighton (England). School of Engineering and Applied Sciences.
THE USE OF OPTICAL TECHNIQUES IN THE INTERPRETATION OF HEAT TRANSFER MEASUREMENTS
J. M. OWEN and J. R. PINCOMBE *In* AGARD Testing and Meas. Tech. in Heat Transfer and Combust. 12 p (SEE N81-12993 03-99) Sep. 1980 refs
Avail: NTIS HC A13/MF A01

Optical techniques were used to study the flow structure, and to gain a better understanding of the convective heat transfer inside rotating cavities. Flow visualization was used to determine the amount of coolant necessary to seal an air cooled rotor stator system, to delineate regimes of vortex breakdown in rotating cavities with axial throughflow, and to identify the flow regimes in a rotating cavity with a radial outflow of coolant. The LDA measurements of the radial and tangential components of velocity inside the rotating cavity were used to correlate the flow visualization results. For the radial outflow case, these velocity measurements are in good agreement with theoretical predictions. Measured Nusselt numbers reveal the presence of heat transfer regimes corresponding to those identified by the optical techniques. E.D.K.

N81-13008# Poitiers Univ. (France). Lab. d'Energetique et de Detonique.
THE APPLICATION OF UV SPECTROSCOPY TO THE QUANTITATIVE ANALYSIS OF NITROGEN OXIDE [APPLICATION DE LA SPECTROSCOPIE U. V. AU DOSAGE DE LOXYDE NITRIQUE]
J. P. DURAND and J. C. BELLET *In* AGARD Testing and Meas. Tech. in Heat Transfer and Combust. 10 p (SEE N81-12993 03-99) Sep. 1980 refs In FRENCH
Avail: NTIS HC A13/MF A01

Measurements of nitrogen oxide concentration in combustion products, obtained under very different experimental conditions, by ultraviolet absorption spectrometry and by sampling and quantitative analysis using a chemiluminescence analyzer were compared. Results demonstrate that parasitic absorptions of oxygen and anhydrous carbon must be considered when the temperature exceeds about 700 K for the (1,0) gamma band, and 900 K for the (0,0) gamma band. In addition, measurements made in the jet of a turbojet engine at the SMECMA test stand show that other parasitic species not yet identified, but probably incombustibles, interfere with measurements. Transl. by A.R.H.

N81-13009# Office National d'Etudes et de Recherches Aerospatiales, Paris (France).
DIAGNOSING COMBUSTION BY D.R.A.S.C. [DIAGNOSTICS DES COMBUSTIONS PAR D.R.A.S.C.]
B. ATTAL, M. PEALAT, and J. P. TARAN *In* AGARD Testing and Meas. Tech. in Heat Transfer and Combust. 16 p (SEE N81-12993 03-99) Sep. 1980 refs In FRENCH
Avail: NTIS HC A13/MF A01

The coherent anti-Stokes Raman spectrometers (DRASC) used at ONERA are described. The nonresonating instrument permits the use of the BOXCARS technique and eliminates the nonresonating base. Its spectral resolution of 0.7 cm/1 can be reduced to 0.07 c/1 by the simple placement of an optical element and no realignment. A wide band operational mode is also forseen for multiplex spectroscopy. Some characteristic results obtained in a furnace simulating a turbomachine are presented. Detectability is generally between 100 and 1000 ppm. Recent results on iodine give hope that gains in detectability between 100 and 1000 will be possible with the resonating DRASC. A.R.H.

N81-13010*# United Technologies Research Center, East Hartford, Conn.
INVESTIGATIONS OF COHERENT ANTI-STOKES RAMAN SPECTROSCOPY (CARS) FOR PRACTICAL COMBUSTION DIAGNOSTICS
A. C. ECKBREITH, R. C. HALL, and J. A. SHIRLEY *In* AGARD Testing and Meas. Tech. in Heat Transfer and Combust. 14 p (SEE N81-12993 03-99) Sep. 1980 refs Sponsored in part by NASA and EPA
(Contract PROJ. SQUID)
Avail: NTIS HC A13/MF A01

Coherent anti-Stokes Raman spectroscopy (CARS appears very promising for the remote, spatially and temporally precise probing of instrumentally hostile combustion environments due to its large signal conversion efficiency and coherent signal nature. By analyzing the spectral distribution of the CARS signal, temperature measurements can be performed. Species concentration measurements derive from the intensity of the CARS radiation or, in certain cases, from its spectral shape. The CARS spectra were recorded in a variety of flames from N2, O2, CO, H2, H2O, CO2 and CH4 and, for the first five generally show very good agreement with computer synthesized spectra. Quite significantly, CARS was successfully demonstrated with both liquid and gaseous fuels in the primary zone and exhaust of practical combustors. Although thermometry has received the major emphasis, species concentration measurements were performed for H2, O2, and CO. E.D.K.

N81-13011# General Electric Co., Schenectady, N. Y. Corp. Research and Development.
THE STUDY OF TURBULENT DIFFUSION FLAMES: MODELING NEEDS AND EXPERIMENTAL LIGHT SCATTERING CAPABILITIES
M. LADD and R. M. C. SO *In* AGARD Testing and Meas. Tech. in Heat Transfer and Combust. 18 p (SEE N81-12993 03-99) Sep. 1980 refs Sponsored in part by DOE and AFOSR
(Contract PROJ. SQUID)
Avail: NTIS HC A13/MF A01

The capabilities of advanced light scattering measurement techniques are compared with the needs of combustion modeling approaches. Such comparisons are useful in working toward the coupled goals of developing and verifying flame models and providing guidance for the development of experimental probe methods along the most productive paths. The types of experimental data available are compared with those often required in combustion modeling, permitting one to assess the present and potential contributions of the techniques. This assessment is illustrated by consideration of current analytical results based upon Pratt's coalescence/dispersion model, and by recent experimental results from Raman scattering diagnostics of turbulent diffusion flames. The experimental data shown include simultaneously determined values of temperature and major species densities and are presented in the form of pdf's and density-temperature correlations. E.D.K.

N81-13012# Consiglio Nazionale delle Ricerche, Milan (Italy).
FLAME TEMPERATURE PROFILES OBTAINED BY THE TWO-LINE ATOMIC FLUORESCENCE METHOD
G. ZIZAK, F. CIGNOLI, and S. BENECCHI *In* AGARD Testing and Meas. Tech. in Heat Transfer and Combust. 8 p (SEE N81-12993 03-99) Sep. 1980 refs
Avail: NTIS HC A13/MF A01

Flame temperature measurements performed using the two line atomic fluorescence method (TLAF) are described. Several flames were investigated and it is concluded that when a lamp is used, the measuring times for many important flames are much too long. Hence, in actual combustion systems, difficulties arise which may not be easily solved. If a source with higher energy (i.e. a laser) becomes necessary, other techniques are preferable. E.D.K.

N81-13013# Sandia Labs., Livermore, Calif.
APPLICATIONS OF OPTICAL DIAGNOSTIC TECHNIQUES IN COMBUSTION RESEARCH
D. L. HARTLEY and M. A. GUSINOW *In* AGARD Testing and Meas. Tech. in Heat Transfer and Combust. 15 p (SEE N81-12993 03-99) Sep. 1980 refs
(Contract DE-AC04-76DP-00789)
Avail: NTIS HC A13/MF A01

A summary of the application of laser based optical techniques to the diagnostics of combustion problems is presented. The emphasis was on the determination of temperature and species concentrations in a combusting environment. The application of these techniques centered on laminar flames, turbulent flames, particulate laden flows, and internal combustion engines. The constraints of spatial and temporal resolution were achieved, as well as the detection of intermediate species in certain laboratory experiments. E.D.K.

N81-13014# National Center for Energetics and Propulsion, Milan (Italy).
DROPLET SIZE MEASUREMENTS IN COMBUSTION BY THE VISIBILITY METHOD
A. COGHE, C. BRIOSCHI, F. GAMMA, and U. GHEZZI *In* AGARD Testing and Meas. Tech. in Heat Transfer and Combust. 10 p (SEE N81-12993 03-99) Sep. 1980 refs Prepared in cooperation with Politecnico di Milano
Avail: NTIS HC A13/MF A01

Droplet size measurements in a flame of liquid fuel sprays by means of the visibility method is based on the classical LDV optical system, which makes it possible to extract size information from the visibility of the scattered signal generated by a single droplet crossing the probe volume. The purposes of this paper are: (1) to present basic principles and numerical results of the theoretical model based on Mie scattering; (2) to present results obtained by experimental tests performed on liquid fuel sprays under burning conditions; and (3) to discuss the reliability and the limits of this method, its sensitivity, and an improved data processing procedure. E.D.K.

N81-13015# Von Karman Inst. for Fluid Dynamics, Rhode-Saint-Genese (Belgium).
A METHOD FOR THE MEASUREMENTS OF MIXING PROPERTIES IN A FLOW
C. BORREGO and D. OLIVARI *In* AGARD Testing and Meas. Tech. in Heat Transfer and Combust. 16 p (SEE N81-12993 03-99) Sep. 1980 refs
Avail: NTIS HC A13/MF A01

A laser Doppler velocimeter (LDV) and a laser scatter meter (LSM) were used to measure flow velocity and tracer concentration. Tests were carried out on a turbulent air jet of circular cross section exhausting into still air. The method for measuring certain parameters relevant to the mixing process was tested involving laser equipment in combination with the introduction of a tracer in the jet in the form of oil smoke. The flow field was examined at locations varying from two to twenty diameters downstream of the nozzle. Main parameters recorded at each downstream station were: mean axial velocity, mean concentration, fluctuating velocity, and concentration and velocity-concentration correlation. E.D.K.

N82-32256# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
RAMJETS AND RAMROCKETS FOR MILITARY APPLICATIONS
Mar. 1982 266 p refs Mostly in ENGLISH; One in FRENCH Proceedings of 58th Propulsion and Engergetics Symp., London, 26-29 Oct. 1981
(AGARD-CP-307; ISBN-92-835-0312-X; AD-A115370) Avail: NTIS HC A12/MF A01

A comprehensive survey of ramjet and ramrocket technology and its application to missile propulsion is presented. For individual titles, see N82-32257 through N82-32274.

N82-32257# United Technologies Corp., Sunnyvale, Calif. Chemical Systems Div.
LOW-COST COMBUSTOR FOR A SUPERSONIC TACTICAL MISSILE
T. D. MYERS and A. P. PETERS *In* AGARD Ramjets and Ramrockets for Mil. Appl. 15 p (SEE N82-32256 22-99) Mar. 1982
Avail: NTIS HC A12/MF A01

Development of a low cost advanced low volume ramjet (ALVRJ) propulsion system for the supersonic tactical missile (STM) and other tactical mission applications is summarized. A series of propulsion system performance/cost vehicle systems trades were conducted. Key propulsion system requirements that most strongly influenced cost were: (1) fuel flow rate accuracy, (2) inlet pressure recovery, and (3) required combustor operational life. From these trade studies specific low cost ramjet component designs were selected, including: (1) inlet, (2) fuel controller, (3) rocket booster motor nozzle release mechanism, and (4) combustor/thermal protection system (TPS). The low cost combustor/TPS development effort is stressed. The low cost combustor for the STM propulsion system was successfully demonstrated through a series of ground tests and a flight test. The 5:1 combustor cost reduction for the STM propulsion system compared to the ALVRJ propulsion sytem was achieved with no performance penalty. J.D.

N82-32258# Applied Physics Lab., Johns Hopkins Univ., Laurel, Md.
ENGINE SIZING AND INTEGRATION REQUIREMENTS FOR HYPERSONIC AIRBREATHING MISSILE APPLICATIONS
P. J. WALTRUP, F. S. BILLIG, and R. D. STOCKBRIDGE *In* AGARD Ramjets and Ramrockets for Mil. Appl. 41 p (SEE N82-32256 22-99) Mar. 1982 refs
(Contract N00024-81-C-5301)
Avail: NTIS HC A12/MF A01

A procedure that provides a rational means for selecting an inlet/combustor configuration for a hypersonic airbreathing missile is presented. The particular problem that is addressed is the design of the sustained engine of a two stage missile that is constrained to be launched from a stowage volume that is either square or circular in cross section. The sustainer engine accelerates from a

low altitude separation at Mach 4 and climbs to high altitude for cruise at Mach 8. The results show that a missile with an axisymmetric nose inlet provides a somewhat higher thrust capability and slightly better fuel efficiency than a chin type inlet. Aft entry inlets are shown to have a substantially lower thrust potential and lower engine efficiency. A criterion for determining the maximum contraction ratio of a fixed geometry inlet is established and applied to the exemplary missile designs. Combustor area ratio is examined and found to have a relatively small effect on engine perfor[illegible]ce for area ratios equal to or larger than that required to obtain maximum thrust at the take-over Mach number. Author

N82-32259# Stuttgart Univ. (West Germany). Inst. fuer Raumfahrtantriebe.
DESIGN CONSIDERATION AND ANALYTICAL COMPARISON OF DIFFERENT TYPES OF RAMJETS AND RAMROCKETS
P. BENKMANN and P. A. KRAMER *In* AGARD Ramjets and Ramrockets for Mil. Appl. 14 p (SEE N82-32256 22-99) Mar. 1982 refs Sponsored in part by the German Ministry of Defense
Avail: NTIS HC A12/MF A01

Several types of ramjet and ramrocket (or ducted rocket) propulsion systems with hydrocarbon fuels for high sub- to supersonic missile application are theoretically analyzed and compared. Design considerations are discussed with respect to their performance impacts. Fundamental physical connections as well as mission and internal design variables are investigated in order to give some insight into the ramjet's and ramrocket's performance and application potential. The results are presented in graphical form. Author

N82-32260# Calgary Univ. (Alberta). Dept. of Mechanical Engineering.
VALVELESS PULSEJETS AND ALLIED DEVICES FOR LOW THRUST, SUBSONIC, PROPULSION APPLICATIONS
J. A. C. KENTFIELD *In* AGARD Ramjets and Ramrockets for Mil. Appl. 11 p (SEE N82-32256 22-99) Mar. 1982 refs Sponsored in part by the Natural Sciences and Engineering Research Council of Canada
Avail: NTIS HC A12/MF A01

A review is presented of predicted flight performances, based on well established static test stand data, of current technology valveless pulsejets. Comparisons are made with alternative forms of propulsion suitable for small subsonic vehicles. It is shown that valveless pulsejets have some performance advantages over other forms of propulsion for short-range missions requiring low thrust levels of less than about 600 Newtons (approximately less than 130 lb sub f). The advantages of valveless pulsejets in terms of simplicity when compared with other propulsion systems are also shown to be substantial. Possible ways of improving pulsejet performance are discussed. The systems considered involve means for obtaining improved precombustion charge compression using twin alternately firing pulsed combustors and more sophisticated units incorporating dynamic pressure-exchangers. Author

N82-32261# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Cologne (West Germany).
MULTIPLE INTAKES FOR RAMROCKETS
E. O. KROHN and K. TRIESCH *In* AGARD Ramjets and Ramrockets for Mil. Appl. 14 p (SEE N82-32256 22-99) Mar. 1982 refs
Avail: NTIS HC A12/MF A01

Several ramrocket missiles under development have a central combustion chamber and more than one side mounted intake in general four. The junction of different inlet flows in a common chamber causes, in certain cases, flow instability and flow reversal in single ducts. The flow mechanism will be explained by examples. A computer program was developed which calculates the overall performance of the system from single inlet data. The results are compared with wind tunnel measurements. Methods for reducing the negative effects of combining multiple intakes with a common chamber are discussed. Author

N82-32262# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (West Germany).
ONE-DIMENSIONAL NONLINEAR CONSIDERATIONS ON SUPERSONIC DIFFUSER BUZZ
H. L. WEINREICH *In* AGARD Ramjets and Ramrockets for Mil. Appl. 14 p (SEE N82-32256 22-99) Mar. 1982 refs
Avail: NTIS HC A12/MF A01

The fundamental aspects of supersonic intake buzz are discussed. The basic characteristics of the phenomenon are described and its relationship to other unsteady propulsion processes presented. A simplified intake propulsion stability analysis shows the possible influence of diffuser exit Mach number on the stability boundary in comparison to other well-known theories. Nonlinear example calculations using smooth intake pressure recovery curves can illustrate some experimentally observed buzz characteristics. The limits of the theoretical approach are discussed, and the tendencies compared with experimental work. Author

N82-32263# Stuttgart Univ. (West Germany). Inst. fuer Raumfahrtantriebe.
RANGE MAXIMIZATION METHOD FOR RAMJET POWERED MISSILES WITH FLIGHT PATH CONSTRAINTS
U. M. SCHOETTLE *In* AGARD Ramjets and Ramrockets for Mil. Appl. 19 p (SEE N82-32256 22-99) Mar. 1982 refs Sponsored in part by the German Ministry of Defense
Avail: NTIS HC A12/MF A01

Mission performance of ramjet powered missiles is strongly infuenced by the trajectory flown. The trajectory optimization problem considered is to obtain the control time histories (i.e., propellant flow rate and angle of attack) which maximize the range of ramjet powered supersonic missiles with preset initial and terminal fight conditions and operational constraints. The approach chosen employs a parametric control model to represent the infinite-dimensional controls by a finite set of parameters. The resulting suboptimal parameter optimization problem is solved by means of nonlinear programming methods. Operational constraints on the state variables are treated by the method of penalty functions. The presented method and numerical results refer to a fixed geometry solid fuel integral rocket ramjet missile for air-to-surface or surface-to-surface missions. The numerical results demonstrate that continuous throttle capabilities increase range performance by about 5 to 11 percent when compared to more conventional throttle control. Author

N82-32264# Dornier-Werke G.m.b.H., Friedrichshafen (West Germany).
JET-AFTERBODY INTERFERENCE ON MISSILES IN SUPERSONIC FLOW
B. WAGNER *In* AGARD Ramjets and Ramrockets for Mil. Appl. 11 p (SEE N82-32256 22-99) Mar. 1982 refs Sponsored in part by the German Ministry of Defense
Avail: NTIS HC A12/MF A01

Axisymmetric base flow in the presence of an exhaust jet is investigated, taking into account essential physical parameters. Using the method of characteristics for the inviscid flow regions and Korst's treatment for the turbulent shear layers, the influence of the approaching boundary layers is introduced by the concepts of equivalent bleed and origin shift, and the ONERA angular criterion is used for the recompression process. With respect to the interferences in the confluence problem of internal and external shear layers special attention is given to the momentum terms in the ONERA criterion and a modification is performed in order to achieve agreement of both reattachment pressures at the confluence point. The investigations include separation from conical boattails by applying a simple separation criterion and extend to small angles of attack by computing the inviscid flow with the aid of a linearized characteristics method. For the axisymmetric case a first result is provided from numerical solutions of the full Navier-Stokes equations. Author

N82-32265# Georgia Inst. of Tech., Atlanta. School of Aerospace Engineering.
BASE AND EXTERNAL BURNING FOR PROPULSION
W. C. STRAHLE and J. E HUBBARTT *In* AGARD Ramjets and Ramrockets for Mil. Appl. 9 p (SEE N82-32256 22-99) Mar. 1982 refs
(Contract FA9620-78-C-0003)
Avail: NTIS HC A12/MF A01

Experimental studies of base and external burning behind an axisymmetric bluff base body in Mach 3 flight are described. Pure hydrogen and hydrogen diluted with CO2 He and N2 were the fuels. A variety of base configurations were used and external burning used radial jet injection with both subsonic and supersonic jets. Some wind tunnel interference problems arose which limited consideration of the results to base pressure elevation to free stream static pressure. A maximum performance condition was identified as a line in 1 sub SP - base pressure rise space which was achievable with all configurations and combinations of base and external burning. The major determinant of 1 sub SP performance is the total heat dump rate into the wake, and only minor differences in performance result from configuration and fuel type details. Author

N82-32266# Rolls-Royce Ltd., Bristol (England).
SERVICE EXPERIENCE WITH THREE GENERATIONS OF RAMJETS
C. F. FLETCHER and D. R. LANE *In* AGARD Ramjets and Ramrockets for Mil. Appl. 9 p (SEE N82-32256 22-99) Mar. 1982
Avail: NTIS HC A12/MF A01

The development of three generations of ramjets for use in operational surface to air missiles is discussed. Operation and maintenance in tropical, arctic and marine environment was tested. The precautions taken during design to achieve reliability and a low level of mantenance effort are reported. In the third generation, design progressed to the establishment of wooden round status for a factory filled liquid fuelled ramjet. The reliability of the ramjet propulsion system in many practice firings of service maintained missiles by service crews is discussed and compares well with that of rocket systems. E.A.K.

N82-32267# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Hardthausen (West Germany). Inst. fuer Chemische Antriebe und Verfahrenstechnik.
EXPERIMENTAL INVESTIGATION OF A HYDROCARBON SOLID FUEL RAMJET
D. MEINKOEHN and J. W. BERGMANN *In* AGARD Ramjets and Ramrockets for Mil. Appl. 11 p (SEE N82-32256 22-99) Mar. 1982
Avail: NTIS HC A12/MF A01

A solid fuel ramjet motor in a connected pipe air supply under simulated in flight operating conditions was investigated. Diffuser losses based on empirical efficiencies were considered and a set of states of the air upstream of the ramjet combustor was theoretically derived to simulate certain in flight conditions of a ramjet-powered missile. Internal ballistics, combustion efficiency and overall combustor performance which covers a range of Mach numbers between 1.5 and 3.0 for altitudes between sea level are investigated and 6000 m Polyethylene was the hydrocarbon fuel used in most of the tests. It is found that a suitable regression can be established for varying peformance requirements even by providing for trajectory dependent combustion efficiencies. EAK

N82-32268# Naval Weapons Center, China Lake, Calif.
BORON COMBUSTION IN DUCTED ROCKETS
K. C. SCHADOW *In* AGARD Ramjets and Ramrockets for Mil. Appl. 12 p (SEE N82-32256 22-99) Mar. 1902 refs
Avail: NTIS HC A12/MF A01

The qualitative effect of inlet and combustor parameter on mixing and overall performance for solid boron propellant gas generator ramjets with two opposing 45 deg side air inlets were studied. Highest combustion efficiencies were achieved at lowest air injection momentum and lowest fuel injection momentum. The decrease of the combustion efficiency with increasing air injection was underlined explaining the observed combustion efficiency decrease with decreasing ramjet combustor pressure and increasing air to fuel ratio, which at constant air inlet geometry results in increasing air injection momentum. It is shown that optimum plume ignition at the fuel injector is more difficult to achieve at decreasing fuel mass flow per fuel injector. The importance of the combustor aerodynamics for achieving efficient boron combustion is shown. EAK

N82-32269# Centre de Recherches du Bouchet, Vert de Petit (France). Direction technique Autopropulsion.
STUDY AND PERFECTION OF A SOLID PROPELLANT FOR RAMJET ENGINES [RECHERCHE ET MISE AU POINT D'UN PROPERGOL SOLIDE POUR STATO-FUSEE]
J. BERARD, G. DORIATH, and C. PERUT *In* AGARD Ramjets and Ramrockets for Mil. Appl. 10 p (SEE N82-32256 22-99) Mar. 1982 refs In FRENCH
Avail: NTIS HC A12/MF A01

Gas reductors capable of supplying the fire box of a ramjet can be generated by an oxygenated propellant. By reason of its total discretion, the reserved solution can absorb a small quantity of an orgaic oxidant in a hydrocrbonated bond. The composition designated 1603 is characterized by its use, and its mechanical and ballistic properties. The reaction of grain size, strength of charge and the nature of the binder on the ballistic parameters are evaluated. Transl. by E.A.K

N82-32270# Pisa Univ. (Italy). 1st. di Macchine.
DESIGN OF HYDROGEN FUELED RAMJETS AND RAMROCKETS
D. DINI *In* AGARD Ramjets and Ramrockets for Mil. Appl. 5 p (SEE N82-32256 22-99) Mar. 1982 refs
Avail: NTIS HC A12/MF A01

Problems arising from high energy fuels, particularly hydrogen which impose remarkable changes in interface components, geometry and control, of current ramjets and ramrockets design are discussed. Starting from typical missions scenarios, advanced configurations are established for military applications. Variable geometry nozzles and combustion chambers because of their combined effect with the intake to give good performance and flexibility are considered. A numerical example of overall design is given for very high flight Mach numbers which considers the problem arising from engine/airframe integration and cryogenic fuel storage. Features effecting installation of such engines in aircraft are examined. EAK

N82-32271# University of Southern California, Los Angeles. Dept. of Mechanical Engineering.
THE ROLE OF LIQUID PHASE DROPLET DECOMPOSITION IN AN ADVANCED AIRBREATHING PROPULSION SYSTEM
M. GERSTEIN and P. R. CHOUDHURY *In* AGARD Ramjets and Ramrockets for Mil. Appl. 8 p (SEE N82-32256 22-99) Mar. 1982 refs
(Contract AF-AFOSR-3354-77)
Avail: NTIS HC A12/MF A01

The coupled effect of decomposition and evaporation of a typical fuel spray was studied. It is shown that droplet decomposition at higher pressure for both pure and commercial fuel blends significantly influence the combustion efficiency, carbon build-up on the walls of the combustion chamber and the possble formation of pollutants and particulate matter in the exhaust. E.A.K.

N82-32272# Science Applications, Inc., Canoga Park, Calif. Combustion Science and Advanced Technology Dept.
COMBUSTOR MODELING FOR RAMJET DEVELOPMENT PROGRAMS
P. T. HARSHA, R. B. EDELMAN, S. N. SCHMOTOLOCHA, and R. J. PEDERSON *In* AGARD Ramjets and Ramrockets for Mil. Appl. 18 p (SEE N82-32256 22-99) Mar. 1982 refs
(Contract F49620-80-C-0082; F33615-77-C-2062)
Avail: NTIS HC A12/MF A01

The application of a modular model to predict of the performance of sudden expansion burners is described. the model which is based on a concept in which the recirclation zone, treated as a stirred reactor, is coupled to a parabolic boundary layer formulation for the flow outside of recirclation zone. Hydrocarbon oxidation kinetics and turbulent kinetic energy turbulence models are included. The parabolic flow and stirred reactor elements and a module which represents the fuel injection process was developed. Results of the application of the modular model to the analysis of cold flow and reacting flow dump combustor

experimental data are described, and the use of the model as an interpretative tool in a recent ramjet combustor development program is outlined E.A.K.

N82-32273# Propellants, Explosives and Rocket Motor Establishment, Westcott (England)
THE MATHEMATICAL MODELLING OF AIR-AUGMENTED ROCKET COMBUSTORS: A PROGRESS REPORT
J. C. BIRCHLEY, L. F. GLASSPOOL, and A. S. WILSON *In* AGARD Ramjets and Ramrockets for Mil. Appl. 20 p (SEE N82-32256 22-99) Mar. 1982 refs
Avail: NTIS HC A12/MF A01

The theoretical bases for the calculation of axisymmetric and three dimensional ducted flows are set out and suitable solution procedures are outlined. Results from examples of axisymmetric ducted flow are measured and directions for future work are indicated. E.A.K.

N82-32274# Laval Univ. (Quebec). Dept. of Mechanical Engineering.
COMBUSTOR MODELLING STUDIES FOR RAMJETS
P. ROY, A. F. SCHLADER, and J. ODGERS *In* AGARD Ramjets and Ramrockets for Mil. Appl. 10 p (SEE N82-32256 22-99) Mar. 1982 refs Sponsored in part by the Canadian Natural Sciences and Engineering Research Council
Avail: NTIS HC A12/MF A01

Premixed propane air within a baffle stabilized, ceramic lined combustor was used to measure the gas composition at several stations downstream of the recirculation zone. The test rig was operated at atmospheric conditions over a range of equivalence ratios from phi = 0.70 to 1.82. A simple three equation model was developed to describe the composition and temperature profiles. The model was tested for varification by steam injection. The model is found that is satisfactory for all conditions examined. E.A.K.

X83-73993# Advisory Group for Aerospace Research and Development, Paris (France).
AASC STUDY NO. 9: ADVANCED TECHNOLOGY TO COUNTER THE LOW ALTITUDE THREAT OTHER THAN AIRCRAFT MOUNTED RADAR, TECHNICAL REPORTS ON PROPOSED DEFENSE SYSTEMS, VOLUME 3 (U)
Jun. 1980 48 p This doc. is not avail. from the NASA STI Facility. All requests must be directed to AGARD HQ
(AGARD-AR-103-VOL-3; AD-C022134) NATO Confidential report

Three existing Man Portable Air Defence Systems (MANPADS) candidates are presented and their performance boundaries are outlined. Those three systems must be considered as possible and available examples of high performing Short Range Air Defence Systems. Nevertheless the guidance and control section, warhead fuze section or even the flight and launch motors could also be components from NATO or other short range MANPADS. Four inflight cooperative or non cooperative IFF concepts which have potential for implementing an in-fight abort of a missile are introduced. A digest of mainly archival material relating to the balloon barrages employed between 1914 and 1945 is presented. A background of historical information on the problems experienced is provided. The unresolved difficulties which may be relevant in any debate on the possible future application of balloon barrages are exposed. Author

X83-73994# Advisory Group for Aerospace Research and Development, Paris (France).
COMMUNICATIONS DEVICES SUPPORTING AIR WARFARE WITH REDUCED SUSCEPTIBILITY TO JAMMING, INTERCEPT, AND LOCATION DETERMINATION, MAIN REPORT AND APPENDICES, VOLUME 2 (U)
Apr. 1980 268 p This doc. is not avail. from the NASA STI Facility. All requests must be directed to AGARD HQ
(AGARD-AR-120-VOL-2; AD-C021469) NATO Secret report

Most communications systems supporting aerospace operation are susceptible to jamming, intercept, and direction finding. Jamming would make combat operations extremely difficult without effective counter-countermeasures (CCM). Various measures available to reduce the susceptibility to the threat are considered. Communication requirements supporting air warfare activities; equipment and systems description; electronic warfare considerations; parametric identification of system susceptibility to intercept location determination, and jamming; system concept analysis, parametric estimate of trend and cost-effectiveness; promising areas for future research and development are considered. Author

X83-73995# Advisory Group for Aerospace Research and Development, Paris (France).
TECHNICAL EVALUATION REPORT ON THE FLIGHT MECHANICS PANEL SYMPOSIUM ON MISSILE SYSTEM FLIGHT MECHANICS (U)
W. E. LAMAR Oct. 1980 50 p This doc. is not avail. from the NASA STI Facility. All requests must be directed to AGARD HQ
(AGARD-AR-143; AD-C023781) NATO Secret report

This report evaluates the AGARD Flight Mechanics Panel Symposium on 'Missile System Flight Mechanics' held from 21-24 May 1979 in London, England. The prime objectives of the meeting were to survey and interchange knowledge about missile flight mechanics, and identify areas in which an increased emphasis on the development and application of flight mechanics technologies could improve the effectiveness and/or reduce the cost of tactical missiles and their integration with carrier aircraft. The report presents a review of the meeting, with conclusions and recommendations for future activities. The complete papers from the symposium are published in AGARD Conference Proceedings No.270 (NATO Restricted) and No.270 Supplement (NATO SECRET). Author

X83-73996# Advisory Group for Aerospace Research and Development, Paris (France).
THE IMPACT OF GLOBAL POSITIONING SYSTEM ON GUIDANCE AND CONTROLS SYSTEMS DESIGN OF MILITARY AIRCRAFT, SPECIFIC STUDY NO. 3: INTERDICTION STRIKE, VOLUME 2C (U)
P. MANVILLE, ed. Jun. 1980 12 p This doc. is not avail. from the NASA STI Facility. All requests must be directed to AGARD HQ
(AGARD-AR-147-VOL-2C; AD-C022089) NATO Confidential report

The integration of GPS in aircraft systems were considered and recommendations for implementation made. Interdiction strike is addressed and some of the implications of fitting NAVSTAR to interdiction strike aircraft, the benefits that should arise and the results of an analytical performance study conducted to examine some of the system trade-offs involved are discussed. Author

X83-73997# Advisory Group for Aerospace Research and Development, Paris (France).
AIR TRAFFIC MANAGEMENT: CIVIL/MILITARY SYSTEMS AND TECHNOLOGIES (U)
Mar. 1980 76 p This doc. is not avail. from the NASA STI Facility. All requests must be directed to AGARD HQ
(AGARD-CP-273-SUPPL; AD-C021065) NATO Secret report

This publication is a classified supplement to AGARD Conference Proceedings No.273. The main unclassified document contains 23 papers on the following topics: operational scene and requirements; civil/military cooperation; aspects of air traffic management philosophy - criteria and human factors - communications and separation; air traffic management in hostile environment; flight management in terminal area; subsystem technology; and advanced systems.

X83-73998# Advisory Group for Aerospace Research and Development, Paris (France).
IMAGE AND SENSOR DATA PROCESSING FOR TARGET ACQUISITION AND RECOGNITION (U)
Dec. 1980 234 p This doc. is not avail. from the NASA STI Facility. All requests must be directed to AGARD HQ
(AGARD-CP-290-SUPPL; AD-C023675) NATO Secret report

These proceedings contain the classified papers, summary and discussion presented at the 40th Technical Meeting of the Avionics Panel of AGARD, which was held in Aalborg, Denmark, 8-12 September, 1980. They consist of 17 papers on the subject of 'Image and Sensor Data Processing for Target Acquisition and Recognition', which are divided as follows: overview, 1; target backgrounds and visibility, 5; man-machine interaction, 2; image processing, 3; target tracking, 3; target classification and identification, 4. The companion volume which is unclassified

contains the reamining 21 papers which were unclassified. If possible both texts should be reviewed simultaneously. Author

X83-73999# Advisory Group for Aerospace Research and Development, Paris (France).
GUIDANCE AND CONTROL ASPECTS OF TACTICAL AIR LAUNCHED MISSILES (U)
Oct. 1980 150 p This doc. is not avail. from the NASA STI Facility. All requests must be directed to AGARD HQ
(AGARD-CP-292-SUPPL; AD-C023380) NATO Secret report

The publication is a classified supplement to AGARD Conference Proceedings No.292 of a symposium of the Guidance and Control Panel held at Eglin Air Force Base, Florida, USA - 6/9 May 1980. Twenty six papers were presented on the following topics: optimal requirements, system considerations, air-to-surface guided weapons technology, air-to-air guided weapons technology, and Tactical guided weapons evaluated techniques Author

X83-74000# Advisory Group for Aerospace Research and Development, Paris (France).
TECHNICAL EVALUATION REPORT ON THE FLIGHT MECHNICS PANEL SYMPOSIUM ON THE IMPACT OF MILITARY APPLICATIONS ON ROTORCRAFT AND V/STOL AIRCRAFT DESIGN (U)
W. KOVEN Dec. 1981 20 p This doc. is not avail. from the NASA STI Facility. All requests must be directed to AGARD HQ
(AGARD-AR-170; AD-C027003) NATO Confidential report

This report evaluates the AGARD Flight Mechanic Panel Symposium on 'The Impact of Military Applications on Rotorcraft and V/STOL Aircraft Design', held from 6-9 April 1981 in Paris, France. The papers of the symposium are published as AGARD Conference Proceedings No.313, unclassified, and No.313 (Supplement), Classified NATO Secret. The present report gives an overview of the meeting, including brief summaries of the papers and an account of the closing round table discussion. Author

X83-74001# Advisory Group for Aerospace Research and Development, Paris (France).
POSSIBILITIES FOR ACHIEVING ACCURATE ASM DELIVERY FROM LONG RANGE AND LOW AND HIGH ALTITUDE, VOLUME 1 (U)
Aug. 1981 50 p This doc. is not avail. from the NASA STI Facility. All requests must be directed to AGARD HQ
(AGARD-AR-177-VOL-1; AD-C026040) NATO Secret report

The possibility and effectiveness of long range air to surface missiles released from aircraft flying at both low and high altitudes in the attack of a variety of fixed and mobile targets are assessed, with an imphasis on guidance aspects. Author

X83-74002# Advisory Group for Aerospace Research and Development, Paris (France).
POSSIBILITIES FOR ACHIEVING ACCURATE ASM DELIVERY FROM LONG RANGE AND LOW AND HIGH ALTITUDE, VOLUME 2 (U)
Aug. 1981 196 p this doc. is not avail. from the NASA STI Facility. All requests must be directed to AGARD HQ
(AGARD-AR-177-VOL-2; AD-C026041) NATO Secret report

The possibility and effectiveness of long range air to surface missiles released from aircraft flying at both low and high altitudes in the attack of a variety of fixed and mobile targets are addressed. Author

X83-74003# Advisory Group for Aerospace Research and Development, Paris (France).
PRECISION POSITIONING AND INERTIAL GUIDANCE SENSORS: TECHNOLOGY AND OPERATIONAL ASPECTS (U)
Apr 1981 56 p This doc. is not avail. from the NASA STI Facility. All requests must be directed to AGARD HQ
(AGARD-CP-298-SUPPL; AD-C025179) NATO Confidential report

The publication is a classified supplement to AGARD Conference Proceedings No.298 of a symposium of the Guidance and Control Panel held at Church House, Westminster, London, UK, 14-17 October 1980. Twenty-six papers were presented on the following topics: interial sensors and systems technology, positioning systems, development and status, evaluation methods and results, filtering and estimate, fault tolerance design and redundancy techniques, and systems requirements and applications. Author

X83-74004# Advisory Group for Aerospace Research and Development, Paris (France).
THE IMPACT OF NEW GUIDANCE AND CONTROL SYSTEMS ON MILITARY AIRCRAFT COCKPIT DESIGN (U)
Aug. 1981 112 p This doc. is not avail. from the NASA STI Facility. All requests must be directed to AGARD HQ
(AGARD-CP-312-SUPPL; AD-C026703) NATO Confidential report

This publication is a classified supplement to the AGARD Conference Proceedings No.312. The main unclassified volume contains a Keynote Address, Technical Evaluation Report and 16 papers on the following topics: overview requirements/technology, displays, controls/displays system integration, automated systems/man interface, cockpit systems evaluation. Author

X83-74005# Advisory Group for Aerospace Research and Development, Paris (France).
THE IMPACT OF MILITARY APPLICATIONS ON ROTORCRAFT AND V/STOL AIRCRAFT DESIGN (U)
Jul. 1981 70 p This doc. is not avail. from the NASA STI Facility. All requests must be directed to AGARD HQ
(AGARD-CP-313-SUPPL; AD-C025563) NATO Secret report

This Supplement contains the classified papers that were presented at the AGARD Flight Mechanical Panel Symposium on 'The Impact of Military Applications on Rotorcraft and V-STOL Aircraft Design.' The unclassified papers are published as AGARD Conference Proceedings No.313. The symposium reviewed the technological status of rotorcraft and V/STOL aircraft in the light of operational possibilities and needs; session topics included operational experiences, present status of technology, future trends and military mission effectiveness. A comprehensive Technical Evaluation Report on the meeting appears in AGARD Advisory Report No.170. Author

X83-74006# Advisory Group for Aerospace Research and Development, Paris (France).
NIGHT VISION DEVICES FOR FAST COMBAT AIRCRAFT. VOLUME 4: THE APPLICATION OF NIGHT VISION IMAGING SENSORS FOR AIR-TO-GROUND ATTACK AGAINST ARMOUR USING FAST COMBAT AIRCRAFT (U)
May 1982 328 p This doc. is not avail. from the NASA STI Facility. All requests must be directed to AGARD HQ
(AGARD-AR-73-VOL-4; AD-C028299) NATO Secret report

The utility of television and thermal imaging (FLIR) night vision sensors in a European environment for attacking tanks using fast combat aircraft operating at low level are examined. An hourly meteorological data base is used to generate detailed statistics of the impact of weather over a complete year on typical sensor and aircraft attack system performance, and the methodologies used and developed for mathematical modelling are fully discussed. Attack effectiveness against planned targets and targets of opportunity is assessed for FLIR sensors of evolutionary performance in the context of the UK's BL755 cluster, retarded bomb delivered in level flight, but the techniques used can readily be extended or further developed to cover other attack modes and weapons. Important interactions between aircraft conditions, sensor parameters and external constraints, such as terrain screening, are examined, and sensitivity analyses are used to establish the limitations of the simple modelling procedures employed. Author

X83-74007# Advisory Group for Aerospace Research and Development, Paris (France).
THE POSSIBILITIES OF DELIVERING WITH PRECISION LONG DISTANCE AIR TO SURFACE MISSIONS, AT LOW AND HIGH ALTITUDE (U) [POSSIBILITES DE DELIVRER AVEC PRECISION DES MISSILES AIR-SOL A LONGUE DISTANCE, A BASSE ET HAUTE ALTITUDE]
May 1982 52 p In FRENCH This doc. is not avail. from the NASA STI Facility. All requests must be directed to AGARD HQ
(AGARD-AR-177-VOL-1; AD-C026040) NATO Secret report

This study evaluates the possibilities and the effectiveness of air to ground missiles, released from aircraft flying at low and high altitudes, in attacking numerous fixed and moving targets. Guidance problems are raised in detail. The study is published in

two volumes; Volume 1 is a synthesis and Volume 2 contains the principal report and its appendices. Transl. by A.R.H.

X83-74008# Advisory Group for Aerospace Research and Development, Paris (France).
TECHNICAL EVALUATION REPORT ON THE FLIGHT MECHANICS PANEL SYMPOSIUM ON COMBAT AIRCRAFT MANOEUVRABILITY (U)
W. J. G. PINSKER May 1982 14 p This doc. is not avail. from the NASA STI Facility. All requests must be directed to AGARD HQ
(AGARD-AR-179; AD-C028277) NATO Confidential report

This report evaluates the AGARD Flight Mechanics Panel Symposium on 'Combat Aircraft Manoeuvrability', held from 5-8 October in Florence, Italy. The papers of the symposium are published as AGARD Conference Proceedings No.319. Unclassified, and No.319 (Supplement), Classified NATO Confidential. The present report gives an overview of the meeting, including brief summaries of the papers and an account of the closing round table discussion, together with conclusion and recommendation. Author

X83-74009# Advisory Group for Aerospace Research and Development, Paris (France).
HF COMMUNICATIONS: PRESENT USAGE, FUTURE NEEDS (U)
J. AARONS, ed. Oct. 1982 46 p This doc. is not avail. from the NASA STI Facility. All requests must be directed to AGARD HQ
(AGARD-AR-185; AD-C029694) NATO Secret report

Systems architecture, components, and real time improvement are addressed, based on visits to operating facilities. Author

X83-74010# Advisory Group for Aerospace Research and Development, Paris (France).
AASC STUDY NO. 13: POSSIBILITIES FOR REDUCING RADAR, INFRARED, ACOUSTIC AND OTHER SIGNATURES OF AN AIR VEHICLE. VOLUME 1: EXECUTIVE SUMMARY (U)
Nov. 1982 46 p This doc. is not avail. from the NASA STI Facility. All requests must be directed to AGARD HQ
(AGARD-AR-196-VOL-1; AD-C030099) NATO Secret report

The relative importance of air vehicle designs in terms of probability of detection and recognition was determined. The practicability of reducing these signatures and their impact on the air vehicle performance and design were explored. The penalties in performance, operational utility and cost of these methods were evaluated. Author

X83-74011# Advisory Group for Aerospace Research and Development, Paris (France).
AASC STUDY NO. 13: POSSIBILITIES FOR REDUCING RADAR, INFRARED, ACOUSTIC AND OTHER SIGNATURES ON AN AIR VEHICLE. VOLUME 2: MAIN REPORT (U)
Nov. 1982 204 p This doc. is not avail. from the NASA STI Facility. All requests must be directed to AGARD HQ
(AGARD-AR-196-VOL-2; AD-C030100) NATO Secret report

The study examines the possibilities of the reduction of the ability of an adversary to observe the presence of an air vehicle by reducing radar, infrared, acoustic, visual, laser and other signatures. The study group has determined the relative importance of air vehicle designs in terms of probability of detection and recognition. It has explored ways and the practicability of reducing these signatures, and assessed their impact on the air vehicle performance and design. The study also evaluates the penalties in performance, operational utility and cost of these methods. Author

X83-74012# Advisory Group for Aerospace Research and Development, Paris (France).
AASC STUDY NO. 14: MISSION APPLICATIONS FOR V/STOL COMBAT AIRCRAFT. VOLUME 1: EXECUTIVE SUMMARY (U)
Dec. 1982 26 p This doc. is not avail. from the NASA STI Facility. All requests must be directed to AGARD HQ
(AGARD-AR-197-VOL-1; AD-C030395) NATO Secret report

This report assesses the state of technology and derives design configurations for several categories of V/STOL aircraft concepts which could serve to complement conventional aircraft operations in the mid-nineties. The study is presented in two volumes; Volume 1 is the executive summary. Author

X83-74013# Advisory Group for Aerospace Research and Development, Paris (France).
AASC STUDY NO. 14: MISSION APPLICATIONS FOR V/STOL COMBAT AIRCRAFT. VOLUME 2: MAIN REPORT AND APPENDICES (U)
Dec. 1982 175 p This doc. is not avail. from the NASA STI Facility. All requests must be directed to AGARD HQ
(AGARD-AR-197-VOL-2; AD-C030396) NATO Secret report

This report assesses the state of technology and derives design configurations for several categories of V/STOL aircraft concepts which could serve to complement conventional aircraft operations in the mid-nineties. The study is presented in two volumes; Volume 2 contains the main report and appendices. Author

X83-74014# Advisory Group for Aerospace Research and Development, Paris (France).
IMPACT OF ADVANCED AVIONICS TECHNOLOGY ON GROUND ATTACK WEAPON SYSTEMS (U)
Feb. 1982 170 p This doc. is not avail. from the NASA STI Facility. All requests must be directed to AGARD HQ
(AGARD-CP-306-SUPPL; AD-C027636) NATO Secret report

These proceedings are comprised of the classified papers and summary of discussions and the Round Table which took place at the AGARD Avionics Panel Meeting, held in Agheos-Andreas, Greece, 19 to 23 October, 1981. Papers were divided into four sessions: avionics systems and the operational scenario, avionics in ground attack, avionic subsystems, and avionics for fire and forget. This document contains 12 of the papers presented at the meeting, plus a supplementary paper which could not be presented. The other papers are available in the unclassified portion of the conference proceedings. It also includes a list of attendees, and an evaluation report. Author

X83-74015# Advisory Group for Aerospace Research and Development, Paris (France).
RAMJETS AND RAMROCKETS FOR MILITARY APPLICATIONS (U)
Mar. 1982 204 p This doc. is not avail. from the NASA STI Facility. All requests must be directed to AGARD HQ
(AGARD-CP-307-SUPPL; AD-C028052) NATO Confidential report

The conference proceedings contain 32 papers presented at the AGARD Propulsion and Energetics Panel 58th Symposium on Ramjets and Ramrockets for Military Applications which was held in London, United Kingdom, on 26 to 29 October 1981. The Technical Evaluation Report is included at the beginning of the proceedings. Questions and answers of the discussions follow each paper. The symposium was arranged into six sessions: survey papers (3); propulsion systems (6); inlet diffusors (5); interference and drag reduction, engine testing (5); combustion, fuels, propellants (11); and integral booster and transition (2). A round table discussion followed the sessions. The aim of the symposium was to provide a forum for discussions to research scientists and development engineers and to furnish a comprehensive survey on modern ramjet and ramrocket technology and their possibilities in missile propulsion to application experts in government and military staffs. Author

X83-74016# Advisory Group for Aerospace Research and Development, Paris (France).
GUIDANCE AND CONTROL TECHNOLOGY FOR HIGHLY INTEGRATED SYSTEMS (U)
Apr. 1982 154 p This doc. is not avail. from the NASA STI Facility. All requests must be directed AGARD HQ
(AGARD-CP-314-SUPPL; AD-C028299) NATO Confidential report

This publication is a classified supplement to the AGARD Guidance and Control Conference Proceedings No.314. The unclassified volume contains 10 papers on the following topics: operational requirements; cooperative/interdependent system considerations; threat and target detection and identification; autonomous integrated weapons systems; and affordability and survivability considerations. Papers were presented at the Guidance and Control Panel 33rd Symposium held at the Agios-Andreas Air

Force Base in Marathon, Greece on 13 to 16 October 1981. Author

X83-74017# Advisory Group for Aerospace Research and Development, Paris (France).
COMBAT AIRCRAFT MANOEUVRABILITY (U)
Mar. 1982 14 p This doc. is not avail. from the NASA STI Facility. All requests must be directed to AGARD HQ (AGARD-CP-319-SUPPL; AD-C027770) NATO Confidential report

This supplement contains the classified papers that were presented at the AGARD Flight Mechanics Panel Symposium on Combat Aircraft Manoeuvrability held in Florence, Italy, 5 to 8 October 1981. The unclassified papers are published in AGARD-CP-319. The symposium reviewed the operational requirements for the manoeuvrability, technical prospects for manoeuvrability improvements, and prediction and assessment methods and their value. A comprehensive Technical Evaluation Report on the meeting appears in AGARD Adivsory Report No. 179. Author

X83-74018# Advisory Group for Aerospace Research and Development, Paris (France).
PRECISION GUIDED MUNITIONS: TECHNOLOGY AND OPERATIONAL ASPECTS (U)
Oct. 1982 236 p This doc. is not avail. from the NASA STI Facility. All requests must be directed to AGARD HQ (AGARD-CP-320-SUPPL; AD-C029793) NATO Secret report

This publication is a classified supplement to the AGARD GCP Conference Proceedings No.320. It contains most of the papers presented at the 34th GCP Symposium under the following sessions: systems analysis; supporting technology; seeker technology; guidance and control; and weapon developments. Papers were presented at the Guidance and Control Panel 34th Symposium held in Norway on 4 to 7 May 1982. Author

X83-74019# Advisory Group for Aerospace Research and Development, Paris (France).
AIRCRAFT DYNAMIC RESPONSE TO DAMAGED AND REPAIRED RUNWAYS (U)
Oct. 1982 13 p This doc. is not avail. from the NASA STI Facility. All requests must be directed to AGARD HQ (AGARD-CP-326-SUPPL; AD-C029827) NATO Confidential report

During 1981 and 1982 the AGARD Structures and Materials Panel held two technical meetings on 'Aircraft Dynamic Response to Damaged and Repaired Runways'. The 1981 meeting focused on the environment of damaged airfields; while the 1982 Specialists' Meeting focused on aircraft dynamic response. The meetings had two main goals: (1) to review the programs and methods within the AGARD countries for dynamic analysis and testing of taxiing aircraft, and (2) to encourage the exchange of information on aircraft dynamic response, thereby improving the interoperability of NATO military aircraft. Conference proceedings CP-326 contains the 17 unclassified papers, this supplement contains the one classified paper. Papers were presented at the 52nd meeting of the AGARD Structures and Materials Panel in Cesme, Turkey on 5 to 10 April 1981 and at the 54th meeting in Brussels, Belgium on 4 to 9 April 1982. Author

X83-74020# Advisory Group for Aerospace Research and Development, Paris (France)
PROPAGATION EFFECTS OF ECM RESISTANT SYSTEMS IN COMMUNICATION AND NAVIGATION (U)
Nov 1982 183 p This doc. is not avail. from the NASA STI Facility. All requests must be directed to AGARD HQ (AGARD-CP-331-SUPPL; AD-C030142) NATO Confidential report

These proceedings include papers and discussions presented at the AGARD/EPP-Symposium on Propagation Effects of ECM-Resistant Systems in Communication and Navigation (NATO-Secret)' held in Copenhagen, Denmark, in May 1982. The entire subject of the symposium was covered by 28 papers in four sessions, concerning propagation limitations to modern systems, system adaptation to propagation features, propagation effects in electronic warfare scenarios, and general propagation/system interaction. A round table discussion was used to finally review propagation effects in the various modes of military system applications and possible future development in relevant areas, such as line-of-sight, diffraction and scatter paths, ionospheric propagation (HF) and satellite links. The proceedings are published in two parts: one volume with the unclassifed papers of the first three sessions, and a special volume with classified papers of the first three sessions, the Session 4 'General Propagation 'System Interaction', the discussions on all papers, as well as a detailed summary record of the round-table discussion. Author

X83-74533# Advisory Group for Aerospace Research and Development, Paris (France).
PROJECT 2000 OVERVIEW, SECOND PRINTING, WITH EDITORIAL REVISIONS (U)
Mar. 1980 100 p This doc. is not avail. from the NASA STI Facility. All requests must be directed to AGARD HQ (AGARD-AR-160; AD-C020964) NATO Secret report

Concepts are developed for future military systems that NATO might bring into being 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 new technologies to system design are highlighted. Author

X83-74534# Advisory Group for Aerospace Research and Development, Paris (France).
ATTACK OF SURFACE TARGETS, SUMMARY, SECOND PRINTING, WITH EDITORIAL REVISIONS, VOLUME 1 (U)
Mar. 1980 84 p This doc. is not avail. from the NASA STI Facility. All requests must be directed to AGARD HQ (AGARD-AR-161-VOL-1; AD-C020965) NATO Secret report

Concepts are developed for future surface target attack systems that NATO might bring into being 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

X83-74535# Advisory Group for Aerospace Research and Development, Paris (France).
ATTACK OF SURFACE TARGETS, MAIN REPORT, VOLUME 2 (U)
Jul. 1980 242 p This doc. is not avail. from the NASA STI Facility. All requests must be directed to AGARD HQ (AGARD-AR-161-VOL-2; AD-C077122) NATO Secret report

Concepts are developed for future surface target attack systems that NATO might bring into being 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

X83-74536# Advisory Group for Aerospace Research and Development, Paris (France).
DEFENCE AGAINST MISSILES, SUMMARY REPORT, SECOND PRINTING WITH EDITORIAL REVISIONS, VOLUME 1 (U)
Mar. 1980 50 p This doc. is not avail. from the NASA STI Facility. All requests must be directed to AGARD HQ (AGARD-AR-162-VOL-1; AD-C020966) NATO Secret report

Concepts are developed for future missile defence systems that NATO might bring into being 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

X83-74537# Advisory Group for Aerospace Research and Development, Paris (France).
DEFENCE AGAINST MISSILES, MAIN REPORT, VOLUME 2 (U)
Jun. 1980 202 p This doc. is not avail. from the NASA STI Facility. All requests must be directed to AGARD HQ (AGARD-AR-162-VOL-2; AD-C022049) NATO Secret report

Concepts are developed for future missile defence systems that NATO might bring into being 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

X83-74538# Advisory Group for Aerospace Research and Development, Paris (France).
DETECTION, LOCATION AND RECOGNITION OF GROUND TARGETS, SUMMARY REPORT, SECOND PRINTING WITH EDITORIAL REVISIONS (U)
Mar. 1980 78 p This doc. is not avail. from the NASA STI Facility. All requests must be directed to AGARD HQ
(AGARD-AR-163-VOL-1; AD-C020967) NATO Secret report

Concepts are developed for future ground target detection, location and recognition systems that NATO might bring into being over the next two or three decades. For each of the system concepts an evaluation is made of the various sensors and platforms 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

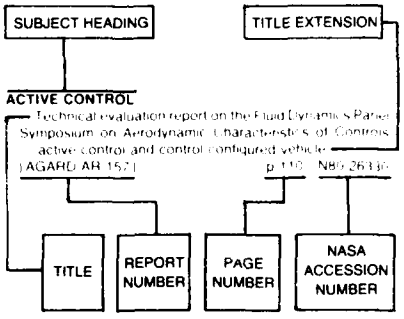
X83-74539# Advisory Group for Aerospace Research and Development, Paris (France).
DETECTION, LOCATION AND RECOGNITION OF GROUND TARGETS, MAIN REPORT, VOLUME 2 (U)
Aug. 1980 310 p This doc. is not avail. from the NASA STI Facility. All requests must be directed to AGARD HQ
(AGARD-AR-163-VOL-2; AD-C022503) NATO Secret report

Concepts are developed for future ground target detection, location and recognition systems that NATO might bring into being over the next two or three decades. For each of the system concepts an evaluation is made of the various sensors and platforms 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

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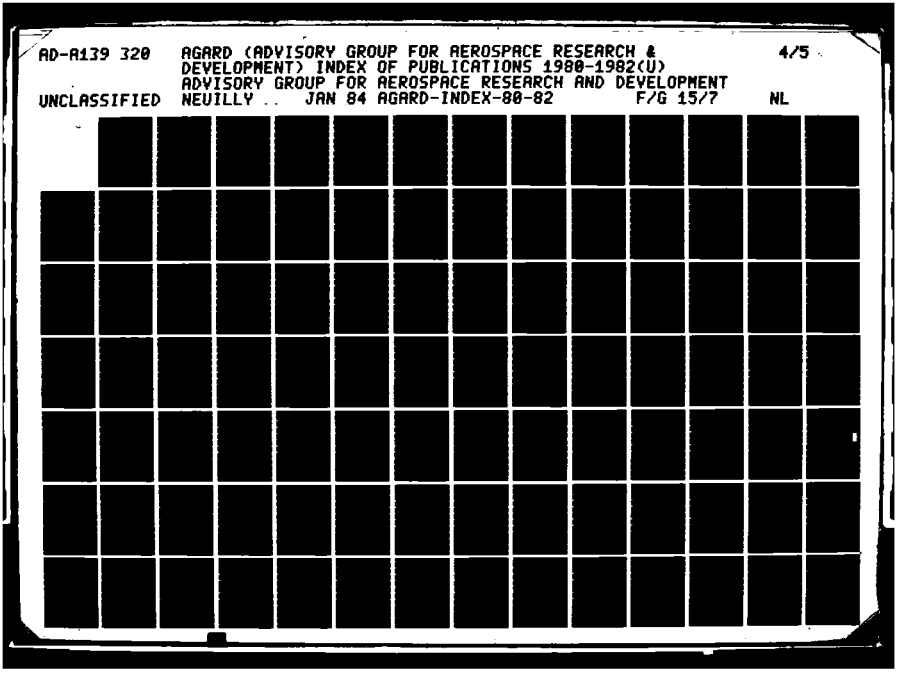
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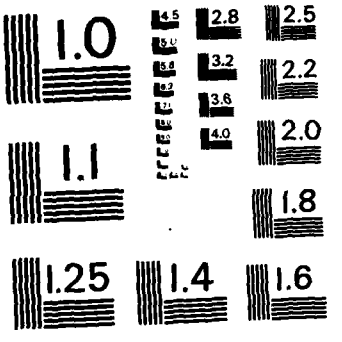
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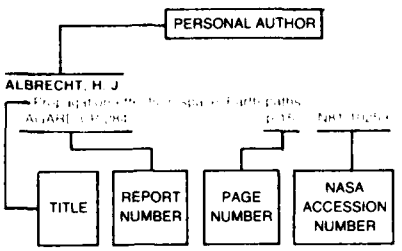
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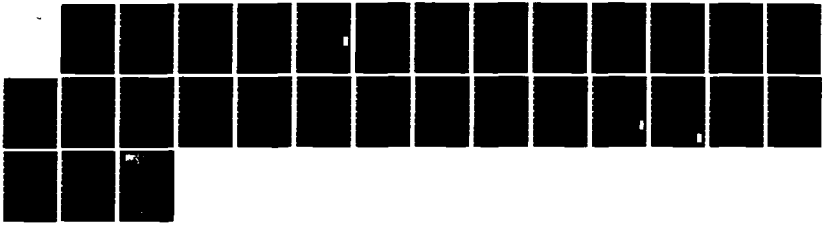
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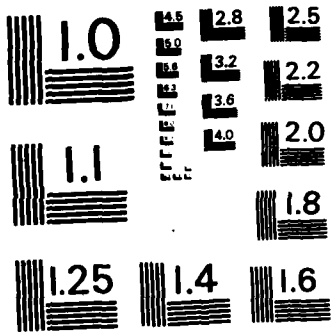
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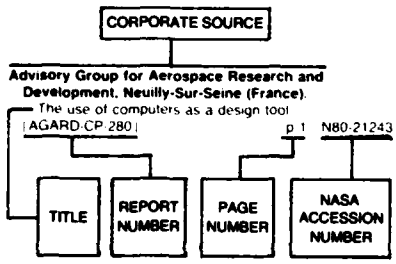
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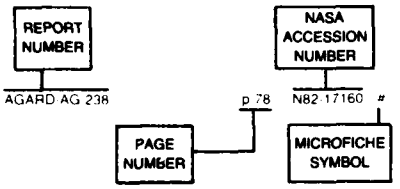
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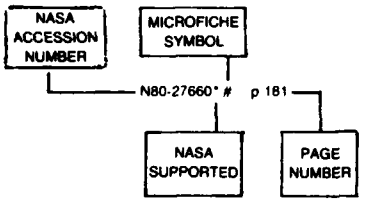
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