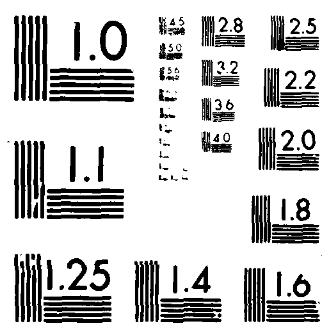
AD-A085 465 ADVISORY GROUP FOR AEROSPACE RESEARCH AND DEVELOPMENT--ETC F/G 1/3
TECHNICAL EVALUATION REPORT ON THE FLIGHT MECHANICS PANEL SYMPO--ETC(U)
MAR 80 S WAGNER
UNCLASSIFIED AGARD-AR-158 NL

1 OF 1

AD
A085465

END
DATE
FILMED
7-80
DTIC



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

B.S.

AGARD-AR-158

AGARD-AR-158

AGARD

ADVISORY GROUP FOR AEROSPACE RESEARCH & DEVELOPMENT

7 RUE ANCELLE 92200 NEUILLY SUR SEINE FRANCE

AD A085465

AGARD ADVISORY REPORT No. 158

Technical Evaluation Report on the Flight Mechanics Panel Symposium on The Use of Computers as a Design Tool

DISTRIBUTION STATEMENT A
Approved for public release;
Distribution Unlimited

DTIC ELECTE JUN 13 1980 S A

NORTH ATLANTIC TREATY ORGANIZATION

DDC FILE COPY

DISTRIBUTION AND AVAILABILITY ON BACK COVER

80 6 13 063

14 AGARD-AR-158

NORTH ATLANTIC TREATY ORGANIZATION

ADVISORY GROUP FOR AEROSPACE RESEARCH AND DEVELOPMENT

(ORGANISATION DU TRAITE DE L'ATLANTIQUE NORD)

11 Mar 80

12 22

9

AGARD Advisory Report No.158

6

TECHNICAL EVALUATION REPORT

on the

FLIGHT MECHANICS PANEL SYMPOSIUM

on

THE USE OF COMPUTERS AS A DESIGN TOOL

by

10

Professor Dr-Ing Siegfried Wagner

Hochschule der Bundeswehr München
Werner-Heisenberg-Weg 39
8014 Neubiberg, Germany

This Advisory Report was prepared at the request of the Flight Mechanics Panel of AGARD.

40 043

THE MISSION OF AGARD

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:

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

The highest authority within AGARD is the National Delegates Board consisting of officially appointed senior representatives from each member nation. The mission of AGARD is carried out through the Panels which are composed of experts appointed by the National Delegates, the Consultant and Exchange Programme and the Aerospace Applications Studies Programme. The results of AGARD work are reported to the member nations and the NATO Authorities through the AGARD series of publications of which this is one.

Participation in AGARD activities is by invitation only and is normally limited to citizens of the NATO nations.

Published March 1980

ISBN 92-835-1353-3

Printed by Technical Editing and Reproduction Ltd
Harford House, 7–9 Charlotte St, London, W1P 1HD

CONTENTS

TECHNICAL EVALUATION REPORT
ON THE
FLIGHT MECHANICS PANEL SYMPOSIUM
ON
THE USE OF COMPUTERS
AS A DESIGN TOOL

by

Professor Dr.-Ing. Siegfried N. Wagner
Luftfahrttechnik
Hochschule der Bundeswehr München
Werner-Heisenberg-Weg 39
8014 Neubiberg, W. Germany

1. INTRODUCTION

The Symposium was held at the Hochschule der Bundeswehr München, Neubiberg, Germany, September 3-6, 1979. Approximately 150 attendees from eleven NATO countries registered at the Symposium, most of them attending through the four days.

The theme of the Symposium was stated in the meeting announcement as follows:

"The complexity of aircraft design procedures; the large financial investment and technical efforts involved; and the increasing importance of the basic initial options in any new aircraft programme require heavy reliance upon computers to generate valid and competitive solutions. The rapid and great advances in computer hardware and software, and the more and more specialized nature of computation, have resulted in the generation of a new breed of computer system engineers. There has been a tendency for two diverging groups to emerge: one group highly specialized in computing and knowing little about design; the other very familiar with design, but with limited knowledge in computing. This undesirable situation could be avoided by improving the communication between the designer and the computer specialist. There is also a need to overcome the problems of communication between the designer and computer itself and to handle the difficulties arising from the need for perpetual updating of computer programmes. With these points in mind it is intended that this symposium will seek to examine the opportunities for using computers more efficiently, in particular in the preliminary design phase."

The complete compilation of papers will be published as Conference Proceedings No.280. The purpose of this report is to present a comprehensive review and evaluation of each session. In particular, this report includes a summary of the final Round Table Discussion. The evaluation includes most of the comments and recommendations, which were received from the members of the Round Table Discussion, session chairmen, and participants in the Symposium.

2. SUMMARY AND EVALUATION OF SYMPOSIUM

The Symposium was arranged in five sessions covering the technical areas identified by sections 2.1 through 2.5 in the Table of Contents. The total of 30 papers was reasonably distributed over the five sessions and over the contributing countries (USA: 30%; Europe: 70%). The time-schedule was met, but it was a difficult task indicating that a meeting with a 30-paper structure is marginal and does not leave a possibility to maneuver. Limitation of discussion is probably not a healthy solution of this problem. Based on this experience, it is recommended for the future to choose no more than 25 to 27 papers for a four-day meeting.

2.1 Summary of Specifications and Assessment of Requirements

Session I contained five overview papers designed to set the stage for the remainder of the symposium. Reflecting both governmental and industrial practice in Germany, the Netherlands, the United Kingdom, and the United States, they illustrated several general methods being used for preliminary design, tradeoff analysis, and system optimization. Design and use philosophy of these mathematical models was repeatedly discussed, and their importance in the increasingly complex aircraft and missile design area was stressed. Multivariable optimization was illustrated in several of the papers and considerable discussion was generated concerning local optima and sensitivities of the processes to variations in secondary variables and boundary conditions.

The most significant papers were No. 1 by Dr. Ebeling et al of IABG, and No. 5 by Mr. Torenbeek of the Delft University of Technology. Paper No. 1 described two computer aided design programs for both missile and aircraft weapon systems. Starting from basic designs, where the intuitive engineering work is required, these programs can be used to analyze subsystems (e.g. mass, aerodynamic characteristics, propulsion, etc.) and to evaluate performance and cost. Due to the relatively small computer time required, these calculations can be repeated many times for parametric studies in early design stages. Therefore built-in optimization procedures are quite helpful. However, some care is necessary to get the true optimum and not a local optimum. There are three areas where these procedures can effectively be applied:

- set up the framework for tactical requirements of future systems
- perform modifications and scaling of given basic designs to meet certain preset objectives
- analyze design of weapon systems with partly unknown characteristics.

Paper No. 2 by R. Haas of AFFDL was deprived of its promised impact due to difficulties in obtaining required clearances. The paper offered an overview of the use of computers in a new system definition process, which builds on techniques associated with computer aided design capability. It was shown that the objective of developing new weapon systems is no longer simply a point design aircraft, but rather a complete concept based on complex payoff functions having the nature of maximizing return on investment based on new approaches to measures of merit. It was pointed out that three key questions

- survivability
- lethality
- efficiency

are the basis for new higher order criteria such as cost per target kill, exchange ratio, number of targets killed etc., which have replaced classical figures of merit such as range/payload, maneuverability and persistence. The essential elements such as knowledge of the technological options available, cost,effectiveness etc., that are requisite to the solution of this complex problem,were discussed.

Paper No. 3 by Th. J. Gregory et al of NASA-Ames addressed general philosophy. The author explained some of the reasons why the trend towards more computerization has not been wholly accepted, especially by those in decision-making or managerial roles who must rely on computer-generated results, although the role of the computer in aircraft design and its usage by technical specialists appear to be increasing. The factors that limit acceptance were 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, especially in large design programs, were due solely to technical issues such as limited detail in aircraft synthesis and major simplifying assumptions in the technical specialties. Suggestions for improved acceptance included publishing basic programs so that they may be reviewed, edited, and read. The big problem of publishing or exchanging big programs is the fact that competitive design becomes limited.

Paper No. 4 by B. Edwards of RAE merits careful reading and contains much more information than the oral presentation. It was about multivariate optimization (MVO) computer programs in the field of transport and fighter aircraft design. The constitution of such programs, which embody an optimization method and a mathematical model of aircraft design and operation comprised of aircraft design synthesis and performance analysis methods, were discussed in general terms. The main part of the paper was concerned with some techniques for using MVO programs and showed how the optimization method could be used to explore the model and cultivate an insight into its characteristics. It was emphasized that the user of an MVO program should make every effort to acquire insight into the working of its model and to take every opportunity to deepen and to extend this insight. The user should be familiar not only with the methods embodied in the model, but also with the precise way in which they have been formulated. The paper concluded that an MVO program should not be regarded as a means to produce isolated optimum designs, but as a versatile tool which can be used to assemble comprehensive sets of consistent data and to understand interactions between the contending effects within the model.

Paper No. 5 by E. Torenbeek of Delft University of Technology described a basic analytical approach to conceptual design optimization intended to enhance the understanding of the basic design problems of transport aircraft and to contribute to certain classes of practical design studies. Contrary to the past where, for instance, optimization of cruise altitude and engine thrust was performed to get maximum payload fraction, the author discussed the choice of a suitable merit function and the structure of different design problems. Based on these ideas, criteria were presented to find the optimum cruise conditions applicable to a given aircraft with arbitrary type of powerplant and drag polars, including drag rise. In addition, the problem was treated to select optimum cruise conditions for a given airframe shape, in which turbofan engines have to be installed. The minimum thrust required to take an aircraft out of a given airfield was derived from approximate take-off analysis. Finally,the criteria for optimum wing aspect ratio, wing loading, lift coefficient, cruise altitude and thrust-to-weight ratio were derived for engines sized for cruising and field performance, respectively.

2.2 Summary of Computer Aided Design and Computer Graphics

Session II contained six papers, where some of them were overview papers on Computer Aided Design (CAD). The main theme of these papers was showing the state of the art of a relatively young tool for designers, especially in Europe. Therefore, most of the papers from Europe showed recent experience with CAD, whereas the contribution of Dr. Baker of Lockheed-California Co. demonstrated an impressive degree of experience with CADAM (Computer Augmented Design and Manufacture).

Paper No. 6 by D. Weinhauer of VFW-Focker was a Survey and Review of the S.M.P. Specialists Meeting on Computer Aid in the Production Design Office. All papers of that meeting are published in AGARD Conference Proceedings No. 250, January 1979. According to the paper of D. Weinhauer, in the USA CAD and CAM (Computer Aided Manufacture) already represent the state of the art in design methodology widely spread all over the main aircraft manufacturers. Since in Europe the situation is different, the S.M.P. Specialists Meeting was mainly outlined to present the level of usage of CAD and CAM in Europe, especially due to the fact that all main aircraft developments, e.g. Jaguar, MRCA Tornado, Alpha-Jet and Airbus are multi-national products. The conclusion of the S.M.P. Specialists Meeting was:

a. In Europe CAD/CAM has been introduced by many companies on their own initiative. The level reached differs remarkably and the degree of commonality in the sense of the NATO community is poor.

b. There is no doubt about the need and benefit of CAD/CAM, but a broad and genuine breakthrough has not taken place.

c. There was a lot of discussion about 3-D-Systems, but no solution.

d. The participants of the S.M.P. Meeting expressed their interest and readiness for follow-up activities. AGARD was regarded an outstanding platform for these objectives because of its non-competitive status.

In paper 7a by V. Antl et al of MBB Co. a FORTRAN program system, entitled GEOLAN, was introduced, which enables the designer to define geometric objects in several ways and to reuse these objects together with some additional input in order to define different and/or more complex objects. Furthermore, GEOLAN can perform operations, e.g. shifting to a new position, smoothing by splines, with the defined objects. Defined surfaces can be intersected and these intersects can be drawn full scale. The system works in an interactive manner. All defined objects are stored for later use and can be shown on a graphic display.

Paper 7b by L. Thieme et al of Dornier Co. introduced a similar FORTRAN program as in paper 7a. The program system is used to define and machine general surfaces, and has a syntax and semantics similar to APT. The application of the program system in all stages of a project was demonstrated, e.g. aerodynamics (modification, smoothing, NC data of wind tunnel models), preliminary design (calculation and NC drawing of intersections, NC milling of templates), design (NC drawing, partial design drawing, calculation of contour-dependent dimensions), tools (master models, jigs), manufacture of components (NC punched tapes for finishing milling of a complete wing), and inspection.

R. I. Hacking and B. Reuben of BAe explained in paper 7c usage and experience of two program systems named NMG (Numerical Master Geometry System) and MAXIS (Multiple AXis Interactive System). The first system came into existence in 1965 as a shape description technique and was first used in production on the Concorde project. It has been used for the Tornado design and on several other civil and military projects. It is intended to extend the system to representation of real three dimensional structuresand to make it available, directly from the computer, to any user department. The user should require only minimal training to obtain his information. The second system has been used extensively by draughtsmen mainly, so far, in a lofting environment to produce templates for production pruposes, and to create input geometry for an N.C. system. Usage of these two systems includes all the applications described in papers 7a and 7b. The objective of BAe is to bring together the various facets of CAD, some of which were described in the paper and to combine the best features of the existing systems.

The most significant paper of Session II was paper No. 8 by Dr. Baker of Lockheed-California Co. Dr. Baker described the CADAM system that is being used by many aerospace companies in Europe, Japan and in the USA. The system includes currently a large central host computer for data management and interactive graphics calculations and a number of local terminals and graphic display units tied to the host computer by high data rate communication lines. Functionally, CADAM can be divided into an interactive or realtime portion and a batch portion. The interactive portion allows a console operator to construct geometry and text to be stored in a large data base. This geometry may later be input to batch routines to produce output in the form of hardcopy or to produce a tape to run digitally driven devices such as NC machines. Both two- and three-dimensional shapes may be represented. The major benefit of CADAM is reduction in man-hours for a given task and increase in productivity. Geographical dispersion, security protection, and ease of adding remote units provide substantial operational convenience. A more detailed description and utilization of CADAM and future trends are contained in the written version of this interesting paper.

Another system called SYSTRID I is being used at Aerospatiale in Marignane (Paper No. 9 by Monique Slissa) and has the same objective as stated by M. Slissa: a better product at lower cost in a shorter time. The program system produces, similar to CADAM and the other systems, drawings and data for NC machines. M. Slissa reported on time gains between 45 and 90% and financial gains between 21 and 71%. Although the display can only be two-dimensional, the computing is three-dimensional.

Dr. Bishop of BAe (paper 10) touched on a common problem of large, geographically dispersed design teams, that are now the norm in manufacturing industries. He showed that computer systems could be used for data storage, communications, interactive design, administrative functions and numerical calculations. The basic idea is to have a large data bank of the order of 10,000 megabytes for each project, where shared administrative and technical data will be stored. Each member of the design team has access to these data via distributed micro/mini/midi computers. To maintain a very high standard of privacy and integrity, special input and output controllers are installed at each terminal of the user. When a design work is complete, the resulting data will go through several approval processes before being made available for access. The framework also includes an approach to the implementation of application programs.

Paper No. 11 by J. P. Pauzat of Aerospatiale treated a special theme of CAD, namely computer aided electrical system drives. The first program system named G.I.C.E. (Gestion Informatique des Cablages Electriques) manages the complete electrical system of an aircraft, i.e. definition, realization and layout. The computer carries out modifications and checks the electric system. The documentation is simplified by this management system. According to the authors, 10,000 hours of work can be saved. The second system named C.A.O.C.E. (Conception Assistée par Ordinateur des Câblages Electriques) is a set-up of an electrical symbol library. The engineer creates the symbols on the screen and the computer produces the listing of parts, their connections and also the exact drawings that have high quality. 90% of work (drawings) is carried out by the computer for different levels of development: design, production, sales department. All changes can be detected by comparison of the initial and the final drawing.

In the final discussion of Session II there was some concern about the certainty that changes are made correctly and whether they are checked by stress people, for instance. The anwer was that there were always final checks (e.g. by stress people) after changes, and each person has only access to a certain portion of the system.

2.3 Summary of Computational Aerodynamics and Design

Session III contained seven papers, most of them being excellent. In this session one had the impression that the computer has been an extensively used design tool for a fairly long time. Therefore the theories, methods and also the philosophies have reached a rather sophisticated level in research and industry.

The first presentation of Session III by Dr. Bailey et al of NASA-Ames (Paper No. 12) was unique at this meeting, since Dr. Bailey did not only clearly demonstrate the technological and economic advances in computational aerodynamics that have been possible through the much greater increase in computer speed and memory than computer cost, but he also extrapolated from the remarkable progress that has been made in developing efficient solution procedures for a hierarchy of approximations to the compressible Navier-Stokes equations to the future architecture of large high speed computer systems, that differ from conventional computers by use of parallel/vector computers. It is expected from such new systems like the Numerical Aerodynamic Simulation Facility (NASF)-feasibility studies of which have been undertaken at Ames Research Center - that a two order-of-magnitude performance gain over conventional computers could be achieved. This would provide an advanced computing tool for simulating three-dimensional viscous flows for both design and research applications by solving the Reynolds averaged Navier-Stokes equations for airfoils, inclined bodies, compressor and turbine blades. For complete aircraft configurations only the transonic inviscid flow could be simulated at this stage of development. However, based on projected computer technology trends and continued advances in numerical methods, the practicality of large eddy simulation was predicted before the end of this century.

The next six papers documented state of the art in aerodynamic analysis and design of civil and military aircraft configurations in France, Germany, Italy and U.S.A.. The level of numerical efficiency or depth of theoretical model might be slightly different in different organizations, but all companies include the transonic flight regime in their computational capacity. They all have production-type programs, so that computation time is acceptable. Confidence in several of the computational aerodynamic methods has been generated due to their successful application in a wide range of design problems. These methods help the engineer to achieve efficient integrated designs, to gain insight into complex flow fields, to better understand test data, and to explore innovative configuration concepts. Even though aerodynamic design and analysis techniques have progressed considerably by developing methods like lower and higher order panel and vortex lattice methods for subsonic and supersonic flow, finite difference, finite element and finite volume methods for the transonic flight regime, transonic and supersonic area rules with nonaxisymmetric extension and fairly sophisticated methods to take into account even three-dimensional boundary layer effects, most of the existing methods either contain areas of empiricism, cannot model the complete configuration, or are unable to account for all aspects of the physics of flow, e.g. the interaction of strong shock waves and boundary layer, the three-dimensional viscous flow computation of high-lift wings while taking-off, landing or performing maneuvers.

P. Perrier of Marcel Dassault - Bréguet Co. (Paper No. 13) demonstrated application of finite difference and finite element method to optimize airfoils and complex configurations for supersonic and transonic speeds. In particular interactive computation was discussed. While using features of conical flow, a so-called 2.5-D method was derived for optimization purposes, that gave good answers in many cases and saved a lot of computation time compared to full 3-D flow computations. The same purpose fulfilled the so-called three-point method.

L. Fornasier of Aeritalia Co. (Paper No. 14) demonstrated the design loop of a supercritical airfoil using a hodograph method and of a three-dimensional supercritical wing using a finite-element method, a panel method, and the integral method of Walz to take into account boundary-layer effects.

B. Dillner of Boeing Commercial Airplane Co. (Paper No. 15) reviewed panel methods for subsonic and supersonic flow, methods for transonic analysis both 2-D and 3-D, boundary layer methods 2-D and 3-D, design and analysis methods for multielement high lift devices. Examples were given on recent applications of these methods to design configurations such as airfoils and wings for transport airplanes, nacelle/airframe integration, winglets, high lift devices for transport airplanes, supersonic cruise design, and variable camber for combat airplanes. An evaluation of usefulness of these methods and recommendations for future development were given.

P. Sacher et al of MBB Co. (Paper No. 16) demonstrated an optimization-cycle on a high-speed computer during aerodynamic fighter configuration development and analyzed various techniques that are necessary to cover the low speed, high angle of attack range, the transonic flight regime (maneuver capability), and the high speed supersonic region with maximum SEP. Efficient numerical methods allowed this trade-off to be performed in a short-time period and resulted in an optimized configuration. In addition, detailed optimization of components (e.g. direct design of 3-D wing, tail/canard or maneuver devices) improved performance and led to definition of wind tunnel models, to check accuracy of numerical models and to fill up shortcomings of prediction methods.

R. D. Child of Rockwell International Co. (Paper No. 17) discussed the aerodynamic design of the NASA HIMAT configuration using both linear and nonlinear theory and the experience gained in application of available computer codes to the multiple surface design to achieve transonic performance goals. The theoretical results were compared with wind tunnel data and subsequent program modifications were described, which more accurately predicted the data.

Dr. W. Schmidt of Dornier Co. (Paper No. 18) discussed not only various theoretical methods in aircraft design, but more specifically the validity and application of current 3-D transonic programs including boundary layer effects. The accuracy, applicability, and the limitations of 3-D transonic TSP and full potential methods were evaluated by comparison with experiment. By combination with a 3-D boundary layer code, the influence of viscous effects was also shown. Inclusion of wind tunnel wall boundary conditions into the inviscid code finally led to a set of methods that could be used semi-automatically to analyze and design transonic configurations in free flight and in wind tunnels.

A common feature of many contributions of this session seemed to be that, in the past, experimental programs were largely directed toward obtaining aerodynamic characteristics for a point design and obtaining systematic data for configurations and flow-field data not amenable to analysis. The advanced capability of numerical methods and the limitations imposed by most experimental programs are placing increased emphasis on tests specifically oriented to check theory at a few critical points or to generate data for improved theoretical flow models. Since required performance of future aircraft is increasing enormously, more and more wind tunnel tests of the described kind will be necessary to substantiate theory. In addition, more extensive configuration variations with a deeper physical insight will be imperative to meet this goal, and the available budget forces one to more theoretical parameter sweeps rather than to expensive models and wind tunnel testing.

2.4 Summary of Structural Analysis and Design

Session IV contained six papers, which documented practice in structural design, analysis and optimization in Belgium, France, Germany, United Kingdom and the United States.

J. L. Rogers of NASA Langley (Paper No. 19) discussed the problem of maintaining a large, general purpose, finite element computer program, the well-known NASTRAN (NASA STRuctural ANalysis) program, which is being used by many users and is available for three computer systems (IBM, CDC, and UNIVAC). The maintenance effort includes: (1) error correction, (2) incorporation of advances in technology, (3) documentation, and (4) new level generation. There was some controversy about the advantages of such large, versatile program systems in the discussion after the presentation. It was stated that NASTRAN was five years behind the finite element era and that it was useful for medium-size companies. But large companies had their own routines with extensive experience and had not the problem of adapting it to their computer. The advantage is that such a program system can be used by several companies who are working together on the same project. The maintenance effort of such a system is approximately 6 man-years.

The remarkable Paper No. 20 by A. J. Morris of RAE described the design and use of a modular computer program for structural optimization in a wide variety of design regimes. A special feature of this program is the fact that it incorporates a user-oriented command language, which allows the user to simply, but effectively, control the program performance. In addition, it can interface with a variety of existing analysis programs of NASTRAN IASAS type. It has furthermore the capability for employing a range of optimization techniques, which it can automatically select and change depending on the convergence rate experienced. Thus, the program provides an integrated design package with its own, internal monitoring facilities.

D. Mathias et al of Dornier Co. (Paper No. 21) presented a program system that is based on the finite-element-method and contains springs, beams, and membrane elements in the current version. Purpose of this program is the weight-optimal design of aircraft structures with regard to constraints on stresses in the elements and on the minimum flutter speed. The stiffness of the elements are design-variables. For such a linear optimization process, the number of variables must be equal to the number of constraints.

Dr. Fleury et al of the University of Liège critically reviewed the application of mixed and dual methods in structural optimization (Paper No. 22). The most significant detail was the conclusion about the advantages and drawback of both mixed and dual methods:

- dual methods are usually efficient and computationally economical, but they are subject to instability in the convergence of structural weight; mixed (primal) methods facilitate better control over convergence of the entire optimization process at the price of higher computational costs;

- mixed modes can be applied to objective functions that are more complex than structural weight, or to problems requiring nonseparable approximation of the behavior constraints, while dual methods cannot; dual methods are readily extendable to problems involving discrete design variables, while known primal methods appear to be cumbersome and computationally expensive for such problems;

- the computer implementation of the structural optimization method seems to be more reliable with dual algorithms than with primal ones, because the dual problem exhibits a much simpler form than the primal one.

One of the most significant presentations of this session was Paper No. 23 by C. Petiau et al of Marcel Dassault-Bréguet Co. It described an optimization method for minimizing weight by a finite element model, where the optimization parameters are multiple factors of the stiffness of linked finite elements. Different types of optimization constraints are allowed. The significance of this paper compared to the others of this session was the fact that the iterative optimization process included three steps:

- Analysis: it contained not only statics, but also dynamics and aeroelastics

- Computation of partial derivatives of the constraints relative to the parameters

- Explicit nonlinear optimization.

Convergence is obtained after 3 to 4 iterations, where the optimization process costs reach from 8 to 12 times the costs of a simple analysis. Furthermore, the applicability of this method was not only demonstrated on the complete Mirage 2000 Fighter and the Mirage 4000 wing, but also on a carbon fiber empennage, where the proper fiber orientation was selected.

Finally, J. Massmann of IABG (Paper No. 24) showed not only the efficient application of the Finite Element Method and of the Finite Difference Method for nonlinear dynamic structural analysis and design, but also of a mixed Finite Element/Finite Difference method, which takes advantage of the superiority of each method.

2.5 Summary of Propulsion and Systems Design

Session V contained six papers, two of which were dedicated to the problem of optimally installing an engine into an airframe. Two papers delt with problems and models of air combat simulation on a computer. One presentation described a computer-aided design system for control law design and system synthesis. The last paper showed computer usage in flight test evaluation.

While Paper No. 25 by R. Smyth of VFW-Fokker was more dedicated to the problem of designing and optimizing main parameters of high bypass-ratio engines (e.g. bypass-ratio, length of fan-cowl, use of mixing or non-mixing nozzles, accessory arrangement) to minimize drag, weight and to optimize performance, Paper No. 26 by H. Fishbach of NASA's Lewis Research Center was more engaged with computational techniques to determine the optimum propulsion system for future aircraft applications and to identify system tradeoffs and technology requirements. This included general cycle analysis, engine weight prediction, life cycle cost, installation effects and drag prediction.

Subject of Paper No. 27 by N. Mitchell of BAe was the mathematical modelling and its use in the design and analysis of aircraft weapon systems, an example where large high-speed computers are mandatory. The simulations of air combat and ground attack situations on a digital computer were very impressive. The simulation also included a basically simple pilot model which could be increased in complexity for short-period manoeuvres. The objective of such investigations is to investigate new tactics, to derive requirements for new weapon systems and to save money. According to the author, the relation between a model run and a flight test run with respect to costs is 1 to 1000.

A similar objective was the subject of Paper No.28 by I. Jones of BAe. The difference was that a versatile and tenacious interactive opponent was simulated for use in a single-dome, piloted, air combat simulator.

The most interesting feature of Paper No. 29 by U. Korte et al of MBB Co. was a new idea in control law design. The solution is a dialogue between the system engineer and the computer via an interactive graphic display, i.e. a computer aided design for feed-back control system.

Paper No. 30 by D. P. Maunder of Edwards AFB presented an overview of the uses of advanced computer techniques in flight test evaluations. This included real-time mission control, integrated systems testing, flutter testing, and nonreal-time data processing. Future computer analysis capabilities and considerations for the next generation of computer hardware were also discussed.

2.6 Round Table Discussion

The round table discussion was chaired by Dr. J. M. Klineberg, Deputy Director of NASA-Lewis Research Center and Member of the Technical Programme Committee. The six panel members were:

J. Czinczenheim, Société Avions Marcel Dassault-Bréguét Aviation and second Member of the Technical Programme Committee

R. S. Shevell, Professor, Stanford University

R. J. Balmer, British Aerospace, Deputy Chairman of FMP

J.-M. Duc, Direction des Recherches, Ètudes et Techniques, Service des Recherches

O. Sensburg, MBB Co., München

S. N. Wagner, Professor, Hochschule der Bundeswehr München

Each panel member made about a five-minute statement, in turn, after which the audience participated in the discussion. Summaries of the initial statements of the panel members follow.

Dr. Klineberg

This Symposium was organized because of the Panel's perception that there has been a rapidly increasing reliance on computers in aircraft design; that there have been recent and dramatic advances in both hardware and software for CAD; and that, perhaps, we are becoming overly specialized in the sense that the experts know their own specialties well, but are not aware of the designers' problems and the designers cannot even communicate with the numerical analysts. This last assumption was partially validated during the course of the Symposium. The Panel was also concerned about the designers' interface with the computer. As the Symposium showed, the designers lives are becoming easier through some of the recent hardware and software advances described, and they are using the computer more and more, perhaps because they simply have no choice. The Symposium was also to indicate if there were ways to use the computer more efficiently in the preliminary design phase. Several papers showed that data base management would be the key problem of the future, and our difficulties in the coming years will most likely be in the software, not in the hardware. In the US, for example, they are now predicting minicomputers with the power of the Cray-1 by 1985. With that sort of computing power available, the problems of interfacing and managing the vast amounts of data generated will certainly be formidable. Comparing computational aerodynamicists and structural designers, both want larger computers, but of different architecture. The big problem for fluid dynamics people seems to be geometry - forced by the nature of their equations - and grid generation. Progress is impressive, and the more complicated methods seem to be gaining acceptance in industry. The structures people already have some very complicated programs in wide use, e.g. NASTRAN, and are now more concerned with improving optimization methods. The size of the data base makes the iteration speed a critical question.

Mr. Czinczenheim

As a member of the Technical Programme Committee, Mr. Czinczenheim expressed his appreciation to all authors, who presented their papers in a convincing and objective manner despite the tight time schedule. For this reason, however, discussion was cut short sometimes. This was regretted, since discussions supplement papers and stimulate future activities. The first conclusion that was drawn from the Symposium was the outstanding role of the human being during all steps of the computerized design of an aircraft. The computer, even if sophisticated to a very high degree, is only a powerful tool the engineer must learn to use cleverly. And this is not an easy task. Second, thanks to the tremendous development of computer hardware and software, remarkable progress has been made in many areas such as aerodynamics, structures, propulsion, CAD etc. This is also true as far as optimization procedures are concerned, although some problems and some new aspects of this delicate technique have been demonstrated. One domain, where considerable difficulties were evidenced, is the integrated design, especially when touching new and detailed areas of research. While acceptable procedures have been developed to be used during the concept and predesign phase of new projects, the design team is still forced, like in the past and will also be forced in the near future, to rely on the detailed knowledge of the specialists and on their highly developed procedure to partially integrate subsystems like aerodynamics/structures, aerodynamics/propulsion. The rest of integration is more or less being done "by hand". But it is desirable that the procedures of partial integration find acceptance in design offices. The third conclusion of this Symposium was that meetings of this kind, where the specialists, the so-called generalists and the computer experts come together, should be arranged periodically to improve communication and appreciation of the problems of these groups.

Professor Shevell

There is no doubt about the great productivity of modern high speed, high capacity computers, no question about their ability to solve problems not feasible by lesser means, no hesitation to praise the virtue of relieving engineers from the burden of repetitious numerical calculations. Nevertheless, there are some problems brought about rather than solved by computers. Two areas of concern are brought up. First, the analytical engineer becomes absorbed with feeding parameters to a computer and loses his knowledge of and feeling for the underlying physical relationships. Computer aided detail design does not introduce this problem since the screen shows the actual drawing and the machine produces the hard copy. But the analyst has his equations buried in memory modules. He must constantly remind himself of the relationships between the variables, that the young engineer may never have solidly learned. This young man will be in real trouble, unless the in-plant training system does something about this problem. What can and should be done about this? The second concern is the development and use of overall computerized advanced design programs that bring together existing smaller programs solving specific problems such as drag prediction, weight estimation. Coding the overall synthesis program creates a big effort. After being put into use, these programs sometimes turn out to have a very short life. Some of the reasons are the limited number of engineers who really know the program, or one overall expert leaves the department and everyone else becomes doubtful of the accuracy of the unknown subroutines. Sometimes the basic methods are improved and no one is available to update the program, etc. Perhaps the idea to build an advanced design synthesis program in a certain period of time is a gross oversimplification and some on-going revision is required forever. This subject is worthy of discussion.

Mr. Balmer

Being responsible for the aerodynamic and structural aspects of all aircraft of British Aerospace, the question is what can be done on computers, how good are the answers, and how much will it cost. It is also interesting to know what new developments in computer hardware and software would be worthwhile to have. Some papers of the Symposium showed that in the field of design, methods are now available to solve problems in structural optimization and aerodynamic design, that could not have been tackled a few years ago. But there are also limitations. Panel methods cannot yet supersede wind tunnel testing. Finite element calculations do not yet make structural testing redundant. Even if more sophisticated hardware and software is available to possibly eliminate the need for wind tunnel or structural testing, will it be cheaper? Computer programs will - indeed they already do - help tremendously in the design process. But is there some upper limit beyond which it is not cost-effective to expand computer programs,and it is more economic to use the wind tunnel? There is another aspect worthwhile for discussion. Most of the computer programs have been developed by engineers, who combined programming skills with a deep understanding and experience in their particular disciplines. They knew enough about stressing or aerodynamics, because they have done hand calculations in the past. But what will happen when these computing tools are given to young graduates fresh from college or university? They will get the answers, but will the latter be right? How can engineering skills in the human being be generated in a computer environment? The question is how best to use the computer and not to misuse it.

Mr. Duc

The subject of this Symposium was very well chosen. Aircraft production without the computer is not conceivable any more. The papers were highly qualified. Mr. Duc expressed his appreciation to the authors. According to his opinion, a little bit more could have been said about the usage of the computers in market investigation and market research, where the computer plays an important role to define technical specifications and quality specifications, and to optimize operating costs and operational effectiveness of an aircraft fleet. In addition, the usage of computers could have been discussed as a support to save time and costs when controlling wind tunnel tests in real time, when automatically correcting and plotting test results or when being used to prevent accidents during tests. Some authors demonstrated possibly a little too high optimism and magic confidence in the potentials of a computer. Sometimes it seems that it is just not fashionable not to use computers. One should also see the role of aeronautics with respect to other industries such as automobile industry, nuclear energy etc., to investigate whether aeronautics will have some impact on the new generation of computer systems or vice versa. There is also no information of the cost-effectiveness of computers. The trend still is to develop more accurate and more capable software. There is also a problem that stems from the vulnerability of the computer, which is the case when there are not enough specialists, when the engineer uses incorrect input data or when the computer fails. For these reasons one should not forget the high risk when using computers. This was not the case to such an extent when relying on wind tunnel and structural testing in aircraft design. Some effort would also be desirable to develop more and more simple command languages, so that not highly qualified computer specialists could also easily use the computer for their problems.

Finally, the computer is not an absolute cure for all problems. There is no doubt about the advantages of the computer. But there is also some risk of improperly standardizing design methods that finally could block the development of originality and creativity.

Mr. Sensburg

Mr. Sensburg complimented the Technical Programme Committee on the excellent job of selecting the authors and of covering the subject. He restricted his comments to structural analysis. He felt that the NASTRAN program is still very useful, especially since it contains a dynamic part, which is - in his opinion - the best of available programs. In addition, it is very advantageous in a multi-national cooperation, where different companies are responsible for different substructures. Having one agreed program, it is easier to find the boundary conditions and to couple the parts together. There were several good contributions in Session IV. The highlight of this session, however, came from Mr. Petiau et al of the Marcel Dassault Company. They showed a structural optimization system for structures, dynamics and aeroelastics, and they have already applied it to a real flying airplane. This program can also deal with unisotropic elements and can select the right fiber orientation. The state of structural analysis has very far advanced. In 1960 structural models of a Delta-wing bomber, the B-58, were built, because the influence coefficients could not be calculated accurately. Actually a structural model was built, which was not put into the wind tunnel. For the F-104 wing a network was made by Lockheed, and potentiometers were adjusted to match ground resonance test results. This was then used for flutter analysis, because the airplane had 6 spars connected to the fuselage, which could not be modeled accurately enough at that time. Nowadays, there are structural optimization programs, which give a lot of useful information to the designer, which way he has to go. It is also possible to do accurate analysis of structures for certification purposes.

Professor Wagner

Many papers of the Symposium demonstrated how the computer can help to analyze and to optimize a design with respect to aerodynamics, structures, engines and engine installation, and, of course, with respect to the complete system and its application. The computer is used extensively in testing models in wind tunnels or in evaluating the final product or to control a weapon system. With the aid of the computer, the engineers get better and more reliable information, and get them faster and, maybe, at a lower cost, but only maybe. But this meeting showed again that final decisions in the design loop or after an operations research study have to be made by the engineer. The engineer is the one who tells the computer to investigate, for instance, a delta wing or a trapezoidal wing with strakes. With the aid of the computer, the engineer will be able to analyze and optimize each of these two wings very quickly and he will then select the best compromise for his tasks and also the best compromise between the different disciplines, because, for instance, the aerodynamicist and the structures engineer have usually an optimal design with respect to their discipline, respectively, but they have different ones. Thus, the best compromise between all disciplines that contribute to an aircraft design will have to be found. And this can usually not be done by the computer. Many examples of this meeting showed that the computer reduces the routine work-load of the engineer. With user-oriented command languages, the engineer is even able to use the computer without a major education in programming. However, the engineer is more and more forced to critically review the data that he gets from the computer and to interpret results in the right manner. Therefore, the universities, the companies, and the government agencies will have to put more and more emphasis on the proper education and the further training of the engineers and the scientists. Maybe the panel can get some ideas from the audience of how this can be done best.

Major Points Raised by Audience

The following is a summary of the major points discussed during the second part of the round table, which involved audience participation.

Mr. Petiau of Société Avions Marcel Dassault-Bréguét Aviation

Obviously, there are some people who fear that they are losing control over their problems when using computers extensively. As far as structural problems are concerned, usage of finite elements is more or less a series of corrections of human errors. A calculation by finite elements is never exact, it is more or less wrong. When applying optimizing procedures, the solution does not come from the omnipotent computer. In this case it is up to the responsible structures engineer to see the critical points of the structure and to define the concept of analysis. This is a matter of experience.

Usage of a common program that comes from across the ocean is a political problem, that should not be touched by AGARD. So only the operational part of the problem should be discussed. It is clear that a program that was written for thousands of users cannot be the non plus ultra for special cases. It must last for at least one to two years and it must not fail after every fifty times of usage. But is it really necessary that for multinational projects all participants have the same program? This should not be necessary. Since all elements that are used in finite element methods are well documented, the management may have confidence in the users to correctly solve linear systems. In addition, there are enough checking methods for all important programs, so that one can assume that correct calculations are performed. Marcel Dassault-Bréguét Aviation and SNIAS cooperate on many common projects, but they do not have the same programs.

Therefore, this problem seems to be negligible.

Dr. Klineberg

There does not seem to be any reason for everyone to use the same program, in fact, that would be quite dangerous. But the first point was an argument that there is nothing about doing computations, particularly in the structures area, that forces one to believe in the omnipotence of the computer, which the audience might agree with. But there was also the implication that it does not take the engineer away from the physical aspects of the problem, and that was the concern voiced by the panel. In the aerodynamics area, it used to be necessary for one to make some rather sophisticated approximations to the problem long before one could go to the computer. And this itself required a great understanding of the physics of the fluid to know which types of approximations to make. These days with finite difference solutions of the complete Navier/Stokes equations, one might have a need for considerably less intuition and understanding of how the flow behaves. The aerodynamicist simply goes to finer and finer grids, to better and better definitions of the flow field and does not really have to understand that a shock wave incident on a boundary layer causes separation upstream of the shock because of a subsonic region of the boundary layer, as an example.

Maybe, as our tools get more and more sophisticated, our need for physical understanding of the problem diminishes. But there is a danger for the new engineer of simply knowing how to run a computer program, but not understanding the problem.

Mr. Petiau

This is true for aerodynamics but not for structures.

Dr. Sobiesky of NASA-Langley

There is an interesting implication to the way engineers go through their professional lives coming from the integrated computer - based approach to engineering design. In the past, a chief designer in an aircraft company was a very capable generalist, he knew all essential things about aerodynamics and structures. Things have progressed. Most engineers were forced to become narrow specialists to qualify themselves highly. They devoted so much time to it, that it became impossible to keep up with developments outside of their own speciality. However, conditions are now being created for reemergence of a generalist. Because working with an integrated computer system, supported by a staff of specialists, who guarantee that results coming out from the modules of that system are good, that generalist can afford now to manipulate things in structures and aerodynamics, in proportion and all aspects of the aircraft. Ultimately that design is coming out of his brain, but supported by detailed knowledge coming out from all disciplines. The consequences of it should not be lost in our teaching establishments.

Mr. Balmer

We have always needed a good chief designer. The thought of an aeroplane design by a whole series of specialists working individually is quite horrifying. What this rubs in is that it is important in the aerospace industry, that people should not take one job all the time. We have to learn to move people around, perhaps, particularly those people who are ambitious enough to manage a project and are not happy being immersed in computer tapes and so on.

Mr. Fishbach of NASA Lewis

Probably many people of the audience have noticed a great increase in the use of the computer, and some have noticed the obsolescence of some of the older engineers, who have not kept up with the computer techniques. The same thing could happen to us. There are new advances in computers, especially the minicomputers, and those of us who are very clever in forging programs in large computers, may be completely obsolete when everybody has got their own minicomputer in the office. Therefore,the companies will have to make available training programs to keep the staff up to date in the techniques available to them.

Professor Shevell

Although for certain types of small problems one can visualize engineers developing their own programs on their own minicomputer, it is a problem to run an engineering organization in which everybody has the right to develop their own way of computing anything. For many types of important calculations there would still be some people who are the experts and in the case of minicomputer maybe put the program on a disk and the engineer could go and use it. But to prove out a program is a very meticulous job, and it was pointed out, that, perhaps, to use it 50 times you get a mistake every 50 times after you had a skilled group working on it. It would be very hazardous to let everybody do their own programming because of the problem of worrying about whether the program is really checked out. There is a question of how the minicomputer will be used and controlled in that way.

Mr. Jones, British Aerospace

Two points really ran through all the comments made by the panel. One is the engineer is getting away from an understanding of the physics of the problem, the other one is the misuse of the computer. The one thing that characterizes the problem - the computer is a prime example - is a very rapid advance and a very rapid change and a very rapid widening in the amount of information. People are coming up against a barrier of being unable to fully understand in detail all the facets of the systems they are dealing with. For instance, most people who use computers do not understand how the compiler translates the FORTRAN program. But they have come to accept it, and the way they have accepted this is by looking at the results and by experience on a different level. Although it is a rather dramatic change, it is happening already to people who have to come to accept, perhaps by experience, the modular programs. They only do this through an understanding of the people or the firms involved on a continuous use and proving impractical application of these programs. But there is a problem in people feeling that they need to and must understand all the facets, because that will mean that we will come to a threshold, beyond which we will not go. If we move up and understand on a higher plane, then other people can deal with the details. Clearly, if an aerodynamicist is generating aerodynamic computer modules, he must understand the aerodynamics. There may be someone operating above him, a chief designer, who is using the computer quite happily, but using aerodynamic modules developed by others on structure modules and understanding and being experienced at a higher level.

Dr. Klineberg

Mr. Czinczenheim brought up the point that, perhaps, we should do this again, at least getting the various specialists in the same room with people who are concerned with aircraft design or close to the generalist. Is this a good idea? Is this the right venue and the right kind of thing, or are there better ways of getting people to talk with each other?

Professor Wagner

It is a good idea to have meetings like this. Just a very simple example: The aerodynamicist who is designing a supercritical wing does not always think about the accuracy of the model or the final airplane that has to be built. He just assumes that the accuracy of production will be achieved that he wants to. When people from the design office and the production plant come together with him, then they can tell him what kind of accuracy might be achieved, whether it is worthwhile to build the model or the airplane that way or what kind of trade-offs must be accepted. He can then decide whether his idea is feasible or not.

It was regretted by the audience that only very few people from the military users, who are the root and also the end point of many design activities, attended the Symposium. One of the big misuses of computation was manifested by the fact that users have heard of computers as design as well as analysis tools, but the use of the computer is not well understood by many of the people, who are the ones that instigate the design activity in the first place. The quick turn-around possible in designs with conceptional designs, preliminary designs, the depth and the wealth of information that is available has lured many people in the military and outside into a never-never-land of continual study, which can eventually become a quagmire. They almost always have too high an estimate of the quality and the accuracy of the number that can be got out of it, and there is a naive belief on the part of many of them that the solution can be found by creating a critical mass of computer output. It would be a good contribution to that community to educate them a little bit on the uses and misuses of the computer and what is a reasonable expectation from a computer study. The panel members are urged to actively involve those people the next time when this subject is addressed.

3. CONCLUSIONS

The following conclusions were drawn from the information presented at the symposium.

<u>General Conclusions</u>

- The human being plays a critical role during all steps of computerized aircraft design.
- Due to the tremendous development of computer hardware and software, remarkable progress has been made in many areas related to aircraft design.
- Despite the enormous progress in computerized aircraft design there are still areas where the designer has to rely on wind tunnel and structural testing.
- Meetings of this kind where the specialists, the generalists and the computer experts come together should be arranged periodically to improve communication and appreciation of the problems of these groups.
- The computer has reduced the routine work-load of the engineer to save time for creative work.

Specific Conclusions

- A variety of large scale computer-aided design modules exist and are continuing to evolve. The designer is embracing these models to stay competitive.

- It is desirable to document and disseminate major computer programs to all interested potential users. While some companies will prefer to tailor their own computer modules standardized programs are invaluable for the government evaluator and for smaller firms.

- A growing linkage of disciplines is seen in major modelling efforts. As this trend continues, data base management will emerge as a key prerequisite to successful application.

- The explosion of computer technology, particularly stand-alone mini computers, will permit increasing decentralization and greater detail for each specialist's input.

- Greater understanding of multivariate optimization is important, particularly with respect to the impact of locally optimized variables on off-design performance.

- There is some concern that stems from the prospect of integrating the synthesis process and the technical specialties. The complexity of this process might become so enormous that even the most astute computer scientists and designers on the team will not be able to adequately understand the total process.

- While the proper use of both measured and calculated data will certainly give aircraft design the most credibility in a design program, it may be difficult to discern the extent to which the airplane is based on test data, empirical information, or totally theoretical approaches. At this point, it may be difficult to assess the risk in taking the airplane to flight test or to productions.

- Multivariate optimization (MVO) computer programs cannot only be used as a means to produce isolated optimum designs, but also as a versatile tool to assemble comprehensive sets of consistent data.

- Computational models in aircraft design need careful documentation. Otherwise they can only be used by the author.

- In many places in Europe remarkable effort has been initiated by companies to develop and introduce CAD/CAM on their own risk. However, the degree of commonality in the sense of the NATO common defense posture is poor.

- There is no question about the efficiency of CAD/CAM in general, since the return from this system in the conceptual design phase is not likely to result in lower costs, less lead time, but will result in improved designs. Less time spent in noncreative tasks presumably means more resources for creative tasks.

- A final statement or trend analysis about host computers or distributed design computers was not reached at the S.M.P. Specialists' Meeting.

- There is a need for full 3-D geometric modeling capability in CAD.

- The costs of computing power are rapidly decreasing and should continue to decrease. This allows greater use of powerful local computers in CAD/CAM.

- Interactive computer graphics will become a major tool in engineering analysis and design.

- Distributed graphics systems have the significant advantage to be located as a powerful tool directly in the user's working location.

- To meet the demands of computational physics for increased processing speed, computers are necessary with new architectures based on parallel processing principles.

- Engineering design simulations are presently conducted on conventional computers using mature models, the accuracy of which still require that the bulk of the desired performance data be generated experimentally.

- Recent developments in computational aerodynamics have had a major impact on the aircraft configuration design process. It provides better (higher technology) designs, less risk, better understanding of test results and of the design, reduced requirements for testing or a better product for a given number of test cycles.

- There are still major voids in the technology of aerodynamic design of airplanes:
  - Better geometry systems and automatic grid generation for complete configurations.
  - Drag computation (including exact representation of suction force).
  - 3-D high-lift methods including viscous effects and separation.
  - 3-D transonic methods for complete configurations including the effects of shock induced separation.
  - Supersonic analysis of nonslender configurations.
  - 3-D methods to simulate unsteady flows.
- There exist several practical programs for the optimization of aircraft structures. However, the computer is only a tool and must be used intelligently.
- Safeguards are necessary to prevent the unwary from obtaining senseless answers, i.e. the designer still needs to have a feel for what constitutes a sensible solution to the problem and must learn how to use the computer.
- Flexible command languages allow the exploitation of a variety of optimization methods without a major education in programming.
- Structural optimization programs have reached a high standard. They allow optimization of a complete aircraft and usage of different constraints, e.g.:
  - Technological minimum thickness, simple tooling rules,
  - limited displacements, stresses and strains, miscellaneous failing under tensile stress and local buckling,
  - static aeroelastic limitations on aeroelastic coefficients and control efficiencies,
  - limitations on flutter speed and dynamic responses.
- Pre- and postprocessors should be refined in order to reduce costs for the idealization of the structure and the interpretation of the results.
- Computer models will improve in their representation of real life of weapon systems and will eventually enable a full definitive system to be designed and "proved" on the ground before deciding on the particular hardware solution to be implemented.
- The computer has become an indispensible requirement in nearly all aspects of a test program. The driving factors have been the desire for a more complete analysis resulting ultimately in a better system for the user and in a reduction in the total cost of the developmental test and evaluation cycle through a saving of test hours.

4. RECOMMENDATIONS

Recommendations worthy of consideration are listed below. Necessary action can be taken by AGARD through its Panels, the North Atlantic Military Committee, or the R&D organizations within the NATO member nations.

- Since it was concluded that meetings of this kind should be arranged periodically, it should be considered to introduce each session of the specialists by an introductory paper about the general problems of this subject.
- In order to have enough good so-called generalists, the best of whom might become chief designers or project managers, it might be worthwhile to move people around in companies or research institutions.
- To generate engineering skills in the human being in a computer environment it will be worthwhile to think about highly sophisticated in-plant training systems.
- A specification for a realistic 3-D-system related to the users' requirements should be developed for all CAD users.
- An interface specification should be developed to enable data transfer between design offices of different nations and/or companies.
- A common specification for design-specific data bases (e.g. standards) should be generated.
- True interactive computing with online graphic display for input checkout and result analysis is desirable to make computational aerodynamics and structural analysis an engineering tool.

- Automated interfaces are needed between related programs used in the design process.
- Faster turnaround (design cycle) times are necessary to speed up the design process.
- Flexible command languages would allow usage of highly sophisticated program packages by design people who may not be computer-software experts.
- Further research is necessary to better understand the physics. This will end up in better mathematical models to simulate the problems of aviation.

APPENDIX 1
LIST OF PAPERS

SESSION I - SPECIFICATIONS AND ASSESSMENT OF REQUIREMENTS

1. "The Use of Computer Aided Design Methods in Airborne Systems Evaluation"
   P. Ebeling, E. Pfisterer, IABG, FRG

2. "Criteria for Technology"
   R. Haas, AFFDL, Wright-Patterson AFB, USA

3. "An Acceptable Role for Computers in the Aircraft Design Process"
   T. J. Gregory and L. Roberts, NASA-Ames, USA

4. "The Use of Computer Based Optimization Methods in Aircraft Studies"
   J. B. Edwards, RAE, UK

5. "Some Fundamental Aspects of Transport Aircraft Conceptual Design Optimization"
   E. Torenbeek, Delft University of Technology, NL

SESSION II - COMPUTER AIDED DESIGN AND COMPUTER GRAPHICS

6. "Survey Paper on Computer Aided Design"
   D. Weinhauer, VFW-Fokker, FRG

7a "Computer Graphics and Related Design Process at MBB"
   V. Antl and W. Weingartner, MBB, FRG

7b "Computer Graphics, Related Design and Manufacture Process at Dornier"
   J. Nagel, L. Thieme and A. Harter, Dornier, FRG

7c "Computer Graphics and Related Design Process in UK"
   R. I. Hacking, BAe Warton, and R. Reuben, BAe Kingston Brough, UK

8. "Distributed Graphics System for Computer Augmented Design and Manufacture"
   A. N. Baker, Lockheed-California Co., USA

9. "Le Role de l'Interactivité dans la Conception et la Fabrication Assistées par Ordinateur"
   Mme M. Slissa, Aérospatiale, France

10. "A Framework for Distributed Design Computing"
    A. W. Bishop, British Aerospace, UK

11. "Liasse Electrique Assistée par Ordinateur"
    J. P. Pauzat, Aérospatiale, France

SESSION III - COMPUTATIONAL AERODYNAMICS AND DESIGN

12. "Use of Advanced Computers for Aerodynamic Flow Simulation"
    F. R. Bailey and W. F. Ballhaus, NASA-Ames, USA

13. "Utilisation de l'Ordinateur pour le Dessin de Configurations Aerodynamiques"
    P. Perrier, Avions Marcel Dassault-Bréguet Aviation, France

14. "Wing Design Process by Inverse Potential Flow Computer Programs"
    L. Fornasier, Aeritalia, Italy

15. "The Role of Computational Aerodynamics in Airplane Configuration Development"
    B. Dillner and C. A. Koper, Jr., Boeing, USA

16. "Computational Aerodynamic Design Tools and Techniques Used at Fighter Development"
    P. Sacher, W. Kraus and R. Kunz, MBB, FRG

17. "Use of Computers in Aerodynamic Design of the HiMAT Fighter"
    R. D. Child, Rockwell International, USA

18. "Numerical Methods for Design and Analysis as an Aerodynamic Design Tool for Modern Aircraft"
    W. Schmidt, Dornier, FRG

SESSION IV - STRUCTURAL ANALYSIS AND DESIGN

19. "Maintenance of NASTRAN as a State-of-the-Art Computer Program"
    J. L. Rogers, Jr., NASA-Langley, USA

20. "Computer Based Systems for Structural Design, Analysis and Optimization"
    A. J. Morris, RAE, UK

21. "Structural Optimization with Static and Aeroelastic Constraints"
D. Mathias, H. Röhrle and J. Artmann, Dornier, FRG

22. "Applications of Mixed and Dual Methods in Structural Optimization"
G. Sander, C. Fleury, M. Geradin, University of Liege, Belgium

23. "Elements Finis et Optimisation des Structures Aeronautiques"
C.Petiau et G.Lecina, Avions Marcel Dassault-Bréguet Aviation, France

24. "New Computer Applications for Special Structural Problems"
J. Massmann, IABG, FRG

SESSION V - PROPULSION AND SYSTEMS DESIGN

25. "Computer Programmes for the Design and Performance Evaluation of Nacelles for High Bypass Ratio Engines"
R. Smyth, VFW-Fokker, FRG

26. "Computerized Systems Analysis and Optimization of Aircraft Engine Performance, Weight, and Life Cycle Costs"
L. H. Fishbach, NASA-Lewis Research Center, USA

27. "Mathematical Modelling in Military Aircraft Weapon System Design"
N. Mitchell, British Aerospace, UK

28. "BACTAC- A Combat-Worthy Computerized Opponent"
I. Jones, British Aerospace, UK

29. "Interactive Aided Design System for Aircraft Dynamic Control Problems"
W. Kubbat, G. Oesterhelt, U. Korte, MBB, FRG

30. "The Use of Advanced Computer Techniques in Flight Test Evaluations"
R. E. Lee and D. P. Maunder, AFFTC, Edwards AFB, USA

REPORT DOCUMENTATION PAGE

1. Recipient's Reference	2. Originator's Reference	3. Further Reference	4. Security Classification of Document
	AGARD-AR-158	ISBN 92-835-1353-3	UNCLASSIFIED

5. Originator Advisory Group for Aerospace Research and Development
North Atlantic Treaty Organization
7 rue Ancelle, 92200 Neuilly sur Seine, France

6. Title
TECHNICAL EVALUATION REPORT on the FLIGHT MECHANICS PANEL SYMPOSIUM on THE USE OF COMPUTERS AS A DESIGN TOOL

7. Presented at

8. Author(s)/Editor(s)	9. Date
Professor Dr-Ing. Siegfried Wagner	March 1980

10. Author's/Editor's Address	11. Pages
Hochschule der Bundeswehr München Werner-Heisenberg-Weg 39 8014 Neubiberg, Germany	21

13. Keywords/Descriptors

Computer aided design
Utilisation
Design criteria
Aircraft
Personnel

14. Abstract

This report evaluates the AGARD Flight Mechanics Panel Symposium on 'The Use of Computers as a Design Tool' held from 3–6 September 1979 at Neubiberg, Germany. The primary conclusions were 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 rely on wind tunnel and structural testing. The computer has reduced the routine work-load 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.

Recommendations are made for future activities by AGARD. The full papers of the Proceedings are published as AGARD Conference Proceedings No.280. A083 203

This Advisory Report was prepared at the request of the Flight Mechanics Panel of AGARD.

AGARD Advisory Report No.158
Advisory Group for Aerospace Research and Development, NATO
TECHNICAL EVALUATION REPORT on the FLIGHT MECHANICS PANEL SYMPOSIUM on THE USE OF COMPUTERS AS A DESIGN TOOL
by Professor Dr-Ing. Siegfried Wagner
Published March 1980
21 pages

This report evaluates the AGARD Flight Mechanics Panel Symposium on "The Use of Computers as a Design Tool" held from 3–6 September 1979 at Neubiberg, Germany. The primary conclusions were that the human being still plays a critical role during all steps of computerized aircraft design and that

P.T.O.

AGARD-AR-158

Computer aided design
Utilisation
Design criteria
Aircraft
Personnel

AGARD Advisory Report No.158
Advisory Group for Aerospace Research and Development, NATO
TECHNICAL EVALUATION REPORT on the FLIGHT MECHANICS PANEL SYMPOSIUM on THE USE OF COMPUTERS AS A DESIGN TOOL
by Professor Dr-Ing. Siegfried Wagner
Published March 1980
21 pages

This report evaluates the AGARD Flight Mechanics Panel Symposium on "The Use of Computers as a Design Tool" held from 3–6 September 1979 at Neubiberg, Germany. The primary conclusions were that the human being still plays a critical role during all steps of computerized aircraft design and that

P.T.O.

AGARD-AR-158

Computer aided design
Utilisation
Design criteria
Aircraft
Personnel

AGARD Advisory Report No.158
Advisory Group for Aerospace Research and Development, NATO
TECHNICAL EVALUATION REPORT on the FLIGHT MECHANICS PANEL SYMPOSIUM on THE USE OF COMPUTERS AS A DESIGN TOOL
by Professor Dr-Ing. Siegfried Wagner
Published March 1980
21 pages

This report evaluates the AGARD Flight Mechanics Panel Symposium on "The Use of Computers as a Design Tool" held from 3–6 September 1979 at Neubiberg, Germany. The primary conclusions were that the human being still plays a critical role during all steps of computerized aircraft design and that

P.T.O.

AGARD-AR-158

Computer aided design
Utilisation
Design criteria
Aircraft
Personnel

AGARD Advisory Report No.158
Advisory Group for Aerospace Research and Development, NATO
TECHNICAL EVALUATION REPORT on the FLIGHT MECHANICS PANEL SYMPOSIUM on THE USE OF COMPUTERS AS A DESIGN TOOL
by Professor Dr-Ing. Siegfried Wagner
Published March 1980
21 pages

This report evaluates the AGARD Flight Mechanics Panel Symposium on "The Use of Computers as a Design Tool" held from 3–6 September 1979 at Neubiberg, Germany. The primary conclusions were that the human being still plays a critical role during all steps of computerized aircraft design and that

P.T.O.

AGARD-AR-158

Computer aided design
Utilisation
Design criteria
Aircraft
Personnel

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 rely on wind tunnel and structural testing. The computer has reduced the routine work-load 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.

Recommendations are made for future activities by AGARD. The full papers of the Proceedings are published as AGARD Conference Proceedings No.280.

This Advisory Report was prepared at the request of the Flight Mechanics Panel of AGARD.

ISBN 92-835-1353-3

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 rely on wind tunnel and structural testing. The computer has reduced the routine work-load 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.

Recommendations are made for future activities by AGARD. The full papers of the Proceedings are published as AGARD Conference Proceedings No.280.

This Advisory Report was prepared at the request of the Flight Mechanics Panel of AGARD.

ISBN 92-835-1353-3

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 rely on wind tunnel and structural testing. The computer has reduced the routine work-load 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.

Recommendations are made for future activities by AGARD. The full papers of the Proceedings are published as AGARD Conference Proceedings No.280.

This Advisory Report was prepared at the request of the Flight Mechanics Panel of AGARD.

ISBN 92-835-1353-3

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 rely on wind tunnel and structural testing. The computer has reduced the routine work-load 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.

Recommendations are made for future activities by AGARD. The full papers of the Proceedings are published as AGARD Conference Proceedings No.280.

This Advisory Report was prepared at the request of the Flight Mechanics Panel of AGARD.

ISBN 92-835-1353-3

DATE
ILMED
8