



Aeronautical  
Engineering  
A Continuing  
Bibliography  
with Indexes

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## ACCESSION NUMBER RANGES

Accession numbers cited in this Supplement fall within the following ranges.

STAR (N-10000 Series)                      N86-20341– N86-22536

IAA (A-10000 Series)                      A86-26300 – A86-29722

# AERONAUTICAL ENGINEERING

## A CONTINUING BIBLIOGRAPHY WITH INDEXES

(Supplement 202)

A selection of annotated references to unclassified reports and journal articles that were introduced into the NASA scientific and technical information system and announced in June 1986 in

- *Scientific and Technical Aerospace Reports (STAR)*
- *International Aerospace Abstracts (IAA).*



This supplement is available from the National Technical Information Service (NTIS), Springfield, Virginia 22161, price code A06.

# INTRODUCTION

This issue of *Aeronautical Engineering -- A Continuing Bibliography* (NASA SP-7037) lists 447 reports, journal articles, and other documents originally announced in June 1986 in *Scientific and Technical Aerospace Reports (STAR)* or in *International Aerospace Abstracts (IAA)*.

The coverage includes documents on the engineering and theoretical aspects of design, construction, evaluation, testing, operation, and performance of aircraft (including aircraft engines) and associated components, equipment, and systems. It also includes research and development in aerodynamics, aeronautics, and ground support equipment for aeronautical vehicles.

Each entry in the bibliography consists of a standard bibliographic citation accompanied in most cases by an abstract. The listing of the entries is arranged by the first nine *STAR* specific categories and the remaining *STAR* major categories. This arrangement offers the user the most advantageous breakdown for individual objectives. The citations include the original accession numbers from the respective announcement journals. The *IAA* items will precede the *STAR* items within each category.

Seven indexes -- subject, personal author, corporate source, foreign technology, contract number, report number, and accession number -- are included.

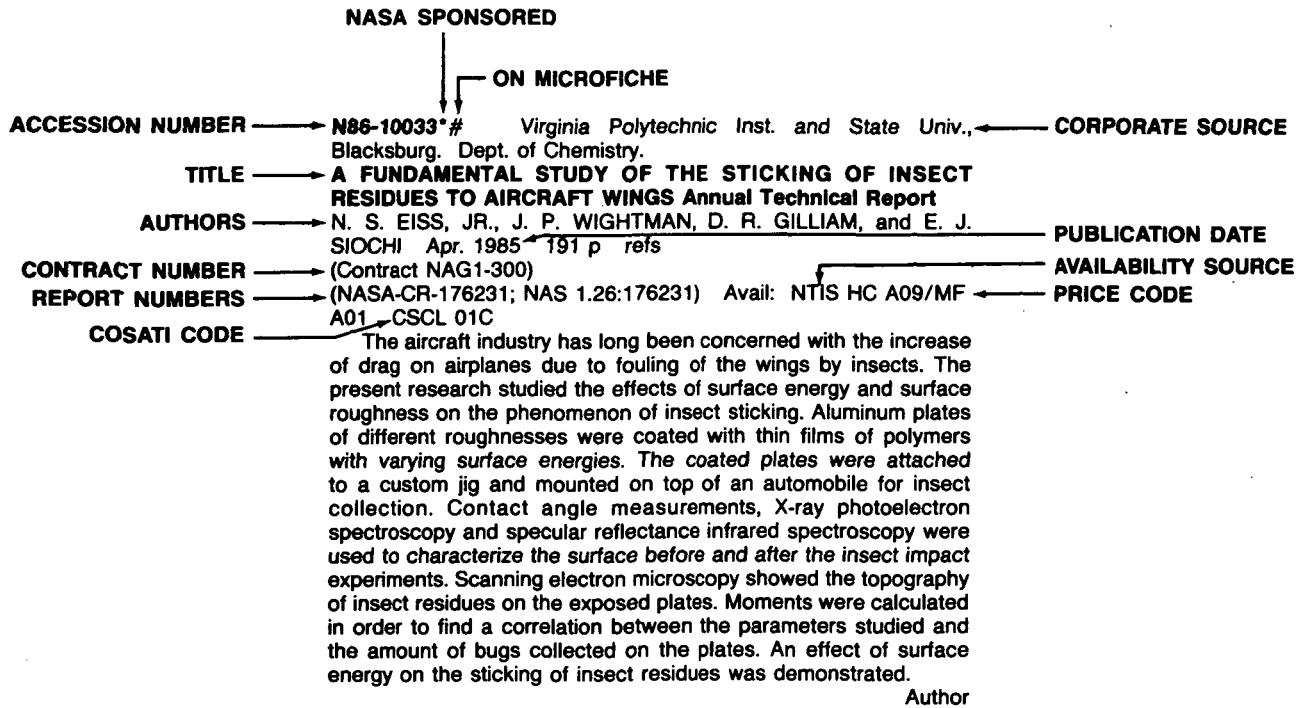
An annual cumulative index will be published.

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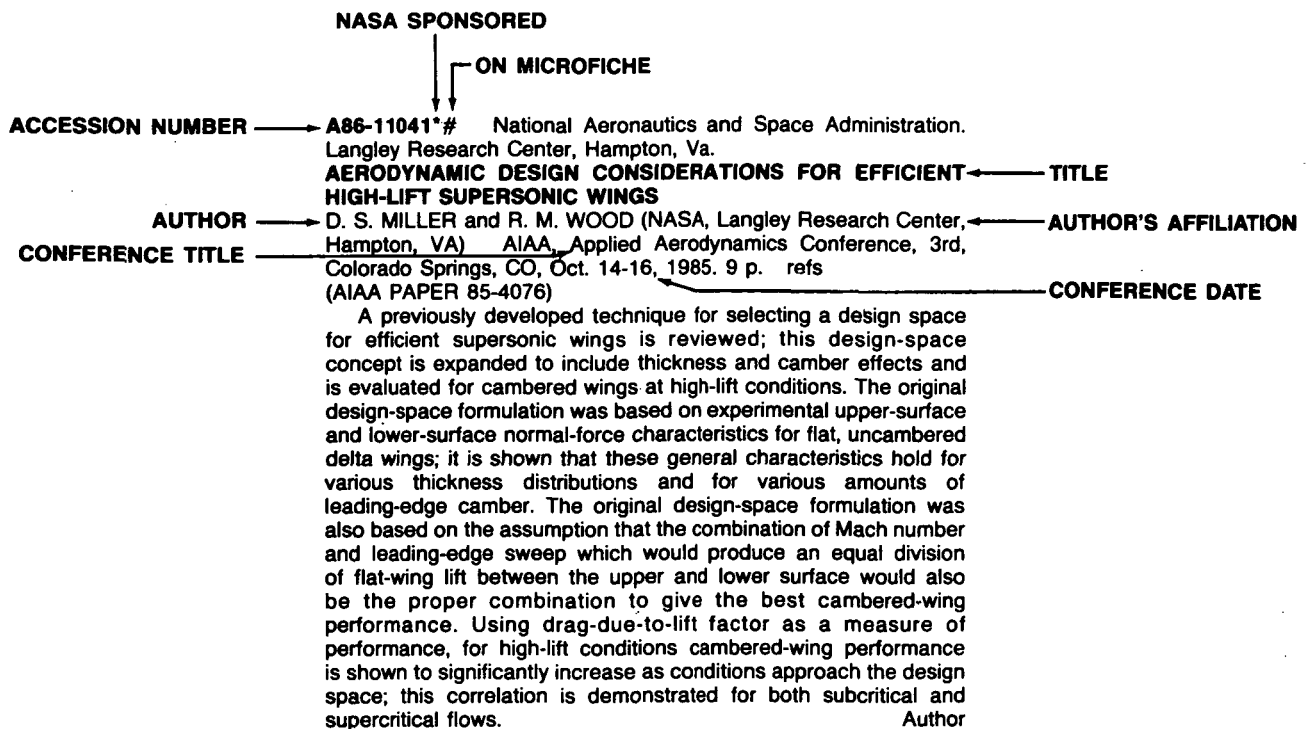
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## TYPICAL CITATION AND ABSTRACT FROM STAR



## TYPICAL CITATION AND ABSTRACT FROM IAA





JULY 1986

01

## AERONAUTICS (GENERAL)

### A86-27020 STRENGTH IN ADVERSITY

H. HOPKINS Flight International (ISSN 0015-3710), vol. 129, Feb. 8, 1986, p. 24-26, 29.

Airworthiness aspects of the new alloys, composites, and hybrid materials appearing in increasing percentage in modern commercial aircraft are considered. Current metal alloys such as those of aluminum-lithium aim at strength, stiffness, and low weight, but their composition exposes them to stress concentration, fatigue, and corrosion. Aramid-reinforced aluminum laminate (Aral) with fracture toughness in addition to the qualities of composites has application for fatigue-critical parts, especially thin, stiffened wing structures. Airbus' experience with composite material (more expensive than metal, but with lower production and maintenance costs) suggests that metals alloys will offer much better weight reduction than any developments in composites until improvements in fibers are matched by advances in resin systems. For fail-safe and damage-tolerance certification, nondestructive testing is conducted using ultrasonic methods for composites, and mechanical impedance analysis for both metals and composites. According to the CAA the long-term European aim must be the acceptance of safe-life design only if damage tolerance is impracticable.

R.R.

### A86-27145# ELECTROMAGNETIC PULSE TEST AIRCRAFT (EMPTAC) PROGRAM

D. I. LAWRY (USAF, Weapons Laboratory, Kirtland AFB, NM) IN: International Symposium on Electromagnetic Compatibility, Wakefield, MA, August 20-22, 1985, Record. New York, Institute of Electrical and Electronics Engineers, 1985, p. 373-375.

Electromagnetic pulses (EMP) which will only occur in the event of nuclear war represent a threat to modern weapon systems such as aircraft. The electromagnetic pulse test aircraft (EMPTAC) program is to provide a dedicated aircraft for conducting tests required in connection with EMP-related investigations. Attention is given to the EMP threat, past EMP efforts, details regarding the objectives of the EMPTAC program, the testbed aircraft, efforts in progress to support the development of subsystem and system level hardening specifications and associated verification testing, and aspects of hardness surveillance. Details of test technology are also considered along with a data analysis, questions of technology transition, and the challenge presented by the EMPTAC program.

G.R.

### A86-27651

#### INTERNATIONAL CONFERENCE ON ROTORCRAFT BASIC RESEARCH, RESEARCH TRIANGLE PARK, NC, FEBRUARY 19-21, 1985, PROCEEDINGS

Conference sponsored by AHS and U.S. Army. Alexandria, VA, American Helicopter Society, 1985, 352 p. For individual items see A86-27652 to A86-27669.

Various papers on rotorcraft basic research are presented. The subjects discussed include: analytical and experimental studies of textile structural composites, static postbuckling behavior of composite sandwich plates, optimal design of composite power transmission shafting, finite difference computations of rotor loads, semiempirical simulations of steady and unsteady rotor blade aerodynamic loading, wing/rotor and rotor/rotor interactions in tilt-rotor aircraft, helicopter model rotor-blade vortex interaction impulsive noise, and effects of side-stick controllers on rotorcraft handling qualities in terrain flight. Also addressed are: development of microcomputer codes for studying the flight dynamics and performance of helicopters, dynamic stability of hingeless and bearingless rotors in forward flight, structural dynamic aspects of rotor antiresonant isolation, kinematic observers for rotor control, aeroelastic stability analysis of a bearingless composite blade in hover, wake model for high resolution airloads, and prediction of flow around blade tips.

C.D.

### A86-28306

#### ACCELERATED TESTING AS A MEANS OF ENSURING THE RELIABILITY OF AIRCRAFT EQUIPMENT [USKORENNYE ISPYTANIYA KAK SREDSTVO OBESPECHENIYA NADEZHNOСТИ AVIATIONNOI TEKHNIKI]

A. V. MAIOROV IN: Problems in aircraft reliability. Moscow, Izdatel'stvo Mashinostroenie, 1985, p. 17-24. In Russian.

The methodological principles of the design and execution of laboratory tests on aircraft equipment are examined. It is emphasized that by properly designing and conducting accelerated test programs, it is possible to obtain, within a short period of time, information on changes in the technical condition of aircraft systems that are equivalent to changes occurring under conditions of actual flight operations. A chart of the operating factors included in a basic test cycle is presented.

V.L.

### A86-28521

#### AIRCRAFT OF SPECIAL CONFIGURATIONS [SAMOLETY OSOBYKH SKHEM]

D. A. SOBOLEV Moscow, Izdatel'stvo Mashinostroenie, 1985, 136 p. In Russian. refs

Various nontraditional aircraft concepts are reviewed from a historical and a technical standpoint. Particular attention is given to the tailless and canard aircraft configurations and to the factors that have limited the widespread use of these configurations. Also presented is a brief history of some other nontraditional aircraft concepts, such as tandem configurations, circular-wing aircraft, and sweptforward wing aircraft, as well as some unrealized designs.

V.L.

## 01 AERONAUTICS (GENERAL)

**N86-20342\*#** National Aeronautics and Space Administration, Langley Research Center, Hampton, Va.

### **AEROELASTICITY AT THE NASA LANGLEY RESEARCH CENTER RECENT PROGRESS, NEW CHALLENGES**

P. W. HANSON Dec. 1985 76 p refs  
(NASA-TM-87660; NAS 1.15:87660) Avail: NTIS HC A05/MF A01 CSCL 01B

Recent progress in aeroelasticity, particularly at the NASA Langley Research Center is reviewed to look at the questions answered and questions raised, and to attempt to define appropriate research emphasis needed in the near future and beyond. The paper is focused primarily on the NASA Langley Research Center (LaRC) Program because Langley is the lead NASA center for aerospace structures research, and essentially is the only one working in depth in the area of aeroelasticity. Historical trends in aeroelasticity are reviewed broadly in terms of technology and staffing particularly at the LaRC. Then, selected studies of the Loads and Aeroelasticity Division at LaRC and others over the past three years are presented with attention paid to unresolved questions. Finally, based on the results of these studies and on perceptions of design trends and aircraft operational requirements, future research needs in aeroelasticity are discussed. Author

**N86-21500#** Air Force Inst. of Tech., Wright-Patterson AFB, Ohio. School of Systems and Logistics.

### **DEVELOPMENT OF A COMPUTERISED METHOD OF DETERMINING AIRCRAFT MAINTENANCE INTERVALS M.S. Thesis**

D. B. OHEARN Sep. 1985 102 p  
(AD-A161339; AFIT/GLM/LSM/85S-59) Avail: NTIS HC A06/MF A01 CSCL 05A

Scheduled maintenance is considered one of the largest costs of aircraft ownership. For some components that exhibit an increasing failure rate, this cost can be minimized by changing the components at their optimal age replacement intervals which can be determined using the Total-Time-on-Test statistic. However, the age replacement model treats all components as separate entities and does not recognize economies that can be achieved by changing groups of components at the same time. This study develops a heuristic model for determination of near optimal groupings of components and the replacement intervals for these components. This heuristic model is illustrated using actual field data for a number of components fitted to the C130H aircraft engines operated by the Royal Australian Air Force. GRA

## 02

## AERODYNAMICS

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

**A86-26409**

### **AN ENGINEERING APPROACH TO THE INVERSE TRANSONIC WING DESIGN PROBLEM**

E. GREFF and J. MANTEL (Messerschmitt-Boelkow-Blohm GmbH, Bremen, West Germany) (International Conference on Inverse Design Concepts in Engineering Sciences, Austin, TX, Oct. 17-19, 1984) Communications in Applied Numerical Methods (ISSN 0748-8025), vol. 2, Jan.-Feb. 1986, p. 47-56. refs

The present state of the art in industrial wing design requires extensive configuration iterations through repeated wind tunnel test loops. The involved procedure is costly and time-consuming. It is, therefore, proposed to place greater emphasis on inverse design procedures in order to limit the number of wind tunnel models and reduce costly wind tunnel experiments. A new two-dimensional transonic direct inverse design method is presented, taking into account the use of a transonic direct code and a subsonic inverse code. The Direct Inverse Analogy Method (DIVA) considered takes advantage of the accuracy of subsonic airfoil design procedures

and full potential transonic analysis methods. Attention is given to sample two-dimensional design cases, and aspects of transonic wing design. G.R.

**A86-26474**

### **BASIC AERODYNAMICS**

C. B. STRIBLING London, Butterworths, 1984, 174 p. refs

It is the aim of this book to link computer programming with instruction in the fundamentals of aerodynamic theory. The book uses the BASIC language. An introduction to BASIC is provided, and the elements of fluid mechanics are examined, taking into account the properties of fluids, fluid statics, basic fluid dynamics, Reynolds number and Mach number, dimensional analysis, and similarity and wind tunnel testing. Other subjects investigated are related to stream function and velocity potential, the boundary layers, the airfoil section theory, finite wing theory, and supersonic flow. Attention is given to isentropic duct flow, a comparison of supersonic airfoil theories, pressures in a tip Mach triangle of a rectangular wing, the calibration of a Machmeter, shock waves, supersonic flow over curved surfaces and at corners, vortex theory, lifting line theory, lifting surface theory, properties of a specified wing, the lifting properties of a swept wing, the properties of a slender delta wing, thin airfoil theory, and boundary layer thicknesses. G.R.

**A86-27656#**

### **SEMI-EMPIRICAL SIMULATION OF STEADY AND UNSTEADY ROTOR BLADE AERODYNAMIC LOADING**

U. LEISS (Muenchen, Hochschule der Bundeswehr, Munich, West Germany) IN: International Conference on Rotorcraft Basic Research, Research Triangle Park, NC, February 19-21, 1985, Proceedings. Alexandria, VA, American Helicopter Society, 1985, 15 p. refs  
(Contract BMFT-LFF-83408)

A general formulation was developed to simulate the aerodynamic coefficients of a rotor blade at arbitrary angles of attack and Mach numbers by analytical expressions in steady and unsteady flow. The real aerodynamic behavior is simulated by the superposition of different flow types. Theory for a flat plate is the basis for the semi-empirical load simulation of arbitrary shapes. Only this physical superposition principle of steady flow enables a consistent formulation of unsteady effects. The difference between the method and measurement data is within the measurement accuracy. The comparison with other methods indicates a significant progress. The modular form of the model allows any refinement without any change of structure. In some cases analytical integration in radial direction is possible. Author

**A86-27666#**

### **A WAKE MODEL FOR HIGH RESOLUTION AIRLOADS**

T. S. BEDDOES (Westland Helicopters, Ltd., Yeovil, England) IN: International Conference on Rotorcraft Basic Research, Research Triangle Park, NC, February 19-21, 1985, Proceedings. Alexandria, VA, American Helicopter Society, 1985, 12 p. refs

A rotor wake model has been constructed which identifies the important features of the wake and evaluates the local, dominant effects accurately. The greater part of the wake, which in this application is less important, is treated more approximately but still with small absolute error. Each turn of the spiral trailing vortex is considered, defining the geometry and determining the critical points relative to the portion of the blade under consideration. The induced velocity is then estimated by positioning large elements in critical locations and adding a remainder term for the rest of the spiral turn. A finite core model for the structure of the trailing vortices is included, and the influence of the relative local skew angle between the blade and vortex is considered. C.D.

A86-27667#

**FREE WAKE MODEL OF HOVERING ROTORS HAVING STRAIGHT OR CURVED BLADES**

A. ROSEN (Rensselaer Polytechnic Institute, Troy, NY) and A. GRABER (Technion Israel Institute of Technology, Haifa) IN: International Conference on Rotorcraft Basic Research, Research Triangle Park, NC, February 19-21, 1985, Proceedings. Alexandria, VA, American Helicopter Society, 1985, 16 p. refs

A free-wake model of hovering rotors or rotors in axial flight is derived. Straight or curved blades can be analyzed. The blades are modeled as lifting surfaces having one cell in the chordwise direction. The wake is divided into near and far regions. The near-wake is formed of straight vortex elements while semi-infinite helical vortex lines form the far wake. Results for two rotors having straight blades are presented. Convergence and stability of the numerical model are investigated. Comparison with experimental results shows good agreement in most of the cases. Author

A86-27668#

**THE PREDICTION OF FLOW AROUND BLADE TIPS**

B. E. WAKE, N. L. SANKAR, S. G. LEKOUKIS, and R. B. GRAY (Georgia Institute of Technology, Atlanta) IN: International Conference on Rotorcraft Basic Research, Research Triangle Park, NC, February 19-21, 1985, Proceedings. Alexandria, VA, American Helicopter Society, 1985, 10 p. Army-supported research. refs

The problem of predicting the aerodynamics of the flow around blade tips is reviewed, and the different methods for predicting that flowfield are discussed. A solution procedure, based on the Euler equations is developed, and it is coupled with Gray's wake model for hover, by splitting the flow variables into two components. One of the components is prescribed and the other is computed, while their sum satisfies the conservation laws. Calculations are presented for tip flows at transonic speeds and they are compared with measured data. Author

A86-27669\*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

**RECONSTRUCTION OF A THREE-DIMENSIONAL, TRANSONIC ROTOR FLOW FIELD FROM HOLOGRAPHIC INTERFEROGRAM DATA**

Y. H. YU, J. K. KITTLESON (NASA, Ames Research Center; U.S. Army, Aeromechanics Laboratory, Moffett Field, CA), and F. BECKER (Max-Planck-Institut fuer Stroemungsforschung, Goettingen, West Germany) IN: International Conference on Rotorcraft Basic Research, Research Triangle Park, NC, February 19-21, 1985, Proceedings (A86-27651 11-01). Alexandria, VA, American Helicopter Society, 1985, 26 p. Previously announced in STAR as N85-21112. refs (AIAA PAPER 85-0370)

Holographic interferometry and computer-assisted tomography (CAT) are used to determine the transonic velocity field of a model rotor blade in hover. A pulsed ruby laser recorded 40 interferograms with a 2-ft-diam view field near the model rotor-blade tip operating at a tip Mach number of 0.90. After digitizing the interferograms and extracting fringe-order functions, the data are transferred to a CAT code. The CAT code then calculates the perturbation velocity in several planes above the blade surface. The value from the holography-CAT method compare favorably with previously obtained numerical computations in most locations near the blade tip. The results demonstrate the technique's potential for three-dimensional transonic rotor flow studies. Author

A86-28525

**AERODYNAMICS OF AIRCRAFT ELEMENTS [AERODINAMIKA ELEMENTOV LETATEL'NYKH APPARATOV]**

K. P. PETROV Moscow, Izdatel'stvo Mashinostroenie, 1985, 272 p. In Russian. refs

The aerodynamic characteristics of the principal aircraft components, such as airfoils, wings of finite length, lift-increasing devices, fuselage, and control elements, are examined in a systematic manner for various flight conditions. The discussion is based on the results of recent experimental studies and contains formulas for approximate aerodynamic calculations. Specific topics

discussed include pressure distribution on an airfoil; aerodynamic characteristics of swept wings at low angles of attack in the subsonic and transonic ranges; characteristics of flow past bodies of high aspect ratios; and the effect of the cross-sectional shape of a body of high aspect ratio on its principal aerodynamic characteristics. Finally, some problems associated with the interference between individual aircraft components are examined. V.L.

A86-28535#

**A PERTURBATIVE LAMBDA FORMULATION**

A. DADONE and M. NAPOLITANO (Bari, Universita, Italy) AIAA Journal (ISSN 0001-1452), vol. 24, March 1986, p. 411-417. Research supported by the Ministero della Pubblica Istruzione and CNR. refs

This paper provides a new perturbative lambda formulation for the numerical solution of compressible flows. The time-dependent Euler equations are recast into compatibility equations for perturbative bicharacteristic variables that are the differences between the standard Riemann variables and those corresponding to an appropriate steady incompressible flow. In this way, the geometry-induced gradients are accounted for by the incompressible flow solution and the smooth correction accounting for compressibility effects is solved accurately even on a coarse mesh. The new perturbative lambda equations for two-dimensional homentropic flows are provided in a general orthogonal curvilinear coordinate system and solved numerically by means of an alternating direction implicit method. Results are presented for flow past a NACA 0012 airfoil that demonstrate the remarkable accuracy of the proposed methodology. Author

A86-28558#

**COMMENT ON 'CONICAL SIMILARITY OF SHOCK/BOUNDARY-LAYER INTERACTIONS GENERATED BY SWEEPED AND UNSWEEPED WINGS'**

S. M. BOGDONOFF (Princeton University, NJ) and S. WANG (Chinese Aerodynamics R&D Center, Sidhuan, People's Republic of China) AIAA Journal (ISSN 0001-1452), vol. 24, March 1986, p. 540; Authors' Reply, p. 541, 542. refs

A86-28565#

**STEADY AND UNSTEADY TRANSONIC PRESSURE DISTRIBUTIONS ON NACA 0012**

H. TRIEBSTEIN (DFVLR, Institut fuer Aeroelastik, Goettingen, West Germany) (International Council of the Aeronautical Sciences, Congress, 14th, Toulouse, France, September 9-14, 1984, Proceedings. Volume 1, p. 483-493) Journal of Aircraft (ISSN 0021-8669), vol. 23, March 1986, p. 213-219. Previously cited in issue 22, p. 3172, Accession no. A84-44982. refs

**A86-28569\*# Vigyan Research Associates, Inc., Hampton, Va. AN ATTACHED FLOW DESIGN OF A NONINTERFERING LEADING-EDGE EXTENSION TO A THICK DELTA WING**

F. GHAFARI (Vigyan Research Associates, Inc., Hampton, VA) and J. E. LAMAR (NASA, Langley Research Center, Hampton, VA) Journal of Aircraft (ISSN 0021-8669), vol. 23, March 1986, p. 237-243. Previously cited in issue 07, p. 844, Accession no. A85-19689. refs

A86-28637#

**AN EXPERIMENTAL STUDY OF THE FLOW AND WALL PRESSURE FIELD AROUND A WING-BODY JUNCTION**

M. A. Z. HASAN, M. J. CASARELLA (Catholic University of America, Washington, DC), and E. P. ROOD (David W. Taylor Naval Ship Research and Development Center, Bethesda, MD) IN: Shear flow - Structure interaction phenomena; Proceedings of the Winter Annual Meeting, Miami Beach, FL, November 17-22, 1985. New York, American Society of Mechanical Engineers, 1985, p. 89-95. Navy-supported research. refs

The flow and the wall-pressure field around a wing-body junction has been investigated in a quiet, low-turbulence wind tunnel, measuring the point spectral densities along the centerline in front of the wing and along several spanwise locations. The strong

## 02 AERODYNAMICS

adverse pressure gradient on the upstream centerline causes a three-dimensional flow separation at approximately one wing thickness upstream, inducing the formation of the horseshoe root vortex which wraps around the wing and becomes embedded within the boundary layer. Significant increases in the level of turbulence were observed both in the attached boundary layer and within the secondary flow. The data on the spectral content of the wall pressure fluctuations indicate that the increased levels of turbulence can be attributed to the low-frequency organized motion associated with the root vortex. I.S.

### **A86-29415 THREE-DIMENSIONAL AND UNSTEADY BOUNDARY-LAYER COMPUTATIONS**

J. COUSTEIX (ONERA, Centre d'Etudes et de Recherches de Toulouse, France) IN: Annual review of fluid mechanics. Volume 18. Palo Alto, CA, Annual Reviews, Inc., 1986, p. 173-196. refs

Three-dimensional boundary layers which develop on a wing or fuselage of an aircraft, and unsteady boundary layers that are formed by imposed unsteadiness are studied. The coordinate system and equations for three-dimensional boundary layers are presented; the use of finite-difference methods to solve the equations is examined. The occurrence of singularities in two-dimensional and three-dimensional boundary layer computations is investigated. The development of turbulence models for two-dimensional and three-dimensional boundary layers is described; the effects of near-wall treatment on turbulence modeling is analyzed. I.F.

### **A86-29417 VORTEX FLOWS IN AERODYNAMICS**

J. H. B. SMITH (Royal Aircraft Establishment, Farnborough, England) IN: Annual review of fluid mechanics. Volume 18. Palo Alto, CA, Annual Reviews, Inc., 1986, p. 221-242. refs

Planar vortex flows and three-dimensional flows from boundary-layer separation lines which arise in the external aerodynamics of aircraft, are studied. The difficulties encountered in modeling the Prandtl-Batchelor flows of an inviscid fluid past a two-dimensional body are examined. The characteristics of three-dimensional flows from swept separation lines, and the need to include secondary and turbulent separations in the modeling of the flows are described. The uses of the vortex-sheet model in the slender-body (SB) framework and the multiple line-vortex models in the SB and Prandtl-Glauert frameworks to represent and predict three-dimensional vortex flows are investigated. The inviscid modeling of vortex flow with the Euler equations, which take into account vorticity, is analyzed; examples revealing the applicability of Euler models are presented. I.F.

### **A86-29474 TRANSONIC FLOW CALCULATIONS FOR AIRCRAFT**

A. JAMESON (Princeton University, NJ) IN: Numerical methods in fluid dynamics. Berlin and New York, Springer-Verlag, 1985, p. 156-242. refs

The present evaluation of recent advancements in computational aerodynamics gives attention to the calculation of steady transonic flows over bodies of extreme geometric complexity, including those cases in which the domain is multiply connected, using either the potential flow equation or the Euler equations. The discussion encompasses the choice of a mathematical model, transonic potential flow equation upwind differencing, the treatment of complex geometric configurations, and convergence acceleration, as well as modification of the Euler equations for faster convergence to a steady state, the MacCormack and semidiscrete finite volume schemes, and viscous flow calculations. O.C.

### **A86-29840 AERODYNAMICS. PART 1 - FUNDAMENTALS OF THEORY. AERODYNAMICS OF AN AIRFOIL AND A WING**

N. F. KRASNOV (Moskovskoe Vysshee Tekhnicheskoe Uchilishche, Moscow, USSR) Moscow, Mir Publishers, 1985, 512 p. Translation. refs

An introductory treatment of the aerodynamics of airfoils wings is presented. The fundamental theoretical problems of airfoil aerodynamics are considered, with emphasis given to: the equations of motion in viscous and inviscid flows; energy diffusion equations of gaseous media; and shock wave theory. Methods for calculating the stationary aerodynamic characteristics of airfoils and wings are discussed, including; the method of characteristics; Eulerian approaches; and Lagrangian methods. The application of flow calculations to specific aircraft designs is addressed in a companion volume. I.H.

### **A86-29841 AERODYNAMICS. PART 2 - METHODS OF AERODYNAMIC CALCULATIONS**

N. F. KRASNOV (Moskovskoe Vysshee Tekhnicheskoe Uchilishche, Moscow, USSR) Moscow, Mir Publishers, 1985, 432 p. Translation. Previously cited in issue 15, p. 2351, Accession no. A82-33387. refs

**N86-20343#** Iowa State Univ. of Science and Technology, Ames. Coll. of Engineering.

### **MODULAR APPLICATION OF A SHOCK/BOUNDARY LAYER INTERACTION SOLUTION TO SUPERCRITICAL VISCOUS-INVISCID FLOW FIELD ANALYSIS**

G. R. INGER and W. G. HABASHI, ed. 1984 40 p refs Reprinted from Computational Methods in Viscous Flows. Volume 3: Recent Advances in Numerical Methods in Fluids (Swansea, England), 1984 p 1-38

Avail: NTIS HC A03/MF A01

Shock boundary layer interaction influence extends significantly downstream within the boundary layer and thereby alters the global aerodynamic properties of lift, drag and pitching moment. Shock boundary layer interactions and their Reynolds and Mach number scaling must be fundamentally understood and appropriate theoretical tools be developed for their prediction in engineering applications. Features of an approximate nonasymptotic triple deck theory of shock turbulent boundary layer interaction and its application as an element in the overall viscous flow analysis of the body are described. Two main aspects of the problem are examined: 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 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. Author

### **N86-20344\*#** George Washington Univ., Washington, D.C. **EXPLORATORY LOW-SPEED WIND-TUNNEL STUDY OF CONCEPTS DESIGNED TO IMPROVE AIRCRAFT STABILITY AND CONTROL AT HIGH ANGLES OF ATTACK M.S. Thesis**

D. E. HAHNE Dec. 1985 73 p refs Sponsored by NASA (NASA-CR-176615; NAS 1.26:176615) Avail: NTIS HC A04/MF A01 CSCL 01A

A wind tunnel investigation of concepts to improve the high angle-of-attack stability and control characteristics of a high performance aircraft was conducted. The effect of vertical tail geometry on stability and the effectiveness of several conventional and unusual control concepts was determined. These results were obtained over a large angle-of-attack range. Vertical tail location, cant angle and leading edge sweep could influence both longitudinal and lateral-directional stability. The control concepts tested were found to be effective and to provide control into the post stall angle-of-attack region. Author

**N86-20345\*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.  
**EFFECT OF UNDERWING AFT-MOUNTED NACELLES ON THE LONGITUDINAL AERODYNAMIC CHARACTERISTICS OF A HIGH-WING TRANSPORT AIRPLANE**  
 W. K. ABEYOUNIS and J. C. PATTERSON, JR. Dec. 1985 139 p refs  
 (NASA-TP-2447; L-15664; NAS 1.60:2447) Avail: NTIS HC A07/MF A01 CSCL 01A

As part of a propulsion/airframe integration program, tests were conducted in the Langley 16-Foot Transonic Tunnel to determine the longitudinal aerodynamic effects of installing flow through engine nacelles in the aft underwing position of a high wing transonic transfer airplane. Mixed flow nacelles with circular and D-shaped inlets were tested at free stream Mach numbers from 0.70 to 0.85 and angles of attack from -2.5 deg to 4.0 deg. The aerodynamic effects of installing antishock bodies on the wing and nacelle upper surfaces as a means of attaching and supporting nacelles in an extreme aft position were investigated. Author

**N86-20346\*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.  
**INSTALLATION EFFECTS OF LONG-DUCT PYLON-MOUNTED NACELLES ON A TWIN-JET TRANSPORT MODEL WITH SWEPT SUPERCRITICAL WING**  
 E. E. LEE, JR. and O. C. PENDERGRAFT, JR. Dec. 1985 145 p refs  
 (NASA-TP-2457; L-15932; NAS 1.60:2457) Avail: NTIS HC A07/MF A01 CSCL 01A

The installation interference effects of an underwing-mounted, long duct, turbofan nacelle were evaluated in the Langley 16-Foot Transonic Tunnel with two different pylon shapes installed on a twin engine transport model having a supercritical wing swept 30 deg. Wing, pylon, and nacelle pressures and overall model force data were obtained at Mach numbers from 0.70 to 0.83 and nominal angles of attack from -2 deg to 4 deg at an average unit Reynolds number of  $11.9 \times 1,000,000$  per meter. The results show that adding the long duct nacelles to the supercritical wing, in the near sonic flow field, changed the magnitude and direction of flow velocities over the entire span, significantly reduced cruise lift, and caused large interference drag on the nacelle afterbody. Author

**N86-20349\*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.  
**AERODYNAMIC CHARACTERISTICS OF SEVERAL CURRENT HELICOPTER TAIL BOOM CROSS SECTIONS INCLUDING THE EFFECT OF SPOILERS**  
 J. C. WILSON and H. L. KELLEY Jan. 1986 74 p refs  
 (Contract DA PROJ. 1L1-61102-AH-45)  
 (NASA-TP-2506; L-15978; NAS 1.60:2506; AVSCOM-TR-85-B-3)  
 Avail: NTIS HC A04/MF A01 CSCL 01A

Aerodynamic characteristics were determined of three cylindrical shapes representative of tail boom cross sections of the U.S. Army AH-64, UH-60, and UH-1H helicopters. Forces and pressures were measured in a wind-tunnel investigation at the Langley Research Center. Data were obtained for a flow incidence range from -45 to 90 deg and a dynamic pressure range from 1.5 to 50 psf. These ranges provided data representative of full-scale Reynolds numbers and the full range of flow incidence to which these helicopter tail boom shapes would be subjected at low flight speeds. The effects of protuberances such as tail rotor drive-shaft covers and spoilers were evaluated. The data indicate that significant side loads on tail booms of helicopters can be generated and that the addition of spoilers can beneficially alter the side loads. Although an increase in vertical drag occurs, the net effect through reduction of tail rotor thrust required can be an improvement in helicopter performance. Author

**N86-20350\*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.  
**FLIGHT MEASUREMENTS OF SURFACE PRESSURES ON A FLEXIBLE SUPERCRITICAL RESEARCH WING**  
 C. V. ECKSTROM Dec. 1985 120 p refs  
 (NASA-TP-2501; L-15877; NAS 1.60:2501) Avail: NTIS HC A06/MF A01 CSCL 01A

A flexible supercritical research wing, designated as ARW-1, was flight-tested as part of the NASA Drones for Aerodynamic and Structural Testing Program. Aerodynamic loads, in the form of wing surface pressure measurements, were obtained during flights at altitudes of 15,000, 20,000, and 25,000 feet at Mach numbers from 0.70 to 0.91. Surface pressure coefficients determined from pressure measurements at 80 orifice locations are presented individually as nearly continuous functions of angle of attack for constant values of Mach number. The surface pressure coefficients are also presented individually as a function of Mach number for an angle of attack of 2.0 deg. The nearly continuous values of the pressure coefficient clearly show details of the pressure gradient, which occurred in a rather narrow Mach number range. The effects of changes in angle of attack, Mach number, and dynamic pressure are also shown by chordwise pressure distributions for the range of test conditions experienced. Reynolds numbers for the tests ranged from 5.7 to  $8.4 \times 1,000,000$ . Author

**N86-20351\*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.  
**THE APPLICATION TO AIRFOILS OF A TECHNIQUE FOR REDUCING ORIFICE-INDUCED PRESSURE ERROR AT HIGH REYNOLDS NUMBERS**  
 E. B. PLENTOVICH Jan. 1986 44 p refs  
 (NASA-TP-2537; L-16002; NAS 1.60:2537) Avail: NTIS HC A03/MF A01 CSCL 01A

A wind tunnel investigation was conducted in the Langley 0.3-Meter Transonic Cryogenic Tunnel to study the effects of porous (sintered metal) plug orifices on orifice-induced static-pressure measurement error at high Reynolds numbers. A NACA airfoil was tested at Mach numbers from 0.60 to 0.80 and at Reynolds numbers from  $6 \times 1,000,000$  to  $40 \times 1,000,000$ . Data are included which compare pressure measurements obtained from porous plug orifices and from conventional orifices with diameters of 0.025 cm (0.010 in.) and 0.102 cm (0.040 in.). The two dimensional airfoil code GRUMFOIL was used to calculate boundary layer displacement thickness. The response time and the downstream effect of the porous plug orifice were considered in this investigation. The results showed that the porous plug orifice could be a viable method of reducing pressure error. The data also showed that the pressure measurements obtained with a 0.102-cm-diameter orifice were very close to the measurements obtained with 0.025-cm-diameter orifice over such of the airfoil and that downstream of a shock the orifice size was not critical. Author

**N86-20353#** National Aeronautical Lab., Tokyo (Japan).  
**RESEARCH ON THE AERODYNAMIC CHARACTERISTICS OF VEHICLES BY FREE FLIGHT TESTING AT SUPERSONIC SPEEDS**

I. KAWAMOTO Sep. 1985 74 p refs In JAPANESE; ENGLISH summary  
 (NAL-TR-876; ISSN-0389-4010) Avail: NTIS HC A04/MF A01

A new free flight testing technique was developed in the 1mx1m blow-down supersonic wind tunnel. The following results were obtained: (1) a new launching method in which a model is installed inside the launcher was developed, and various models were successfully launched at various angles of attack; (2) a data processing program for moving models was developed by use of a parameter identification method under the assumption of three degrees of longitudinal freedom of motion; (3) cone models, Mercury capsule models, blunt cone capsule models, sounding rocket models and supersonic aircraft models were launched, results were obtained from the flight tests. There sometimes existed a short duration of the freedom motion, the data reduction to this

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partial duration of motion are in agreement with the conventional wind tunnel force test results in the aerodynamic coefficients, the divergence of the pitching motion of the Mercury Capsule model was shown in pictures; (4) the relations between the amount of data gathered during a run and the aerodynamic characteristics derived therefrom are discussed; and (5) the excessive nonlinear terms of alpha for the aerodynamic expressions sometimes result in unacceptable aerodynamic characteristics. E.A.K.

**N86-20354#** National Aeronautical Lab., Bangalore (India). Fluid Mechanics Div.

### **JET PLUME TEMPERATURE EFFECTS ON AFTERBODY PRESSURE DISTRIBUTION AND DRAG**

N. B. MATHUR and K. S. YAJNIK Mar. 1985 10 p refs (NAL-TM-FM-8502) Avail: NTIS HC A02/MF A01

A typical axisymmetric configuration with a circular arc boattailed afterbody was investigated to study the jet plume temperature effects on afterbody pressure distribution and drag. The experiments which were carried out at a free stream Mach number of 0.62 and jet pressure ratio of about 3.0 show that as the jet temperature ratio is increased the afterbody pressures tend to increase and the afterbody pressure drag tends to decrease. It is a reduction in afterbody pressure drag by about 30 to 40% is shown when the jet plume temperature is increased from 307 deg K (cold jet) to 945 deg K. Both jet plume temperature and the afterbody surface temperature effects generally contribute to the observed changes in the pressure distribution and drag.

E.A.K.

**N86-20356#** National Aeronautical Lab., Bangalore (India). Aerodynamics Div.

### **SIDE FORCE CHARACTERISTICS OF A 20 DEG CONE AT HIGH ANGLES OF ATTACK**

P. R. VISWANATH and K. Y. NARAYAN May 1985 24 p refs (NAL-TM-AE-8503) Avail: NTIS HC A02/MF A01

Force measurements were made on a 20 deg. cone to study the features of side force generation at high angles of attack. The experiments covered a Mach number range of 0.17 to 0.25 and a Reynolds number range of 0.5 to 2.8x1,000,000. The model incidence was varied up to 47 deg. The magnitude of side forces and the onset angle of attack for side force generation are in fairly good agreement with other published data on cones.

E.A.K.

**N86-20358\*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

### **EFFECTS OF PLANFORM GEOMETRY ON HOVER PERFORMANCE OF A 2-METER-DIAMETER MODEL OF A FOUR-BLADED ROTOR**

A. E. PHELPS, III and S. L. ALTHOFF Mar. 1986 33 p refs (Contract DA PROJ. 1L1-61102-AH-45) (NASA-TM-87607; L-16020; NAS 1.15:87607; AVSCOM-TR-85-B-6) Avail: NTIS HC A03/MF A01 CSCL 01A

Hover tests were conducted on three small scale rotors to evaluate the effects of blade planform taper on rotor hover performance. Tests were conducted on a rectangular swept-tip configuration, on a configuration with a 3 to 1 taper over the outboard 20 percent of the span, and on a configuration with a 5 to 1 taper over the outboard 20 percent of the blade span. The investigation covered a range of thrust coefficients from 0 to 0.0075 and a range of tip speeds from 300 to 600 ft/sec. The tests showed that both tapered configurations had better hover performance than the swept-tip rectangular configuration and that the 3 to 1 taper configuration was better than the 5 to 1 taper configuration. The test results were compared with predictions made with a prescribed wake analysis, a momentum analysis, and a simplified free wake analysis. Author

### **N86-20360\*#** Vigyan Research Associates, Inc., Hampton, Va. **METHOD FOR THE PREDICTION OF THE INSTALLATION AERODYNAMICS OF A PROPFAN AT SUBSONIC SPEEDS: USER MANUAL**

B. CHANDRASEKARAN Jan. 1986 100 p refs (Contract NAS1-17826)

(NASA-CR-178057; NAS 1.26:178057) Avail: NTIS HC A05/MF A01 CSCL 01A

This document is the user's guide for the method developed earlier for predicting the slipstream wing interaction at subsonic speeds. The analysis involves a subsonic panel code (HESS code) modified to handle the propeller onset flow. The propfan slipstream effects are superimposed on the normal flow boundary condition and are applied over the surface washed by the slipstream. The effects of the propeller slipstream are to increase the axial induced velocity, tangential velocity, and a total pressure rise in the wake of the propeller. Principles based on blade performance theory, momentum theory, and vortex theory were used to evaluate the slipstream effects. The code can be applied to any arbitrary three dimensional geometry, expressed in the form of HESS input format. The code can handle a propeller alone configuration or a propeller/nacelle/airframe configuration, operating up to high subcritical Mach numbers over a range of angles of attack. Inclusion of a viscous modelling is briefly outlined. Wind tunnel results/theory comparisons are included as examples for the application of the code to a generic supercritical wing/overwing Nacelle with a powered propfan. A sample input/output listing is provided.

Author

### **N86-20361\*#** Vigyan Research Associates, Inc., Hampton, Va. **SUBSONIC FLOW INVESTIGATIONS ON A CRANKED WING DESIGNED FOR HIGH MANEUVERABILITY Final Report**

D. M. RAO Feb. 1986 45 p refs

(Contract NAS1-17420)

(NASA-CR-178046; NAS 1.26:178046) Avail: NTIS HC A03/MF A01 CSCL 01A

The characteristic pitching moment nonlinearity of cranked wings limits their usable lift coefficient well below  $C_{sub L max}$ . The potential of several aerodynamic devices, viz., fences, pylon vortex generators (PVG), mid-span strakes and cavity flaps, in delaying the pitch up onset on a 70/50 deg cranked wing was explored in low speed tunnel tests. Upper surface pressure measurements and low visualizations were conducted on a semi-span wing model to observe the vortex flow development with increasing angle of attack, and then to assess the effectiveness of the devices in controlling the collapse of vortex lift over the wing panel outboard of the crank. Force tests on a full span wing and body model were also conducted to assess the fence and PVG in improving the usable  $C_{sub L}$ . Author

**N86-20362#** Aeronautical Research Labs., Melbourne (Australia).

### **A VISUALISATION STUDY OF THE VORTEX FLOW AROUND DOUBLE-DELTA WINGS**

D. H. THOMPSON 1985 70 p refs

(ARL-AERO-R-165; AR-004-047) Avail: NTIS HC A04/MF A01

A family of double delta wings with leading edge sweep combinations of 80/80, 80/70, 80/60, 80/50, and 80/40 degrees was tested in a small towing tank. The hydrogen bubble technique was used to visualize the vortex patterns above the wings over a range of Reynolds numbers (based on centerline chord) from 7,000 to 100,000. The effects of variations in incidence and leading edge kink angle were examined. Reynolds number and leading edge cross section shape were found to have significant effects on the vortex structure. Attempts to visualize details of the upper surface secondary vortex flows met with only partial success.

Author

**N86-20364#** National Aerospace Lab., Tokyo (Japan).  
**NUMERICAL ANALYSIS OF INVISCID FLOWS ABOUT WING-FUSELAGE COMBINATIONS. 2: DEVELOPMENT OF FULL POTENTIAL FLOW CODE YOKUDO-P**  
 T. ISHIGURO 1985 87 p refs In JAPANESE; ENGLISH summary

(NAL-TR-881; ISSN-0389-4010) Avail: NTIS HC A05/MF A01  
 The main purpose of this paper is to numerically analyze inviscid flows about wing-fuselage combinations. In the second series a numerical procedure is developed for calculating full potential flows about wing-fuselage combinations by the successive-line-over-relaxation method of the rotated finite difference scheme, using the grids which have already been generated by the code YOKUDO-G in the first series. A user's manual for the FORTRAN code of the procedure is also described. Furthermore, many numerical examples are presented in order to show the utility of this code for flows about several wing-fuselage combinations under several free stream boundary conditions. The numerical results obtained by this code are compared with the experimental results and with numerical results of other methods.

Author

**N86-20368#** Naval Ship Research and Development Center, Bethesda, Md.  
**LIFT DISTRIBUTION ON A HIGH ASPECT RATIO CIRCULATION CONTROL WING WITH ROOT LIFT CUTOUT Final Report, 1 Oct. 1982 - 1 Oct. 1983**

R. J. FUREY Jun. 1985 56 p refs  
 (AD-A157024; DTNSRDC-85/030; AR-1294) Avail: NTIS HC A04/MF A01 CSCL 20D

A computational procedure is developed, based on lifting line theory, which successfully predicts the spanwise lift distribution at moderate blowing momentum coefficient on a high aspect ratio (AR - 18) circulation control wing-body model with several variations in the spanwise extent of blowing. Experimental data are presented on the spanwise lift distribution which validates this procedure.

Author

**N86-20371#** Sandia National Labs., Albuquerque, N. Mex.  
**DEVELOPMENT DROP TEST RESULTS OF THE 15-FT-DIA RIBBON PARACHUTE AND 73-FT-DIA CROSS PARACHUTE FOR THE US ARMY NATICK LABORATORY UHLCADS SYSTEM**

W. B. PEPPER Sep. 1985 27 p  
 (Contract DE-AC04-76DP-00789)  
 (DE85-017614; SAND-84-2183) Avail: NTIS HC A03/MF A01

During 1984 a series of 12 drop tests was conducted at the US Army Yuma Proving Ground near Yuma, Arizona to develop a new system to recover a 2200-lb resupply container from high altitude. The parachute system consists of a 15-ft-dia ribbon parachute reefed for 10 s and a 73-ft-dia cross parachute with no reefing. The system has been successfully demonstrated by flight tests. The impact velocity is 30 fps. DOE

**N86-20374#** Technische Hogeschool, Eindhoven (Netherlands). Vakgroep Transportfysica.  
**A REVISION OF THE ACTUATOR DISK CONCEPT AND MOMENTUM THEORY**  
 G. A. M. VANKUIK Aug. 1985 62 p refs  
 (REPT-R-732-D) Avail: NTIS HC A04/MF A01

The analytical solution of the singularity problem in the limit case of edge flow on a disk with constant surface load is analyzed, leading to an extension of the actuator disk concept with edge forces. If these forces are taken into account in the momentum theory, the results are more convincing, and nuclear experimental phenomena can be explained. The shift of the momentum theory results is only indicated qualitatively. Author (ESA)

**N86-21504** Maryland Univ., College Park.  
**COMPUTATION OF THREE DIMENSIONAL POTENTIAL FLOW AROUND A FINITE WING WITH A LEADING-EDGE DISCONTINUITY AT HIGH ANGLE OF ATTACK Ph.D. Thesis**  
 T. CHO 1985 219 p

Avail: Univ. Microfilms Order No. DA8523059

The aerodynamics of a finite wing above the stall angle of attack is investigated computationally. Vortex panel computer programs have been developed which can be used to calculate two dimensional separated flows over airfoils and three dimensional separated flow over a wing with leading edge droop modification. On each wind surface panel, a bound vortex is assumed to be distributed linearly in the spanwise direction and also in the chordwise direction. For the three dimensional flow around a finite thickness wing, the upper and lower surfaces are assumed to be independent infinitely thin wings located on top of each other. For three dimensional separated flow calculations, two different computational models are developed. One is a semi-empirical engineering model which is applied to an infinitely thin wing. The location of the separation and the pressure inside the separation region are provided from experiment. Inside the separation region, constant strength vortex panels are distributed corresponding to the constant pressure,  $C_p = -0.6$ , which is confirmed by various experiments. Dissert. Abstr.

**N86-21508#** National Aerospace Lab., Tokyo (Japan).  
**A VISCOUS-INVISCID INTERACTION METHOD TO PREDICT THE AERODYNAMIC PERFORMANCE OF AIRFOILS AT TRANSONIC SPEED**

K. MASUNO 1985 34 p refs In JAPANESE; ENGLISH summary  
 (NAL-TR-873) Avail: NTIS HC A03/MF A01

The present paper describes a calculation method for predicting the aerodynamic performance of single airfoils in the transonic flows of high Reynolds numbers. For the inviscid part of the method, a transonic full potential equation represented on an algebraically generated C-topology coordinate system is solved by a fully conservative AF2 iteration scheme. A finite difference method (PC-CN Scheme) is used for the boundary layer and wake solutions. In the viscous method, an algebraic turbulence model for the asymmetric near wake is also developed. The model used to achieve viscous-inviscid coupling is the equivalent source model. The wake thickness and curvature are taken into account. The calculations for turbulent wake flows indicated good agreement with the experimental data, and show that the velocity profiles across the wake and minimum velocities can be computed satisfactorily with the present method. Comparisons of the predictions with high Reynolds number wind tunnel experiments show good agreement for pressure distributions, lift and drag.

Author

**N86-21509\*#** National Aeronautics and Space Administration, Washington, D.C.

**COMPARISON OF COMPUTATIONAL RESULTS OF A FEW REPRESENTATIVE THREE-DIMENSIONAL TRANSONIC POTENTIAL FLOW ANALYSIS PROGRAMS**

K. TANAKA and H. HIROSE Jan. 1986 19 p refs Transl. into ENGLISH of "Sanjigen Sen-Onsokunagare Kaisetsu Kakashu Puroguramu Niyoru Keisankekka no Hikaku" presented at the NAL Symposium on Aircraft Computational Aerodynamics, 1983 p 157-167 Symposium held in Tokyo, Japan, 30 Jun. - 1 Jul. 1983 Original language document was announced as N85-26628 Transl. by Scientific Translation Service, Santa Barbara, Calif. (Contract NASW-3542)  
 (NASA-TM-77963; NAS 1.15:77963) Avail: NTIS HC A02/MF A01 CSCL 01A

The development of transonic aerodynamic computation methods and specific examples, as well as examples of three-dimensional transonic computation in design, are discussed. The case of the transonic transport and the case of the small transport are analyzed. Requirements for programs of the future are itemized. Author

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**N86-21510\*#** National Aeronautics and Space Administration, Washington, D.C.

### **VORTEX CONCEPTION OF ROTOR AND MUTUAL EFFECT OF SCREW/PROPELLERS**

A. M. LEPILKIN Jan. 1986 48 p refs Transl. into ENGLISH from Bulletin of the Academy of Sciences USSR, Mechanics and Machine Building (USSR), no. 5, 1963 p 77-107 Transl. by Kanner (Leo) Associates, Redwood City, Calif.

(Contract NASW-4005)

(NASA-TM-77979; NAS 1.15:77979) Avail: NTIS HC A03/MF A01 CSCL 01A

A vortex theory of screw/propellers with variable circulation according to the blade and its azimuth is proposed, the problem is formulated and circulation is expanded in a Fourier series. Equations are given for inductive velocities in space for crews, including those with an infinitely large number of blades and expansion of the inductive velocity by blade azimuth of a second screw. Multiparameter improper integrals are given as a combination of elliptical integrals and elementary functions, and it is shown how to reduce elliptical integrals of the third kind with a complex parameter to integrals with a real parameter. Author

**N86-21511\*#** National Aeronautics and Space Administration, Washington, D.C.

### **PROPULSION AND CONTROL PROPELLERS WITH THRUSTER NOZZLES PRIMARILY FOR AIRCRAFT APPLICATIONS**

W. PABST Mar. 1986 8 p Transl. into ENGLISH of West German Patent no. P3440369.8 (5 Nov. 1984) p 1-6 Transl. by The Corporate Word, Inc., Pittsburgh, Pa.

(Contract NASW-4006)

(NASA-TM-77715; NAS 1.15:77715) Avail: NTIS HC A02/MF A01 CSCL 01A

A propulsion and control propeller with thruster nozzles, primarily for aircraft application is described. Adjustability of rotor blades at the hub and pressurized gas expulsion combined with an air propeller increase power. Both characteristics are combined in one simple device, and, furthermore, incorporate overall aircraft control so that mechanisms which govern lateral and horizontal movement become superfluous. Author

**N86-21514\*#** National Aeronautics and Space Administration, Langley Research Center, Hampton, Va.

### **INTEGRATION EFFECTS OF UNDERWING FORWARD- AND REARWARD-MOUNTED SEPARATE-FLOW, FLOW-THROUGH NACELLES ON A HIGH-WING TRANSPORT**

M. LAMB and W. K. ABEYOUNIS Apr. 1986 31 p refs (NASA-TM-87627; L-16026; NAS 1.15:87627) Avail: NTIS HC A03/MF A01 CSCL 01A

An experimental investigation was conducted in the Langley 16-Foot Transonic Tunnel at free-stream Mach numbers from 0.70 to 0.82 and angles of attack from -2.5 to 4.0 degrees to determine the integration effects of pylon-mounted underwing forward and rearward separate-flow, flow-through nacelles on a high-wing transonic transport configuration. The results showed that the installed drag of the nacelle/pylon in the rearward location was slightly less than that of the nacelle/pylon in the forward location. This reduction was due to the reduction in calculated skin friction of the nacelle/pylon configuration. In all cases the combined value of form, wave, and interference drag was excessively high. However, the configuration with the nacelle/pylon in a rearward location produced an increase in lift over that of the basic wing-body configuration. Author

**N86-21516\*#** National Aeronautics and Space Administration, Washington, D.C.

### **THREE-DIMENSIONAL BOUNDARY LAYER ANALYSIS PROGRAM BLAY AND ITS APPLICATION**

K. I. MATSUNO and T. ISHIGURO Jan. 1986 24 p refs Transl. into ENGLISH from proceedings of the NAL Symposium on Aircraft Computational Aerodynamics, 1983 p 207-218 Symposium held in Tokyo, Japan, 30 Jun. - 1 Jul. 1983 Original language document was announced as N85-26632 Transl. by Scientific Translation Service, Santa Barbara, Calif.

(Contract NASW-4004)

(NASA-TM-77962; NAS 1.15:77962) Avail: NTIS HC A02/MF A01 CSCL 01A

The boundary layer calculation program (BLAY) is a program code which accurately analyzes the three-dimensional boundary layer of a wing with an undefined plane. In comparison with other preexisting programs, the BLAY is characterized by the following: (1) the time required for computation is shorter than any other; (2) the program is adaptable to a parallel processing computer; and (3) the program is associated with a secondary accuracy in the z-direction. As a boundary layer modification to transonic nonviscous flow analysis programs, it is used to adjust viscous and nonviscous interference problems repeatedly. Its efficiency is an important factor in cost reduction in aircraft designing.

Transl. by B.G.

**N86-21518\*#** National Aeronautics and Space Administration, Langley Research Center, Hampton, Va.

### **A NEW METHOD FOR LAMINAR BOUNDARY LAYER TRANSITION VISUALIZATION IN FLIGHT: COLOR CHANGES IN LIQUID CRYSTAL COATINGS**

B. J. HOLMES, P. D. GALL, C. C. CROOM, G. S. MANUEL, and W. C. KELLIHER Jan. 1986 9 p refs Original contains color illustrations

(NASA-TM-87666; NAS 1.15:87666) Avail: NTIS HC A02/MF A01 CSCL 01A

The visualization of laminar to turbulent boundary layer transition plays an important role in flight and wind-tunnel aerodynamic testing of aircraft wing and body surfaces. Visualization can help provide a more complete understanding of both transition location as well as transition modes; without visualization, the transition process can be very difficult to understand. In the past, the most valuable transition visualization methods for flight applications included sublimating chemicals and oil flows. Each method has advantages and limitations. In particular, sublimating chemicals are impractical to use in subsonic applications much above 20,000 feet because of the greatly reduced rates of sublimation at lower temperatures (less than -4 degrees Fahrenheit). Both oil flow and sublimating chemicals have the disadvantage of providing only one good data point per flight. Thus, for many important flight conditions, transition visualization has not been readily available. This paper discusses a new method for visualizing transition in flight by the use of liquid crystals. The new method overcomes the limitations of past techniques, and provides transition visualization capability throughout almost the entire altitude and speed ranges of virtually all subsonic aircraft flight envelopes. The method also has wide applicability for supersonic transition visualization in flight and for general use in wind tunnel research over wide subsonic and supersonic speed ranges. Author

**N86-21521#** Boston Univ., Mass. Center for Computational and Applied Dynamics.

### **TWO METHODS FOR VISCOUS AND INVISCID FREE-WAKE ANALYSIS OF HELICOPTER ROTORS Final Report, 15 Feb. 1983 - 14 Apr. 1985**

L. MORINO and B. BHARADVAJ Aug. 1985 147 p

(Contract DAAG29-83-K-0050)

(AD-A161513; CCAD-TR-85-2; ARO-19797.3-EG) Avail: NTIS HC A07/MF A01 CSCL 20D

Two integral equation methods for the free wake analysis of helicopter rotors (for potential and rotational flows, respectively) have been presented. The rotational flow formulation is based upon Helmholtz scalar/vector-potential decomposition. The



advantages of the rotational flow formulation over the potential flow formulation have been discussed. The numerical equivalence of the two methods have been demonstrated. It should be noted that (whereas in the potential flow problem viscosity may be introduced only as artificial viscosity) in the rotational-flow formulation the presence of viscosity is consistent with the formulation. Therefore, this formulation is applicable to the solution of time-averaged Navier-Stokes equations: in particular, a simplified thin-wake analysis with an elementary eddy-viscosity model for turbulence is used in the numerical applications. Analysis of the computer times indicates that the new formulation presented here (for rotational flows) has much broader applicability than the formulation for potential flows, while requiring approximately the same amount of computer time. GRA

**N86-22258#** Joint Publications Research Service, Arlington, Va. **NUMERICAL ANALYSIS OF NONEQUILIBRIUM FLOW ABOUT AIRFOIL IN THIN SHOCK LAYER APPROXIMATION Abstract Only**

V. N. GOLUBKIN and V. V. NEGODA *In its* USSR Report: Physics and Mathematics (JPRS-UPM-86-003) p 5 5 Feb. 1986 Transl. into ENGLISH from Zhurnal Vychislitel'noy Matematiki i Matematicheskoy Fiziki (Moscow, USSR), v. 25, no. 4, Apr. 1985 p 599-608 Original language document was announced in IAA as A85-33593

Avail: NTIS HC A04

An efficient method is presented for solving nonlinear equations for a thin nonequilibrium shock layer on a low-aspect-ratio wing in hypersonic gas flow. The effect of the nonequilibrium of three-dimensional flow on the shape of the shock wave attached to the leading edge, pressure distribution, and the force and moment characteristics of the wing is discussed. Results of numerical calculations are presented. V.L.

## 03

## AIR TRANSPORTATION AND SAFETY

Includes passenger and cargo air transport operations; and aircraft accidents.

**A86-26640#**  
**VERIFICATION AND APPLICATION OF THE ICING SCALING EQUATIONS**

G. A. RUFF (Sverdrup Technology, Inc., Middleburg Heights, OH) AIAA, Aerospace Sciences Meeting, 24th, Reno, NV, Jan. 6-9, 1986. 25 p. refs (AIAA PAPER 86-0481)

An experimental icing scaling research program was conducted at the Arnold Engineering Development Center which has verified a set of icing scaling equations for a limited range of icing conditions. By applying these equations, test conditions can be calculated so that ice accretion profiles are scaled to within the repeatability of the ice accretion measurement technique. The application of these scaling equations is discussed and a practical example of their solution is presented. Limitations of the method are also discussed. Author

**A86-28000**  
**ULTRALIGHT AIRCRAFT - A NEED FOR BETTER REGULATION THAN 14 C.F.R. SECTION 103**

R. H. JACK (Jack and Jack, Athens, GA) Journal of Air Law and Commerce (ISSN 0021-8642), vol. 51, Winter 1986, p. 415-460. refs

The need to eliminate the hazards to other aircraft from uncertified operators of ultralight vehicles is examined. The development of ultralight vehicles and civil aviation safety regulations is reviewed. The use of congressional legislation and executive agencies' regulations to control the hazards of ultralights is described. Judicial remedies which include the use of mandamus

or tort action to solve the inadequacies of ultralight vehicle regulations are studied. The implementation of a licensing system for ultralight vehicle operators similar to the ones of Canada and Great Britain is proposed. I.F.

**A86-28564\*#** Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**MEASUREMENTS OF THE RESPONSE OF TRANSPORT AIRCRAFT CEILING PANELS TO FUEL FIRES**

C. P. BANKSTON and L. H. BACK (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, CA) Journal of Aircraft (ISSN 0021-8669), vol. 23, March 1986, p. 207-212. NASA-supported research. Previously cited in issue 07, p. 851, Accession no. A85-19720. refs

**A86-28571#**  
**THRUST-VECTORED TAKEOFF, LANDING, AND GROUND HANDLING OF AN AIRSHIP**

B. L. NAGABHUSHAN and N. P. TOMLINSON (Goodyear Aerospace Corp., Akron, OH) (Lighter-Than-Air Systems Conference, 6th, Norfolk, VA, June 26-28, 1985, Technical Papers, p. 100-107) Journal of Aircraft (ISSN 0021-8669), vol. 23, March 1986, p. 250-256. Research supported by the Goodyear Independent Research and Development Program. Previously cited in issue 18, p. 2613, Accession no. A85-38792. refs

**N86-20377#** National Transportation Safety Board, Washington, D. C.

**SAFETY STUDY: ULTRAVIOLET VEHICLE ACCIDENTS Safety Study Report, Mar. 1983 - Sep. 1984**

2 Jul. 1985 406 p refs

(PB85-917001; NTSB/SS-85/01) Avail: NTIS HC A18/MF A01

Since 1982, the Federal Aviation Administration (FAA) has regulated the operation of ultralight vehicles under 14 CFR Part 103. Increasing numbers of reports of ultralights being operated in regulated airspace and for nonrecreational purposes made it apparent to the Safety Board that an evaluation of the effectiveness of the FAA's regulatory approach to ultralights was needed. In the absence of a systematic accident data collection process on which to base the analysis, the Safety Board in March 1983 decided to investigate all fatal accidents involving a powered ultralight and other selected powered ultralight accidents involving obvious safety issues. Between March 1983 and September 1984, the Safety Board investigated 177 ultralight accidents, of which 88 involved a total of 93 fatalities. The Safety Board has prepared a report which describes the safety problems identified through analyses of these accidents, explores safety concerns raised by organizations and associations interested in ultralights, and recommends improvements in existing ultralight safety measures, where appropriate. Author

**N86-20378#** RMS Technologies, Inc., Trevese, Pa.  
**GALLEY AND OVERHEAD COMPARTMENT EXPERIMENT RESULTS: FULL-SCALE TRANSPORT CONTROLLED IMPACT DEMONSTRATION Final Report, Jun. 1981 - Dec. 1985**

R. M. LLOYD and D. JOHNSON Dec. 1985 57 p refs

(Contract DTFA03-81-C-00040)

(DOT/FAA/CT-85/33) Avail: NTIS HC A04/MF A01

An air-to-ground impact test demonstration was conducted with a remotely piloted transport category airplane. The Full-Scale Transport Controlled Impact Demonstration Program (CID) is discussed. The program includes activities involved in the development and subsequent demonstration of an antimisting fuel experiment and experiments relating to improvements in cabin fire safety and structural impact protection. The results of structural experiments associated with two onboard galleys and overhead stowage compartments are reported. During the impact demonstration, both compartments remained in place without spillage of their internal contents, while the post crash fire resulted in minor galley damage and total destruction to the overhead compartments. E.A.K.

### 03 AIR TRANSPORTATION AND SAFETY

**N86-20379\*#** Wichita State Univ., Kans.

**PARTICLE TRAJECTORY COMPUTATION ON A 3-DIMENSIONAL ENGINE INLET Final Report Ph.D. Thesis**

J. J. KIM Jan. 1986 115 p refs

(Contract NAG3-566)

(NASA-CR-175023; NAS 1.26:175023; DOT-FAA-CT-86-1) Avail: NTIS HC A06/MF A01 CSCL 01C

A 3-dimensional particle trajectory computer code was developed to compute the distribution of water droplet impingement efficiency on a 3-dimensional engine inlet. The computed results provide the essential droplet impingement data required for the engine inlet anti-icing system design and analysis. The droplet trajectories are obtained by solving the trajectory equation using the fourth order Runge-Kutta and Adams predictor-corrector schemes. A compressible 3-D full potential flow code is employed to obtain a cylindrical grid definition of the flowfield on and about the engine inlet. The inlet surface is defined mathematically through a system of bi-cubic parametric patches in order to compute the droplet impingement points accurately. Analysis results of the 3-D trajectory code obtained for an axisymmetric droplet impingement problem are in good agreement with NACA experimental data. Experimental data are not yet available for the engine inlet impingement problem analyzed. Applicability of the method to solid particle impingement problems, such as engine sand ingestion, is also demonstrated. Author

**N86-20380\*#** Toledo Univ., Ohio. Coll. of Engineering.

**A NUMERICAL AND EXPERIMENTAL INVESTIGATION OF ELECTROCHEMICAL AIRCRAFT DEICING M.S. Thesis Final Report**

K. L. LEFFEL Jan. 1986 268 p refs

(Contract NAG3-72)

(NASA-CR-175024; NAS 1.26:175024) Avail: NTIS HC A12/MF A01 CSCL 01C

This study was composed of three parts. The first part involved the extension of an existing transient two dimensional numerical code for an electrothermal deicer so that it would simulate the situation where a variable thickness ice layer existed at the outer surface. The Enthalpy Method was used to simulate the phase change, and Gauss-Seidel iteration was used to solve the resulting system of finite difference equations. A set of criteria were developed for determining when a variable thickness ice layer had an effect on deicer performance. The second part was the acquisition and analysis of experimental data. The test model was a section of a Bell UH-1H helicopter blade equipped with an electrothermal deicer. A total of fifty-two thermocouples were utilized to document the thermal response of the blade and deicer assembly. In the deicing runs, the experimental temperature response data clearly showed when melting, shedding or refreezing occurred. The tests illustrated that the criterion for shedding in the three cases where it did occur was that the abrasion shield interface temperature was 32 to 34 F. The third part concerned the validation of a one dimensional transient thermal model of an electrothermal deicer by comparison of the predictions with the experimental data. The Enthalpy Method was found to effectively model the phase change which occurred, and the ice shedding algorithm employed in the simulation was also evaluated. Author

**N86-21525#** National Transportation Safety Board, Washington, D. C. Bureau of Accident Investigation.

**AIRCRAFT ACCIDENT REPORT: AIR CANADA FLIGHT 797, McDONNELL DOUGLAS DC-9-32, C-FTLU GREATER CINCINNATI INTERNATIONAL AIRPORT, COVINGTON, KENTUCKY, JUNE 2, 1983 Accident Report, 2 Jun. 1983**

31 Jan. 1986 118 p refs

(PB86-910402; NTSB/AAR-86-02) Avail: NTIS HC A06/MF A01 CSCL 01C

A fire aboard a McDonnell Douglas DC-9-32, at the Greater Cincinnati International Airport, Covington, Kentucky, and the death of 23 passengers is reported. A fire in the aft lavatory was discovered while in flight and an emergency descent was made. Airport support, escape measures, and fire fighting are described. It was determined that the probable causes of the accident were:

(1) a fire of undetermined origin; (2) an underestimate of fire severity; and (3) misleading fire progress information provided to the captain. It is concluded that the time taken to evaluate the nature of the fire and to decide to initiate an emergency descent contributed to the severity of the accident. E.A.K.

**N86-21526#** National Transportation Safety Board, Washington, D. C. Bureau of Accident Investigation.

**AIRCRAFT ACCIDENT REPORT: GALAXY AIRLINES, INC., LOCKHEED ELECTRA-L-188C, N5532, RENO, NEVADA, JANUARY 21, 1985**

4 Feb. 1986 89 p

(PB86-910401; NTSB/AAR-86-01) Avail: NTIS HC A05/MF A01 CSCL 01C

About 0102:30 Pacific standard time on January 21, 1985, Galaxy Airlines Flight 203, a Lockheed Electra charter flight en route to Minneapolis, Minnesota, departed runway 16R of the Reno-Cannon International Airport. Approximately one minute later, the crew requested a turn to a left downwind to return to the airport because of a vibration in the airplane. In accordance with the request, the tower controller cleared the flight to make a left turn to a downwind traffic pattern. The airplane crashed at 0104 into an area 1 1/2 miles from the departure end of runway 16R, and 3/4 mile to the right of the extended runway centerline. The impact and subsequent fire killed the crew of six and 64 of the 65 passengers onboard. The airplane was destroyed. The sky was clear and the visibility was 12 miles at the time of the accident. The National Transportation Safety Board determines that the probable cause of this accident was the captain's failure to control and the copilot's failure to monitor the flight path and airspeed of the aircraft. This breakdown in crew coordination followed the onset of unexpected vibration shortly after takeoff. Contributing to the accident was the failure of ground handlers to properly close an air start access door, which led to the vibration. Author

**N86-21527#** Flight Safety Foundation, Inc., Arlington, Va. **PROCEEDINGS OF CABIN SAFETY CONFERENCE AND WORKSHOP HELD ON 11-14 DECEMBER 1984 Final Report**

Aug. 1985 221 p Conference and Workshop held 11-14 Dec. 1984

(AD-A160950; DOT/FAA/ASF-100-85/01; DOT-TSC-FAA-85-6)

Avail: NTIS HC A10/MF A01 CSCL 01B

These proceedings contain formal conference presentations as well as summaries of informal workshop discussions on how to further improve aircraft cabin occupant safety. The overall objective of the conference is increased communication between various segments of the aviation community in the area of aircraft safety. Also included are the FSF's analysis and future recommendations for occupant safety. Topics covered include: overview of aircraft occupant safety problems; cabin safety initiatives; inflight occupant protection; crash and fire protection; evacuation and survival; economics and regulatory considerations. GRA

**N86-21528#** Air Force Aero Propulsion Lab., Wright-Patterson AFB, Ohio.

**AIRCRAFT MISHAP FIRE PATTERN INVESTIGATIONS Final Report, 1 Jun. 1984 - 31 Jul. 1985**

J. M. KUCHTA (Green International, Inc., Sewickley, Pa.) and R. G. CLODFELTER Aug. 1985 190 p

(Contract F33615-83-C-2359)

(AD-A161094; AFWAL-TR-85-2057) Avail: NTIS HC A09/MF A01 CSCL 01B

This manual was prepared to provide the aircraft mishap investigator with state-of-the-art data and guidelines for investigating aircraft fires and explosions. Sections are included on investigating procedures, properties of air atmospheres, properties of aircraft combustibles (liquids, gases, or solids), properties of ordnance explosives, and damage analyses relating to fires and explosions. Procedures for accumulating, developing, and analyzing the evidence are outlined, and various combustion data are summarized for use in determining the ignition source, combustible source, and mishap scenario. To help establish the mishap scenario, damage criteria are given in terms of material or

biological response to fire temperatures, explosion pressures, toxic gases, and other potentially hazardous exposures. Methods for calculating combustion quantities and damage potentials, including material failures, are included in this manual. Author (GRA)

04

## AIRCRAFT COMMUNICATIONS AND NAVIGATION

Includes digital and voice communication with aircraft; air navigation systems (satellite and ground based); and air traffic control.

**N86-21529#** Federal Aviation Administration, Atlantic City, N.J.  
**AIRCRAFT INTERIOR PANEL TEST CRITERIA DERIVED FROM FULL-SCALE FIRE TESTS Final Report**  
 R. G. HILL, T. I. EKLUND, and C. P. SARKOS Sep. 1985 65 p  
 Original contains color illustrations  
 (AD-A161637; FAA/CT-85/23) Avail: NTIS HC A04/MF A01  
 CSCL 01B

Full-scale cabin fire tests were conducted to determine potential increases in passenger survivability associated with different interior honeycomb panel constructions. The test fuselage was a C-133 with a simulated wide-body door opening exposed to an 8-foot by 10-foot fuel fire. In the first series, the interior near the door was lined with the honeycomb panels to determine whether earlier studies performed with small-scale enclosures were consistent with the full-scale counterpart. These earlier studies resulted in the selection of the Ohio State University (OSU) Rate of Heat Release Apparatus as the most appropriate type test to evaluate aircraft panels. The first series was followed by tests that included fire-blocked seats and carpeting as well as the panels to determine the type survivability increases that could be attained from low heat release materials. The scenario employed generally resulted with flashover within 2 minutes for panels considered typical in performance. A low heat release phenolic/fiberglass panel demonstrated a flashover delay until about 4 minutes into the test. An incombustible panel prevented flashover altogether. The performance of the various panels was evaluated to develop recommended flammability criteria for a modified OSU Rate of Heat Release Apparatus. GRA

**N86-21530#** Transportation Systems Center, Cambridge, Mass.  
**GENERAL AVIATION PILOT AND AIRCRAFT ACTIVITY SURVEY Final Report, 1984**  
 C. FRANK and J. OHMAN Sep. 1985 83 p Prepared in cooperation with Automated Sciences Group, Inc., Silver Spring, Md.  
 (Contract DTRS-57-84-C-00100)  
 (AD-A161665; TSC-FAA-85-7; FAA-MS-85-1) Avail: NTIS HC A05/MF A01 CSCL 14B

A summary and analysis of the data collected in the 1984 General Aviation Pilot and Aircraft Activity Survey is provided. The survey was conducted at a random sample of general aviation airports across the nation throughout the months of July, August, September, and October, 1984 by the Federal Aviation Administration with the assistance of the Civil Air Patrol. The survey data provide information regarding the magnitude and characteristics of general aviation including: type and source of weather information services, trip length in time and distance, and pilot age and certification. Estimates are made of total 1984 general aviation operations, fuel consumption and aircraft miles flown. GRA

### A86-26438\*# HELICOPTER FLIGHT TEST DEMONSTRATION OF DIFFERENTIAL GPS

R. P. DENARO and J. BESER (TAU Corp., Los Gatos, CA) IN: Institute of Navigation, National Technical Meeting, San Diego, CA, January 15-17, 1985, Proceedings. Washington, DC, Institute of Navigation, 1985, p. 116-121. NASA-sponsored research. refs

An off-line post-mission processing facility is being established by NASA Ames Research Center to analyze differential GPS flight tests. The current and future differential systems are described, comprising an airborne segment in an SH-3 helicopter, a GPS ground reference station, and a tracking system. The post-mission processing system provides for extensive measurement analysis and differential computation. Both differential range residual corrections and navigation corrections are possible. Some preliminary flight tests were conducted in a landing approach scenario and statically. Initial findings indicate the possible need for filter matching between airborne and ground systems (if used in a navigation correction technique), the advisability of correction smoothing before airborne incorporation, and the insensitivity of accuracy to either of the differential techniques or to update rates. Author

### A86-26440# A SURVEY OF COMMERCIALLY AVAILABLE POSITIONING SYSTEMS

S. R. SAMPSON (Cubic Corp., San Diego, CA) IN: Institute of Navigation, National Technical Meeting, San Diego, CA, January 15-17, 1985, Proceedings. Washington, DC, Institute of Navigation, 1985, p. 162-166.

The requirement to accurately position and track a moving aircraft, vehicle or vessel requires the user to select from an often bewildering array of commercial positioning systems. Each offers a different combination of range, accuracy, dynamics, operational modes and inherent limitations. This paper presents a tabular summary of the available commercial systems and their key specifications. Supporting text uses the transmitted frequency band to divide the systems into generic categories with generally common performance. Within each group, the characteristic capabilities and limitations are discussed. Topics include GDOP, calibration, multipath, skywave, propagation velocities, frequency allocation and measurement ambiguities. The reader will find the paper provides the basic navigation aids required to chart a safe course through the maze of systems available. Author

### A86-26442# OMEGA - COMMERCIAL EXPERIENCES WITH A MATURE SYSTEM

G. GIBBS (Canadian Marconi Co., Montreal, Canada) and H. BANSBACH (Litton Aero Products, Moorpark, CA) IN: Institute of Navigation, National Technical Meeting, San Diego, CA, January 15-17, 1985, Proceedings. Washington, DC, Institute of Navigation, 1985, p. 183-190. refs

The operation of Omega equipment within the commercial airborne community is reviewed. The development of the automated, economical navigation system which employs hyperbolic or rho-rho-rho principles is examined. The applications of Omega systems to land, sea, and air navigation by military and commercial operators are described and a list of commercial users of the system is provided. The problems encountered with the installation of the Omega receiver antenna on the aircraft, distinguishing short and long path signals, and the Omega coverage and signal geometry, and the facilities used to maintain the equipment are analyzed. I.F.

**A86-26443#**

### **DECENTRALIZATION FILTERING AND REDUNDANCY MANAGEMENT/FAILURE DETECTION FOR MULTISENSOR INTEGRATED NAVIGATION SYSTEMS**

T. KERR (Intermetrics, Inc., Cambridge, MA) IN: Institute of Navigation, National Technical Meeting, San Diego, CA, January 15-17, 1985, Proceedings . Washington, DC, Institute of Navigation, 1985, p. 191-208. refs

Current failure detection isolation and reconfiguration procedures applicable to navigation systems are reviewed. The design of a failure detection/redundancy management technique which incorporates voter monitoring methodology, decentralized Kalman filter mechanization, and a semiautonomous multisensor navigation system is described. The technique involves the use of Gaussian confidence regions to account for the inherent difference in accuracy between the various sensor subsystems and on-line estimates of covariances from the Kalman filter are utilized for this assessment. The technique evaluates the probability of detecting failed component subsystems and the probability of false alarms to be incurred. The development of a Kalman filter on a chip is analyzed. I.F.

**A86-26444#**

### **MICROWAVE LANDING SYSTEM (MLS)**

J. J. STRONG (Hazeltine Corp., Commack, NY) IN: Institute of Navigation, National Technical Meeting, San Diego, CA, January 15-17, 1985, Proceedings . Washington, DC, Institute of Navigation, 1985, p. 209-218.

The Microwave Landing System (MLS) which uses microwave frequencies in the 5000 MHz range and 200 operating channels to provide azimuth and elevation guidance, and continuous range information to aircraft is examined. A scanning beam concept in which the time differences between two scans of the azimuth and elevation antennas are measured to obtain angular guidance data is employed in the MLS. The azimuth, elevation and back azimuth stations, and data links of the MLS are described. The precision distance measuring equipment transponder produces range data and operates in initial and final approach modes. The implementation of the MLS worldwide for military and civilian applications, and the FAA's national implementation program for the MLS are discussed. I.H.

**A86-26501**

### **INSTITUTE OF NAVIGATION, ANNUAL MEETING, 41ST, U.S. NAVAL ACADEMY, ANNAPOLIS, MD, JUNE 25-27, 1985, PROCEEDINGS**

Meeting supported by the Bell Aerospace Textron, Charles Stark Draper Laboratory, Inc., Dynamics Research Corp., et al. Washington, DC, Institute of Navigation, 1985, 124 p. For individual items see A86-26502 to A86-26512.

Among the topics discussed are: tensor products in signal processing for satellite navigation applications; satellite selection criteria for altimeter aiding of GPS; and application of GPS to weapons systems. Consideration is also given to commercial aviation GPS navigation set test flight data; civil helicopter flight; operations using differential GPS; onboard rendezvous navigation for the Space Shuttle; and Chinese commercial navigation systems. Additional topics include: Space Station navigation design issues; the contribution of handheld computers to space navigation in the future; and automatic sextant development for space applications. I.H.

**A86-26507#**

### **COMMERCIAL AVIATION GPS NAVIGATION SET FLIGHT TEST RESULTS**

A. K. BROWN and M. A. STURZA (Litton Aero Products, Moorpark, CA) IN: Institute of Navigation, Annual Meeting, 41st, Annapolis, MD, June 25-27, 1985, Proceedings . Washington, DC, Institute of Navigation, 1985, p. 41-48.

This paper presents lab test and flight test results obtained with the LTN-700 GPS Navigation Set. The LTN-700 is the first GPS Navigation Set specifically designed for commercial aviation applications. Its architecture was previously described at the ION

National Technical Meeting, January, 1984. The difficulties encountered in instrumenting the flight tests of a system as precise as GPS are discussed. Static lab test results are shown to demonstrate absolute navigation accuracy. Flight testing of the LTN-700 has been conducted on Litton Systems' Merlin IV aircraft. Data is presented showing the receiver tracking performance in a commercial aviation environment. Comparative data showing the performance of the LTN-700 and a high quality Inertial Navigation System (INS) is provided. Other LTN-700 tests are also briefly described. Author

**A86-26509\*#**

National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

### **CIVIL HELICOPTER FLIGHT OPERATIONS USING DIFFERENTIAL GPS**

F. G. EDWARDS (NASA, Ames Research Center, Moffett Field, CA) and P. V. W. LOOMIS (TAU Corp., Los Gatos, CA) IN: Institute of Navigation, Annual Meeting, 41st, Annapolis, MD, June 25-27, 1985, Proceedings . Washington, DC, Institute of Navigation, 1985, p. 54-63. refs

The results of NASA flight trials of a dual-receiver differential global positioning system (DGPS) for civilian helicopter navigation applications, are presented. The three principal components of the DGPS system are described, including the GPS ground-reference system, a range tracking system, and an on-board sequential GPS receiver. The ground-based receiver in the DGPS operates at a known fixed location and receives C/A code signals from NAVSTAR satellites. System bias errors in the ground receiver are subtracted from the airborne solution for the navigational fix. Calculations of the differential bias error are carried out using an on-board PDP-11/34 M research computer. The ground-reference differential corrections for satellites are given in a table. It is shown that the differential correction signal of the DGPS contains only a small (0.1 rad/sec) high-frequency component which can be attributed to system error. A schematic diagram of the DGPS postflight data processing routine is provided. I.H.

**A86-27128#**

### **AIRCRAFT COUPLING MODEL EVALUATIONS AT SHF/EHF**

G. GENELLO and A. PESTA (USAF, Rome Air Development Center, Griffiss AFB, NY) IN: International Symposium on Electromagnetic Compatibility, Wakefield, MA, August 20-22, 1985, Record . New York, Institute of Electrical and Electronics Engineers, 1985, p. 72-74. refs

Severe overcrowding of the RF spectrum, especially at UHF, has been one primary motivator to extend military communications into the SHF and finally the EHF band. The potential interference of placing new SHF/EHF terminals on-board existing and new aircraft platforms is unknown and must be assessed. Several EMC-related computer analysis programs are available to predict the coupling between aircraft antennas. However, the models contained in these codes may not be adequate for prediction analysis at these higher frequencies. Coupling measurements have been performed on a KC-135 style aircraft and a F-16 tactical fighter to evaluate the validity of the computer models. A comparison analysis of predicted and actual coupling data is presented. Author

**A86-27784**

### **THE MCDONNELL AIRCRAFT TELEMETRY TRACKING SYSTEM AT EDWARDS AIR FORCE BASE, CA**

J. L. HANEY and C. O. HILGARTH (McDonnell Aircraft Co., St. Louis, MO) IN: ITC/USA/'85; Proceedings of the International Telemetering Conference, Las Vegas, NV, October 28-31, 1985 . Research Triangle Park, NC, Instrument Society of America, 1985, p. 101-106.

McDonnell Aircraft Company recently completed installation of a telemetry tracking system at their Edwards Air Force Base, CA flight test facility. A discussion of the planning, specifications, acquisition, installation, operation, as well as observations and comments about the system is presented from a user's perspective. Author

A86-27789

**REAL-TIME TELEMETRY OF COMPLETE 1553 DATA BUSES**

P. M. BREEDLOVE and C. R. STEPHENS (Loral Corp., Loral Instrumentation, San Diego, CA) IN: ITC/USA/'85; Proceedings of the International Telemetry Conference, Las Vegas, NV, October 28-31, 1985. Research Triangle Park, NC, Instrument Society of America, 1985, p. 167-174.

As MIL-STD-1553 Multiplex Data Bus usage proliferates, the ability to remotely monitor bus traffic has become important. Common applications include flight testing of missiles and aircraft, and the field maintenance of vehicles. Due to the high data rate and asynchronous characteristics of the 1553 Data Bus special problems exist in the acquisition and analysis of 1553 bus traffic. The acquisition of the complete bus traffic is especially important during system testing and diagnostic operations. Several approaches are being utilized today to transmit 1553 bus traffic. The first approach is an extension of the PCM technique in which all of the bus traffic, during a specific time window, is buffered and then output in a PCM style format. This has the advantage of being synchronous, but a significant amount of bus information is lost, primarily the protocol and bus timing. An alternative approach is to transmit raw unbuffered bus traffic. Bus timing and protocol are retained, but the telemetry signal is asynchronous. A third approach, developed by Loral Data Systems in conjunction with Loral Instrumentation, is a 1553 Data Acquisition System that retains bus timing and protocol and synchronizes the signal to a common clock.

Author

A86-27804

**TSPI DATA PROCESSING IN THE TELEMETRY ENVIRONMENT**

G. REED (Computer Sciences Corp., Lompoc, CA) IN: ITC/USA/'85; Proceedings of the International Telemetry Conference, Las Vegas, NV, October 28-31, 1985. Research Triangle Park, NC, Instrument Society of America, 1985, p. 333-343.

Most test ranges are required to process both telemetry and Time Space Position Information (TSPI) data in real time. Using the Integrated Flight Data Processing System (IFDAPS) at Edwards AFB as an example, some of the basic differences between telemetry and TSPI data processing are identified and methods of integrating the two types of processing are discussed. Included for consideration in the integrated processing are data acquisition, measurement displays, recording, derived measurement computations using both types of data, and post flight merging of telemetry and TSPI data. Data processing is discussed in a concurrent, multiple operation environment using separate, integrated processors.

Author

A86-27813

**REMOTE AIRCRAFT MAINTENANCE MONITORING USING TELEMETRY**

D. DOWLING and R. A. LANCASTER (ARINC Research Corp., Annapolis, MD) IN: ITC/USA/'85; Proceedings of the International Telemetry Conference, Las Vegas, NV, October 28-31, 1985. Research Triangle Park, NC, Instrument Society of America, 1985, p. 449-456.

The purpose of this paper is to present a concept utilizing digital telemetry links to upgrade the military aircraft maintenance approach in the future. The evolution of digital avionics in both military and commercial aircraft is creating changes that affect today's approach to maintenance. Commercial aviation has made significant progress in the direction of maintenance monitoring using a digital telemetry link. This paper presents the status of maintenance-monitoring efforts within the commercial airlines and, recognizing the differences that exist between the military and commercial application, proposes an aircraft maintenance concept for the military in the 1990s.

Author

A86-27819

**FREQUENCY SYNTHESIS TYPE AIRBORNE TRANSMITTERS**

W. MARTINI (Intertechnique, S.A., Departement Telemesures et Systemes, Les Ulis, France) IN: ITC/USA/'85; Proceedings of the International Telemetry Conference, Las Vegas, NV, October 28-31, 1985. Research Triangle Park, NC, Instrument Society of America, 1985, p. 575-585.

Two basic schemes for a frequency modulation type airborne telemetry transmitter, are examined: a transmitter with transposition through mixing and filtering and a transmitter with phased-in servoing of the carrier to a reference after frequency division. The schemes are studied in terms of the ability to accept high base bands and the possibility of frequency synthesis that they offer. The reasons for the choice of one of these schemes and the resulting market reception in France are explained. Technical difficulties arising from the concept of a frequency synthesis transmitter are discussed.

C.D.

A86-27829#

**A PROCEDURE FOR THE EVALUATION AND ANALYSIS OF THE OPERATIONAL PRACTICABILITY AND EFFECTIVENESS OF AUTOMATED TRAFFIC FLOW CONTROL PROCEDURES FOR THE NEAR TERMINAL AREA [EIN VERFAHREN ZUR BEWERTUNG UND ANALYSE DER OPERATIONELLEN PRAKTIKABILITAET AUTOMATISIERTER VERKEHRSFLUSSSTEUERUNGSVERFAHREN FUER DEN FLUGHAFENNAHBEREICH]**

A. HOERMANN Berlin, Technische Universitaet, Fachbereich Verkehrswesen, Dr.-Ing. Dissertation, 1985, 215 p. In German. refs

The continuously increasing air traffic volume makes it necessary to enhance the capacity of the airports. The main aim of the present study is related to the development of criteria for an objective evaluation of competing automated flight management and air traffic control concepts in the Terminal Maneuvering Area (TMA), taking into account also an assessment of the effects of technological and/or operational modifications of system components. Details regarding the air traffic flow control in the TMA are discussed, giving attention to manual control in the near terminal area, the principles and algorithms of the control techniques, and the employment of automated control procedures. The Variable Path Speed Control (VPSC) procedure and the Fixed Path Speed Control (FPSC) procedure are examined. A simulation model is considered along with the program system TASIMD (Terminal area simulation program considering the aircraft dynamics), the derivation of a quality functional for a relative evaluation of the considered automated procedures and the results of an air traffic simulation.

G.R.

A86-27849

**THE USE OF MICROCOMPUTERS IN INERTIAL NAVIGATION SYSTEMS WITH STRAPDOWN SENSORS AND FOR MEASUREMENT SYSTEMS OF AVERAGE ACCURACY [EIN BEITRAG ZUM EINSATZ VON MIKRORECHNERN IN TRAEHETSNAVIGATIONSSYSTEMEN MIT FAHRZEUGFESTEN SENSOREN UND ZUR STUETZUNG VON MESS-SYSTEMEN MITTLERER GENAUIGKEIT]**

C. DEHN Braunschweig, Technische Universitaet, Fakultae fuer Maschinenbau und Elektrotechnik, Dr.-Ing. Dissertation, 1983, 156 p. In German. refs

A navigational computer composed of three microcomputers has been developed, and its practical application in flight tests is reported. This computer is distinguished from inertial units by its flexibility and modular program configuration. Procedures for improving accuracy in position determination are discussed.

C.D.

## 04 AIRCRAFT COMMUNICATIONS AND NAVIGATION

**A86-27852#**

**FLIGHT MECHANICS CONTRIBUTIONS TO THE TIME-BASED TRAJECTORY CONTROL IN THE AIRCRAFT LONGITUDINAL PLANE [FLUGMECHANISCHE BEITRAEGE ZUR ZEITBEZOGENEN BAHNFUEHRUNG IN DER FLUGZEUGLAENGSEBENE]**

R. LUCKNER Braunschweig, Technische Universitaet, Fakultae fuer Maschinenbau und Elektrotechnik, Dr.-Ing. Dissertation, 1984, 196 p. In German. refs

The continuously increasing volume of air traffic requires an enhancement of the capacity of air traffic systems. In this context, a transition is required from the air traffic systems of the third generation to the new systems of the fourth generation, which are distinguished by an extension of automation and subsystem integration. The present study is concerned with one vital aspect of the considered transition, taking into account the ability of future aircraft to fly along trajectories which are provided with respect to the path and the time at which a given point on this path has to be occupied by the aircraft (4-D navigation). An investigation is conducted regarding the phenomena of flight mechanics which arise in connection with the new requirements. It will be necessary to stabilize the aircraft with the aid of a position controller. Attention is given to the characteristics of time-based trajectory control, a mathematical model representing the involved problems, the compensation for errors regarding horizontal speed and position, positional control, and a simple control system. G.R.

**A86-27898**

**A NEW SYSTEM SIMULTANEOUSLY COVERING EN ROUTE NAVIGATION AND LANDING [UN NOUVEAU SYSTEME COUVRANT, A LA FOIS, LA NAVIGATION 'EN ROUTE' ET L'ATTERRISSAGE]**

M. SCHILLIGER (LMT Radio Professionnelle, Boulogne-Billancourt, France) Navigation (Paris) (ISSN 0028-1530), vol. 34, Jan. 1986, p. 15-27. In French.

The proposed system, derived from the standard TACAN, is suited for both civil and military applications. The ground beacon operates normally to perform the navigation function, but also transmits additional information needed for landing. On board, the received signals are processed together with the altitude information, and the result is displayed for the pilot on the navigation and ILS indicators. The extra data transmitted can cover several airfields in the vicinity of the ground beacon. Test results obtained with the Nord-260 aircraft and the SA-330 Puma helicopter are summarized. B.J.

**A86-27899**

**FLIGHT TESTS OF MLS ELEVATION GUIDANCE [ESSAIS EN VOL DU GUIDAGE EN SITE DU MLS]**

K. KOREMURA and T. KATANO (Ministry of Transport, Electronic Navigation Research Institute, Tokyo, Japan) Navigation (Paris) (ISSN 0028-1530), vol. 34, Jan. 1986, p. 63-72. In French.

The accuracy of the MLS elevation guidance subsystem is degraded owing to reflection and diffraction in the vicinity of the MLS antennas. This paper describes flight-test studies of these effects carried out by the Japanese Electronic Navigation Research Institute at Sendai Airport; the tests involved the use of an aircraft equipped with an MLS receiver, a telemetry system, and a TV tracking system. The results indicate that, even when the equipment is sited very unfavorably with respect to nearby buildings, a high guidance accuracy can be achieved if the approach is made along the median line; the accuracy is equal to one-third of the value defined by the SARP for the angle guidance ground subsystems of the MLS. B.J.

**A86-27900**

**ERRARE HUMANUM EST . . . SED PERSEVERARE DIABOLICUM OR NAVIGATION ERRORS OF THE 747 AND THE 'HEADING' POSITION [ERRARE HUMANUM EST . . . SED PERSEVERARE DIABOLICUM OU LES ERREURS DE NAVIGATION DU 747 ET LA POSITION 'HEADING']**

J. FOURNIER Navigation (Paris) (ISSN 0028-1530), vol. 34, Jan. 1986, p. 92-94. In French.

Navigation errors due to a selector located on the front panel of the Boeing 747 cockpit are examined with reference to Flight JL-441 (Tokyo-Paris via Moscow) which strayed off course near Sakhalin on October 30, 1985. It is suggested that a flashing alarm system can reduce these errors. B.J.

**A86-28311**

**A COMBINED OPTIMAL ALGORITHM FOR FILTERING AND CALCULATING NAVIGATION COORDINATES [OB'EDINENNYI OPTIMAL'NYI ALGORITM FIL'TRATSII I SCHISLENIIA NAVIGATSIONNYKH KOORDINAT]**

O. A. BABICH IN: Problems in aircraft reliability. Moscow, Izdatel'stvo Mashinostroenie, 1985, p. 71-82. In Russian.

The problem of filtering signals from the on-board transducers is formulated mathematically for the case of an excess number of measured parameters. A mathematical model of the errors of an inertial navigation system is examined, and coupling equations are presented. An analysis is also made of the errors of the on-board ranging system. A discrete-continuous algorithm for filtering and calculating coordinates is proposed which involves integrating eleventh-order differential equations and is almost as accurate as a full continuous algorithm. V.L.

**A86-28312**

**RELIABILITY OF AIRCRAFT NAVIGATION [NADEZHNOST' NAVIGATSII LETATEL'NYKH APPARATOV]**

A. A. KRASOVSKII IN: Problems in aircraft reliability. Moscow, Izdatel'stvo Mashinostroenie, 1985, p. 82-97. In Russian. refs

Navigation methods and the structure of navigational complexes are briefly reviewed, and an assessment is made of the reliability with which certain requirements for flight paths in real two- and three-dimensional space are satisfied and the time of arrival at specified navigation points is determined. The reliability of navigation is evaluated analyzing probabilities for a given set of events and determining the current probability density in the navigation coordinate space. V.L.

**A86-28326**

**NAECON 1985; PROCEEDINGS OF THE NATIONAL AEROSPACE AND ELECTRONICS CONFERENCE, DAYTON, OH, MAY 20-24, 1985. VOLUMES 1 & 2**

Conference sponsored by IEEE. New York, Institute of Electrical and Electronics Engineers, 1985. Vol. 1, 917 p.; vol. 2, 809 p. For individual items see A86-28327 to A86-28517.

Among the topics discussed are: signal processing; airborne computers and voice communications; and data transmission and fiber optics. Consideration is also given to: advanced computer architecture and hardware; airborne image processing; target recognition acquisition systems; and navigation systems. Additional topics discussed include: weapons guidance and interface; Kalman filtering methods; flight control design techniques; and software development and management for military aviation. I.H.

**A86-28335**

**A NOVEL VOICE ACTIVATED SWITCH (VOX) FOR HIGH NOISE ENVIRONMENTS**

R. VEMULA, E. LEE, and G. BOUKIS (Telephonics Corp., Huntington, NY) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 1. New York, Institute of Electrical and Electronics Engineers, 1985, p. 56-60.

A newly developed VOX circuit for detecting the speech characteristics of the cockpit noise background is described. The circuit consists of a 12-bit A/D converter which collects signal samples at a rate of 2500 samples per second. The A/D converter

is clocked by counters which provide an appropriate clock rate for feeding the samples into a microprocessor. Before the signal is supplied to the converter, it is lowpass filtered to about 800 Hz. Timing measurements show that only 20 percent of the processor time is used to implement the circuit. An example of a speech waveform which was detected by the VOX circuit during performance tests is given in graphic form and a schematic diagram of the VOX circuit is provided. I.H.

**A86-28337****A DISTRIBUTED, FAULT-TOLERANT IMPLEMENTATION OF THE AIRBORNE DIGITAL MAP USING VLSI COMMON PROGRAMMABLE MODULES**

J. C. WAHTERA, J. B. PEARCE (Harris Corp., Melbourne, FL), O. M. CROMER, and S. S. SINOR (Westinghouse Electric Corp., Baltimore, MD) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 1. New York, Institute of Electrical and Electronics Engineers, 1985, p. 70-77. refs

The Digital Map Generator (DMG) provides an aircraft pilot with a full-color, planar map display for nap-of-the-earth flight. It also provides a digital terrain data base for use in advanced avionics functions such as *terrain correlation and autonomous navigation*. The DMG has been configured as a group of custom dedicated hardware processors implemented in conventional digital integrated circuits. As advanced aircraft are developed, requiring expanded capability and flexibility of digital map functions, advanced DMG architectures also must be developed. These architectures would be fault-tolerant, fully-integrated subsystems of general-purpose multiprocessors. This paper presents an advanced DMG architecture that implements the map functions in VLSI common programmable modules. The map function software is distributed among the processing modules, and execution is controlled by utilizing dynamic task allocation. Commonality of hardware and dynamic reassignment of tasks allows fault-tolerant techniques to be implemented and facilitates integration of other avionics functions within the same multiprocessor system. Author

**A86-28356****NAVIGATION METHODOLOGY - AN INVESTIGATION OF AN INERTIAL NAVIGATION SYSTEM (INS) ENHANCEMENT**

S. B. RICHTER and D. M. PARRY (Aydin Corp., Horsham, PA) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 1. New York, Institute of Electrical and Electronics Engineers, 1985, p. 223-230. refs

To date, the utility of stored map data is proportional to the accuracy with which the aircraft's position is known. Inertial Navigation Systems (INS) rely heavily upon numerical integration techniques in order to locate the 'relative' position of aircraft and their associated targets. Current INS systems use the spherical modeling system. The INS subsystem at AYDIN is based upon the biaxial ellipsoidal system. Thus the accuracy with which the time and position requirements for certain mission-critical points are satisfied is dependent on the modeling system chosen. Author

**A86-28357****DESIGN TECHNIQUES FOR IMPROVED MAP-AIDED NAVIGATION**

C. A. BAIRD (Harris Corp., Melbourne, FL) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 1. New York, Institute of Electrical and Electronics Engineers, 1985, p. 231-238. refs

This paper presents techniques to effectively combine elevation and derived slope data from digital terrain elevation maps to improve the navigation accuracy of map-aided navigation systems. Elevation correlation processing is used to provide position fixes, signal-to-noise ratio estimates, and acquisition information. The details of this processing are examined using both analytical results and simulations. A modified Kalman filter is used to combine these position fixes with the navigator's position estimates, as well as

provide updates using the derived slope data. The accuracy of the filter's error covariance estimates is emphasized. Throughout this work, simulations based on statistical map and error models, DMA maps, and flight test data are used for system design and evaluation. Tracking mode behavior is emphasized, but the difficult problem of acquisition from large position uncertainties is also addressed. Author

**A86-28358#****MICROWAVE LANDING SYSTEM**

T. E. EVANS (USAF, Aeronautical Systems Div., Wright-Patterson AFB, OH) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 1. New York, Institute of Electrical and Electronics Engineers, 1985, p. 239-243.

The National Microwave Landing System (MLS) program is a joint DOT/DOD/NASA effort to implement a common civil/military precision landing system to replace the current Instrument Landing System (ILS). The MLS will be capable of providing precision landing guidance down to Category III minimum while allowing for complex approach paths in both the horizontal and vertical planes. The system is based on the Time Reference Scanning Beam (TRSB) technique which was selected by the International Civil Aviation Organization (ICAO) in April 1978 as the new international landing system standard. MLS is less susceptible to interference from the surrounding area and provides a greater signal coverage area than ILS. Author

**A86-28360****DESIGN CONSIDERATIONS FOR DOPPLER VOR GROUND STATION ANTENNA ARRANGEMENT**

M. C. CHANDRA MOULY, S. SURENDER, C. DAMODARA RAO (VR Siddhartha Engineering College, Vijayawada, India), and G. VIJAY PRASAD (KL College of Engineering, Vijayawada, India) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 1. New York, Institute of Electrical and Electronics Engineers, 1985, p. 252-259. refs

Commonality of the airborne receiver for both VHF Omni Range (VOR) and Doppler VOR (DVOR) ground transmissions enforces certain restrictions on the DVOR signal format. This paper elucidates these restrictions and brings out the elegance of the DVOR system with respect to the terrain problems. Analytical methods to determine the number of Alford loops have been developed. Nyquist's sampling theorem has been employed for the evaluation of the minimum number. This work provides analytical support for the design of the DVOR ground station antenna arrangement. Author

**A86-28361****CONCEPT AND PERFORMANCE ANALYSIS OF A STRAPDOWN NORTHFINDER**

U. K. KROGMANN (Bodenseewerk Geratetechnik GmbH, Ueberlingen, West Germany) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 1. New York, Institute of Electrical and Electronics Engineers, 1985, p. 260-267.

To determine the north direction with a strapdown northfinder, two components of the earth rate are measured with a dynamically tuned rotor gyro. This simple principle involves the problem that gyro errors and angular disturbances corrupt the useful sensor information. The effect of non-random time-varying drifts can be excluded by measuring the earth rate in different positions of the gyro with respect to the earth. A theoretically dynamic exact method for large angular disturbance rejection is derived and analyzed. It requires the incorporation of two inertial grade tilt - or acceleration-sensors and is based on the definition of an analytic virtual plane. By levelling this virtual plane the northfinder is exposed to an analytic fine leveling. Undisturbed rates signals are amenable within the virtual level loops for an accurate determination of the north direction. Author

## 04 AIRCRAFT COMMUNICATIONS AND NAVIGATION

**A86-28369**

### **JTIDS RELNAV PERFORMANCE EVALUATION**

M. S. MURPHY (VERAC, Inc., San Diego, CA) and J. LINDEGREN (USAF, Eglin AFB, FL) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 1 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 343-350.

The Joint Tactical Information Distribution System (JTIDS) Test Data Optimal Processor (JTIDS TDOP) has been developed, as a tool for the postflight assessment and error allocation of the JTIDS relative navigation (RELNAV) function, which is scheduled for testing during 1985/1986. The JTIDS TDOP utilizes advanced numerical techniques to implement an extended Kalman filter-based navigation smoothing algorithm, which integrates test data from JTIDS, INS, and test-range tracking instrument sources. The Optimal Processor will create accurate trajectory estimates, assess JTIDS RELNAV compliance to accuracy requirements, and analyze actual navigation errors into the contributing causes, thus providing a tool for DT&E test planning. The performance expected from the JTIDS TDOP system was tested on a simulated three-aircraft scenario. I.S.

**A86-28370**

### **AN ADAPTIVE UD-FACTORIZED KALMAN FILTER FOR REAL-TIME TACTICAL AIRCRAFT TRACK-WHILE-SCAN SYSTEMS**

R. M. YANNONE (General Electric Co., Utica, NY) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 1 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 358-363. refs

The application of an adaptive extended Kalman Filter (EKF) is described for removing divergence problems encountered by the use of Kalman filters in treating the kinematic data obtained in the track-while-scan radar mode. The eigenvector analysis used to examine the inherent discrete-time stability behavior of the Kalman filter is discussed, showing the filter stability to be a function of the state transition, Kalman gain, and measurement transformation matrices. An EKF, implemented by the UD factorization algorithm for gain and error covariance updates, was found to be part of the solution. The second part of the solution was to use sequential relinearization and an adaptive thresholding mechanism for selecting the process noise covariance matrix based on the range and the range rate measurement residuals. I.S.

**A86-28385**

### **AUTONOMOUS LANDING GUIDANCE SYSTEMS**

E. F. ROY (Kaiser Aerospace and Electronics Corp., Kaiser Electronics Div., San Jose, CA) and J. W. DAVISON (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 1 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 490-497. refs

The selection of the proper components for autonomous landing guidance systems for low visibility recovery of aircraft to battle damaged and repaired airfields is examined. The use of forward-looking infrared (FLIR) sensors with high resolution radar and flight guidance symbology instead of the instrument landing system is analyzed. The application of specific sensors is limited by the technical properties of the sensor, the effect of the atmosphere on the electromagnetic waveband of the sensor, and the characteristics of the scene. The capabilities and restrictions of active sensors such as pencil beam radar and side-looking airborne radar, and passive sensors such as FLIR and millimeter wave FLIR are described. The sensors performance during various weather conditions are evaluated. The incorporation of image processing techniques into the autonomous landing guidance system for enhancement and integration of the data is discussed. A study of the image processing techniques reveals that median filter is the best method for noise removal and unsharp masking produces edge enhancement, resolution improvement, and contrast enhancement. I.F.

**A86-28389**

### **DEMONSTRATION OF AN INNOVATIVE TECHNIQUE FOR TERRAIN FOLLOWING/TERRAIN AVOIDANCE - THE DYNAPATH ALGORITHM**

R. V. DENTON, J. E. JONES, and P. L. FROEBERG (TAU Corp., Los Gatos, CA) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 1 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 522-529. refs  
(Contract F33615-83-C-3617)

Automated low-altitude maneuvering flight requires a Terrain Following/Terrain Avoidance capability as a central building block to exploit terrain masking while simultaneously assuring safe flight. This paper presents a new TF/TA optimization approach - the Dynapath Algorithm - to efficiently generate an optimum real-time TF/TA trajectory. It has been designed to be compatible with emerging programs that include terrain-masked threat avoidance as well. The optimization technique as described here is based on a dynamic programming approach that demonstrates how high-resolution and efficient coupling to the flight control system can be obtained. Preliminary computer results are provided to show how the approach results in tactically meaningful TF/TA trajectories. Author

**A86-28391**

### **A COMPARISON OF DIGITAL TERRAIN MODELS AND TERRAIN MASKING ALGORITHMS**

B. E. GINDELBERGER and F. J. STEENROD (BDM Corp., McLean, VA) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 1 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 538-542.

Programs used for simulating scenarios involving aircraft and ground sites frequently need some type of terrain model and an algorithm to determine when masking occurs between two points. This paper describes three different terrain models and compares them. Each model was implemented on the same computer and several trials using identical flight paths were executed to derive these results. The comparison shows (1) how closely the different models match the results of each other, (2) the efficiency of each model in terms of processing time, and (3) the size of data files necessary to represent a region of terrain for each model. Author

**A86-28443**

### **A SPEECH RECOGNITION RESEARCH TOOL FOR THE C-130 HERCULES**

C. M. BREEVOORT (Lockheed-Georgia Co., Electronics Research and Development, Marietta, GA) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 2 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 966-969.

Ongoing efforts aimed at providing flexible and reconfigurable research tools for speech recognition, particularly to assist aircraft flight crews, are discussed. The primary advantage for such a system is that a vocal exchange permits pilots to receive information and operate systems while continuing to use their eyes and hands for more critical tasks. Issues examined include: flexibility for the human factors engineer; flexibility for the digital signal processing engineer; and a user-programmable speech recognizer. Much work remains to be done in software development before one can claim 'better than 99 percent' accuracy with the speech recognizer in the cockpit environment aboard the Hercules test-bed aircraft. D.H.



A86-28447

**A SPEECH PROCESSING SYSTEM FOR AN AIR TRAFFIC CONTROL RADAR SIMULATOR**

R. LAWSON (Gould, Inc., Simulation Systems Div., Melville, NY) and J. DAMOULAKIS (Gould Research Laboratories, Rolling Meadow, IL) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 2. New York, Institute of Electrical and Electronics Engineers, 1985, p. 987-989.

A proposed speech control system to replace Track Control Consoles or TCCs (for an air-traffic-control radar simulator) ordinarily operated by pseudo pilots is described. Such Track Control Consoles are manned by personnel who perform the boring task of altering the tracks of simulated aircraft by entering keyboard data in response to the commands from the trainee controller. A speaker-dependent voice recognition system is substituted for the track altering function of each TCC, while a voice synthesis system is substituted for the pilot acknowledgment function. An interface is then created which allows the TCCs to remain in the loop and assume dual aircraft control, should the need arise. A software control system is utilized which permits the rapid movement of voice data from mass storage (on floppy and hard disks) to allow for operation with the required vocabulary. In addition, the relationship between the air traffic control vocabulary and memory requirements is shown, as is the architecture of the proposed system. Finally, the savings in person hours is projected over a typical training scenario for one year of operation. D.H.

A86-28470#

**THE EFFECTS OF ATMOSPHERIC TURBULENCE ON AN AIR-TO-AIR OPTICAL COMMUNICATION LINK**

J. N. KANAVOS (USAF, Foreign Technology Div., Wright-Patterson AFB, OH) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 2. New York, Institute of Electrical and Electronics Engineers, 1985, p. 1174-1182. refs

An analysis is presented of the performance of an optical communications link between aircraft, evaluating the effect of atmospheric turbulence on bit error rate. It is assumed that a direct detection scheme is used with pulse code modulation of the on/off keying type; the optical beam has plane wave characteristics; the optical beam is assumed to be at constant altitude; and the atmosphere is assumed to be moving rather than the aircraft. Statistical techniques are used to describe the time-varying intensity fluctuations. Important quantities are: the probability distribution of the intensity fluctuations, the refractive index structure constant, and the intensity fluctuation power spectral density. It is found that an appropriate choice of altitude level could minimize a link's bit error rate while maximizing its reliable communication range. D.H.

A86-28473

**THE DEVELOPMENT STATUS OF JTIDS DUAL MODE TDMA AND DISTRIBUTED TDMA (DTDMA) FULL SCALE DEVELOPMENT TERMINALS - AN UPDATE**

J. RUBIN (ITT, ITT Avionics Div., Nutley, NJ) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 2. New York, Institute of Electrical and Electronics Engineers, 1985, p. 1206-1214. refs

The successful transition of terminal development featuring the JTIDS (Joint Tactical Information Distribution System) DTDMA (Distributed Time Division Multiple Access) architecture, from the advanced development model phase to the full scale development model phase has been achieved. This next generation C-cubed/C-N-I architecture is claimed to offer the potential for significant improvements in system and terminal data rate capacity, jam resistance, security, reliability, flexibility and a reduced probability of enemy exploitation, at an affordable price. D.H.

A86-29300

**GPS AIDED INERTIAL NAVIGATION**

J. T. NIELSON, G. W. SWEARINGEN, and A. J. WITSMEER (Boeing Aerospace Co., Seattle, WA) IEEE Aerospace and Electronic Systems Magazine (ISSN 0885-8985), vol. 1, March 1986, p. 20-26.

The Global Positioning System is an extremely accurate satellite-based navigation system which, after its completion in 1989, will provide users worldwide, 24 hour, all weather coverage. A joint research project among Boeing, Rockwell-Collins, and Northrop has been completed in which a GPS receiver was integrated with a low-cost strap-down inertial navigation system and a flight computer. A Kalman filter in the latter allows in-flight alignment and calibration of the INS. In addition, feedback from the INS to the GPS receiver improves the system's ability to reacquire satellite signals after outages. The resulting system combines the accuracy of GPS with the jamming immunity and autonomy of inertial navigation. System tests were conducted in which a Boeing owned T-33 jet aircraft was flown through known test patterns to align and calibrate the INS. Earlier tests, including test against an airborne jammer, were conducted in a modified passenger bus. Author

A86-29578#

**A SATELLITE SYSTEM FOR AERONAUTICAL DATA COMMUNICATIONS**

W. A. SANDRIN and D. W. LIPKE (COMSAT, Clarksburg, MD) IN: Communication Satellite Systems Conference, 11th, San Diego, CA, March 17-20, 1986, Technical Papers. New York, American Institute of Aeronautics and Astronautics, 1986, p. 12-17. COMSAT-sponsored research. (AIAA PAPER 86-0602)

A system is described that can provide data communications via satellite to transoceanic commercial aircraft. The system will provide both air traffic control and airline company communications data services, and will require only modest satellite capacity operating at L-band. If this capability can be provided by the INMARSAT space segment, cost benefits will be realized through the sharing of satellites and earth stations in the INMARSAT system. Attention is also given to designs which minimize aircraft equipment costs, in part by the use of low-gain, flush-mounted aircraft antennas. Low data rates are assumed (200 to 400 bit/s), using DPSK modulation and a rate 1/2 convolutional code with interleaved code symbols and soft-detection Viterbi decoding. This modulation/coding scheme was chosen to provide reliable operation in the multipath fading environment. A brief description of the recommended system is given, followed by a discussion of propagation, aircraft antenna, modulation and coding, acquisition and synchronization, and network design issues. Author

A86-29783

**DETECTION OF NON-MOVING TARGETS BY AIRBORNE MM-WAVE RADARS**

S. A. HOVANESSIAN (Hughes Aircraft Co., El Segundo, CA) Microwave Journal (ISSN 0026-2897), vol. 29, March 1986, p. 159, 160, 162 (3 ff.). refs

The mathematical relations involved in studying the conditions for the detection of a stationary ground target by airborne mm-wave radars are briefly examined, and questions of atmospheric attenuation are explored. For specified radar and target parameters, computer programs can be written to compute target, clutter, and rain backscattering S/N as a function of range, including atmospheric attenuation. Attention is given to numerical examples of stationary ground targets, numerical results, the detection of hovering helicopters against hilly background, and calculations regarding the detection ranges of hovering helicopters against hilly background. G.R.

## 04 AIRCRAFT COMMUNICATIONS AND NAVIGATION

**N86-20382** British Aerospace Dynamics Group, Bristol (England). Guidance and Control Dept.

### **INTERPOLATION OF HEIGHTS AND SLOPES FROM A DIGITAL TERRAIN ELEVATION MODEL**

R. F. SCOTT May 1982 12 p  
(BAE-BT-13198) Avail: Issuing Activity

An interpolation scheme for the TERPROM navigation system, that combines third order polynomials in the x and y directions to obtain a continuous surface which fits the terrain model exactly, conforming to whatever degree of intricacy the model can provide, is outlined. It is recommended that flights where deterioration occurred over rugged country are re-run with this interpolation to determine improvements in accuracy. Author (ESA)

**N86-20383#** Army Engineer Waterways Experiment Station, Vicksburg, Miss. Geotechnical Lab.

### **EVALUATION OF THE FAA DESIGN PROCEDURES FOR HIGH TRAFFIC VOLUME PAVEMENTS Report, Jan. 1983 - May 1984**

S. D. KOHN Oct. 1985 144 p refs  
(Contract DTFA01-81-Y-10555)  
(DOT/FAA/PM-84/14) Avail: NTIS HC A07/MF A01

The results of a field study of the performance of high traffic volume airfield pavements is presented. Both rigid (portland cement concrete) and flexible (asphalt concrete) pavements were included in the study. Condition surveys and nondestructive testing were performed on the pavement sections in order to measure present performance and estimate load-carrying capacity. Traffic and material properties data were also collected for each pavement section. These parameters were used to compare thicknesses obtained using the current FAA design procedure and the thicknesses of the existing sections in order to evaluate the adequacy of the current design procedures. In general it was found that the design procedures are adequate; however, further field study has been recommended in order to verify collected data. Author

**N86-20384\*#** Boeing Commercial Airplane Co., Seattle, Wash.  
**PERFORMANCE OF A COMMERCIAL TRANSPORT UNDER TYPICAL MLS NOISE ENVIRONMENT Final Report**

J. K. HO Feb. 1986 55 p refs  
(Contract NAS1-17635)  
(NASA-CR-178032; NAS 1.26:178032; D6-57212) Avail: NTIS HC A04/MF A01 CSCL 17G

The performance of a 747-200 automatic flight control system (AFCS) subjected to typical Microwave Landing System (MLS) noise is discussed. The performance is then compared with the results from a previous study which had a B747 AFCS subjected to the MLS standards and recommended practices (SARPS) maximum allowable noise. A glide slope control run with Instrument Landing System (ILS) noise is also conducted. Finally, a linear covariance analysis is presented. Author

**N86-21531#** European Space Agency, Paris (France).  
**ALGORITHMS FOR THE AUTOMATIC FOUR-DIMENSIONAL GUIDANCE OF AIRCRAFT, TAKING INTO ACCOUNT THE CURRENT WIND SITUATION**

W. LECHNER Oct. 1985 108 p refs Transl. into ENGLISH of "Algorithmen zur automatischen 4 dimensionalen Flugbahnfuehrung unter Beruecksichtigung der momentanen Windsituation" Rept. DFVLR-FB-84-40 Brunswick, West Germany, Sep. 1984  
(ESA-TT-908; DFVLR-FB-84-40) Avail: NTIS HC A06/MF A01

An automatic time-of-arrival control flight mode covering the terminal maneuvering area was developed for the digital flight-control system of the HFB 320 test aircraft and flight tested. The algorithms used for computing four dimensional flight paths taking into account the current wind situation are described. Methods for measuring, filtering, and predicting the wind vector are developed and discussed with reference to the results of the flight tests. Evaluation shows that time error limits of + or - 5 sec can be achieved under varied wind situations. The aircraft-oriented method of wind prediction by extrapolation, based

on the Kalman filter method, proves to be particularly efficient.

Author (ESA)

## 05

## AIRCRAFT DESIGN, TESTING AND PERFORMANCE

Includes aircraft simulation technology.

**A86-26585**

### **FLIGHT TESTING OF AN ASW HELICOPTER**

C. R. GUY and M. J. WILLIAMS (Department of Defence, Aeronautical Research Laboratories, Melbourne, Australia) (Netherlands Association of Aeronautical Engineers and Technische Hogeschool te Delft, European Rotorcraft Forum, 10th, The Hague, Netherlands, Aug. 28-31, 1984) Vertica (ISSN 0360-5450), vol. 9, no. 4, 1985, p. 317-330. refs

A programme of flight trials carried out with a Sea King Mk 50 anti-submarine warfare helicopter is described. An outline is given of the aircraft instrumentation, the data-acquisition system and the data-analysis procedures. Results are presented for conditions of trimmed level flight together with typical examples of dynamic response tests, transition manoeuvres and Doppler and cable hover tests. The flight trials programme was designed to provide results both for use in the validation of a mathematical model of the Sea King helicopter and for more general use in helicopter flight behaviour studies. Author

**A86-26587\*** California Univ., Los Angeles.

### **APPLICATION OF MODERN STRUCTURAL OPTIMIZATION TO VIBRATION REDUCTION IN ROTORCRAFT**

P. FRIEDMANN (California, University, Los Angeles) (Netherlands Association of Aeronautical Engineers and Technische Hogeschool te Delft, European Rotorcraft Forum, 10th, The Hague, Netherlands, Aug. 28-31, 1984) Vertica (ISSN 0360-5450), vol. 9, no. 4, 1985, p. 363-376. refs  
(Contract NAG2-226)

This paper explores a number of techniques which are capable of reducing vibration levels in rotorcraft by redistributing the mass and stiffness properties of the structure. First, vibration reduction in the rotor is considered by using formal structural optimization for ensuring optimal frequency placement. Two cases are considered: in the first case aeroelastic constraints are not enforced and the blade is designed for minimum weight; in the second case aeroelastic constraints are enforced and vibration levels are minimized in forward flight. Next, vibration reduction in the fuselage is considered and the various methods available for vibration reduction by local structural modification are reviewed. The feasibility of combining local structural modification with modern structural optimization is discussed and some extensions of previous research are suggested. Author

**A86-26647#**

### **ELECTRO-IMPULSE DE-ICING OF AIRCRAFT ENGINE INLETS**

D. O. NELEPOVITZ and H. A. ROSENTHAL (Rohr Industries, Inc., Chula Vista, CA) AIAA, Aerospace Sciences Meeting, 24th, Reno, NV, Jan. 6-9, 1986. 7 p.  
(AIAA PAPER 86-0546)

The structure and mechanism of the electroimpulse deicing (EIDI) system are described; the technical advantages the system provides the aircraft are discussed. The wind tunnel testing of turbofan and turboprop inlets is examined; it is observed that the EIDI system is effective for the aircraft. The fatigue testing of the system for turbofan, turboprop, and high by-pass ratio engine inlets is proposed. I.F.

A86-27654#

**OPTIMAL DESIGN OF COMPOSITE POWER TRANSMISSION SHAFTING**

J. W. LIM and M. S. DARLOW (Rensselaer Polytechnic Institute, Troy, NY) IN: International Conference on Rotorcraft Basic Research, Research Triangle Park, NC, February 19-21, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, 13 p. refs  
(Contract DAAG29-82-K-0093)

The replacement of a conventional drive shaft system with a composite drive shaft system with the same transmitted power is studied. As an illustration, the optimal design of a graphite/epoxy tail rotor drive shaft for the next generation of helicopters is considered. The background for the optimal design of a composite tail rotor and synchronization drive shafts is examined, taking into account torsional and lateral vibration. A computer algorithm for the optimal design of the drive shaft is discussed. The parameters of the optimized drive shaft are given and compared with conventional aluminum drive shaft values. It is shown that a composite shaft with a single tube operating supercritically at 6000 rpm can reduce the system weight by as much as 63.1 percent compared to the conventional shaft. The results of a parametric study of the composite shaft are reported, and trends of the optimal design of composite drive shafts are summarized. C.D.

A86-27657#

**ANALYSIS OF THE WING/ROTOR AND ROTOR/ROTOR INTERACTIONS PRESENT IN TILT-ROTOR AIRCRAFT**

D. R. CLARK (Analytical Methods, Inc., Redmond, WA) IN: International Conference on Rotorcraft Basic Research, Research Triangle Park, NC, February 19-21, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, 16 p. refs

An advanced configuration modeling program has been used to analyze the aerodynamics of a representative tilt-rotor/wing combination in both hover and (helicopter) forward flight. The program which combines a panel representation of the wing and a blade element model of the rotor system provides a fully coupled solution of the loads on both components. Results are presented for hover and forward flight conditions for isolated rotor, side-by-side rotors and rotor plus wing configurations and include integrated wing and rotor loads, detailed rotor blade loads and off-body flow field surveys showing the effect of rotor and wing flow in the region of possible tail locations. Author

A86-27661\*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

**IDENTIFICATION AND VERIFICATION OF FREQUENCY-DOMAIN MODELS FOR XV-15 TILT-ROTOR AIRCRAFT DYNAMICS**

M. B. TISCHLER (NASA, Ames Research Center; U.S. Army, Aeromechanics Laboratory, Moffett Field, CA), J. G. M. LEUNG, and D. C. DUGAN (NASA, Ames Research Center, Moffett Field, CA) (Netherlands Association of Aeronautical Engineers and Technische Hogeschool te Delft, European Rotorcraft Forum, 10th, The Hague, Netherlands, Aug. 28-31, 1984) IN: International Conference on Rotorcraft Basic Research, Research Triangle Park, NC, February 19-21, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, 17 p. Previously announced in STAR as N84-34445. refs

Frequency-domain methods are used to extract the open-loop dynamics of the XV-14 tilt-rotor aircraft from flight test data for the cruise condition ( $V = 170$  knots). The frequency responses are numerically fitted with transfer-function forms to identify equivalent model characteristics. The associated handling quality parameters meet or exceed Level 2, Category A, requirements for fixed-wing military aircraft. Step response matching is used to verify the time-domain fidelity of the transfer-function models for the cruise and hover flight conditions. The transient responses of the model and aircraft are in close agreement in all cases, except for the normal acceleration response to elevator deflection in cruise. This discrepancy is probably due to the unmodeled rotor rpm dynamics. The utility of the frequency-domain approach for

dynamics identification and analysis is clearly demonstrated.

Author

A86-27663#

**STRUCTURAL DYNAMIC ASPECTS OF ROTOR ANTIRESONANT ISOLATION**

J. STOPPEL (Messerschmitt-Boelkow-Blohm GmbH, Munich, West Germany) IN: International Conference on Rotorcraft Basic Research, Research Triangle Park, NC, February 19-21, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, 9 p.

The efficiency of the nodal isolation system ARIS based on special antiresonance isolator elements is theoretically and experimentally confirmed using the BK 117 helicopter. It is demonstrated that, when a natural frequency and the antiresonance frequency coincide, the isolator compensates the resonance. This zero compensation in the undamped system can impair the isolating effect for a real damped structure with many modes close to the 4/rev range. The use of finite element methods for eigenvalue analysis and frequency response can be used to predict vibration problems and perform needed modifications. C.D.

A86-27820

**ROTATING AERODYNAMIC EXCITERS FOR IN-FLIGHT FLUTTER TESTING**

M. PENNACHIONI (Centre d'Essais en Vol, Base d'Essais, Istres, France) IN: ITC/USA/'85; Proceedings of the International Telemetering Conference, Las Vegas, NV, October 28-31, 1985 . Research Triangle Park, NC, Instrument Society of America, 1985, p. 587-601.

Structural excitation as observed in-flight flutter testing is considered along with the principles of the 'Colibri' exciters, the design of an in-flight excitation system, aspects of model building, and preliminary tests. Two Colibri units were built, including a low-power unit designed to validate the method by the in-flight testing of a light aircraft, and a medium-power units for an actual test on a large military transport aircraft modified by the installation of pods under its wings. It is found that using the rotating fin method to define an aerodynamic structural exciter leads to an answer which can be usefully combined with existing methods. This principle can be used to design and produce a family of exciters with forces in the range from a few Nextons to a few hundred Nextons. G.R.

A86-28060

**ATRA42 - FIRST OF A FAMILY**

D. LEARMOUNT Flight International (ISSN 0015-3710), vol. 129, Feb. 15, 1986, p. 24-29.

The design of Aerospaiale/Aeritalia's simple low-production-cost ATR42 regional airliner is described with efficiency achieved through advanced wing design and lightness of the aircraft. There is extensive use of composite materials and the cockpit design features flightdeck controls that include a CRT display electronic flight instrument system, an electronic attitude director indicator, an electronic horizontal situation indicator, and a flight computer which controls the standard issue autopilot. Decisions to apply new technology, as well as the selection of more conventional features such as a mechanical control system, were based on simplicity in installation and maintenance, and cost effectiveness. To achieve quietness in the cabin the engines are mounted as far out on the wings as asymmetric engine control would allow, resulting in an unusually large vertical unit design. The aircraft is powered by two PW120 turboprops rated at 18 shp and has a maximum speed of 268 kt. R.R.

## 05 AIRCRAFT DESIGN, TESTING AND PERFORMANCE

**A86-28093**

**LIGHT AIRCRAFT - THE WAY AHEAD IN DESIGN AND OPERATION; PROCEEDINGS OF THE SYMPOSIUM, LOUGHBOROUGH, ENGLAND, MARCH 31, APRIL 1, 1984**

Symposium sponsored by the Royal Aeronautical Society and Loughborough University of Technology. London, Royal Aeronautical Society, 1984, 217 p. No individual items are abstracted in this volume.

The present symposium on contemporary design practices in small general aviation and ultralight aircraft gives attention to guidelines for the scaling and integration of structural and component system features. Among the topics discussed are representative new designs for these classes of aircraft (such as inflatable airframe structures and motor-powered parachutes), the performance characteristics of two- and three-surface unconventional configurations, and a parametric study of light twin-engined aircraft. Also treated are light aircraft manufacture, including home-building with composite materials, as well as modern aircraft engine components, cockpit design, and low cost operation of light aircraft. O.C.

**A86-28281**

**HELICOPTER AIRWORTHINESS SYMPOSIUM, 19TH, LONDON, ENGLAND, DECEMBER 19, 1984, PROCEEDINGS**

Symposium sponsored by the Royal Aeronautical Society. London, Royal Aeronautical Society, 1985, 149 p. No individual items are abstracted in this volume.

Various papers on helicopter airworthiness are presented. The topics addressed include: helicopter structural integrity in relation to airworthiness, strategy for the fatigue substantiation of helicopter dynamic components, monitoring of rotorcraft dynamic systems, and health and usage monitoring system developments in helicopters. Also discussed are: flight aspects, mechanical component health monitoring, crashworthiness of helicopters, and the W30-300 and compliance with HARP. C.D.

**A86-28310**

**OPTIMUM MAINTENANCE OF AIRCRAFT SYSTEMS ON THE BASIS OF THEIR CONDITION WITH ALLOWANCE FOR MEASUREMENT ERRORS [OPTIMAL'NAIA EKSPLUATATSIYA AVIATSIONNYKH SISTEM PO SOSTOIANIIU S UCHETOM OSHIBOK IZMERENIYA]**

M. S. IARLYKOV and E. I. BARZILOVICH IN: Problems in aircraft reliability. Moscow, Izdatel'stvo Mashinostroenie, 1985, p. 62-70. In Russian. refs

The problem of optimum maintenance of aircraft systems on the basis of their actual condition is examined with emphasis on optimal nonlinear filtering of processes based on Markov's theory. In the statement of the problem, the parameters determining the technical condition of a system are represented by components of multidimensional Markovian diffusion processes. An example is presented illustrating the application of the approach proposed here to the maintenance of radio electronic systems. V.L.

**A86-28320**

**CHARACTERISTICS OF THE EFFECT OF THE POWERPLANT JET STREAMS ON THE DESIGN OF VTOL AIRCRAFT [OSOBENOSTI VOZDEISTVIA REAKTIVNYKH POTOKOV SILOVYKH USTANOVOK NA KONSTRUKTSIIU SAMOLETA VERTIKAL'NOGO VZLETA I POSADKI]**

V. V. NOVITSKIĬ and V. F. PAVLENKO IN: Problems in aircraft reliability. Moscow, Izdatel'stvo Mashinostroenie, 1985, p. 245-252. In Russian. refs

The effect of the jet streams from the powerplants and of the turbulent vortices formed as a result of separated flow past the aircraft nose and superstructure on the design of VTOL aircraft is analyzed using the formalism of random functions. Expressions are obtained for calculating the life of structural elements with allowance for the effect of jets and turbulent vortices. V.L.

**A86-28397**

**ELECTROMECHANICAL ACTUATION RELIABILITY AND SURVIVABILITY**

K. A. HAIR (Grumman Aerospace Corp., Bethpage, NY) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 1. New York, Institute of Electrical and Electronics Engineers, 1985, p. 596-603. refs

The level of fault tolerance, desired failure characteristics, and post failure performance of electromechanical actuation systems (EMASs) are evaluated. The designing of EMASs to specific levels of performance is discussed. The features of EMASs which improve reliability and survivability include the multimotor configuration, active isolation of a failure channel with breaks or clutches, and the ability to remotely mount the components; however, the need for redundancy due to the gearbox causes an increase in the weight and size of the actuators. Failure mode effects and criticality analysis were performed on an EMAS and an electrohydraulic actuator (EHA) for the F-14 aircraft. The data reveal that the EHA design has less failure modes and is therefore more reliable; however, the EMAS has a 49 percent probability of a kill compared to 76 percent for the EHA displaying the greater survivability of the EMAS. I.F.

**A86-28398**

**ELECTRONICS FOR ADVANCED ELECTROMECHANICAL ACTUATORS DESIGN CONSIDERATIONS**

M. B. MCCORMICK (Kollmorgen Corp., Inland Motor Div., Radford, VA) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 1. New York, Institute of Electrical and Electronics Engineers, 1985, p. 604-610.

The design process for an electronic controller for an electromechanical actuator (EMA) is studied. Controller specifications and general system specifications for an EMA system are described. The formation of a functional block diagram, and the breadboarding and testing of the individual functional blocks are examined. The need for good communication with the customer in order to produce the desired final product is discussed. I.F.

**A86-28400**

**DIGITAL FAULT TOLERANT FLIGHT ACTUATION SYSTEMS**

H. H. BELMONT (Northrop Corp., Aircraft Div., Hawthorne, CA) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 1. New York, Institute of Electrical and Electronics Engineers, 1985, p. 618-627.

(Contract F33615-80-C-3623; AF PROJECT 2403)

A study was made of the equipments making up a typical flight control actuation system (servo electronics, servo valves, actuators and transducers) to determine where digital technology could replace analog technology for the purpose of providing a more fault-tolerant flight control actuation system. The investigation led to an evaluation of architectural design issues such as where to locate the servo electronics, the adequacy of military standard serial bus systems for control (versus data) applications, and the feasibility of providing electronics which could survive severe environments. Several actuation system configurations were evaluated which led to recommending, as the best developmental prospect, a concept of a locally integrated actuation system consisting of servo electronics, servo valves, actuators and transducers, interfacing with a digital flight control computer over a serial bus. Author

**A86-28402****A SURVIVABLE FLY-BY-WIRE SPOILER ACTUATION SYSTEM FEATURING NONFLAMMABLE FLUID, 8,000 PSI HYDRAULICS AND DIRECT DRIVE VALVES**

R. WHITAKER, A. HARMON (Lockheed-Georgia Co., Marietta), and L. HAYNES (E-Systems, Inc., Montek Div., Salt Lake City, UT) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 1. New York, Institute of Electrical and Electronics Engineers, 1985, p. 633-640. refs

The occurrence of a total of 90 hydraulic fluid fire mishaps during the time from 1970 through 1975 has demonstrated the need to reduce the susceptibility of USAF aircraft to hydraulic fluid related fires. The most significant progress toward such a reduction is currently related to the development of a truly nonflammable hydraulic fluid, CTFE (AO2). Problems arise, however, in connection with the higher mass density of the new fluid. In an attempt to overcome these problems, a joint development program is conducted by two American aerospace companies. The program has the objective to produce an advanced, fireproof, survivable, spoiler actuation system for critical in-flight testing in a High Technology Test Bed (HTTB) aircraft in early 1986. In a system description, attention is given to a roll control system, hydraulic systems, the spoiler servoactuation system, design requirements, and a servoactuator. G.R.

**A86-28405****AN EXPERT SYSTEM FOR INTEGRATED AIRCRAFT/ENGINE CONTROLS DESIGN**

J. H. TAYLOR (General Electric Co., Control Technology Branch, Schenectady, NY) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 1. New York, Institute of Electrical and Electronics Engineers, 1985, p. 661-669. refs

In this paper, we discuss the concepts, requirements and architecture for an expert system for integrated aircraft/engine control systems analysis and design. The purpose of this concept is to provide a high-level environment embodying expertise from the many fields that enter into integrated flight and engine controls design (aerodynamics, structures, propulsion, pilot/aircraft interaction, mission performance requirements, control system design and validation), thereby facilitating the design of integrated aircraft control systems and ensuring that the best possible designs are obtained. The expert system concept also has capabilities to handle data-base management, and to take maximum advantage of existing conventional software. A prototype expert system has been implemented that demonstrates many of the capabilities and benefits of such an environment. A record of a hypothetical controls system modeling, analysis, and design session is included in this paper. Author

**A86-28454#****ARMY 21 - AVIATION**

C. A. FRY (U.S. Army, Human Engineering Laboratory, Aberdeen Proving Ground, MD) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 2. New York, Institute of Electrical and Electronics Engineers, 1985, p. 1046-1049. refs

An Army perspective is presented for the 'ideal' Army helicopter cockpit of the future. The tactical necessities which drive cockpit design are reviewed. Aircrew functions, communications, secondary systems, mission execution and general configuration are discussed with regard to the helicopter that will be needed in the 2010 time frame. Artificial intelligence technologies as well as sensors and display systems will be key elements. D.H.

**A86-28455#****2010 - THE SYMBIONIC COCKPIT**

J. M. REISING and R. W. MOSS (USAF, Flight Dynamics Laboratory, Wright-Patterson AFB, OH) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 2. New York, Institute of Electrical and Electronics Engineers, 1985, p. 1050-1054. refs

The cockpit of the year 2010 is described in terms of both the capabilities and systems it contains and how the pilot interacts with it. A brief mission narrative is provided describing several hours in the life of the Manta air superiority fighter. This is followed by a discussion of the pilot interface components employed in the cockpit including hueristic voice, instrument panel display, canopy display, and holographic display systems. The concept of a 'symbiotic' system is then introduced, describing in some detail the capabilities and features of a cockpit system that senses the physiological and mental state of the pilot and responds accordingly. Finally, conclusions and predictions are made that summarize and emphasize the points made in the paper. Author

**A86-28485****UNIFIED EM TRANSIENT PROTECTION REQUIREMENTS FOR AIRCRAFT AVIONICS LINE REPLACEABLE UNITS**

G. W. KETTERLING (Boeing Military Airplane Co., Seattle, WA), R. C. VOGEL, and S. M. BRIGGS (USAF, Aeronautical Systems Div., Wright-Patterson AFB, OH) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 2. New York, Institute of Electrical and Electronics Engineers, 1985, p. 1310-1319. refs

Unified test requirements and procedures are suggested to achieve a specified inherent transient protection level to transients originating from lightning, NEMP (nuclear electromagnetic pulses), and intrasystems transients. The procedures presented provide a minimum set of test requirements, methods, and procedures that can be utilized to achieve a reasonable and attainable level of equipment inherent protection based on actual test results. Threat environments and transient frequencies dealt with under the procedures are indicated. D.H.

**A86-28514****LIGHTNING SIMULATION TESTS ON A GRAPHITE/EPOXY AIRPLANE MOCKUP**

D. B. WALEN (Boeing Military Airplane Co., Seattle, WA) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 2. New York, Institute of Electrical and Electronics Engineers, 1985, p. 1570-1575. (Contract F33615-82-C-3406)

Two test techniques to characterize aircraft and circuit responses to lightning environments were demonstrated on a graphite/epoxy F-16 mockup and the results are presented in this paper. Low-level swept-frequency transfer functions were measured using computer-controlled network analyzers. These frequency domain measurements required low drive current levels typically less than one ampere. Moderate level current pulse responses were measured using a crowbarred marx generator. The drive current exceeded 20 kA with a  $4 \times 10$  to the 10th A/s peak rate of rise. The test technique demonstration showed that both low level swept-frequency transfer function measurements and moderate level current pulse tests can be used to simulate aircraft responses to lightning environments. Author

**A86-28559\*#****THE JOINED WING - AN OVERVIEW**

J. WOLKOVITCH (ACA Industries, Inc., Torrance, CA) Journal of Aircraft (ISSN 0021-8669), vol. 23, March 1986, p. 161-178. Previously cited in issue 07, p. 853, Accession no. A85-19626. refs

(Contract NAS2-11255; NAS2-11725; N00014-79-C-0953; N00014-82-C-0607)

## 05 AIRCRAFT DESIGN, TESTING AND PERFORMANCE

**A86-28562\*#** Colorado Univ., Boulder.  
**NUMERICAL OPTIMIZATION DESIGN OF ADVANCED TRANSONIC WING CONFIGURATIONS**  
G. B. COSENTINO (Colorado, University, Boulder) and T. L. HOLST (NASA, Ames Research Center, Moffett Field, CA) *Journal of Aircraft* (ISSN 0021-8669), vol. 23, March 1986, p. 192-199. Previously cited in issue 07, p. 853, Accession no. A85-19739. refs  
(Contract NCA2-OR-170-202)

**A86-28563#**  
**A NEW AND LESS COMPLEX ALTERNATIVE TO THE HANDLEY PAGE SLAT**  
A. L. WILLIAMS (Northrop Corp., Aircraft Div., Hawthorne, CA) *Journal of Aircraft* (ISSN 0021-8669), vol. 23, March 1986, p. 200-206. refs

A comparative evaluation is made of the aerodynamic effects and mechanical requirements of devices that have been adopted to delay leading edge stall, such as the Handley Page slat and Kruger flap. While a flexible fiberglass Kruger flap that incorporates the 'ever-opening spiral' geometry allows high lift coefficient to be achieved at high inflow angles, it is a mechanically complex device; attention is accordingly given to the design features and advantages of an ever-opening spiral principle four-bar linkage device that answers to such criteria as compactness. The simplicity thus achieved has led to time and cost reductions in design, fabrication and maintenance. The device may be retrofitted to update existing aircraft. O.C.

**A86-28566#**  
**STALINS METHOD FOR TAKEOFF AND LANDING TRAJECTORY MEASUREMENTS**  
C. G. KRANENBURG, A. POOL, and A. J. L. WILLEKENS (Nationaal Lucht- en Ruimtevaartlaboratorium, Amsterdam, Netherlands) (International Council of the Aeronautical Sciences, Congress, 14th, Toulouse, France, September 9-14, 1984, *Proceedings. Volume 2*, p. 678-684) *Journal of Aircraft* (ISSN 0021-8669), vol. 23, March 1986, p. 220-225. Research supported by the Nederlands Instituut voor Vliegtuigontwikkeling en Ruimtevaart. Previously cited in issue 22, p. 3187, Accession no. A84-45003.

**A86-28567#**  
**COMPARISON OF DISCRETE AND CONTINUOUS GUST METHODS FOR AIRPLANE DESIGN LOADS DETERMINATION**  
R. NOBACK (Nationaal Lucht- en Ruimtevaartlaboratorium, Amsterdam, Netherlands) (International Council of the Aeronautical Sciences, Congress, 14th, Toulouse, France, September 9-14, 1984, *Proceedings. Volume 1*, p. 351-357) *Journal of Aircraft* (ISSN 0021-8669), vol. 23, March 1986, p. 226-231. Previously cited in issue 22, p. 3186, Accession no. A84-44967. refs

**A86-29299#**  
**IN-FLIGHT SIMULATORS**  
J. BARRY, JR. (USAF, Wright-Patterson AFB, OH) and A. E. SCHELHORN (Calspan Corp., Buffalo, NY) *IEEE Aerospace and Electronic Systems Magazine* (ISSN 0885-8985), vol. 1, March 1986, p. 10-16. refs  
The Flight Dynamics Laboratory (FDL) has sponsored and managed the development and use of several generations of in-flight simulators during the last thirty years. These vehicles were designed and fabricated, and are operated by the Flight Research Department of Calspan Corporation, Buffalo, New York. These unique aircraft have been used to develop control laws and control systems, to evaluate new aircraft before first flight, to provide specialized training for test pilots, to perform essential flight research in flying and handling qualities, and to develop and validate the military specifications for handling qualities of piloted airplanes. As aircraft and control systems have become more complex and capable, systems integration issues have required more and more effort resources. Author

**A86-29823**  
**CAD/CAM SUPPORTS FLIGHT TEST MODIFICATIONS**  
J. H. BRAHNEY Aerospace Engineering (ISSN 0736-2536), vol. 6, March 1986, p. 22-27.

An evaluation is made of an aircraft modification/modernization program that incorporates state-of-the-art computer-integrated engineering and manufacturing techniques. The modification center's computer-aided design techniques have been employed to determine optimum placement for new aircraft instrumentation and for the addition of a conformal strap to the structural casing of an aircraft bulkhead for stress relief. Computer-aided manufacturing has been used in previously underestimated prototype construction activities, with high productivity ratings resulting from the ease with which design modifications could be inserted into the numerical control code. Attention is given to the radome nose structure modification work undertaken for the EC-18B aircraft. O.C.

**A86-29824**  
**SOLAR POWERED VEHICLE MAY FLY YEAR-LONG MISSIONS**  
J. H. BRAHNEY Aerospace Engineering (ISSN 0736-2536), vol. 6, March 1986, p. 54-59.

Attention is given to the performance requirements and projected design features of a solar cell-based propulsion unmanned aircraft type designated the 'high altitude powered platform' (HAPP). During daylight hours, the electrical propulsion system would receive its power directly from solar cell arrays covering the upper surfaces of the aircraft; nocturnal propulsion power is furnished by fuel cells that would have been charged by excess daylight power. HAPP aircraft, which may typically have a 300-ft wingspan, would fly at 65,000 ft for essentially unlimited periods (terminated for the sake of maintenance); their mission would be to carry earth resources sensors and transmit the data they obtain to ground stations. O.C.

**A86-29842**  
**STRENGTH ANALYSIS OF FLIGHT VEHICLES [RASCHEK NA PROCHNOST' LETATEL'NYKH APPARATOV]**  
A. S. AVDONIN and V. I. FIGUROVSKII Moscow, Izdatel'stvo Mashinostroenie, 1985, 440 p. In Russian. refs

Applied methods of static strength analysis of flight vehicles, including aircraft, rockets, and spacecraft, are presented. In particular, attention is given to the analysis of loads acting on flight vehicles in flight and during landing; the heating of flight vehicle structures; and methods of the strength analysis of wings of various configurations, including finite element analysis in displacements and forces. The discussion also covers the strength analysis of wings and tail units, chassis, engine installations, fuselage, and other structures; minimum-weight design; and fatigue strength analysis. V.L.

**N86-20385#** National Aeronautical Lab., Bangalore (India). Structural Sciences Div.

**MODAL ANALYSIS OF A TYPICAL FIGHTER AIRCRAFT USING TRANSIENT TESTING TECHNIQUE**  
R. BALASUBRAMANIAM, D. S. RAMAKRISHNA, and P. S. VIJAYAKUMAR Dec. 1985 30 p refs  
(NAL-TM-ST-8517) Avail: NTIS HC A03/MF A01

The dynamic performance of individual structural components and the whole aircraft was evaluated. The dynamic properties of the aircraft and its components were analyzed. One hundred and thirty-nine locations for transient inputs are chosen using an instrumented hammer and on-line data reduction for modal properties. Results from up to six modes of the natural frequency modal mass and stiffness and damping tests are presented. The test set-up, choice of locations for excitations, and actual test procedures are outlined. The advantages of sweep-sine, step relation random and transient test methods on aircraft structures are discussed. E.A.K.

**N86-20386\***# Florida Univ., Gainesville. Dept. of Engineering Sciences.

**OPTIMAL AIRFRAME SYNTHESIS FOR GUST LOADS Final Report**

P. HAJELA Feb. 1986 45 p refs

(Contract NAG1-579)

(NASA-CR-178047; NAS 1.26:178047) Avail: NTIS HC A03/MF A01 CSCL 01C

An optimization capability for sizing airframe structures that are subjected to a combination of deterministic and random flight loads was established. The random vibration environment introduces the need for selecting a statistical process that best describes the random loads and permits computation of the dynamic response parameters of interest. Furthermore, it requires a formulation of design constraints that would minimize the conservativeness in the design and retain computational viability. The random loads are treated as a stationary, homogeneous process with a Gaussian probability distribution. The formulation of the analysis problem, the structure of the optimization programming system and a representative numerical example are discussed. Author

**N86-21532** Royal Aircraft Establishment, Farnborough (England).

**STRUCTURAL MATERIALS IN AERONAUTICS: PROSPECTS AND PERSPECTIVES**

G. G. POPE 28 Aug. 1985 45 p refs Presented at European Pioneers Day Meeting, Paris, 25 Apr. 1985

(RAE-TR-85077; BR97329) Avail: NTIS HC A03/MF A01

Developments in materials and their prospects of application in airframes and engines are reviewed. Technical and cost considerations that govern material selection; and the merits of fiber composites, titanium alloys, steels and aluminum alloys for airframe applications are examined. The benefits offered by fiber composites must be assessed for specific applications in relation to developments in aluminum alloys, notably lithium-containing alloys and alloys produced by rapid solidification or condensation. Titanium alloys and steels are expected to fulfil an important but limited role in airframes. In the engine, titanium and nickel-base alloys respectively will satisfy most compressor and turbine requirements, although use of ceramics is expected. It is concluded that new materials are acceptable only if a clear understanding is achieved of the relationship between composition, microstructure and material behavior, the manufacturing route, and quality control of the product. Author (ESA)

**N86-21533#** Cranfield Inst. of Tech., Bedford (England). Coll. of Aeronautics.

**A PROGRAMME OF RESEARCH INTO THE AERODYNAMICS, STABILITY AND CONTROL CHARACTERISTICS OF A COMBAT AIRCRAFT HAVING A FORWARD SWEEP WING Interim Report, Nov. 1984 - Oct. 1985**

M. V. COOK and F. HEYDARI Oct. 1985 16 p refs CAR-8516 ISBN-0-947767-27-4

Avail: NTIS HC A02/MF A01

The aerodynamic stability and control characteristics of the forward swept wing aircraft, and likely stability augmentation requirements were studied. It is found that: (1) the theoretical aerodynamic models match the observed aerodynamic performance; (2) the estimated stability derivatives when incorporated in a computer simulation provide response characteristics which agree with experimentally derived responses; (3) the parametric identification technique is effective; (4) theoretical predictions of longitudinal static stability margins indicate that the aircraft is more stable than observed in experiments; (5) feedback control is relatively straightforward; and (6) the experimental system permits dynamic testing on the aircraft model with a longitudinal static stability margin as small as -4%. E.A.K.

**N86-21534\***# National Aeronautics and Space Administration, Washington, D.C.

**PROCEDURE FOR UTILIZING THE LIFT AND THRUST FORCES OF ORNITHOPTERS**

C. BEZARD Nov. 1985 15 p Transl. into ENGLISH of French Patent no. 8404354 (21 Mar. 1984) p 1-15 Transl. by The Corporate Word, Inc., Pittsburgh, Pa.

(Contract NASW-4006)

(NASA-TM-77682; NAS 1.15:77682) Avail: NTIS HC A02/MF A01 CSCL 01C

This procedure is distinguished by two beating wings which together describe, in space, a succession of interlaced triangles. On these wings, whose incidence varies automatically, identical forces are exerted: simultaneous lift and thrust when they make their descent, which is inclined toward the front of the craft, and lift alone when they make their ascent, which is inclined toward the rear of the craft and follows a slide horizontal movement. A mechanical device makes these movements possible. It includes: two wings with hollow profiles, connected by a framework located above a rigid frame and attached to it by bars with joints. These bars are moved with control rods which gear down the drive force. A mechanism with elastic bands or springs automatically varies the incidence of the wings. Author

**N86-21535\***# National Aeronautics and Space Administration, Washington, D.C.

**VERTICALLY OPERATING FLIGHT VEHICLE FOR DRILLING AND AGRICULTURAL USE**

W. PABST Mar. 1986 13 p Transl. into ENGLISH of West German Patent no. P3521624.7 (10 Jun. 1985) p 1-12 Transl. by The Corporate Word, Inc., Pittsburgh, Pa.

(Contract NASW-4006)

(NASA-TM-77713; NAS 1.15:77713) Avail: NTIS HC A02/MF A01 CSCL 01C

The invention deals with an aircraft which ascends and descends vertically and which is used for recreational aircraft, as well as for drilling and in agriculture. The invention combines the floating effect of a parachute with the helicopter to develop a flight vehicle with multiple uses which go beyond those of contemporary flight vehicles. Both hub mechanisms and thrust power are implemented to achieve this goal. Four designs are described in detail. Author

**N86-21536#** Boeing Co., Seattle, Wash.

**OPERATION REDWING, PROJECT 5.2, IN-FLIGHT PARTICIPATION OF A B-52**

F. L. WILLIAMS 1 Apr. 1985 69 p refs Prepared in cooperation with Aeronautical Systems Div., Wright-Patterson Air Force Base, Ohio Prepared for DNA, Washington, D.C.

(AD-A995286; WT-1328-EX) Avail: NTIS HC A04/MF A01 CSCL 18C

Measured energy input and aircraft response data on an instrumented B-52 aircraft when subjected to the thermal, blast, and gust effects of a nuclear explosion were examined. The spatial location for the B-52, relative to a detonation, that would result in the desired aircraft inputs and responses was analyzed. The B-52 participated in nine shots. The reliability of the instrumentation system was between 95% and 100% throughout the test program. It is recommended that the B-52 not participate in future nuclear tests as a weapons-capability aircraft. E.A.K.

**N86-21537#** Aeronautical Research Labs., Melbourne (Australia).

**COMPARISON OF AIRBORNE DATA ACQUISITION SYSTEMS AT ARL (AERONAUTICAL RESEARCH LABORATORIES)**

G. F. FORSYTH Sep. 1985 13 p

(AD-A161664; ARL/AERO-PROP-TM-430) Avail: NTIS HC A02/MF A01 CSCL 09B

During formulation of plans to raise contracts to implement a new data acquisition arrangement to suit aircraft engines and other propulsion components, it became necessary to evaluate other systems which might be available for the same or similar tasks. Accordingly details have been collected on all the various airborne

## 05 AIRCRAFT DESIGN, TESTING AND PERFORMANCE

data acquisition systems which may be considered for use at ARL. Later sections of this paper compare the major capabilities of the various airborne data acquisition systems currently available at ARL and of some systems which have recently become available from industry. GRA

### **N86-21539# Naval Postgraduate School, Monterey, Calif. HELICOPTER PERFORMANCE COMPUTER PROGRAMS FOR HP-41 HAND-HELD COMPUTER**

D. M. LAYTON Dec. 1985 73 p  
(AD-A162794) Avail: NTIS HC A04/MF A01 CSCL 01C

This document has reference tables and programs used to evaluate helicopter performance in the areas of: Autorotation; Service and Combat Ceilings; Basic Power Required Parameters; Fuel Consumption; High Speed Effects; Basic Power Considerations; Maximum Endurance Power/Velocity; Maximum Rage Power/Velocity; and Weight Estimation Relationships. These programs present the user of the HP-41 hand-held, programmable calculator with a series of self-prompting, alphanumeric programs that can be used with acceptable results to compute and evaluate helicopter performance. Most of the programs are structured so as to be more expedient when doing preliminary helicopter design where intermediate values are of less a concern than would be the case when studying detailed performance. GRA

### **N86-21540# Department of the Air Force, Washington, D.C. ROBOTIC REFUELING SYSTEM FOR TACTICAL AND STRATEGIC AIRCRAFT Patent Application**

E. R. SCHULTZ, inventor (to Air Force) 12 Aug. 1985 17 p  
(AD-DO11980; US-PATENT-APPL-SN-764820) Avail: NTIS HC  
A02/MF A01 CSCL 01B

A ground based aircraft refueling system uses existing air-to-air refueling technology. A fixed facility design attaches a moveable air-to-air type refueling boom and probe to an overhead track mounted on the ceiling of a TAB VEE aircraft shelter. Movement of the boom and probe is controlled from a remote control room protected from hazardous chemical and biological environments. In a second embodiment a moveable facility design mounts on the top of a tank truck a first boom attached at a right angle to an air-to-air type refueling second boom and probe. The booms and probe are remotely controlled from the truck cab which is protected from hostile chemical and biological environments. A third embodiment adds to the moveable facility design a second tank and nozzle outlet for spraying decontaminate.

Author (GRA)

**N86-21541# Deutsche Forschungs- und Versuchsanstalt fuer  
Luft- und Raumfahrt, Oberpfaffenhofen (West Germany).  
Forschungsbereich Nachrichtentechnik und Erkundung.**

### **THEORETICAL AND EXPERIMENTAL INVESTIGATIONS OF FLOW VECTOR MEASUREMENTS WITH ANGLE-OF-ATTACK AND SIDESLIP SENSORS ON DFVLR METEOROLOGICAL RESEARCH AIRCRAFT Ph.D. Thesis - Technische Univ., Munich, West Germany**

P. MUEHLBAUER Jun. 1985 132 p refs In GERMAN;  
ENGLISH summary Report will also be announced as translation  
(ESA-TT-976)  
(DFVLR-FB-85-50; ISSN-0171-1342) Avail: NTIS HC A07/MF  
A01; DFVLR, Cologne DM 42.50

Calibration of the equipment of three powered sail planes and a jet plane with angle-of-attack and sideslip sensors for measuring the local flow vector is described. The impact of angle-of-attack and sideslip and of other interfering parameters on the measured value was studied. A mathematical simulation of compressible flow at the tip of the probe is followed by experimental wind tunnel investigations, analysis, and application on in-flight measurement. Criteria for flight-test use of the sensors are outlined.

Author (ESA)

## 06

### AIRCRAFT INSTRUMENTATION

Includes cockpit and cabin display devices; and flight instruments.

### **A86-26504# AVNER ELECTRONIC MAGNETIC COMPASS AND LOW COST NAVIGATION SYSTEM**

A. SOBEL (Elbit Computers, Ltd., Ground Systems Div., Haifa, Israel) IN: Institute of Navigation, Annual Meeting, 41st, Annapolis, MD, June 25-27, 1985, Proceedings. Washington, DC, Institute of Navigation, 1985, p. 22-28.

A new type of Electronic Magnetic Compass has been developed by Elbit Computers Ltd. This compass corrects the deviations in the Magnetic Compass reading, when mounted on iron body vehicles, by using a classic formula implemented by a microprocessor. This compass is so flexible that it can even correct the deviations caused by the iron body of tanks with rotatable turret. The compass is self calibrated by a computer program which relieves the crew from the complexity of the process. It is argued that this compass has the potential of becoming a low-cost solution to the navigational problems of the large mass of military and commercial land vehicles, aircraft, and ships operating on its own and in conjunction with GPS. The concept and the construction of the compass is explained, some experimental results, and the project status are given. Author

### **A86-27818 FLIGHT TEST INSTRUMENTATION SYSTEM FTIS FOR TYPE-CERTIFICATION OF THE INDONESIAN AIRCRAFT CN 235**

H.-J. KLEWE (DFVLR, Institut fuer Flugmechanik, Brunswick, West Germany) and A. D. SOELAIMAN (Nurtanio Aircraft Industry, Ltd., Bandung, Indonesia) IN: ITC/USA/'85; Proceedings of the International Telemetry Conference, Las Vegas, NV, October 28-31, 1985. Research Triangle Park, NC, Instrument Society of America, 1985, p. 563-573. refs

A survey of the complete Flight Test Instrumentation System (FTIS) for certifying the Indonesian aircraft CN 235 is presented. The FTIS's necessary data acquisition and evaluation systems are described along with the subsystems necessary for flight testing, such as airborne and ground-calibration systems, video and camera installations. The subsystems of the mobile ground station, which is housed in 14 shelters including a power station and can be seen as a self-supporting system, are covered. C.D.

### **A86-28066 COLOUR DESIGN IN AVIATION CARTOGRAPHY**

R. M. TAYLOR (RAF, Institute of Aviation Medicine, Farnborough, England) Displays (ISSN 0141-9382), vol. 6, Oct. 1985, p. 187-201. refs

The use of color in maps from the earliest times to the present day is reviewed, and that experience is applied to the problems of airborne map displays. Studies of the priorities of various kinds of map information have been carried out. A set of principles and guidelines for the best use of color in airborne map displays is given. Author

### **A86-28346 DIGITAL AVIONICS FOR MODERN AIRCRAFT - A CASE STUDY INTO THE PROBLEMS AND PROMISE OF AIRCRAFT ELECTRONICS**

H. S. ARCHER, III (Lockheed-Georgia Co., Marietta) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 1. New York, Institute of Electrical and Electronics Engineers, 1985, p. 144-151.

With decreasing static stability margins and increasingly rigorous mission requirements, the role of aircraft electronics has become vital. A brief historical perspective of the evolution of avionics is given, and the harsh environmental constraints under which current



avionics must operate are noted. The case for spatially redundant integrated racks composed of standardized modules is made. A state-of-the-art design approach is then presented, followed by a discussion of an advanced system that will be typical of aircraft in the 1990's. The topics discussed include: designing for thermal management, distributed processing, built-in-test requirements, and redundant systems for flight-critical applications. Author

**A86-28362**  
**HIGH STABILITY PRESSURE TRANSDUCERS FOR AIR DATA SYSTEMS AND TEST SETS**

D. W. BUSSE and D. F. PETERSON (Paroscientific, Inc., Redmond, WA) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 1. New York, Institute of Electrical and Electronics Engineers, 1985, p. 270-274.

The design and the operational principles of a digital quartz pressure transducer are presented, together with its pressure/frequency relationship equation and an algorithm for temperature compensation. The characteristics of these transducers include a high operating temperature range (from -54 C to +107 C); high shock and vibration resistance of the isolation housing, which can withstand MIL-STD environments; and long term calibration stability, with the drift rates less than 0.089 millibars/year. The low sensitivity to harsh environments and to power supply fluctuation, and the high level digital output make the quartz pressure transducers ideally suited for many flight applications. I.S.

**A86-28363**  
**A NOVEL PRIMARY AIR DATA QUALITY PRESSURE TRANSDUCER**

P. B. DUPUIS (Honeywell, Inc.; Commercial Aviation Div., Minneapolis, MN) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 1. New York, Institute of Electrical and Electronics Engineers, 1985, p. 275-283. refs

A state-of-the-art pressure transducer is described that senses both pitot and static pressures within a single solid-state sensor. This small, relatively simple, and easily interfaced transducer provides exceptional accuracy and long-term stability over a broad environmental range. The transducer's small size will enable Honeywell to integrate an ARINC 706 equivalent air data computer within an ARINC 704 inertial reference system. Remotely located pressure transducers having ARINC 429 outputs of linearized total pressure (Pt), static pressure (Ps), and impact pressure (Qc) are also made possible by this transducer. Incorporation of this transducer into flight hardware began with the latest HG480 and HG280D80 air data computers, which are standard equipment in Boeing 737-300, Douglas MD-80 and KC-10 series aircraft. This transducer is also being used in an Engine Pressure Ratio (EPR) system for the Fokker F28 MK100 and Gulfstream G-IV aircraft. Author

**A86-28364**  
**WIND TUNNEL CALIBRATION OF A FLOW DIRECTION SENSOR AND A PITOT-STATIC TUBE TO HIGH ANGLES OF ATTACK AND SIDESLIP**

F. W. HAGEN and R. V. DELEO (Rosemount, Inc., Eden Prairie, MN) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 1. New York, Institute of Electrical and Electronics Engineers, 1985, p. 284-290.

Modern high performance military aircraft require accurate air data measurements while operating in maneuvering flight at very high angles of attack and angles of sideslip. Inflight calibration of the air data systems is difficult under these flight conditions. Flight test data obtained on an F-14 are believed to be inaccurate and not representative of actual performance. Therefore, the accuracy of air data measurements at high local flow angles has been evaluated in the Rosemount Transonic Wind Tunnel for two types of air data sensors. The sensors are: (1) a hemispherical flow-angularity sensor that measures both angle of attack and

angle of sideslip, and (2) an L-shaped fuselage-mounted pitot-static tube. Author

**A86-28367**  
**A MODULAR STRESS MANAGEMENT SYSTEM (MSMS) WITH WORLDWIDE APPLICATIONS**

C. J. RADFORD (GEC Avionics, Ltd., Rochester, England) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 1. New York, Institute of Electrical and Electronics Engineers, 1985, p. 317-325.

The paper describes a universal Modular Stores Management System (MSMS) design concept, which features low development costs and timescales, commonality between aircraft types, and VLSI technology, providing high reliability and a common product support and maintenance philosophy. The MSMS was successfully applied to 19 types of aircraft, including E-111, P-3, A-7, and AV-8B, and was shown to be capable of interfacing with at least 11 different weapon systems, including Sea Eagle, JP 233, HARM, and ALARM. In addition, the MSMS can control an extensive range of conventional bombs and mines, nonweapons (such as carriers, launchers, and pods), and particle weapons. The MSMS is MIL-STD-1760A/STANAG 3837AA compatible. I.S.

**A86-28371#**  
**ADAPTIVE FIELD OF VIEW EXPANSION VIA MULTIPLE MODEL FILTERING FOR TRACKING DYNAMIC TARGET IMAGES**

P. S. MAYBECK and R. I. SUIZU (USAF, Institute of Technology, Wright-Patterson AFB, OH) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 1. New York, Institute of Electrical and Electronics Engineers, 1985, p. 364-373. refs

Multiple model adaptive estimation is investigated as a means of changing the field-of-view as well as the bandwidth of an infrared image tracker against a wide dynamic range of targets. The multiple models are created by tuning the filters for best performance at differing conditions of exhibited target behavior and differing the physical size of their respective fields of view, and probabilistically weighted averaging provides the adaptation mechanism. Each filter involves online identification of the target shape function, so that this algorithm can be used against ill-defined and/or multiple-hot-spot targets. When each individual filter has the form of an enhanced correlator/linear Kalman filter, computational loading is very low, whereas an extended Kalman filter, processing the raw infrared data directly and assuming a nonlinear constant turn-rate target dynamics model provides superior tracking capability, especially for harsh maneuvers. Author

**A86-28390**  
**IMPLEMENTATION OF TF/TA IN THE DIGITAL TERRAIN MANAGEMENT AND DISPLAY SYSTEM**

P. WHITEMAN and G. L. MIZE (Harris Corp., Government Aerospace Systems Div., Melbourne, FL) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 1. New York, Institute of Electrical and Electronics Engineers, 1985, p. 531-537. Research supported by General Dynamics Corp.

The configuration of the digital terrain management and display system (DTMDS) is described. The functions of the database, output video, symbol generation, and autonomous navigation processings are analyzed. The algorithms for terrain avoidance (TA) and terrain following (TF) are studied. The development and maintenance of the local terrain elevation database for TA/TF are investigated; the access method for TA/TF to the DTMDS map is examined. Algorithm simulations and processor landing analyses of the TA/TF system are discussed. I.F.

## 06 AIRCRAFT INSTRUMENTATION

**A86-28463#**

### **EMBEDDED TRAINING AVIONICS INTEGRATION**

I. V. GOLOVCSENKO and A. J. BALAZS (USAF, Aeronautical Systems Div., Wright-Patterson AFB, OH) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 2. New York, Institute of Electrical and Electronics Engineers, 1985, p. 1120-1124. refs

Advanced concepts of embedded operational training are examined which future airborne system technology could support. Embedded training involves the shared use of operational and training equipment in an aircraft; it consists of embedding into aircraft systems (particularly the avionics) the capability to conduct airborne training operations including flight against on-board generated 'threats'. The cockpit of the 1990s will very likely be highly dependent of real-time computer generated displays, including heads-up, tactical situation, multisensor, helmet mounted and system status monitor displays. A variety of information, including terrain imagery, moving maps, threats, symbology, and pathways in the sky, will be integrated and presented. The Pave Pillar program is discussed as an example of an approach to a large highly integrated avionics system. Author

**A86-28464**

### **ONBOARD SIMULATION - A DEMONSTRATED TECHNOLOGY BREAKTHROUGH FOR COST EFFECTIVE TESTING AND TRAINING**

B. J. BRADY (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH), R. G. HUGHES (USAF, Human Resources Laboratory, Williams AFB, AZ), and J. H. CARLSON (McDonnell Aircraft Co., St. Louis, MO) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 2. New York, Institute of Electrical and Electronics Engineers, 1985, p. 1126-1131. refs

The aircrew training aspects of the Onboard Simulation system are examined. The baseline Onboard Simulation system was developed as part of the Air Force Integrated Flight/Fire Control (IFFC) program, as described by Lambert (1982). Training currently consists of a mix of academics, training devices including operational simulators, and flight training on local ranges and instrumented test ranges which provide for electronic warfare and composite force training. The use of Onboard Simulation, augmenting conventional simulation and range capabilities, will significantly increase pilot effectiveness and decrease future test and evaluation and training costs. D.H.

**A86-28465#**

### **DESIGN CONSIDERATIONS FOR ON-BOARD SIMULATION**

D. R. BREGLIA (U.S. Navy, Naval Training Equipment Center, Orlando, FL) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 2. New York, Institute of Electrical and Electronics Engineers, 1985, p. 1132-1137. refs

Design implications of embedded training for the F/A-18 aircraft (a multi-role, high performance, single-seat tactical aircraft) are discussed. The primary mission areas are: anti-air warfare; anti-surface warfare; strike warfare; amphibious warfare; mine warfare; mobility; and command, control, and communication. The current F/A-18 training syllabus is reviewed and those training events which can be supplemented and enhanced through the use of on-board simulation are identified. Five design approaches for embedded training systems are related to the training events. D.H.

**A86-28478**

### **ULTRASONIC LIQUID QUANTITY MEASUREMENT**

E. T. RUTLEDGE (Lockheed-Georgia Co., Marietta, GA) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 2. New York, Institute of Electrical and Electronics Engineers, 1985, p. 1236-1242.

Mechanical and electrical techniques are examined for measuring liquid quantities, by using ultrasonic generators as a signal source. Existing techniques for measuring liquid quantities in aircraft use transducers which are not only inaccurate and unreliable but which are frequently difficult to maintain. The techniques proposed for using ultrasonic transducers improve on all of the areas of deficiency and obviate the need for aircraft power in the fuel cells or other liquid containers. As a specific application of the technology, measurement of the engine oil quantity for the Lockheed-Georgia C-130 aircraft is considered. D.H.

**A86-28505**

### **ELECTRONIC DISPLAY LUMINANCE AND GREY SCALE CONTROL**

K. T. BURNETTE (Burnette Engineering, Fairborn, OH) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 2. New York, Institute of Electrical and Electronics Engineers, 1985, p. 1500-1510. refs  
(Contract F33615-81-C-3620; F33615-84-C-3627)

The role that luminance plays in making information depicted on military aircraft video displays both perceptible and interpretable by a pilot is explored. Particular design criteria issues are investigated that involve electronic display luminance and grey scale control: display luminance uniformity, sensor/video system signal transfer characteristics, display picture grey shade content, and the effects of cockpit illumination and glare source viewing conditions. D.H.

**A86-28506**

### **APPLICATION OF MAGNETO-OPTIC MODULATORS TO ADVANCED AVIONIC DISPLAYS**

A. J. MOFFAT, A. QUAGLIA, and R. C. BAJCAR (Litton Systems Canada, Ltd., Rexdale, Canada) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 2. New York, Institute of Electrical and Electronics Engineers, 1985, p. 1511-1518. refs

The magneto-optic light modulator (based on the Faraday effect) is examined as a means of significantly improving avionics displays for future aircraft. The light modulator has application to high brightness raster-scan projector systems suitable for use in head-up displays, head-down displays, and helmet mounted displays. The basic principles of the device and its characteristics are explained. D.H.

**A86-28507\*#** National Aeronautics and Space Administration. Flight Research Center, Edwards, Calif.

### **A CONSTANT ALTITUDE FLIGHT SURVEY METHOD FOR MAPPING ATMOSPHERIC AMBIENT PRESSURES AND SYSTEMATIC RADAR ERRORS**

T. J. LARSON and L. J. EHERNBERGER (NASA, Flight Research Center, Edwards, CA) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 2. New York, Institute of Electrical and Electronics Engineers, 1985, p. 1519-1526. Previously announced in STAR as N85-29951. refs

The flight test technique described uses controlled survey runs to determine horizontal atmospheric pressure variations and systematic altitude errors that result from space positioning measurements. The survey data can be used not only for improved air data calibrations, but also for studies of atmospheric structure and space positioning accuracy performance. The examples presented cover a wide range of radar tracking conditions for both subsonic and supersonic flight to an altitude of 42,000 ft. Author

A86-28511

**REAL-TIME CIRCLE GENERATION FOR RASTER DISPLAYS**

R. J. CARUSO (BDM Corp., Dayton, OH) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 2. New York, Institute of Electrical and Electronics Engineers, 1985, p. 1549-1555. refs

A new method of drawing circles in real time for aircraft displays is presented. If a fixed-size circle needs to be drawn over and over in a real-time display, most circle algorithms spend a significant amount of time recomputing a fixed set of relative points. The new method employs a circle primitive with run-time efficiency; it computes the points needed for an octant of the circle just once, then stores them in reduced form, and uses them as a template for the rest of the circle and for subsequent drawings of the same circle. The problem is analyzed and the algorithm is given.

D.H.

A86-28512

**PILOT/VEHICLE INTERFACE DESIGN SYSTEM (PIVIDS)**

R. D. MOORE and C. A. MOORE (Verac, Inc., San Diego, CA) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 2. New York, Institute of Electrical and Electronics Engineers, 1985, p. 1556-1563.

A concept for a rapid prototyping simulator for the cockpit display problem has been developed. Called the Pilot Vehicle Interface Design System, or PIVIDS, the system is a response to the problem of evaluating the pilot/vehicle interface with regard to complex, new multifunction displays. The F-16C/D cockpit, which has ten computers (communicating with each other over three multiplex buses) and a variety of display units, is considered as an example where PIVIDS can greatly aid the designer. The system is suited to a broad range of other applications.

D.H.

A86-28515

**THE CREW STATION INFORMATION MANAGER - AN AVIONICS EXPERT SYSTEM**

L. D. POHLMANN (Boeing Military Airplane Co., Wichita, KS), P. S. MARKS, and M. R. FEHLING (Advanced Information and Decision Systems, Mountain View, CA) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 2. New York, Institute of Electrical and Electronics Engineers, 1985, p. 1576-1582. refs

(Contract F33615-83-C-1083)

Progress to date is reported on the development of CSIM, the Crew Station Information Manager, which is a prototype avionics expert system being designed and developed under contract to the Air Force Avionics Laboratory. The function of CSIM is to manage the interface between the pilot and the avionics suite of a future tactical aircraft. A review is given of program motivation and objectives, and a set of avionics expert system candidates is identified. Preliminary development and early simulation are discussed, and near-term plans are outlined in connection with a contract extension sponsored by DARPA.

D.H.

A86-28516

**EXPERT SYSTEM PILOT AID**

J. R. JURGENSEN and R. E. FELDMANN (Systran Corp., Dayton, OH) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 2. New York, Institute of Electrical and Electronics Engineers, 1985, p. 1583-1590.

A status report is given for the Expert System Pilot Aid (ESPA) small-business contract with Air Force Avionics Laboratory to study the application of expert system programming techniques to the advanced fighter cockpit. Topics covered include: heuristics vs deterministic; expert system language selection (a modified OPS-5 language is chosen); and mission analysis (emergency scenarios: landing gear failures, engine failure at altitude, system failure during takeoff). A simulation evaluation of ESPA is to be made using the

Avionic System Analysis and Integration Laboratory (AVSAIL) facility at Wright Patterson Air Force Base. D.H.

A86-28842

**LANTIRN FLIGHT TEST - OPENING THE NIGHT WINDOW**

G. W. MATTHES (USAF, Flight Test Center, Edwards AFB, CA) Cockpit (ISSN 0742-1508), Oct.-Dec. 1985, p. 5-20.

The development and testing aspects of the Low Altitude Navigation and Targeting Infrared System for Night (LANTIRN) are discussed. The features and the capabilities of the three LANTIRN subsystems a Wide Angle Raster HUD, a navigation pod, and a targeting pod, are presented together with some testing results. Special attention is given to the testing of the LANTIRN's Navigation Pod and its components, the Environmental Control Unit, the Terrain Following Radar (TFR), and the infrared Fixed Imaging Navigation Sensor (FINS). The system integration testing of the Navigation Pod has shown that the combined effect of the easy to fly TFR guidance and the anticipation cues given by the FINS video make the operations of the night low level flying and weapon delivery, and the exercise of tactically sound egress techniques comparable with the same operations performed in the day low level flying.

I.S.

N86-20387 Department of the Air Force, Washington, D.C.

**ASYMMETRIC THRUST WARNING SYSTEM FOR DUAL ENGINE AIRCRAFT Patent**

W. W. STOCKTON, inventor (to Air Force) 8 Oct. 1985 4 p Supersedes AD-D010978

(AD-D011960; US-PATENT-4,546,353;

US-PATENT-APPL-SN-577412; US-PATENT-CLASS-340-966)

Avail: US Patent and Trademark Office CSCL 01D

An asymmetric thrust warning system for an aircraft having two gas turbine engines. The compressor discharge pressures of the two engines are compared to determine the engine providing the lower thrust and to provide a signal indicative of the actual difference in thrust. If the difference in thrust exceeds a prescribed value related to aircraft altitude, a low thrust warning lamp is illuminated. In addition, the positions of the two augmeter metering valves are compared. If their positions significantly differ, the warning light associated with the valve having the minimum opening will be illuminated. A stall warning circuit may also be included as a part of the system.

GRA

N86-20388# Air Force Inst. of Tech., Wright-Patterson AFB, Ohio. School of Systems and Logistics.

**AVIONICS STANDARDIZATION: PERCEPTIONS AND RECOMMENDATIONS M.S. Thesis**

J. A. FURRU Sep. 1985 139 p

(AD-A161709; AFIT/GSM/LSY/85S-11) Avail: NTIS HC

A07/MF A01 CSCL 15E

This research effort reflects the perceptions and attitudes about avionics standardization by some members of the acquisition community. All of the interviewees were knowledgeable on the subject of and many had extensive experience with, avionics standardization. They either were currently working or had previously worked with avionics standardization. The analysis reflects some of the attitudes about the policies and procedures of avionics standardization and the role of the Deputy for Avionics Control in the process of standardization. The analysis also includes recommended changes to the current process of standardizing avionics equipment. The result of the research effort shows that the acquisition community has not accepted avionics standardization for a number of reasons.

GRA

N86-20401# Marconi Avionics Ltd., Rochester (England). Flight Controls Div.

**DIGITAL FLY-BY-WIRE EXPERIENCE**

A. D. HILLS in AGARD Fault Tolerant Hardware/Software Architecture 8 p Sep. 1985 refs

Avail: NTIS HC A07/MF A01

A description of two recent GEC Avionics (GAv) systems is included: (1) A310 Slats and Flaps Control System; and (2) Jaguar FBW Demonstrator Flight Control System. Particular reference is

## 06 AIRCRAFT INSTRUMENTATION

made to the architecture of the computers and embedded software. Data is included on the two different system design requirements, especially those relating to integrity and availability. Emphasis is placed on the reasons for selecting dissimilarity, as an implementation philosophy, for the A310 system, as against the multiple similar Jaguar demonstrator architecture. The paper then provides a brief description of the design and development program for the two computer units with emphasis on lessons learned, specially in the software areas. The aspects of the system and computer design involved with maintainability and reliability are detailed and current in-service experience discussed where applicable. Conclusions are drawn particularly on dissimilarity, highlighting lessons learned from these successful FBW programs. A potential method of providing software fault tolerance within a dissimilar implementation is discussed and preliminary results of a GEC research program in this area provided. Author

**N86-20405#** Laboratoire d'Automatique et d'Analyse des Systemes, Toulouse (France).

### **DEPENDABLE AVIONIC DATA TRANSMISSION**

D. R. POWELL and J. C. VALADIER *In* AGARD Fault Tolerant Hardware/Software Architecture 19 p Sep. 1985 refs Sponsored in part by Direction des Recherches, Etudes et Techniques. Prepared in cooperation with Crouzet Aerospace and Systems, Valence, France, and Electronique Serge Dassault, St. Cloud, France  
Avail: NTIS HC A07/MF A01

This paper outlines the major constraints imposed on the design of dependable local area networks for avionic systems and underlines the essential differences in requirements that exist with respect to those of ground-based (civil) LANs. The different choices available to the system designer are then discussed: technology (electrical or optical), architecture (bus or loop), general philosophy (centralized or decentralized), medium access control (competition or consultation). The paper then goes on to summarize two different and independent avionic LAN research projects; one which focusses on fault and damage-tolerance and the other on high-speed. Author

**N86-20407#** Massachusetts Inst. of Tech., Cambridge. Lab. for Computer Science.

### **DESIGN ISSUES IN DATA SYNCHRONOUS SYSTEMS**

G. M. PAPADOPOULOS *In* AGARD Fault Tolerant Hardware/Software Architecture 12 p Sep. 1985 refs  
Avail: NTIS HC A07/MF A01

Fault tolerant data synchronous systems are ones where the outputs of all correctly operating redundant channels are guaranteed to bit-for-bit agree, independent of whether the channels are clock, instruction or frame synchronous. Data synchronous systems offer a form of fault tolerant processing capable of correctly supporting a very general class of programs. In fact, the redundancy becomes relatively transparent to the programmer of applications for data synchronous systems, making them ideally suited for complex, algorithmically intensive programs that would be otherwise impossible to support. The various aspects of the design of correct data synchronous systems are examined in detail. These include: Source consistency, the requirement that all correctly operating channels receive precisely the same inputs, Event synchronization, the problem of keeping the time skew between channels within predetermined bounds, as well system initialization. The unsolved problem of latent faults is also presented along with the need for self-test heuristics. Sequential fault tolerant and parallel fault tolerant approaches are contrasted for systems requiring protection from multiple faults. Both hardware and software solutions to these problems are given, emphasizing system performance and economy. The paper concludes with the application of these techniques to the design of triplex fail-operational and quadruplex and dual-dual fail-operational-fail-operational systems. Author

**N86-20408#** Northrop Corp., Hawthorne, Calif. Aircraft Div.

### **DIGITAL FAULT-TOLERANT FLIGHT ACTUATION SYSTEMS**

H. H. BELMONT *In* AGARD Fault Tolerant Hardware/Software Architecture 19 p Sep. 1985  
(Contract F33615-80-C-3623)  
(AFWAL-83-3041) Avail: NTIS HC A07/MF A01

A study was made of the equipments making up a typical flight control actuation system (servo electronics, servo valves, actuators and transducers) to determine where digital technology could replace analog technology for the purpose of providing a more fault-tolerant flight control actuation system. The investigation involved an analysis of where digital-to-analog conversion should take place between the light control computer and the analog control surface, and led to an evaluation of several architectural design issues. Among these were how to functionally partition the system, where to locate the servo electronics, the adequacy of military standard serial bus systems for control (versus data) applications, and the feasibility of providing electronics which could survive severe environments. Several actuation system configurations were evaluated. This led to recommending, as the best development prospect, a locally integrated actuation system consisting of servo electronics, servo valves, actuators, and transducers, interfacing with a digital flight control computer over a serial bus. Author

**N86-20409#** Honeywell Systems and Research Center, Minneapolis, Minn.

### **DESIGN VALIDATION OF FLY-BY-WIRE FLIGHT CONTROL SYSTEMS**

G. L. HARTMANN, J. E. WALL, JR., and E. R. RANG *In* AGARD Fault Tolerant Hardware/Software Architecture 17 p Sep. 1985 refs  
Avail: NTIS HC A07/MF A01

This paper addresses the problem of design validation of fault tolerant architectures. Finite-state machines are used to formally specify flight control functions. Their application is not new to engineering practice in flight control. However, it is believed that their systematic and formal use to form the structure of the system specification will be an aid in the design phase and in the validation phase. Examples are used to illustrate their application to flight control specifications. The second portion of this paper is concerned with the problem of testing highly reliable systems. Models based on fault-trees in the early definition phase of estimating reliability are used to design tests to be performed at the iron bird state (hardware in-the-loop). Confidence in the overall system reliability is derived from a combination of component life-tests and a careful evaluation of the faults that the system is designed to accommodate without loss of control. Author

**N86-21542#** Radio Technical Commission for Aeronautics, Washington, D. C.

### **MINIMUM OPERATIONAL PERFORMANCE STANDARDS FOR AIRBORNE DISTANCE MEASURING EQUIPMENT (DME) OPERATION WITHIN THE RADIO FREQUENCY RANGE OF 960-1215 MEGAHERTZ**

20 Sep. 1985 195 p refs  
(RTCA/DO-189; SC-149) Avail: NTIS HC A09/MF A01

Minimal operational performance standards for airborne distance measuring equipment (DME) operating within the radio frequency range of 960 to 1215 MHz are contained. Information needed to understand the rationale for equipment characteristics and requirements is stated along with the minimum performance standards for the equipment. These standards define required performance under standard operating conditions and stressed physical environmental conditions. The operational performance characteristics are described for equipment installations and conditions and tests that will assure the user that the equipment will perform safely and reliably in the expected operational environment are defined. A configuration of airborne equipment encompassing an antenna system, transmission lines, DME interrogator, interrogator control unit and interfaces with aircraft displays/systems are considered. B.G.

## 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.

**A86-26370****WILL 1990S AIRCRAFT BE POWERED BY PROPFAN OR ADVANCED TURBOFAN?**

D. J. HOLT Aerospace Engineering (ISSN 0736-2536), vol. 6, Feb. 1986, p. 8-12.

The evolution of the engine for a next generation aircraft is discussed, with a look at the Rolls Royce designs for the two principal possibilities, the propfan and the advanced turbofan. Fuel efficiency is the driving factor for the designs, with the propfan offering a 35 percent savings, and the 4th generation turbofan presenting the possibility of a 25 percent savings as compared to modern aircraft. The pusher propfan design uses the swept propeller, contra rotating propellers, and a geared propeller drive to balance propulsive efficiency and cruise speed against noise considerations. Additional 'building block' modifications, including a new exhaust port which exits after the blade, provide additional power and reduce the length down to 17 feet. In the turbofan, placing the fan behind the core engine to remove the low pressure shaft, and the use of a contra rotating fan driven by a contra rotating turbine, allows for a smaller diameter core, a low hub/tip ratio, a high rpm core, and a corresponding reduction in specific fuel consumption. It is concluded that choice of engine designs will be dictated by the future marketplace. R.R.

**A86-26371****PROPFAN ENGINE DESIGNS EXAMINED**

J. H. BRAHNEY Aerospace Engineering (ISSN 0736-2536), vol. 6, Feb. 1986, p. 17-22.

Considerations in the design of the fuel efficient medium-sized aircraft propfan engine, and various on-going developmental efforts are reviewed. Developed because of the propeller's historical 80 percent propulsive efficiency, the propfan utilizes more blades of shorter diameter that are thinner in section and larger in chord than conventional propellers. Limited tip speeds and rear mounting design minimize cabin noise. A rear-mounted counter-rotating propeller arrangement converts swirl energy into usable thrust and is 10 percent more efficient than a single-rotating configuration. The GE unducted fan (UDF) illustrates the less complex, shorter engine that results from the direct-drive approach. Gearing allows optimization of the turbine and propeller rotation rates (increasing their efficiency), and the flexibility of configuration for front and rear mounting. In the UDF, blade speed control and pitch change will be digitally controlled to optimize propulsion efficiency in all flight regimes. The ducted propfan, though two-thirds as efficient as an equivalent propfan, is projected to be more efficient than even an advanced turbofan and has application to larger, long-range airline aircraft. R.R.

**A86-26601#****NONLINEAR ANALYSIS OF PRESSURE OSCILLATIONS IN RAMJET ENGINES**

V. YANG (Pennsylvania State University, University Park) and F. E. C. CULICK (California Institute of Technology, Pasadena) AIAA, Aerospace Sciences Meeting, 24th, Reno, NV, Jan. 6-9, 1986. 13 p. Research supported by Pennsylvania State University. refs (Contract N00014-84-K-0434) (AIAA PAPER 86-0001)

Pressure oscillations in ramjet engines have been studied using an approximate method which treats the flow fields in the inlet and the combustor separately. The acoustic fields in the combustor are expressed as syntheses of coupled nonlinear oscillators corresponding to the acoustic modes of the chamber. The influences of the inlet flow appear in the admittance function at the

inlet/combustor interface, providing the necessary boundary conditions for calculation of the combustor flow. A general framework dealing with nonlinear multi-degree-of-freedom systems has also been constructed to study the time evolution of each mode. The results obtained serve as a basis for investigating the existence and stabilities of limit cycles for acoustic modes. As a specific example, the analysis is applied to a problem of nonlinear transverse oscillations in cylindrical combustors. Author

**A86-26902\*#** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

**FORCED RESPONSE ANALYSIS OF AN AERODYNAMICALLY DETUNED SUPERSONIC TURBOMACHINE ROTOR**

D. HOYNIK (NASA, Lewis Research Center, Cleveland, OH) and S. FLEETER (Purdue University, West Lafayette, IN) IN: Vibrations of blades and bladed disk assemblies; Proceedings of the Tenth Biennial Conference on Mechanical Vibration and Noise, Cincinnati, OH, September 10-13, 1985. New York, American Society of Mechanical Engineers, 1985, p. 1-13. NASA-supported research. refs

The effect of aerodynamic detuning on the supersonic flow induced forced response behavior of a turbomachine blade row is analyzed using an aeroelastic model. The rotor is modeled as a flat plate airfoil cascade representing an unwrapped rotor annulus; the aerodynamic detuning is achieved by alternating the circumferential spacing of adjacent rotor blades. The total unsteady aerodynamic loading on the blading, due to the convection of the transverse gust past the airfoil cascade as well as that resulting from the motion of the cascade, is developed in terms of influence coefficients. The model developed here is then used to analyze the effect of aerodynamic detuning on the flow induced forced response behavior of a twelve-bladed rotor with Verdon's Cascade B flow geometry. V.L.

**A86-26905\*#** Carnegie-Mellon Univ., Pittsburgh, Pa.

**THE EFFECT OF LIMITING AERODYNAMIC AND STRUCTURAL COUPLING IN MODELS OF MISTUNED BLADED DISK VIBRATION**

P. BASU and J. H. GRIFFIN (Carnegie-Mellon University, Pittsburgh, PA) IN: Vibrations of blades and bladed disk assemblies; Proceedings of the Tenth Biennial Conference on Mechanical Vibration and Noise, Cincinnati, OH, September 10-13, 1985. New York, American Society of Mechanical Engineers, 1985, p. 31-40. refs

(Contract NAG3-367)

A model has been developed for studying the effect of mistuning on bladed disk vibration which has the unique feature that the extent of aerodynamic and structural interaction which it simulates can be readily varied from full coupling of all blades on the disk to coupling of each blade with only its nearest neighbors. Simulations utilizing the resulting algorithm show that limited coupling models may be used to predict the statistical distribution of blade amplitudes that characterizes the mistuning effect, which in turn determines stage durability. This approach is used to study the effect of changing various system parameters on amplitude scatter. Gas density, the number of blades on the disk, disk stiffness, and the engine order of the excitation are considered. The results are used to draw some conclusions about how to improve laboratory tests and component design. Author

**A86-27271****ADVANCED STRUCTURAL COMPONENTS BY SPF/DB PROCESSING**

E. D. WEISERT (Ontario Technologies Corp., Menlo Park, CA) IN: Titanium: Science and technology; Proceedings of the Fifth International Conference on Titanium, Munich, West Germany, September 10-14, 1984. Volume 2. Oberursel, West Germany, Deutsche Gesellschaft fuer Metallkunde, 1985, p. 1221-1228.

An account is given of the development status of superplastically formed and diffusion-bonded (SPF/DB) Ti alloy structures, with attention to the design criteria and projective performance improvements contemplated in the application of SPF/DB to the production of aircraft gas turbine engine compressor and fan

## 07 AIRCRAFT PROPULSION AND POWER

blades. The alloys in question are Ti-6Al-4V, Ti-6Al-2Sn-4Zr-2Mo, Ti Code 12, and the developmental 'alpha-2' (lithium aluminate). The manufacturing process for a hollow fan blade is highlighted. Superior engine thrust/weight ratios are the primary goal of these development efforts. O.C.

### A86-27543

#### A LOSS OF DYNAMIC STABILITY OF THE TORSIONAL VIBRATIONS OF BLADES DUE TO CASCADE FLUTTER [POTERIA DINAMICHESKOI USTOICHIVOSTI KRUTIL'NYKH KOLEBANII LOPATOK, OBUSLOVLENNIAI RESHETOCHNYM FLATTEROM]

A. D. LEN, A. A. KAMINER, A. L. STELMAKH, and V. A. BALALAEV (AN USSR, Institut Problem Prochnosti, Kiev, Ukrainian SSR) Problemy Prochnosti (ISSN 0566-171X), Jan. 1986, p. 73-77. In Russian.

Results of a systematic study of the loss of dynamic stability of the torsional vibrations of a plane compressor cascade due to cascade flutter are reported. In the experiments, each cascade consisted of three mechanically uncoupled blades with independent electromagnetic excitation. Based on the results obtained, the Strouhal numbers are determined for various angles of attack and for various relative blade pitch and stagger values. V.L.

### A86-28317

#### A UNIFIED METHOD FOR EVALUATING THE STRENGTH AND RELIABILITY OF THE BLADES OF THE AXIAL-FLOW COMPRESSORS AND GAS TURBINES OF AIRCRAFT ENGINES [UNIFITSIROVANNYI METOD OTSENKI PROCHNOSTI I NADEZHNOSTI LOPATOK OSEVYKH KOMPRESSOROV I GAZOVYKH TURBIN AVIATIONNYKH DVIGATELEI]

V. V. KULESHOV IN: Problems in aircraft reliability. Moscow, Izdatel'stvo Mashinostroenie, 1985, p. 203-223. In Russian.

A unified mathematical model is proposed which relates the initial parameters of an aircraft engine to the geometrical parameters of a stage and strength and reliability parameters of the compressor and turbine blades of gas-turbine engines. Generalized expressions are obtained which relate the gas dynamic parameters and the strength characteristics of a blade. These expressions provide a convenient way to select blade parameters with allowance for specified engine parameters, design factors, and strength characteristics of the materials used. V.L.

### A86-28508

#### AIRCRAFT ELECTRICAL POWER SYSTEMS

E. D. BEAUCHAMP (AiResearch Manufacturing Co., Torrance, CA) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 2. New York, Institute of Electrical and Electronics Engineers, 1985, p. 1527-1535. refs

The potential is examined for powering future aircraft environmental control systems (ECSs) by means of electric drives rather than by main-engine bleed air (which may not be as available in the next generation of engines). Several aspects of electric systems of permanent magnet, brushless induction machines and solid-state power electronics - to provide primary generation or secondary control of electric drives on aircraft - are discussed. For power distribution, conventional 120/208-V, 3-phase, 400-Hz, 270-Vdc, variable frequency/constant voltage, and variable frequency/variable voltage systems are the primary candidates. Specific examples on 270-Vdc power generation, variable speed drives for an ECS compressor and fan motors, and a variable speed drive for an engine fuel pump system are included. D.H.

**N86-20389\*** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

#### METHOD FOR IMPROVING THE FUEL EFFICIENCY OF A GAS TURBINE ENGINE Patent

G. A. COFFINBERRY, inventor (to NASA) (General Electric Co., Cincinnati, Ohio) 5 Nov. 1985 8 p 30 Aug. 1982 (NASA-CASE-LEW-13142-2; US-PATENT-4,550,561; US-PATENT-APPL-SN-413101; US-PATENT-CLASS-60-39.02; US-CLASS-60-39.07; US-PATENT-CLASS-60-736) Avail: US Patent and Trademark Office CSCL 21E

An energy recovery system is provided for an aircraft gas turbine engine of the type in which some of the pneumatic energy developed by the engine is made available to support systems such as an environmental control system. In one such energy recovery system, some of the pneumatic energy made available to but not utilized by the support system is utilized to heat the engine fuel immediately prior to the consumption of the fuel by the engine. Some of the recovered energy may also be utilized to heat the fuel in the fuel tanks. Provision is made for multiengine applications wherein energy recovered from one engine may be utilized by another one of the engines or systems associated therewith.

Official Gazette of the U.S. Patent and Trademark Office

**N86-21543\*#** National Aeronautics and Space Administration, Washington, D.C.

#### HIGH FREQUENCY-HEATED AIR TURBOJET

J. H. D. MIRON Feb. 1986 12 p Transl. into ENGLISH of Spanish Patent no. 293,727 (21 Nov. 1983) p 1-10 Transl. by Scientific Translation Service, Santa Barbara, Calif. (Contract NASW-4004)

(NASA-TM-77710; NAS 1.15:77710) Avail: NTIS HC A02/MF A01 CSCL 21E

A description is given of a method to heat air coming from a turbojet compressor to a temperature necessary to produce required expansion without requiring fuel. This is done by high frequency heating, which heats the walls corresponding to the combustion chamber in existing jets, by mounting high frequency coils in them. The current transformer and high frequency generator to be used are discussed. Author

**N86-21547#** Air Force Inst. of Tech., Wright-Patterson AFB, Ohio. School of Systems and Logistics.

#### JET ENGINE OPERATING AND SUPPORT COST ESTIMATING RELATIONSHIP DEVELOPMENT M.S. Thesis

B. H. COX Sep. 1985 106 p (AD-A161683; AFIT/GSM/LSY/85S-8) Avail: NTIS HC A06/MF A01 CSCL 14A

This investigation derived a jet engine Cost Estimating Relationship (CER) model from multivariate linear regression techniques. Prior to the model's development, all known jet engine cost data bases were examined for applicability to the thesis effort. After identifying constraints and limitations in the data, stepwise regression equations for analysis. The best equation was identified base on pre-established logic and statistical criteria. The equation selected had the following performance, physical, and usage variables: Turbine Inlet Temperature, Specific Fuel Consumption, Weight, and Annual Engine Flying Hours. Results of the model development can be used in comparative cost analyses of present and proposed weapon systems; in cost trade-off studies to determine impact of design alternatives for new engines; in reports to Congress on the costs of operating engines; and in estimating budget requirements. GRA

**N86-21548#** Department of the Air Force, Washington, D.C.

#### DUAL MATERIAL EXHAUST NOZZLE FLAP Patent Application

D. O. NASH, inventor (to Air Force) 1 Oct. 1985 19 p (AD-D011998; US-PATENT-APPL-SN-782332) Avail: NTIS HC A02/MF A01 CSCL 21E

This patent application discloses an exhaust nozzle flap capable of resisting high exhaust temperatures of turbojet engines. The flap is composed of a two-part structure of high strength metal, in a support member, combined with a heat resistant base member

made from a ceramic or carbon-carbon material. The different materials in the base and support members, having substantially different rates of thermal expansion, are not bolted or riveted together, but attached in a unique manner to allow relative movement therebetween. GRA

## 08

## AIRCRAFT STABILITY AND CONTROL

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

**A86-26586**  
**LOW-SPEED STABILITY CHARACTERISTICS OF A HELICOPTER WITH A SLING LOAD**

B. L. NAGABHUSHAN (Goodyear Aerospace Corp., Akron, OH) *Vertica* (ISSN 0360-5450), vol. 9, no. 4, 1985, p. 345-361. refs

The low-speed stability characteristics of a conventional helicopter with an external sling load on a single-point suspension are investigated using an 18th order dynamic model of the two-body system. Nonlinear equations of motion are derived which describe the six degrees of freedom rigid body motion of the helicopter, including its rotor dynamics, coupled with the longitudinal and lateral dynamics of the sling load. Significant differences, including instability and cross-coupling in the associated pendulous motion of the sling load and the inherent oscillatory motions of the helicopter, are found between operation with a short and long sling cable. Operation with a long sling cable damps out the sling-load lateral oscillation and the helicopter longitudinal phugoid, but the associated sling-load pitch oscillation and helicopter Dutch roll mode become unstable. Suspending the sling load from a point ahead of the center of gravity stabilizes the helicopter lateral oscillation, while suspending it from a point aft of the c.g. causes instability in that mode. C.D.

**A86-26629\*#** Texas A&M Univ., College Station.  
**AN EXPERIMENTAL STUDY OF THE LIFT, DRAG AND STATIC LONGITUDINAL STABILITY FOR A THREE LIFTING SURFACE CONFIGURATION**

C. OSTOWARI and D. NAIK (Texas A&M University, College Station) *AIAA, Aerospace Sciences Meeting, 24th, Reno, NV, Jan. 6-9, 1986.* 13 p. refs

(Contract NAG1-344)  
 (AIAA PAPER 86-0398)

The experimental procedure and aerodynamic force and moment measurements for wind tunnel testing of the three lifting surface configuration (TLC) are described. The influence of nonelliptical lift distributions on lift, drag, and static longitudinal stability are examined; graphs of the lift coefficient versus angle of attack, the pitching moment coefficient, drag coefficient, and lift to drag ratio versus lift coefficient are provided. The TLC data are compared with the conventional tail-aft configuration and the canard-wing configuration; it is concluded that the TLC has better lift and high-lift drag characteristics, lift to drag ratio, and zero-lift moments than the other two configurations. The effects of variations in forward and tail wind incidence angles, gap, stagger, and forward wind span on the drag, lift, longitudinal stability, and zero-lift moments of the configuration are studied. I.F.

**A86-26642#**  
**REALTIME PILOTED SIMULATION INVESTIGATION OF HELICOPTER FLYING QUALITIES DURING APPROACH AND LANDING ON NONAVIATION SHIPS**

W. F. JEWELL, W. F. CLEMENT (Systems Technology, Inc., Mountain View, CA), and J. B. JOHNS (U.S. Naval Material Command, Naval Air Development Center, Warminster, PA) *AIAA, Aerospace Sciences Meeting, 24th, Reno, NV, Jan. 6-9, 1986.* 9 p. refs

(Contract N62269-82-C-0728)  
 (AIAA PAPER 86-0490)

The Naval Air Development Center (NADC) is revising the Helicopter Flying and Ground Handling Qualities Specification, MIL-H-8501A. As a part of this effort, an investigation is conducted of aspects of helicopter flight dynamics which are unique to Navy operational requirements. Clement and Jewell (1985) have discussed a piloted simulation study of helicopter shipboard landing which had been conducted in connection with this investigation. This paper is essentially a condensation of this discussion. Attention is given to a helicopter mathematical model, the Vertical Motion Simulator (VMS), the environmental conditions, and the simulation protocol. The technical approach is considered along with baseline flying quality ratings, the effect of sea state, the flying qualities rating boundaries, lateral control problems, and visual cues and texture. G.R.

**A86-27081**  
**MATHEMATICAL MODELS FOR STUDYING AIRCRAFT VIBRATIONS WITH ALLOWANCE FOR STRUCTURAL HYSTERESIS [MATEMATICHESKIE MODELI DLIA ISSLEDOVANIJA KOLEBANII SAMOLETA S UCHETOM KONSTRUKSIONNOGO GISTEREZISA]**

A. N. KOBTSEV *IN: Energy dissipation connected with vibrations of mechanical systems. Kiev, Izdatel'stvo Naukova Dumka, 1985, p. 83-90. In Russian.*

Mathematical models are presented which have been developed for the analysis of the dynamic loading of nonlinearly elastic aircraft during their arbitrary spatial motion. The models proposed here reproduce the nonlinear properties of the chassis and the internal damping of the aircraft structure. Some modeling results are presented, with particular attention given to the effect of hysteresis and damping parameters on the dynamic loading and fatigue damage of the airframes of several kinds of commercial aircraft. V.L.

**A86-27446**  
**MATRIX EQUATIONS OF THE SPATIAL FLIGHT OF AN ASYMMETRICAL RIGID BODY [MATRICHNYE URAVNENIJA PROSTRANSTVENNOGO POLETA ASIMMETRICHNOGO TVERDOGO TELA]**

V. V. KRAVETS (Dnepropetrovskii Institut Inzhenerov Zheleznodorozhnogo Transporta, Dnepropetrovsk, Ukrainian SSR) *Prikladnaia Mekhanika* (ISSN 0032-8243), vol. 22, Jan. 1986, p. 105-110. In Russian. refs

Matrix equations describing the dynamics of the spatial flight of an asymmetrical rigid body are proposed whose variables include quasi-velocities and the Rodrigues-Hamilton parameters. The dynamic equations and other auxiliary relationships are expressed in terms of unified matrices, which makes the equations well-organized, compact, and convenient in programming, providing for more efficient use of computers. V.L.

## 08 AIRCRAFT STABILITY AND CONTROL

**A86-27659\*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

### **EFFECTS OF SIDE-STICK CONTROLLERS ON ROTORCRAFT HANDLING QUALITIES FOR TERRAIN FLIGHT**

E. W. AIKEN (NASA, Ames Research Center, U.S. Army, Aeromechanics Laboratory, Moffett Field, CA) IN: International Conference on Rotorcraft Basic Research, Research Triangle Park, NC, February 19-21, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, 11 p. Previously announced in STAR as N85-25267. refs

Pertinent fixed and rotary-wing feasibility studies and handling-qualities research programs are reviewed and the effects of certain controller characteristics on handling qualities for specific rotorcraft flight tasks are summarized. The effects of the controller force-deflection relationship and the number of controlled axes that are integrated in a single controller are examined. Simulation studies were conducted which provide a significant part of the available handling qualities data. The studies demonstrate the feasibility of using a single, properly designed, limited-displacement, multi-axis controller for certain relatively routine flight tasks in a two-crew rotorcraft with nominal levels of stability and control augmentation with a high degree of reliability are incorporated, separated three or two-axis controller configurations are required for acceptable handling qualities. Author

**A86-27660#**

### **THE DEVELOPMENT OF MICROCOMPUTER CODES FOR STUDYING THE FLIGHT DYNAMICS AND PERFORMANCE OF HELICOPTERS**

B. W. MCCORMICK (Pennsylvania State University, University Park) and R. P. HENNIS (U.S. Navy, Naval Surface Weapons Laboratory, Dahlgren, VA) IN: International Conference on Rotorcraft Basic Research, Research Triangle Park, NC, February 19-21, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, 11 p.

A sequence of computer codes for predicting the dynamic behavior of a single rotor/tail rotor helicopter is described. Four basic codes are described, each of which can be run on current minicomputers. A static trim program calculates the control angles and the helicopter angle of attack, and a dynamic program numerically integrates the Euler equations of motion to fly a prescribed maneuver. A third program determines stability derivatives which are then used in the fourth program to analyze the helicopter stability. The latter program generates root loci as a function of stabilizing and control feedback gains. The programs include possible contributions from a stub wing and a horizontal tail with an angle of incidence which can be linked to the longitudinal cyclic pitch. Reasonable agreement is found between predicted results and flight tests simulating the launching of a ballistic rocket. C.D.

**A86-27662#**

### **DYNAMIC STABILITY OF HINGELESS AND BEARINGLESS ROTORS IN FORWARD FLIGHT**

I. CHOPRA (Maryland, University, College Park) and B. PANDA IN: International Conference on Rotorcraft Basic Research, Research Triangle Park, NC, February 19-21, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, 16 p. refs (Contract DAAG29-83-K-0002)

The successful application of the finite element method based on Hamilton's principle to determine the response and dynamic stability of hingeless and bearingless rotor blades in forward flight is reported. Four beam elements were sufficient to obtain satisfactory response and stability solutions for a hingeless rotor blade, while six elements were needed for a bearingless rotor blade. For response normal mode equations, six rotating modes were adequate for both hingeless and bearingless blades. The vibratory amplitude and mean level of response depend on the advance ratio and the blade structural stiffness. Stability results are obtained for both soft-inplane and stiff-inplane rotors using elastic blade modeling. The effect of dynamic inflow on blade stability in hingeless and bearingless rotors is discussed. C.D.

**A86-27664#**

### **KINEMATIC OBSERVERS FOR ROTOR CONTROL**

R. M. MCKILLIP, JR. (Princeton University, NJ) IN: International Conference on Rotorcraft Basic Research, Research Triangle Park, NC, February 19-21, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, 10 p. refs

A simple scheme for estimating the state variables of a helicopter rotor is presented. The method incorporates the use of blade-mounted accelerometers and position transducers to reconstruct modal displacements and velocities. The design of the observer structure and feedback gains is simplified by the fact that the method requires only knowledge of simple kinematic relationships between the various modal quantities. This observer structure is particularly well-suited to control problems where the use of a traditional Kalman Filter would be too complex or costly. The technique can be viewed as decreasing the requirements on observer complexity while increasing the need for an enhanced sensor complement. Author

**A86-28377**

### **QUANTITATIVE FEEDBACK DESIGN APPROACH TO PILOT-IN-THE-LOOP ANALYSIS**

P. WEI (Lockheed-Georgia Co., Marietta, GA) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 1 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 416-423.

The quantitative feedback technique of Horowitz et al. (1980) is applied, in conjunction with the Neal-Smith criterion, to the pilot-in-the-loop flight control system design. The uncertain control plants are developed by varying the pilot model parameters and pilot compensation work, and the boundaries of the system performance requirements are specified on the basis of the Neal-Smith criterion. As an example, a shaping filter is designed to improve the flying qualities from a possible Level 3 to a definite Level 1. I.S.

**A86-28378**

### **DISCRETE MANEUVER FLYING QUALITIES CONSIDERATIONS IN CONTROL SYSTEM DESIGN**

E. D. ONSTOTT and J. S. WARNER (Northrop Corp., Aircraft Div., Hawthorne, CA) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 1 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 424-430. Research supported by Northrop Independent Research and Development Program. refs

An analysis of published NT-33 flight test data, a ground-based flight simulation, and time domain pilot/aircraft modeling techniques have shown that the criteria used in the established models may not be sufficiently responsive to the full range of piloted control activity. Large-amplitude, abrupt attitude changes must be specifically considered. An analytical method has been developed using parameters that describe discrete pilot activities. As an example, an actuator rate saturation problem is analyzed. I.S.

**A86-28379**

### **DEVELOPMENT OF HARDWARE FOR X-29A FLIGHT CONTROL SYSTEM**

J. DANNENHOFFER (Grumman Aerospace Corp., Bethpage, NY) and J. LINDAHL (Honeywell Inc., St. Louis Park, MN) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 1 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 440-445. refs

The forward swept wing X-29 aircraft's sensor computer subsystem hardware maintains the lowest possible system costs through the use of off-the-shelf components. A triplex digital system together with triplex analog backup are used to satisfy fail-safe requirements, using extensive self-test and input/output comparisons to satisfy the requirements for a flight safety-oriented system. Attention is presently given to the methods by means of



which system requirements were converted into the triplexed hardware, as well as to flightworthiness test results. O.C.

**A86-28380#**  
**MULTIVARIABLE CONTROL LAW DESIGN FOR THE AFTI/F-16 WITH A FAILED CONTROL SURFACE**

R. A. ESLINGER (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) and J. J. DAZZO (USAF, Institute of Technology, Wright-Patterson AFB, OH) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 1. New York, Institute of Electrical and Electronics Engineers, 1985, p. 453-459. refs

The utilization of Porter's multivariable design technique (1981) to develop self-repairing flight control laws that allow the aircraft to maintain stability following a control surface failure is discussed. Linear state space models are created for a healthy F-16 aircraft and an F-16 with a free-floating right horizontal tail. The application of the Porter technique and the state equations to the model designs is described. The checking for transmission and decoupling zeros in the system with the computer program ZERO and the formation of control design laws with the program MULTI are examined. The responses of the models to longitudinal maneuvers (g-command, pitch pointing, and longitudinal translation) and lateral maneuvers (roll, sideforce, yaw pointing, and lateral translation) are evaluated. It is observed that the longitudinal and lateral maneuvers in the control surface failed aircraft are maintained with the control design laws applied to the models. It is concluded that the Porter method is useful in designing aircraft flight control systems which retain stability after control surface failure. I.F.

**A86-28384**  
**AN INTEGRATED FLIGHT CONTROL SYSTEM FOR A STOL TRANSPORT AIRCRAFT**

P. BRIGGS, L. GARDNER (Sperry Corp., New York), and T. G. WOOD (Lockheed-Georgia Co., Marietta) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 1. New York, Institute of Electrical and Electronics Engineers, 1985, p. 482-489. refs

The development of a flight control system (FCS) for short takeoff and landing (STOL) aircraft using the High Technology Test Bed is studied. The main requirements for the future FCS are: (1) autonomous STOL capability, (2) automatic flight path control, (3) control reconfiguration, and (4) a ground-based maintenance diagnostics system; advances in these areas are discussed. The control of the spoilers and tail surface by the DFCS utilizing fail-operational roll stability and control augmentation, direct lift control, fail-operational yaw and pitch stability and control augmentation, and five dual electromechanical actuator systems is described. The input signal management, actuator signal management, synchronization, error handling, power-up reset and recovery, and the built-in test capabilities of the redundancy management of the DFCS are examined. The functional organization of the DFCS is explained. I.F.

**A86-28386**  
**VARIABLE CONTROL POLICIES FOR FUTURE AEROSPACE VEHICLES**

F. R. GILL and K. W. ROSENBERG (GEC Avionics, Ltd., Rochester, England) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 1. New York, Institute of Electrical and Electronics Engineers, 1985, p. 500-506. refs

There exists a class of variable control policies with which all dynamic properties of a system are improved compared with the best achievable with conventional linear control. Examples of variable feedback and feedforward controllers are discussed and a new failure testing hypothesis is introduced. Author

**A86-28387**  
**DESIGN OF DIRECT DIGITAL FLIGHT-MODE CONTROL SYSTEMS FOR HIGH-PERFORMANCE AIRCRAFT USING STEP-RESPONSE MATRICES**

B. PORTER (Salford, University, England) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 1. New York, Institute of Electrical and Electronics Engineers, 1985, p. 507-513. refs

(Contract SERC-GR/C/77653)

In this paper, fast-sampling error-actuated direct digital flight-mode control systems are designed for the F-16 aircraft using only the appropriate step-response matrix of the compensated open-loop aircraft instead of the first Markov parameter. It is shown that the resulting digital controllers exhibit set-point tracking characteristics which compare favorably with those of direct digital flight-mode controllers previously designed using a mathematical model of the aircraft in state-space form. Since step-response matrices can be readily determined from direct input-output measurements in the time domain, a basis is thus provided for the synthesis of adaptive self-repairing digital flight control systems operating in real time. Author

**A86-28392**  
**DETECTION AND ISOLATION OF CONTROL SURFACE EFFECTIVENESS FAILURES IN HIGH PERFORMANCE AIRCRAFT**

J. L. WEISS, A. S. WILLISKY, D. P. LOOZE, J. T. CRAWFORD (ALPHATECH, Inc., Burlington, MA), and R. R. HUBER (General Electric Co., Aircraft Control Systems Dept., Binghamton, NY) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 1. New York, Institute of Electrical and Electronics Engineers, 1985, p. 552-559. refs

This paper presents the design of a failure detection and identification (FDI) algorithm for flight control system failures. This algorithm, which is a key component in an overall fault-tolerant control strategy, is based on analytic redundancy and follows the decentralized philosophy which was originally developed and applied to dual redundant sensor FDI systems on the F-8 aircraft. This philosophy, which is generalized and extended here, addresses the problems associated with 'real-world' model errors. Test results using a nonlinear six-degree-of-freedom aircraft simulation are presented to demonstrate the algorithm's performance. Author

**A86-28393**  
**EVALUATION OF CONTROL MIXER CONCEPT FOR RECONFIGURATION OF FLIGHT CONTROL SYSTEM**

K. S. RATTAN (Wright State University, Dayton, OH) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 1. New York, Institute of Electrical and Electronics Engineers, 1985, p. 560-569. refs

(Contract F49620-82-C-0035)

Reconfiguration of flight control law after effector failure is studied in this paper. The objective of this paper is to evaluate the control mixer concept which utilizes generalized inverse to distribute control authority among the remaining effectors after failure. The unmanned research vehicle (URV) was selected as a test bed for evaluating this concept. A mathematical model containing split surfaces and linearized equations of motion for coupled longitudinal and lateral-direction axes is developed. Control mixer gain matrices are obtained for failed surfaces and a comparison of the unimpaired and reconfigured aircraft responses is made using the Continuous System Modeling Program (CSMP). Difficulties encountered with the generalized inverse based control mixer concept are discussed. Author

## 08 AIRCRAFT STABILITY AND CONTROL

**A86-28394\*** Alphatech, Inc., Burlington, Mass.  
**AN AUTOMATIC REDESIGN APPROACH FOR  
RESTRUCTURABLE CONTROL SYSTEMS**

D. P. LOOZE, J. L. WEISS, J. S. ETERNO, and N. M. BARRETT  
(ALPHATECH, Inc., Burlington, MA) IN: NAECON 1985;  
Proceedings of the National Aerospace and Electronics  
Conference, Dayton, OH, May 20-24, 1985. Volume 1. New York,  
Institute of Electrical and Electronics Engineers, 1985, p.  
570-577. refs

(Contract NAS1-17411)

This paper presents an approach to the automatic redesign of flight control systems for aircraft that have suffered one or more control element failures. The procedure is based on Linear Quadratic design techniques, and produces a control system that maximizes a measure of feedback system performance subject to a bandwidth constraint. Author

**A86-28395**  
**YF16CCV FLIGHT CONTROL SYSTEM RECONFIGURATION  
DESIGN USING QUANTITATIVE FEEDBACK THEORY**

I. HOROWITZ (Weizmann Institute of Science, Rehovot, Israel),  
P. B. ARNOLD (USAF, Test Pilot School, Edwards AFB, CA), and  
C. H. HOUPIS (USAF, Institute of Technology, Wright-Patterson  
AFB, OH) IN: NAECON 1985; Proceedings of the National  
Aerospace and Electronics Conference, Dayton, OH, May 20-24,  
1985. Volume 1. New York, Institute of Electrical and Electronics  
Engineers, 1985, p. 578-585. refs

A fixed compensation design theory is presented for achieving flight control performance, despite one or more simultaneous failures, hardover and varying flight conditions. No identification is used. The theory is a natural extension of Quantitative Feedback Theory (QFT) for uncertain systems, and clearly reveals the cost of feedback needed. This enables the designer to make intelligent trade-offs between fixed compensation, scheduling and identification-adaptation. Identification, when it is necessary, can be done more slowly and accurately if a QFT design is made so the system is at least stable over many simultaneous failures. The theory is applied to the YF16CCV model with elevators and flaperons for pitch and roll rate control. Author

**A86-28396**  
**LOCKHEED-GEORGIA AND ELECTRIC PRIMARY FLIGHT  
CONTROL SYSTEMS**

K. THOMPSON, R. ALDEN (Lockheed-Georgia Co., Marietta), and  
L. HUNTER (USAF, Flight Dynamics Laboratory, Wright-Patterson  
AFB, OH) IN: NAECON 1985; Proceedings of the National  
Aerospace and Electronics Conference, Dayton, OH, May 20-24,  
1985. Volume 1. New York, Institute of Electrical and Electronics  
Engineers, 1985, p. 588-595. refs

The designs of various electric actuation systems (EASs) are studied. The components and functions of the C-141 dual channel EAS for the aileron are described. The system operation/fault monitoring of the two channels of the EAS are examined. The performance capabilities of the EAS are compared to a hydraulic power control actuation system. The utilization of EASs to improve STOL capabilities, aircraft survivability, flight stations, and integrated control and avionics is being studied in the High Technology Test Bed program. The development of an electric rudder tab control actuation system and a yaw stability and control augmentation system is analyzed. I.F.

**A86-28401**  
**MICROPROCESSOR CONTROLLED AND MANAGED  
FLY-BY-WIRE HYDRAULIC ACTUATOR**

C. C. CHENOWETH and D. B. SLAUGH (Boeing Military Airplane  
Co., Seattle, WA) IN: NAECON 1985; Proceedings of the National  
Aerospace and Electronics Conference, Dayton, OH, May 20-24,  
1985. Volume 1. New York, Institute of Electrical and Electronics  
Engineers, 1985, p. 628-632.

During the past few years, the greatest technological advances in the aerospace industry have been associated with aircraft flight controls. In connection with these advances, mechanical systems are being replaced by fly-by-wire systems in which the pilot is

linked to an array of actuators through a central aircraft control computer complex. A new actuation technology development is presented, taking into account the use of microprocessor-based actuation controllers communicating with aircraft-control computers over digital data buses. Attention is given to the advantages of fly-by-wire systems, aspects of smart actuator development, and future plans. G.R.

**A86-28490\*** E-Systems, Inc., Dallas, Tex.  
**AN EXPERT PLANNER FOR THE DYNAMIC FLIGHT  
ENVIRONMENT**

D. C. CHEN (E-Systems, Inc., Garland Div., Dallas, TX) IN:  
NAECON 1985; Proceedings of the National Aerospace and  
Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 2  
. New York, Institute of Electrical and Electronics Engineers, 1985,  
p. 1347-1354. refs

(Contract NAG1-288; F49620-82-K-0009)

This paper presents a robust robot planner that functions in the complex and dynamic flight domain. The robot pilot flies an aircraft between two airports and can adjust in flight to changes in the environment such as closed destination airport, thunderstorm in the flight path, and failed engine. The planner adjusts to the world changes by locally patching around the break point instead of complete re-planning. The planning architecture is based on the vertical decomposition of domain knowledge, resulting in shallow planning and recovery planning. This robot flight planner can be utilized as the front end of an intelligent flight monitor. The flight planner dynamically generates the references that are used to determine whether the flight crew should be notified of potential problems. The implementation of this robot planner is also discussed. Author

**A86-28498**  
**KNOWLEDGE ENGINEERING FOR A FLIGHT MANAGEMENT  
EXPERT SYSTEM**

B. M. ANDERSON, J. M. BEAL, C. MCNULTY, and R. C. STERN  
(Texas Instruments, Inc., Dallas) IN: NAECON 1985; Proceedings  
of the National Aerospace and Electronics Conference, Dayton,  
OH, May 20-24, 1985. Volume 2. New York, Institute of Electrical  
and Electronics Engineers, 1985, p. 1431-1435. refs

The development of an F-16 emergency procedures knowledge base for EPES (emergency procedures expert system) is described. A detailed view of the knowledge acquisition problems is presented, followed by a methodology for efficiently building a knowledge base for emergency procedures. A multiple emergency example is considered (loss of canopy and towershaft failure while cruising at 400 knots above 40,000 feet), where the inference engine resolves a conflict in procedures. D.H.

**A86-28499#**  
**PATH-FINDER - AN HUERISTIC APPROACH TO AIRCRAFT  
ROUTING**

C. S. LIZZA and G. LIZZA (USAF, Wright Aeronautical Laboratories,  
Wright-Patterson AFB, OH) IN: NAECON 1985; Proceedings of  
the National Aerospace and Electronics Conference, Dayton, OH,  
May 20-24, 1985. Volume 2. New York, Institute of Electrical and  
Electronics Engineers, 1985, p. 1436-1443. refs

A solution is examined for the problem of developing an effective computer algorithm to route aircraft through hostile enemy defenses. The problem was proposed to assist in studies of the impact of varied, onboard countermeasures upon preplanned aircraft routes. The quality of a route can be defined in terms of the cost of interaction between the aircraft and threats encountered along the path. Current methods of automated routing are either inefficient or produce unsatisfactory results. Beginning with a more general description of the problem, a solution is detailed for developing routes by using the AI technique of heuristic search in an A(asterisk) algorithm. The algorithm uses heuristics based upon estimates of the degree of threat interactivity and distance from a point to the goal. Due to the nature of the heuristic, the A(asterisk) algorithm cannot guarantee development of a least-cost path, but the heuristic can be adjusted to ensure reasonably good results in most cases. The flexibility of the algorithm allows application to

the specific aircraft routing problem and to other route planning tasks. D.H.

**A86-28509**

**FLYING QUALITIES DESIGN CRITERIA FOR HIGHLY AUGMENTED SYSTEMS**

D. J. MOORHOUSE (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) and W. A. MORAN (McDonnell Aircraft Co., St. Louis, MO) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 2. New York, Institute of Electrical and Electronics Engineers, 1985, p. 1536-1545. refs

Interpretation and application of the military flying qualities specification, MIL-F-8785C, as the best guide to excellent flying qualities, is suggested. A summary is given of the government's flight control requirements of the Statement of Work of the STOL and Maneuver Technology Demonstration Program (SMTDP). The program contractor, McDonnell Aircraft Company, has had recent experience developing the digital flight control system of the F/A-18A. Lessons learned from that development are used to define the appropriate interpretations of specific requirements in MIL-F-8785C. These are expressed as preliminary detailed flying qualities criteria for the SMTDP, plus 'second tier' criteria to be used for additional design guidance. D.H.

**A86-28510#**

**MULTIVARIABLE CONTROL LAW DESIGN FOR THE X-29 AIRCRAFT**

J. J. DAZZO and T. L. COURTHEYN (USAF, Institute of Technology, Wright-Patterson AFB, OH) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 2. New York, Institute of Electrical and Electronics Engineers, 1985, p. 1546, 1547.

Flight control laws have been developed for the X-29 forward swept wing demonstrator aircraft, using a design technique based on a multivariable control law theory. The computer-aided design program called MULTI is used to develop and refine the control laws. MULTI also simulates the complete closed-loop control system and generates appropriate time response plots for analysis. Control laws are developed to stabilize the aircraft and to perform longitudinal maneuvers (direct climb, vertical translation, and pitch pointing) at three different flight conditions. The use of a proportional plus integral control law for a digital output feedback flight control system produced very good performance. The ability to incorporate actuator dynamics and computational time delay in the control law generation adds to the design capability. Investigation of further applications is warranted. D.H.

**A86-29058**

**ADVANCING FLIGHT CONTROL TECHNOLOGY**

H. BERMAN (Grumman Aerospace Corp., Bethpage, NY) Horizons (ISSN 0095-7615), vol. 21, no. 3, 1985, p. 14-21.

The development of fly-by-wire (FBW) controls for aircraft has been driven by the need to augment the muscular power expended by pilots to control their aircraft, to provide increasingly greater maneuverability, and to lower the weight penalty of the control mechanisms. The X-29, with a 35 percent negative margin of static stability, is the cutting edge of FBW technology. The reduced stability of the X-29 furnishes the desired enhanced maneuverability, and can only work if the aircraft is continuously under computer control. The X-29 stability is maintained by control adjustment inputs at 40 times per second in a manner transparent to the pilot. The computer is fed a constant stream of flight status data which is analyzed to make the control decisions by means of a polling procedure among three on-board computers. The forward swept supercritical wings of the X-29 are equipped with two-segment trailing edge flaps that make the wings variable camber so the computers can vary the lift/drag characteristics of the wings in-flight. The experimental aircraft is also serving as a testbed for reconfigurable controls which would compensate for the presence of damaged control surfaces, for an automated

approach fine-tuning system, and for examining supermaneuverability at flight speeds into the transonic. M.S.K.

**N86-20397\*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**AIRPLANE AUTOMATIC CONTROL FORCE TRIMMING DEVICE FOR ASYMMETRIC ENGINE FAILURES Patent application**

E. C. STEWART, inventor (to NASA) 23 Oct. 1985 14 p (NASA-CASE-LAR-13280-1; NAS 1.71:LAR-13280-1; US-PATENT-APPL-SN-790556) Avail: NTIS HC A02/MF A01 CSCL 01C

The difference in dynamic pressure in the propeller slipstreams as measured by sensors is divided by the freestream dynamic pressure generating a quantity proportional to the differential thrust coefficient. This quantity is used to command an electric trim motor to change the position of trim tab thereby retrimming the airplane to the new asymmetric power condition. The change in position of the trim tab produced by the electric trim motor is summed with the pilot's input to produce the actual trim tab position.

NASA

**N86-20399#** Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). Guidance and Control Panel.

**FAULT TOLERANT HARDWARE/SOFTWARE ARCHITECTURE FOR FLIGHT CRITICAL FUNCTION**

Loughton, England Sep. 1985 146 p refs Lecture series held at Edwards AFB, Calif., 1-2 Oct. 1985, in Copenhagen, Denmark, 17-18 Oct. 1985, and in Athens, Greece, 21-22 Oct. 1985 (AGARD-LS-143; ISBN-92-835-1510-2) Avail: NTIS HC A07/MF A01

This Lecture Series is intended to provide basic concepts and theories in the design of fault-tolerant architectures for flight critical systems. It is intended to cover experience with flight tested fly-by-wire systems as well as issues in redundancy management of synchronous and asynchronous approaches. It will specifically address the individual aspects of software fault tolerance, actuation fault tolerance, reliable data communication, and multi-computer operation using the Ada language.

**N86-20400#** Honeywell Systems and Research Center, Minneapolis, Minn.

**INTRODUCTION TO LECTURE SERIES NO. 143: FAULT TOLERANT HARDWARE/SOFTWARE ARCHITECTURES FOR FLIGHT CRITICAL FUNCTIONS**

G. L. HARTMANN in AGARD Fault Tolerant Hardware/Software Architecture 3 p Sep. 1985 refs Avail: NTIS HC A07/MF A01

Modern weapon systems, driven by escalating performance demands, are becoming complex and sophisticated. Demands for higher accuracy, improved reliability/survivability, all-weather operation, and more automation are placing increased emphasis on the control function. Nowhere is this increased emphasis more evident than in the control functions required in advanced aircraft systems. Due to the expanded role of automation many functions are becoming flight-critical (i.e., loss of this function is catastrophic). Flight critical architectures are more complex than fault-tolerant computers. In addition to airborne computers, overall reliability depends on proper design and management of: (1) Sensors and their interfaces; (2) Actuation elements; and (3) Data communication along the distributed elements. Previous NATO-AGARD publications have dealt with related aspects of this subject. This lecture series covers experience with flight tested fly-by-wire systems as well as issues in redundancy management of synchronous and asynchronous systems. It specifically addresses software fault tolerance, actuation fault tolerance, reliable data communications, and multi-computer operation using the Ada language. Author

## 08 AIRCRAFT STABILITY AND CONTROL

**N86-21549\*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**STEP AND STEPSPL: COMPUTER PROGRAMS FOR AERODYNAMIC MODEL STRUCTURE DETERMINATION AND PARAMETER ESTIMATION**

J. G. BATTERSON Jan. 1986 142 p refs  
(NASA-TM-86410; NAS 1.15:86410) Avail: NTIS HC A07/MF A01 CSCL 01C

The successful parametric modeling of the aerodynamics for an airplane operating at high angles of attack or sideslip is performed in two phases. First the aerodynamic model structure must be determined and second the associated aerodynamic parameters (stability and control derivatives) must be estimated for that model. The purpose of this paper is to document two versions of a stepwise regression computer program which were developed for the determination of airplane aerodynamic model structure and to provide two examples of their use on computer generated data. References are provided for the application of the programs to real flight data. The two computer programs that are the subject of this report, STEP and STEPSPL, are written in FORTRAN IV (ANSI 1966) compatible with a CDC FTN4 compiler. Both programs are adaptations of a standard forward stepwise regression algorithm. The purpose of the adaptation is to facilitate the selection of an adequate mathematical model of the aerodynamic force and moment coefficients of an airplane from flight test data. The major difference between STEP and STEPSPL is in the basis for the model. The basis for the model in STEP is the standard polynomial Taylor's series expansion of the aerodynamic function about some steady-state trim condition. Program STEPSPL utilizes a set of spline basis functions. Author

**N86-21550\*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**EFFECTS OF WING MODIFICATION ON AN AIRCRAFT'S AERODYNAMIC PARAMETERS AS DETERMINED FROM FLIGHT DATA**

R. A. HESS Jan. 1986 72 p refs  
(NASA-TM-87591; NAS 1.15:87591) Avail: NTIS HC A04/MF A01 CSCL 01C

A study of the effects of four wing-leading-edge modifications on a general aviation aircraft's stability and control parameters is presented. Flight data from the basic aircraft configuration and configurations with wing modifications are analyzed to determine each wing geometry's stability and control parameters. The parameter estimates and aerodynamic model forms are obtained using the stepwise regression and maximum likelihood techniques. The resulting parameter estimates and aerodynamic models are verified using vortex-lattice theory and by analysis of each model's ability to predict aircraft behavior. Comparisons of the stability and control derivative estimates from the basic wing and the four leading-edge modifications are accomplished so that the effects of each modification on aircraft stability and control derivatives can be determined. Author

**N86-21551#** Virginia Univ., Charlottesville. Dept. of Mechanical and Aerospace Engineering.

**LIMITING PERFORMANCE OF NONLINEAR SYSTEMS WITH APPLICATIONS TO HELICOPTER VIBRATION CONTROL Final Report, 1 Aug. 1982 - 31 Oct. 1984**

W. D. PILKEY Aug. 1985 9 p  
(Contract DAAG29-82-K-0164)  
(AD-A161457; ARO-18643.10-EG) Avail: NTIS HC A02/MF A01 CSCL 20K

Several problems concerning the vibration control of helicopters were studied. A method for introducing structural modifications leading to vibration reduction has been developed. In particular, a formulation for attaching appendages to continuous structural members was completed and applied to a two-beam helicopter model. Author (GRA)

**N86-21553#** Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Oberpfaffenhofen (West Germany). Forschungsbereich Flugmechanik/Flugfuehrung.

**A CONTRIBUTION TO THE DIGITAL COMPENSATION OF PERIODIC DISTURBANCES WITH FREQUENCIES IN BOUNDED INTERVALS Ph.D. Thesis - Technische Univ., Berlin, West Germany**

R. FRORIEP Sep. 1985 141 p refs In GERMAN; ENGLISH summary Report will also be announced as translation (ESA-TT-979)  
(DFVLR-FB-85-55; ISSN-0171-1342) Avail: NTIS HC A07/MF A01; DFVLR, Cologne DM 45.50

A general design method for the simplest possible compensator was developed in order to satisfy the requirement of stationary disturbance compensation within given tolerance limits for all helicopter rotor speeds within a given bounded interval. The approach to the suppression of rotor induced vibrations is to suspend the fuselage from the rotor by electrohydraulic actuators. Using a digital computer the most dominant harmonics of the disturbance can be actively compensated. For compensation at sampling instants, a structure of a digital controller is introduced and motivated, in which a minimal number of parameters is adapted to a varying rotor speed. The remaining parameters are to be held constant during operation independent of rotor speed. In the design, these parameters are systematically improved with a multidisturbance model approach and a design methodology with vector performance index. For disturbance suppression between sampling instants a design method for impulse forming filters is proposed. Author (ESA)

## 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.

**A86-28278**

**FUTURE APPLICATIONS AND PROSPECTS FOR FLIGHT SIMULATION; PROCEEDINGS OF THE SPRING CONVENTION, LONDON, ENGLAND, MAY 9, 10, 1984**

Convention sponsored by the Royal Aeronautical Society, London, Royal Aeronautical Society, 1985, 134 p. No individual items are abstracted in this volume.

The present conference on prospective developments in the field of flight simulation considers the upgrading of simulator technology, the changing role of supplemental simulators, applications of air combat simulation to pilot training, Line Orientation Flight Training inflight simulation, and the development status and future potential of training management systems. Also discussed are human factors and the use of the image visual system to meet training requirements, fiber-optic helmet-mounted displays, AV-8B (Harrier II) training capabilities, B-757/767 program engineering development simulators, third-generation digital flight controls, a military view of future flight simulation capabilities, and the use of simulators in the U.S. Navy's T-45 jet trainer integrated system for carrier aircraft pilots. O.C.

**A86-28457#**

**LOW COST PART TASK TRAINER FOR THE GBU-15 GUIDED BOMB**

J. W. ACKERSON and D. W. RUCK (USAF, Aeronautical Systems Div., Wright-Patterson AFB, OH) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 2. New York, Institute of Electrical and Electronics Engineers, 1985, p. 1068-1073.

The design and development of an interim part task trainer for the GBU-15 standoff precision attack weapon system for the destruction of fixed targets is described. Using either electro-optical

or infrared images transmitted by RF datalink signals, an operator in either in the delivery aircraft or another aircraft guides the bomb to the target. Each trainer, controlled by a microcomputer, generates the required imagery from a photographic filmplate. The benefits of this approach are short development time, minimal manpower requirements, and development of baseline information for future procurement of a more powerful trainer. Author

**A86-28458  
MODULAR SIMULATORS - A COMPREHENSIVE UNIFIED ARCHITECTURE**

S. SEIDENSTICKER (Logicon, Inc., Tactical and Training Systems Div., San Diego, CA) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 2 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 1074-1079.

Various aspects are explored for a comprehensive unified modular approach to design, construction, and procurement of flight simulators. Issues addressed include module definition, interface specification, implementation approaches, standards, and potential impact on technology. At the heart of the architecture is a universal interface that interconnects all modules; this interface is embodied in a high capacity Local Area Network (LAN). D.H.

**A86-28459  
MODULAR SIMULATORS - HOW TO MAKE IT WORK**

M.-E. HECKER (Logicon, Inc., Tactical and Training Systems Div., San Diego, CA) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 2 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 1080-1085. (Contract F33657-83-C-2201)

Factors to be considered in building complex modular simulators are examined. The functions of simulators are divided among carefully defined modules, which may each come from a different vendor. The modules must both send and receive messages necessary for running of their respective modeling and environmental simulation programs. Interfaces must be standardized and not require unique design or contractor proprietary information. Flexibility to incorporate good new engineering developments at a late stage is necessary. To accomplish such a complex task, there must be defined from the outset a central authority (to control module and message definition), a separate support module (which functions specifically to monitor logistics and support), and a users' group (to explore new ideas and exchange findings). D.H.

**A86-28460  
MODULAR SIMULATORS - IS A LOCAL AREA NETWORK SUFFICIENT?**

D. L. JOHNSTON (Logicon, Inc., Tactical and Training Systems Div., San Diego, CA) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 2 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 1086-1093. refs (Contract F33657-83-C-2201)

A local area network, Ethernet, is examined for its use in modular flight simulators. A computer model of a data communication network is developed to assess the capacity and timing of Ethernet. Estimates of the communication requirements for modular configurations of T-37 and F-16 simulators are used with the network model. The results show that Ethernet will easily transfer the data required for real-time operation by these simulator configurations. Author

**A86-28462  
INSTRUCTOR STATION FOR THE ILLIMAC GENERAL AVIATION INSTRUMENT TRAINING SIMULATOR**

H. L. TAYLOR, F. C. HYMAN, R. E. TODD, and A. S. HODEL (Illinois, University, Urbana) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 2 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 1111-1118.

A software program that permits a standard computer terminal to be used as an instructor station was developed for the University of Illinois Micro Aviation Computer (ILLIMAC) simulator. A split screen format was used to display menus, from which instrument training scenarios could be developed, and to display information on the current status of the instructor inputs to the simulator. A training manual was developed to provide self-paced instruction on the operation of the instructor station. Twelve flight instructors evaluated the effectiveness of the training manual and the instructor station. Results indicated that scenarios could be entered without assistance with a minimum error rate after about one hour self-paced training. Response to a questionnaire on the effectiveness of the training program and the instructor station was very positive. Author

**A86-28560#  
DIRECT DERIVATIVE MEASUREMENTS IN THE PRESENCE OF STING PLUNGING**

M. E. BEYERS (National Research Council of Canada, Ottawa) Journal of Aircraft (ISSN 0021-8669), vol. 23, March 1986, p. 179-185. Previously cited in issue 20, p. 2856, Accession no. A84-42355. refs

**A86-28561\*#  
NUMERICAL SIMULATION OF A CONTROLLED-FLOW TUNNEL FOR V/STOL TESTING**

P. C. PARIKH (Vigyan Research Associates, Inc., Hampton, VA) and R. G. JOPPA (Washington, University, Seattle) Journal of Aircraft (ISSN 0021-8669), vol. 23, March 1986, p. 186-191. Previously cited in issue 20, p. 2856, Accession no. A84-41330. refs (Contract NSG-2260)

**N86-20410#  
OBSTRUCTION MARKING AND LIGHTING**

Oct. 1985 66 p (AC-70/7460-1G) Avail: NTIS HC A04/MF A01 The Federal Aviation Administration's (FAA) standards for marking and lighting of obstructions as identified by FAA regulations part 77, are described. Provision's for marking and lighting wind turbines, towers, and moored balloons are given. R.J.F.

**N86-21555#  
RUBBER REMOVAL SPECIFICATION DEVELOPMENT Final Report, May 1983 - Sep. 1985**

R. A. GRAUL, L. R. LENKE, and D. L. STANDIFORD Oct. 1985 56 p refs Prepared in cooperation with Air Force Engineering Services Center, Tyndall AFB, Fla. (Contract F29601-84-C-0080) (FAA/PM-85/33; ESL-TR-85-67) Avail: NTIS HC A04/MF A01

The phenomenon of runway touchdown-zone rubber buildup is a potentially hazardous problem. Rubber buildup covers the runway surface and occludes the surface texture. This results in a reduced wet friction coefficient between the runway pavement and aircraft tires. Methods and equipment are available for evaluating the wet friction coefficient; however, these methods are expensive and require highly trained personnel. Currently, no guidelines have been established for determining the need and effectiveness of rubber removal. Therefore, most airport and airbase managers rely exclusively on visual impressions of rubber buildup in lieu of quantitative measurements. Quantitative evaluation techniques are desirable for evaluating rubber buildup. An extensive literature review suggested that pavement surface texture measurement techniques are indicative of rubber buildup and resultant reduction in wet friction coefficients. A statistically designed field experiment

## 09 RESEARCH AND SUPPORT FACILITIES (AIR)

determined that surface texture measurements were indicative of pavement friction levels; however, these relationships lacked the precision necessary for inclusion in performance specifications.

Author

**N86-21556#** New Mexico Univ., Albuquerque. Engineering Research Inst.

### **RUNWAY RUBBER REMOVAL SPECIFICATION DEVELOPMENT Final Report, May 1983 - Sep. 1985**

R. A. GRAUL, L. R. LENKE, and D. L. STANDIFORD Oct. 1985 56 p refs Prepared in cooperation with Air Force Engineering and Services Center, Tyndall AFB, Fla.

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Author

## 10

### 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.

#### **A86-28802 DIRIGIBLE AIRSHIPS FOR MARTIAN SURFACE EXPLORATION**

W. M. CLAPP (MIT, Cambridge, MA) IN: The case for Mars II. San Diego, CA, Univelt, Inc., 1985, p. 489-496. refs (AAS 84-176)

A balloon, an aeroplane, and a dirigible were analyzed to determine their flight performance on Mars. The dirigible proved to offer the highest payload fraction of the three systems, which were designed for a total lift of 1000 kg and a range of 100 nautical miles. In addition, the dirigible offered several operational advantages in the Mars environment.

Author

**N86-20485\*#** Columbia Univ., New York. Dept. of Civil Engineering and Engineering Mechanics.

### **VIBRATIONS AND STRUCTUREBORNE NOISE IN SPACE STATION Progress Report, 1 Jul. - 31 Dec. 1985**

R. VAICAITIS 31 Dec. 1985 119 p refs

(Contract NAG1-541)

(NASA-CR-176520; NAS 1.26:176520) Avail: NTIS HC A06/MF A01 CSCL 22B

Theoretical models were developed capable of predicting structural response and noise transmission to random point mechanical loads. Fiber reinforced composite and aluminum materials were considered. Cylindrical shells and circular plates were taken as typical representatives of structural components for space station habitability modules. Analytical formulations include double wall and single wall constructions. Pressurized and unpressurized models were considered. Parametric studies were conducted to determine the effect on structural response and noise transmission due to fiber orientation, point load location, damping in the core and the main load carrying structure, pressurization, interior acoustic absorption, etc. These analytical models could serve as preliminary tools for assessing noise related problems, for space station applications.

Author

## 11

### CHEMISTRY AND MATERIALS

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

#### **A86-26326**

### **CONFERENCE ON STEELS AND SPECIAL ALLOYS IN AERONAUTICS, 11TH, LE BOURGET, FRANCE, JUNE 6, 1985, PROCEEDINGS [COLLOQUE SUR LES ACIERS ET LES ALLIAGES SPECIAUX DANS L'AERONAUTIQUE, 11TH, LE BOURGET, FRANCE, JUNE 6, 1985, PROCEEDINGS]**

Matériaux et Techniques (ISSN 0032-6895), Oct.-Nov. 1985, 158 p. In French and English. For individual items see A86-26327 to A86-26338.

Three different development status assessments are presented by leading industry representatives for French advancements in the formulation and processing of aircraft specialty steels, aluminum alloys, and titanium alloys. Performance comparisons are persistently made in view of continuing improvements in the field of advanced organic matrix composites, especially those composites reinforced with continuous carbon fibers. The meeting at which these evaluations were made covered new developments in airliner, helicopter, and spacecraft structures, novel primary aircraft structure materials, landing gear metals, the evolution of turbine blade materials, single crystal superalloys for gas turbine blades, turbofan thrust reverser materials, novel aluminum alloys, trends in Ti alloy processing technology development, thermomechanical processing during closed dye forging, and high strength stainless steels.

O.C.

#### **A86-26327**

### **NEW DEVELOPMENTS IN THE MATERIALS USED IN AIRLINER, HELICOPTER AND SPACECRAFT STRUCTURES [EVOLUTION DES MATERIAUX UTILISES DANS LES STRUCTURES DES AVIONS, HELICOPTERES ET ENGINES]**

J. ODORICO (Aerospatiale, Paris, France) (Colloque sur les Aciers et les Alliages Speciaux dans l'Aeronautique, 11th, Le Bourget, France, June 6, 1985) Matériaux et Techniques (ISSN 0032-6895), Oct.-Nov. 1985, p. 531-539. In English and French.

A development status and development trend evaluation is undertaken for advanced materials applicable to commercial aircraft, helicopter and spacecraft primary structures. In the case of high strength steels, little developmental success is seen in recent work which is (which is primarily concerned with damage

tolerance); by contrast, promising trends are noted in superplastic forming/diffusion bonding techniques for titanium alloys. Especially encouraging are activities in the formulation of novel aluminum alloys employing additions of zinc, copper, and lithium, and in the application of bonded aluminum sheet/aramid fiber laminates (Aral). Attention is given to performance gains over metallic materials that are obtainable by means of carbon fiber-reinforced plastics. O.C.

**A86-26328****WHAT DOES THE FUTURE HOLD FOR 1990'S NEW AIRFRAME MATERIALS [LA PLACE DES MATERIAUX NOUVEAUX DANS LES CELLULES D'AVIONS DES ANNEES 1990]**

D. CHAUMETTE (Avions Marcel Dassault-Breguet Aviation, Vaucresson, France) (Colloque sur les Aciers et les Alliages Speciaux dans l'Aeronautique, 11th, Le Bourget, France, June 6, 1985) *Materiaux et Techniques* (ISSN 0032-6895), Oct.-Nov. 1985, p. 541-546. In English and French.

Development trends are projected into the 1990s for the application of advanced steels, aluminum alloys such as aluminum-lithium, titanium, and carbon or kevlar fiber-reinforced composites, to the construction of a major French manufacturer's aircraft. It is noted that aluminum-lithium alloys' attractiveness is detracted from by their appearance at the very moment when second-generation carbon fibers (for polymer matrix reinforcement) with markedly improved strength and rigidity are becoming commercially available. Predictions are made for prospective usage of these materials in combat aircraft such as the Rafale fighter, business aircraft, and the Hermes spacecraft. O.C.

**A86-26329****DEVELOPMENT OF MATERIALS USED IN LANDING GEAR [EVOLUTION DES MATERIAUX DANS LES ATERRISSEURS]**

G. HENAULT (Messier-Hispano-Bugatti, Montrouge, France) (Colloque sur les Aciers et les Alliages Speciaux dans l'Aeronautique, 11th, Le Bourget, France, June 6, 1985) *Materiaux et Techniques* (ISSN 0032-6895), Oct.-Nov. 1985, p. 547-558. In English and French.

In aircraft landing gear fabrication, semifinished castings and forgings of precisely formulated materials may represent as much as 40 percent of the cost of the finished component after machining and assembly. The present evaluation of the development status and trends in this industry notes no revolutionary developments or prospects; steels will remain the primary materials for landing gear applications. The high strength 7000-series alloys are in more general use, and 7010-T736 has been chosen for further development. Ti alloys and composites are not expected to make substantial inroads into landing gear design. O.C.

**A86-26330****THE EVOLUTION OF TURBINE BLADE MATERIALS [L'EVOLUTION DES MATERIAUX POUR AUBES DE TURBINE]**

J.-P. HERTEMAN (SNECMA, Paris, France) (Colloque sur les Aciers et les Alliages Speciaux dans l'Aeronautique, 11th, Le Bourget, France, June 6, 1985) *Materiaux et Techniques* (ISSN 0032-6895), Oct.-Nov. 1985, p. 559-566. In English and French. refs

The joint development of precision investment casting processes and of high creep strength/low work hardening rate materials has been a primary factor in the continuing increase of aircraft gas turbine inlet temperatures. The development of single crystals, oxide dispersion-strengthened, and oriented eutectic alloys has been especially fruitful. Significant advancements are expected in the case of single crystal alloys, through a gradual reduction of specific gravity, which will reduce the stresses currently borne by turbine disks. O.C.

**A86-26332****MATERIALS IN THRUST REVERSERS [LES MATERIAUX DANS LES INVERSEURS DE POUSSEE]**

G. LADOUX (Hispano-Suiza, Saint-Cloud, France), R. CAMEO (Microfusion, S.A., Gennenvilliers, France), and J. BARILLOT-CREUZET (Ets Robert Creuzet Sarl, Marmande, France) (Colloque sur les Aciers et les Alliages Speciaux dans l'Aeronautique, 11th, Le Bourget, France, June 6, 1985) *Materiaux et Techniques* (ISSN 0032-6895), Oct.-Nov. 1985, p. 579-584. In English and French.

The design features of contemporary high bypass turbofan thrust reverser mechanisms, which are integral parts of the engine cowl paneling, are presently discussed with a view to the materials and fabrication technologies that satisfy such devices' performance criteria. Steel have limited use in fasteners and hydraulic tubing. Aluminum alloys constitute the largest portion of material used, with the remainder made up of epoxy-matrix composite materials. Aluminum elements are fabricated from forged blocks, thick sheet metal, precision castings, thin sheet honeycomb cores, pressings, superplastically formed plates, and extrusions. Carbon/epoxy composite paneling is essential for noise-control purposes. O.C.

**A86-26334****THE NEW ALUMINIUM ALLOYS FOR THE AERONAUTICAL INDUSTRY [LES NOUVEAUX ALLIAGES D'ALUMINIUM POUR L'AERONAUTIQUE]**

P. MEYER (Cegedur Pechiney, Centre de Recherche et Developpement de Voreppe, France) and S. DERMARKAR (Cegedur Pechiney, Department Techniques Avancees, Paris, France) (Colloque sur les Aciers et les Alliages Speciaux dans l'Aeronautique, 11th, Le Bourget, France, June 6, 1985) *Materiaux et Techniques* (ISSN 0032-6895), Oct.-Nov. 1985, p. 593-601. In English and French.

A development status and prospective structural performance evaluation is presented for recent advancements in the field of aircraft aluminum alloys that encompass Al-Li alloys, powder metallurgy alloys, and aluminum-matrix composites. The four Al-Li alloys in question, designated CP 271, 274, 276, and 277, respectively offer density reductions of 10, 8, 8, and 12 percent over conventional aircraft alloys. Attention is given to the performance improvements obtainable by means of short and long fiber reinforcement of aluminum alloy matrices, especially with respect to specific elastic modulus and specific ultimate tensile strength. O.C.

**A86-26337****THE DEVELOPMENT OF HIGH STRENGTH STAINLESS STEELS FOR THE AERONAUTICAL INDUSTRY [EVOLUTION DES ACIERS INOXYDABLES A HAUTE RESISTANCE POUR CONSTRUCTION AERONAUTIQUE]**

R. RAVEZ (Acieries Aubert et Duval, S.A., Neuilly-sur-Seine, France), M. DELARBOULAS, and R. COZAR (Imphy, S.A., Paris-la-Defense, France) (Colloque sur les Aciers et les Alliages Speciaux dans l'Aeronautique, 11th, Le Bourget, France, June 6, 1985) *Materiaux et Techniques* (ISSN 0032-6895), Oct.-Nov. 1985, p. 619-621. In English and French.

An account is given of the development history of high strength stainless steels possessing good drop forge-shaping ductility, which facilitates the production of aircraft structural components. Attention is given to maraging stainless steels from which the carbides and ferrite that compromise ductility in other formulations can be entirely eliminated. The engine nacelle strut of the A 320 airliner has been fabricated from such a steel; histograms of dispersions obtained during acceptance tests for these components are presented. Tensile strengths are of the order of 1200-1250 MPa. O.C.

## 11 CHEMISTRY AND MATERIALS

**A86-26338**

**PROPERTIES AND POTENTIAL AEROSPACE APPLICATIONS OF E Z 3 CNDA 13-08 STEEL. II [CARACTERISTIQUES ET POSSIBILITES D'APPLICATIONS AEROSPATIALES DE L'ACIER E Z 3 CNDA 13-08]**

M. DELARBOULAS and R. COZAR (Imphy, S.A., Paris-la-Defense, France) (Colloque sur les Aciers et les Alliages Speciaux dans l'Aeronautique, 11th, Le Bourget, France, June 6, 1985) *Materiaux et Techniques* (ISSN 0032-6895), Oct.-Nov. 1985, p. 622-631. In English and French. refs

The precipitation-hardened martensitic stainless steel E Z 3 CNDA 13-08, heat-treated to yield strength levels above 1 150 MPa is becoming increasingly attractive for aerospace applications. Improved understanding of the underlying metallurgy has led to greater control over melting and processing, resulting in better strength-toughness combinations. Potential aerospace applications are illustrated by both experimental results and industrially produced components. Author

**A86-27084**

**THE DAMPING CAPACITY OF LAYERED MATERIALS [DEMPFIRUIUSHCHAIA SPOSOBNOST' SLOISTYKH MATERIALOV]**

V. N. VIAKIN, G. G. KARTASHOV, N. S. KONDRASHOV, and V. I. SUSLIKOV IN: Energy dissipation connected with vibrations of mechanical systems. Kiev, Izdatel'stvo Naukova Dumka, 1985, p. 215-225. In Russian. refs

The paper reports the results of an experimental study of the damping properties of layered materials consisting of a combination of adhesives and sealants with metal layers or with layers of metal and nonmetal composites. On the basis of the results obtained, the damping properties of a titanium-base sound-absorbing material have been improved by saturating it with a viscoelastic filler, and efficient sound-absorbing structures have been developed by using composite materials. The results of the study are currently used for developing shells and enclosures for gas-turbine engines. V.L.

**A86-27198**

**STRENGTH PROFILE IN AL-LI PLATE MATERIAL**

M. PETERS, J. ESCHWEILER, and K. WELPMANN (DFVLR, Institut fuer Werkstoff-Forschung, Cologne, West Germany) *Scripta Metallurgica* (ISSN 0036-9748), vol. 20, Feb. 1986, p. 259-264. refs

An explanation is sought for an anisotropic strength profile seen in low-density, high-stiffness Al-Li alloys, in plate form, where tensile properties showed a variation through the plate thickness. The alloy investigated was DTD XXXA with a nominal composition in weight percent of Al-2.5Li-1.2Cu-0.7Mg-0.12Zr. The results suggest that the strong strength gradient observed is primarily due to texture hardening. (111) pole figures are given for DTD XXXA and 2024 plate material for comparison purposes. D.H.

**A86-27201**

**TITANIUM: SCIENCE AND TECHNOLOGY; PROCEEDINGS OF THE FIFTH INTERNATIONAL CONFERENCE ON TITANIUM, MUNICH, WEST GERMANY, SEPTEMBER 10-14, 1984. VOLUMES 1-4**

G. LUETJERING, ED. (Hamburg, Technische Universitaet, West Germany), U. ZWICKER, ED. (Erlangen-Nuernberg, Universitaet, Erlangen, West Germany), and W. BUNK, ED. (DFVLR, Cologne, West Germany) Conference supported by DFG. Oberursel, West Germany, Deutsche Gesellschaft fuer Metallkunde, 1985. Vol. 1, 719 p.; vol. 2, 820 p.; vol. 3, 726 p.; vol. 4, 724 p. For individual items see A86-27202 to A86-27421.

Numerous Ti alloy preparation, processing and recycling techniques are discussed. Attention is given to methods of reducing or recycling the amounts of waste chips and/or pollutants which are byproducts of the production and shaping of Ti alloys. The benefits and drawbacks of various techniques for melting Ti ingots and chips are explored, along with the microstructures of hot isostatically pressed materials. Forming techniques such as hot die forming, rolling and extrusion are investigated as to their effects

on the microstructures of finished billets, their relative costs, and their capabilities of yielding near-net shape parts. Finally, the potential for using new techniques which require lower heats and thereby reduced costs so that parts can be manufactured from more economical Ti alloys at competitive costs are investigated. M.S.K.

**A86-27202**

**APPLICATIONS OF TITANIUM AND TITANIUM ALLOYS**

T. W. FARTHING (IMI Titanium, Ltd., Birmingham, England) IN: Titanium: Science and technology; Proceedings of the Fifth International Conference on Titanium, Munich, West Germany, September 10-14, 1984. Volume 1. Oberursel, West Germany, Deutsche Gesellschaft fuer Metallkunde, 1985, p. 39-54.

Areas of applications of Ti alloys are surveyed, together with the prospects of improving the quality of the products. The demand for Ti products will continue to rise due to the favorable properties of Ti in aircraft components, even though the number of aircraft produced may not increase by much. Ti offers high temperature creep resistance, improved performance from rotating parts, and can be shaped using techniques such as superplastic forming and diffusion bonding. New gas turbine engines feature up to 25 percent by weight Ti, mainly in the blades, disks and housing. The same percentage is used in current military aircraft airframes and control surfaces, falling to 7 percent in commercial aircraft. Attempts are being made to increase the percentage of parts by increasing the quality of HIP-manufactured components. In other areas, Ti has proven useful in salt water environments, particularly for deep-sea diving vessels and heat exchangers. Ti alloys have shown no adverse effects when used in prosthetic devices and have shown no adverse effects when used in prosthetic devices and have exhibited favorable properties when combined with other elements in superconductors. M.S.K.

**A86-27207**

**AN EVALUATION OF CENTRIFUGALLY CAST TI-4AL-4MO-2SN-0.5SI (IMI 550) ALLOY**

M. W. KEARNS (IMI Titanium, Ltd., Birmingham, England) and C. M. WARD-CLOSE (Royal Aircraft Establishment, Farnborough, England) IN: Titanium: Science and technology; Proceedings of the Fifth International Conference on Titanium, Munich, West Germany, September 10-14, 1984. Volume 1. Oberursel, West Germany, Deutsche Gesellschaft fuer Metallkunde, 1985, p. 195-202. Research supported by the Ministry of Defence (Procurement Executive). refs

The results of tests of the room temperature tensile, fracture toughness and plain and notched high cycle fatigue life of centrifugally cast and cast/HIPped IMI 550 Ti alloy are reported. Three specimens, 70, 125 and 180 mm long, were centrifugally cast and subjected to HIP conditions and heat treatment of 1 hr at 900 C, air cooling and aging for 24 hr at 500 C. Other samples were prepared with the same process as Ti-6Al-4V and with varying thickness as would be found in an aerospace component. The mechanically tested parts were examined by radiography and microscopy. The fully aged IMI 550 alloy yielded a 20 percent increase in mechanical properties compared to samples of Ti-6Al-4V. The HIP process eliminated shrinkage porosity by retained the beta acicular features. However, HIPping increased the plain specimen fatigue performance to twice that of comparable wrought alloy materials. M.S.K.

**A86-27209**

**REQUIREMENTS FOR RECYCLING OF VALUABLE CHIPS FROM AND FOR AIRCRAFT MANUFACTURING**

J. BERGGREEN (Messerschmitt-Boelkow-Blohm GmbH, Augsburg, West Germany) IN: Titanium: Science and technology; Proceedings of the Fifth International Conference on Titanium, Munich, West Germany, September 10-14, 1984. Volume 1. Oberursel, West Germany, Deutsche Gesellschaft fuer Metallkunde, 1985, p. 241-248.

The ratio of scrap chips of Ti to the actual materials used in making stiffened airframes can approach 100:1, although chips are valued at only 0.01 the worth of raw material. Neither electrolytic



dissolving nor powdering of the chips to obtain useful Ti alloy forms is a cost-effective process. Another significant impediment to recycling the chips is keeping them from being mixed with other materials, such as cigarette ends, glass splinters, other metal scraps, milling coolants, etc., in the shop. A system is described whereby the chips are removed from the workbench by vacuum suction or conveyers and transferred to a storage location. The chips are carried to a recycling plant in sealed containers which are inspected by X ray techniques. Remelted scrap handled to avoid contamination has exhibited mechanical properties and chemical composition equivalent to the original Ti sponge, provided the oxygen content is closely controlled during remelt and sufficient sponge material is added to the melt. M.S.K.

**A86-27224**  
**DEVELOPMENT IN PM HHDH-Ti6Al4V TECHNOLOGY FOR AIRCRAFT APPLICATION**

R. TANG, T. LAN, and C. LU (Baoji Institute for Nonferrous Metal Research, People's Republic of China) IN: Titanium: Science and technology; Proceedings of the Fifth International Conference on Titanium, Munich, West Germany, September 10-14, 1984. Volume 1. Oberursel, West Germany, Deutsche Gesellschaft fuer Metallkunde, 1985, p. 443-450. refs

The preliminary results of the development in the High-quality Hydride Dehydrogenating Process (HHDH) on PM Ti6Al4V alloy for aircraft applications are described in the paper. The powder characteristics and the mechanical properties of HHDH-Ti6Al4V alloy consolidated by HIP are presented. The effects of HIP temperature, powder particle size and its oxygen content on the microstructure and mechanical properties of HHDH-Ti6Al4V alloy are discussed in detail. The experimental result shows that the mechanical properties of the HHDH alloy can be compared with the best properties of HIP'ed centrifugal atomization Ti6Al4V and conventional wrought material reported up to now. Furthermore, the HHDH process has even more advantages and possesses the competition in the cost effectiveness. Therefore, the HHDH process will be a more economical and important approach to manufacture the PM titanium alloy components for aircraft applications. M.S.K.

**A86-27231**  
**EFFECT OF PROCESSING AND HEAT TREATMENT ON THE MECHANICAL PROPERTIES OF Ti-6Al-2Sn-4Zr-6Mo ALLOY**

H. YANO, Y. TSTUMORI, T. MATSUMOTO, K. YASUI, and T. NISHIMURA (Kobe Steel, Ltd., Japan) IN: Titanium: Science and technology; Proceedings of the Fifth International Conference on Titanium, Munich, West Germany, September 10-14, 1984. Volume 1. Oberursel, West Germany, Deutsche Gesellschaft fuer Metallkunde, 1985, p. 507-514.

Experimental trials were run to determine the minimum forging reduction in the alpha-beta field to obtain good ductility for the alloy Ti-6246. Attention was also given to the impacts that solution treatment conditions have on the mechanical properties of the alloy. Various forging reductions up to 80 percent in the alpha-beta field were imposed on alloy bars forged at 900 C. The bars were later tested for the tensile properties. Heat treatment effects were evaluated in terms of the results of tensile, notch test, and creep tests. Tensile strength was not affected by the forging reduction while elongation and areal reduction were both observed with forging reductions of 53-63 percent. The amount of age hardening determined the tensile strength of the end product. A double solution treatment produced enhanced tensile strength and creep resistance. The second treatment caused the material to become at least 10 percent alpha phase. The mechanical properties of all the solution treated die forged specimens satisfied criteria for use as jet engine disks. M.S.K.

**A86-27260**  
**PROPERTIES OF DIFFUSION BONDED BUTT JOINTS IN Ti-6Al-4V AND Ti-4Al-4Mo-2Sn-0.5Si (IMI 550) ALLOYS**

T. S. BAKER and P. G. PARTRIDGE (Royal Aircraft Establishment, Farnborough, England) IN: Titanium: Science and Technology; Proceedings of the Fifth International Conference on Titanium, Munich, West Germany, September 10-14, 1984. Volume 2. Oberursel, West Germany, Deutsche Gesellschaft fuer Metallkunde, 1985, p. 861-868. refs

A critical requirement for successful superplastic forming/diffusion bonding of Ti-6Al-4V and IMI550 Ti alloys is an understanding of the factors affecting the mechanical properties of diffusion bonds. Tensile, fatigue and impact strengths are presently determined for butt joints containing various amounts of residual porosity at the interface, following diffusion bonding. The results obtained suggest that, unless impact strength is more sensitive to the presence of very small voids than is the fatigue testing method, toughness is reduced by the presence of an oxygen-rich region near the bond interface. O.C.

**A86-27264**  
**FATIGUE-CRACK PROPAGATION THROUGH TITANIUM WELDS**

P. S. PAO, T. C. PENG, and J. E. ONEAL (McDonnell Douglas Research Laboratories, St. Louis, MO) IN: Titanium: Science and technology; Proceedings of the Fifth International Conference on Titanium, Munich, West Germany, September 10-14, 1984. Volume 2. Oberursel, West Germany, Deutsche Gesellschaft fuer Metallkunde, 1985, p. 887-894. Research supported by the McDonnell Douglas Independent Research and Development Program. refs

Attention is given to the influence exerted by gas-tungsten arc, electron beam, and laser beam weldment microstructures on the mechanical properties and fatigue crack growth kinetics of the alpha-beta alloy Ti-6Al-4V and the beta alloy Ti-15V-3Cr-3Al-3Sn. Modified wedge-opening-load specimens oriented either longitudinally or transversely were used to determine crack growth kinetics. It is found that the fatigue crack growth rates through the weld zones of both alloys are not significantly affected by the three welding processes, although scatter bands for electron and laser beam welding are narrower than for the gas-tungsten arc process. O.C.

**A86-27274**  
**FATIGUE PROPERTIES OF Ti-10V-2Fe-03Al**

R. S. CAREY (Beckman Instruments, Inc., Palo Alto, CA), R. R. BOYER (Boeing Co., Seattle, WA), and H. W. ROSENBERG (Timet, Pittsburgh, PA) IN: Titanium: Science and technology; Proceedings of the Fifth International Conference on Titanium, Munich, West Germany, September 10-14, 1984. Volume 2. Oberursel, West Germany, Deutsche Gesellschaft fuer Metallkunde, 1985, p. 1261-1267. Research supported by the Boeing Co. and Timet.

The near-beta titanium forging alloy Ti-10V-2Fe-3Al has come to find frequent use in state-of-the-art commercial aircraft in virtue of its outstanding combination of weight reduction-yielding strength and toughness; recent investigations have noted excellent fatigue strength, as well. Attention is presently given to the results of investigations concerning applications where fatigue may be a critical factor: commercial airframes, helicopters, and centrifuges. In each case, Ti-10V-2Fe-3Al appears to outperform the heretofore more prominent Ti-6Al-4V alloy. O.C.

**A86-27275**  
**FATIGUE BEHAVIOUR OF TITANIUM MATERIALS IN AIRCRAFT ENGINES**

R. GRAETER and H. HUFF (MTU Motoren- und Turbinen-Union Muenchen GmbH, Munich, West Germany) IN: Titanium: Science and technology; Proceedings of the Fifth International Conference on Titanium, Munich, West Germany, September 10-14, 1984. Volume 2. Oberursel, West Germany, Deutsche Gesellschaft fuer Metallkunde, 1985, p. 1269-1273.

Because the fatigue strength of titanium and its alloys is strongly influenced by such factors as surface finish, structure topology

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and material microstructure, as well as by fretting, precise definitions of surface and structure are required. An evaluation is presently made of the interrelationships among these factors, with attention to the consequences of microstructure type, the influence of tool-originated flaws on structure surface, and the geometry of loads incurred during operation (in such cases as turbomachine blades) which cause significant fretting. O.C.

**A86-27279**

### **EMBRITTLING TRAILING EDGES OF COMPRESSOR BLADES (TITANIUM ALLOY Ti6Al-4V AND Ti6Al2Sn4Zr2Mo) OF GAS TURBINE AERO-ENGINES**

J. SPECHT (MTU Motoren- und Turbinen-Union Muenchen GmbH, Munich, West Germany) IN: Titanium: Science and technology; Proceedings of the Fifth International Conference on Titanium, Munich, West Germany, September 10-14, 1984. Volume 2. Oberursel, West Germany, Deutsche Gesellschaft fuer Metallkunde, 1985, p. 1301-1306.

The embrittlement recently noted at the trailing edges of aircraft gas turbine compressor blades is due to hydrogen, which is present in the form of titanium hydride; its absorption may be promoted by the rough airfoil surface at the upper half of the trailing edge, which is caused by surface enlargement. Hydrogen absorption is found to occur, not from moisture during operation, but from cleaning baths given in the course of maintenance with a solution of NaOH + Na<sub>2</sub>Cr<sub>2</sub>O<sub>7</sub>. The cleaning procedure has accordingly been modified. O.C.

**A86-27370**

### **THE FRETTING FATIGUE BEHAVIOUR OF THE TITANIUM ALLOY Ti-6Al-4V**

E. BROSZEIT, K. H. KLOOS, and B. SCHWEIGHOFER (Darmstadt Technische Hochschule, West Germany) IN: Titanium: Science and technology; Proceedings of the Fifth International Conference on Titanium, Munich, West Germany, September 10-14, 1984. Volume 4. Oberursel, West Germany, Deutsche Gesellschaft fuer Metallkunde, 1985, p. 2171-2178. DFG-supported research.

The phenomenon of fretting can be observed in many cases. It can arise, for instance, at the blade foot of turbine blades. In this case, weld marks can be the consequence of oscillating sliding movements of very small amplitude. In aircraft engines with turbine blades made from titanium alloys, macrocracks can develop as the result of fretting. The considered study is concerned with the fretting fatigue behavior of the material combination Ti-6Al-4V/Ti-6Al-4V, taking into account the feasibility of improvements on the basis of material and surface modifications. It is found that the fretting fatigue properties of the considered material combination can be improved by a number of approaches, giving attention to the combination of high residual compressive stresses with a shear resilient surface. Such a surface can be obtained by selecting a favorable machining process, or by applying soft coatings. G.R.

**A86-27383**

### **THE STRAIN CONTROLLED FATIGUE BEHAVIOUR OF A NEAR-ALPHA TITANIUM ALLOY**

M. R. WINSTONE and M. J. WEAVER (Royal Aircraft Establishment, Farnborough, England) IN: Titanium: Science and technology; Proceedings of the Fifth International Conference on Titanium, Munich, West Germany, September 10-14, 1984. Volume 4. Oberursel, West Germany, Deutsche Gesellschaft fuer Metallkunde, 1985, p. 2275-2280. refs

This paper presents the results of an investigation which has been conducted to assess the strain controlled fatigue behavior of the near-alpha titanium alloy IMI 829 in the temperature range from 20 to 300 C. A zero to maximum strain cycle was employed for all the tests. Attention is given to details regarding the experimental procedure, the results, and aspects of engineering significance. When the near-alpha titanium alloy IMI 829 was fatigue tested under strain control using O-Max triangular waveform (0.0167 Hz), the life to failure for a given inelastic strain range was found to increase slightly with temperature in the range from 20 to 300 C. At 20 C and 80 C, the introduction of a 120 second hold time

at maximum strain increases the inelastic strain range for a given cyclic life, whereas at 120 and 300 C, the relationship remains unchanged. G.R.

**A86-27384**

### **STUDIES ON CRACK GROWTH RATE OF HIGH TEMPERATURE TITANIUM ALLOYS**

S. FUJISHIRO (USAF, Materials Laboratory, Wright-Patterson AFB, OH) and T. MATSUMOTO (Kobe Steel, Ltd., Japan) IN: Titanium: Science and technology; Proceedings of the Fifth International Conference on Titanium, Munich, West Germany, September 10-14, 1984. Volume 4. Oberursel, West Germany, Deutsche Gesellschaft fuer Metallkunde, 1985, p. 2281-2288. refs

The present study is concerned with the identification of a processing method which provides the lowest crack growth rate for high temperature Ti alloys commonly employed in aircraft engines. Ti-6246, which is utilized in advanced jet engine components, has a very high strength. However, prior studies indicate that this alloy has a much faster fatigue crack growth (FCG) rate than other high-temperature Ti alloys. Investigations were, therefore, conducted with the aim to improve the FCG rate of Ti-6246 by thermomechanical processing, taking into account also Ti-6242S, and Ti-64. At room temperature, Ti-6246, regardless of the type of processing used, was found to have the fastest FCG rate of all alloys studied. G.R.

**A86-27385**

### **HIGH TEMPERATURE FATIGUE BEHAVIOR OF IMI 685**

R. MARISSIN, M. PETERS, K. SCHULTE, K.-H. TRAUTMANN, and H. NOWACK (DFVLR, Institut fuer Werkstoff-Forschung, Cologne, West Germany) IN: Titanium: Science and technology; Proceedings of the Fifth International Conference on Titanium, Munich, West Germany, September 10-14, 1984. Volume 4. Oberursel, West Germany, Deutsche Gesellschaft fuer Metallkunde, 1985, p. 2289-2296. DFG-supported research. refs

Near-alpha-titanium alloys show a high specific strength combined with good corrosion resistance, and, when compared to the (alpha+beta)-Ti alloys, superior high temperature properties. For this reason, the considered alloys are widely used as compressor disk material for gas turbine aircraft engines, and information about fatigue crack initiation and crack propagation is important. The present paper is concerned with the crack propagation stage. A description is given of studies performed on the near-alpha Ti alloy IMI 685 (Ti-6Al-5Zr-0.5Mo-0.25Si). It is found that a fine equiaxed and a coarse lamellar microstructure shows considerably lower crack growth rates as compared to a fine equiaxed microstructure for room temperature as well as for 450 C. G.R.

**A86-27388**

### **DEVELOPMENTS IN HIGH TEMPERATURE ALLOYS**

P. A. BLENKINSOP (IMI Titanium, Ltd., Birmingham, England) IN: Titanium: Science and technology; Proceedings of the Fifth International Conference on Titanium, Munich, West Germany, September 10-14, 1984. Volume 4. Oberursel, West Germany, Deutsche Gesellschaft fuer Metallkunde, 1985, p. 2323-2338. refs

The earliest work concerning high temperature alloys was carried out in the U.S. in the early 1950s. The alloys considered included alpha phase alloys, alpha+beta phase alloys, and meta-stable beta phase alloys. It was soon recognized that solid solution strengthening of the alpha phase with additions of Al, Sn, and Zr provided improvements in room and elevated temperature tensile and creep properties. Attention is given to attempts to develop 'super alpha' alloys in the mid to late 1950s, UK alloys in this group, the Ti+beta stabilizing element, Ti+alpha and beta stabilizing elements, advances in the development of creep resistant titanium alloys in the late 1950s, effects of an addition of Zr and Si, major developments related to aircraft engines and the acceptance of titanium alloys in the 1960s, and a major change of alloy philosophy occurring in the UK. Recent developments discussed are related to the importance of fatigue strength, the utilization of the effect of the cooling rate, and new development

alloys. New developments are partly concerned with the temperature barrier at 600-650 C. G.R.

**A86-27652#****ANALYTICAL AND EXPERIMENTAL STUDIES OF TEXTILE STRUCTURAL COMPOSITES**

T.-W. CHOU (Delaware, University, Newark), B. I. SHEHATA (U.S. Army, Ballistic Research Laboratory, Aberdeen Proving Ground, MD), and J.-M. YANG IN: International Conference on Rotorcraft Basic Research, Research Triangle Park, NC, February 19-21, 1985, Proceedings. Alexandria, VA, American Helicopter Society, 1985, 13 p. Army-Navy-supported research. refs

This paper reports the recent research in modeling the thermo-elastic behavior of textile structural composites and the parametric study of composite performance. Firstly, a three-dimensional finite-element analysis has been performed to determine the elastic properties of plain weave fabric composites, which have not been accurately predicted by the previous modeling work. The theoretical and experimental results coincide very well. Secondly, a parametric study has been performed on cross-ply, angle ply, woven fabric and three-dimensional braided composites. The variation of thermo-elastic properties of these composites with fiber and matrix properties, fiber orientation, and weaving and braiding parameters have been identified. The unique performance of textile structural composites has been demonstrated. Author

**A86-27691****LIFE PREDICTION FOR AROMATIC POLYAMIDE REINFORCEMENTS**

A. HOWARD and N. J. PARRATT (Royal Armament Research and Development Establishment, Waltham Abbey, England) IN: ICCM - V; Proceedings of the Fifth International Conference on Composite Materials, San Diego, CA, July 29-August 1, 1985. Warrendale, PA, Metallurgical Society, Inc., 1985, p. 277-292. refs

Mechanical tests have been carried out on Kevlar 49 yarn of 1420 denier with a view to estimating the useful life of this aromatic polyamide fiber used in aircraft and missile composite structures. It is shown that the tensile creep observed in Kevlar 49 yarn under dry conditions is reversible and unrelated to the loss of strength with time. There is instead a consolidation of the normal fiber under stress, reflected in a permanent increase in elastic modulus. From stress-rupture data at 150, 110, and 65 C, the most probable yarn lifetimes are predicted at temperatures between 25 and 200 C and stress levels between 10 and 70 percent of the ultimate strength. V.L.

**A86-27702****S-2 GLASS FIBER - ITS ROLE IN MILITARY APPLICATIONS**

S. J. WALLING (Owens-Corning Fiberglas Corp., Advanced Composites Marketing Section, Toledo, OH) IN: ICCM - V; Proceedings of the Fifth International Conference on Composite Materials, San Diego, CA, July 29-August 1, 1985. Warrendale, PA, Metallurgical Society, Inc., 1985, p. 443-456.

An introduction to S-2 glass fiber products, the fiber and composite properties, and the benefits of the products is presented. Comparative data for S-2 glass and E-glass are given, including physical properties, thermal properties, electrical properties, corrosion resistance, tensile and shear strength. The strength properties of laminates of these glasses are shown. Current applications of S-2 fibers are discussed, stressing lightweight composites in military vehicle structures and armor. C.D.

**A86-27730\*** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

**AEROSPACE APPLICATIONS OF PMR POLYIMIDE COMPOSITES**

T. T. SERAFINI (NASA, Lewis Research Center, Cleveland, OH) IN: ICCM - V; Proceedings of the Fifth International Conference on Composite Materials, San Diego, CA, July 29-August 1, 1985. Warrendale, PA, Metallurgical Society, Inc., 1985, p. 1007-1023. refs

The current status of the novel class of processable, addition-type polyimides known as PMR (for in situ polymerization of monomer reactants) polyimides, developed by NASA at the Lewis Research Center, is reviewed. Highlights of PMR technology studies conducted at NASA Lewis are presented. Several examples of industrial applications of PMR-15 polyimide composites to aerospace structural components are examined. C.D.

**A86-27754****DIFFUSION OF WATER IN CARBON EPOXY COMPOSITES**

M. A. GRAYSON and C. J. WOLF (McDonnell Douglas Research Laboratories, St. Louis, MO) IN: ICCM - V; Proceedings of the Fifth International Conference on Composite Materials, San Diego, CA, July 29-August 1, 1985. Warrendale, PA, Metallurgical Society, Inc., 1985, p. 1463-1473. refs

An innovative method, Precision Abrasion Mass Spectrometry (PAMS), has been used to investigate the diffusion of water in a high performance neat epoxy resin, a unidirectional carbon epoxy composite, and a cross-ply carbon epoxy composite. Test coupons were immersed in water at 50, 65, and 80 C for time intervals up to 5000 h. PAMS and gravimetric data were used to investigate diffusion processes in these materials. Two diffusion processes are observed in the resin, one fast and presumably Fickian, the other a factor of 30 slower and non-Fickian. The early stages of diffusion in the resin and the composites are essentially the same and have an activation energy of 49 kJ/mol. The diffusion coefficient in the unidirectional composite, calculated on the basis of the fibers occupying a finite volume, is in good agreement with the measured values. Author

**A86-27759****NEW ARAMID DEVELOPMENTS FOR AEROSPACE/AIRCRAFT APPLICATIONS**

J. J. PIGLIACAMPI and G. E. ZAHN (Du Pont de Nemours and Co., Wilmington, DE) IN: ICCM - V; Proceedings of the Fifth International Conference on Composite Materials, San Diego, CA, July 29-August 1, 1985. Warrendale, PA, Metallurgical Society, Inc., 1985, p. 1545-1556.

Near-term aramid fiber research and development is discussed, with emphasis on its utility in aircraft/aerospace applications. The tensile strength and adhesion characteristics of new aramid fibers are given and their practical significance is addressed. New products with aramid fibers are described, including improved roving for pressure vessels, low denier Kevlar 49, short fibers, pulp-reinforced elastomers, and low-density spunlaced aramid sheet products. New applications of aramid fibers in the areas of phenolic systems for aircraft interiors, radomes, and supertough wrapped rods are discussed. C.D.

**A86-27765****SOME RECENT RESEARCH AND DEVELOPMENT OF COMPOSITES IN JAPAN**

T. HAYASHI (Japan Plastics Inspection Association, Tokyo) IN: ICCM - V; Proceedings of the Fifth International Conference on Composite Materials, San Diego, CA, July 29-August 1, 1985. Warrendale, PA, Metallurgical Society, Inc., 1985, p. 1641-1654. refs

Japan's project on advanced composite materials is discussed. The aim of the project is to create fiber reinforced plastic (FRP) and fiber reinforced metal (FRM) composites applicable to aerospace structures and jet engines. The development of high performance FRPs and FRMs, and of fabrication techniques for FRPs and FRMs are described. New procedures for design technology and quality evaluation technology are examined. I.F.

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A86-28096

**SYNTHETIC LUBRICANTS AND WORKING FLUIDS; INTERNATIONAL COLLOQUIUM, 4TH, ESSLINGEN, WEST GERMANY, JANUARY 10-12, 1984, REPORTS [SYNTHETISCHE SCHMIERSTOFFE UND ARBEITSFLUESSIGKEITEN; INTERNATIONALES KOLLOQUIUM, 4TH, ESSLINGEN, WEST GERMANY, JANUARY 10-12, 1984, VORTRAEGE]**

W. J. BARTZ, ED. Esslingen, West Germany, Technische Akademie Esslingen, 1984, 640 p. In German and English. No individual items are abstracted in this volume.

Important subjects relevant to synthetic fluids and their application as lubricants and operational fluids are discussed. The topics covered include: ester base stocks, analysis of ester constituents in synthetic and semisynthetic oils, brake fluids, lubrication of plastics by perfluoropolyether fluids, frictional behavior of experimental synthetic and semisynthetic gear oils, potential performance of synthetic fluids for automotive gear oil applications, process variables in the manufacture of polyalphaolefins, synthetic lubricants for turbocharged passenger cars, gas engine lubricants, and nonflammable hydraulic system development for aerospace. Also discussed are: synthesis and properties of adamantane synthetic lubricants, lubrication and cooling in electricity generating plants, industrial applications of synthetic lubricants, waste treatability of aqueous-based synthetic metalworking fluids, characteristics of synthetic lubricating greases, shell fire-resistant grease, synthetic protective lubricants, experience with lead-free gear oils, properties and applications of perfluoropolyether lubricants, spreading of perfluorinated fluids on metal surfaces, and oxidation and inhibition of pentaerythritol esters. C.D.

**N86-20499\*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

**THE 1-(DIORGANOXYPHOSPHONYL)METHYL-2, 4- AND -2, 6-DINITRO AND DIAMINO BENZENES AND THEIR DERIVATIVES Patent Application**

J. A. MIKROYANNIDIS and D. A. KOURTIDES, inventors (to NASA) 16 Aug. 1984 19 p (NASA-CASE-ARC-11425-2; NAS 1.71:ARC-11425-2; US-PATENT-APPL-SN-641152) Avail: NTIS HC A02/MF A01 CSCL 07C

The 1-(Diorganooxyphosphonyl)methyl]-2,4- and -2,6-dinitro- and diamino benzenes are prepared by nitrating an (organophosphonyl)methyl benzene to produce the dinitro compounds which are then reduced to the diamino compounds. The organo groups (alkyl, haloalkyl, aryl) on the phosphorus may be removed to give the free acids (HO)2P(=O)-. The diamino compounds may be polymerized with dianhydrides or diacyl halides to produce fire and flame resistant polymers which are useful in the manufacture of aircraft structures. NASA

**N86-20508\*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**STRENGTH OF GRAPHITE/EPOXY BOLTED WING-SKIN SPLICE SPECIMENS SUBJECTED TO OUTDOOR EXPOSURE UNDER CONSTANT LOAD AND YEARLY FATIGUE LOADING**

G. R. WICHOREK and J. H. CREWS, JR. 1986 35 p refs (NASA-TP-2542; L-16065; NAS 1.60:2542) Avail: NTIS HC A03/MF A01 CSCL 11D

The results of an experimental study to provide long-term durability data on detailed full-scale graphite/epoxy wing-skin joint designs under environmental exposure and cyclic loading associated with commercial transport aircraft are reported. The specimens consisted of a single-row bolt configuration fabricated from T300/5208 and a double-row bolt configuration fabricated from T300/5209. The unpainted specimens were exposed to the outdoor environment under a sustained tensile load, and at yearly intervals, they were subjected to fatigue loading. Experimental results showed a slight reduction in residual tensile strength for both graphite/epoxy joints under the exposure times and fatigue loadings reported. A 7.5-percent decrease in residual strength was observed for the T300/5208 single-row joint after 5 years exposure and two lifetimes of fatigue loading. A 5.3-percent decrease in residual strength was observed for the T300/5209 double-row joint

after 7 years exposure and 2.8 lifetimes of fatigue loading. The 5208 epoxy material was more susceptible to degradation by ultraviolet radiation than the 5209 epoxy material. Author

**N86-20522#** Air Force Wright Aeronautical Labs., Wright-Patterson AFB, Ohio.

**FUEL PROPERTY EFFECTS ON COMBUSTION Final Report, Sep. 1984 - Apr. 1985**

C. A. OBRINGER Oct. 1985 20 p

(Contract AF PROJ. 304-8)

(AD-A162451; AFWAL-TR-85-2051) Avail: NTIS HC A02/MF A01 CSCL 21D

This report deals with fuel property effects on gas turbine engine combustors. In order to increase jet fuel availability and decrease cost, the Air Force is investigating alternate feedstocks such as tar sands, shale oils, heavy oils, and coal derived fuels. As these lower quality feedstocks begin to play a major role as sources of military jet fuels, it becomes increasingly important to be able to evaluate the effects of these fuels on engine life and performance. These effects have usually been measured using expensive and time-consuming engine tests. Of major concern in each of these programs was the effects of fuel properties and composition on soot formation, and the effects of soot on engine performance and durability. Being able to predict the change in soot formation due to changing fuel properties would be an invaluable tool in future research and development efforts to eliminate soot formation and its deleterious effects on engines. The reduction in exhaust plume, through reduced soot formation, reduces a vehicle's visibility for tracking and targeting purposes, thus increasing its survivability. It was concluded that smoke and combustion linear radiative heating correlate well with hydrogen content. That hydrogen content is as effective as any parameter at predicting soot formation; and the questioning of the validity of the data, and the need for more and better data. GRA

**N86-20560\*** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

**COPOLYMERS OF VINYL STYRILPYRIDINES OR VINYL STILBAZOLES WITH BISMALIMIDE Patent**

J. A. PARKER, A. H. HEIMBUCH, M. T. S. HSU, and T. S. CHEN, inventors (to NASA) 2 Jul. 1985 11 p Filed 18 Nov. 1983 (NASA-CASE-ARC-11429-1-CU; US-PATENT-4,526,925; US-PATENT-APPL-SN-553339; US-PATENT-CLASS-524-548; US-PATENT-CLASS-525-186; US-PATENT-CLASS-526-262; US-PATENT-526-265) Avail: US Patent and Trademark Office CSCL 11B

Vinyl pyridines including vinyl stilbazole materials and vinyl styrylpyridine oligomer materials are disclosed. These vinylpyridines form copolymers with bismaleimides which copolymers have good fire retardancy and decreased brittleness. The cure temperatures of the copolymers are substantially below the cure temperatures of the bismaleimides alone. Reinforced composites made from the cured copolymers are disclosed as well.

Official Gazette of the U.S. Patent and Trademark Office.

**N86-20569#** Department of the Navy, Washington, D. C. **CONDUCTIVE HETEROCYCLIC LADDER POLYMERS Patent Application**

O. K. KIM, inventor (to Navy) 30 May 1985 10 p

(AD-D011915; US-PATENT-APPL-SN-739354) Avail: NTIS HC A02/MF A01 CSCL 07C

The present invention pertains generally to electroactive materials and in particular to electroactive organic ladder polymers. The electrical properties of organic polymers have attracted a great deal of attention from the scientific and industrial communities. Conductive polymers would be useful for the production of light weight batteries for electric vehicles and for use in place of metallic conductors aboard aircraft, where weight is an important consideration. They may also prove useful where corrosion resistance is required. It is one object of this invention to obtain and organic ladder polymer with high electrical conductivity. It is a further object of this invention to obtain a conductive ladder polymer that is stable against both thermal and chemical degradation.

Phenothiazine Ladder Polymer, PTL (or di-chloro-PTL) was prepared by polycondensation of 2,5-diamino-1, 4-benzenedithiol with 2,5 dichloro (or 2,3,5,5-tetrachloro)-p-benzoquinone in polyphosphoric acid at 250 C. Phenoxazine Ladder Polymer, POL, was prepared from 2,5-dichloro-p-phenyldiamine and 2,5-dihydroxy-p-benzoquinone under the same conditions as used for PTL synthesis. Di-chloro-POL and other derivatives can be made under a similar condition. These polymers conduct electricity. GRA

**N86-20580#** Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).

**PRODUCTIBILITY AND COST STUDIES OF AVIATION KEROSENE**

C. C. ROSEN, III, ed. Jul. 1985 51 p refs  
(AGARD-AR-227; ISBN-92-835-1504-8) Avail: NTIS HC A04/MF A01

A computer analysis conducted by Exxon Research and Engineering Company and NASA used standard refinery planning methods to determine the optimum processing path within model refineries to achieve minimum cost for various product outputs. Crude feedstock types were combined and refinery configurations selected to create regional calculation models. Principal objectives were: to determine the effect of jet fuel quality variations on the maximum yield of jet fuel; to determine the effect of jet fuel quality variations on refining costs for regional models based on future supply and demand; and to determine, for the United States Air Force, the effect of changing from wide cut (naphtha) to kerosene jet fuels on refining cost and production yield in the United States and Europe. B.G.

**N86-21615#** B and M Technological Services, Inc., Cambridge, Mass.

**STATE-OF-THE-ART REVIEW ON COMPOSITE MATERIAL FATIGUE/DAMAGE TOLERANCE Final Report, Jul. - Nov. 1984**

R. L. AMORY and D. S. WANG Dec. 1985 81 p refs  
(Contract DTFA03-84-C-00052)  
(FAA/CT-85/7; FAA-84-03-F) Avail: NTIS HC A05/MF A01

A state of the art review on composite material fatigue/damage tolerance was conducted to investigate the literature for fatigue life prediction methodologies including stress based methodologies, strength degradation models, and damage growth models. A critical review was made of each methodology and its commensurate basic equations of importance. Experimental data were reviewed and the behavior of specimens was correlated with that of civil aircraft components. Six recognized methods for the non-destructive testing of fibrous composite materials were examined and the most effective methods identified. Author

**N86-21662#** Fairchild Republic Co., Farmingdale, N.Y.  
**STRUCTURAL EVALUATION OF SUPERPLASTIC ALUMINUM. PART 1. MECHANICAL, CORROSION, METALLURGICAL DATA Final Report, Jun. 1983 - Mar. 1985**

H. C. LIPSIUS, J. STOCK, and A. SHAMES Aug. 1985 120 p  
(Contract F33615-83-C-3208)  
(AD-A161366; AFWAL-TR-85-3050-PT-1) Avail: NTIS HC A06/MF A01 CSCL 11F

The mechanical, corrosion, metallurgical and secondary fabricability properties of the superplasticity formable Supral alloy were evaluated to assess the amenability of these alloys to standard aircraft practices. Fracture and fatigue properties were evaluated through extensive testing of superplasticity formed parts and discs. The mechanical property test results meet Alcan/Superform claims provided that the microaviation is restricted to less than three percent of the volume. Research findings show that Supral 100, 150, and 220 are alloys suitable for aircraft use. Testing of shop manufacturing practices and welding techniques indicate that the Supral alloys are comparable to standard U.S. aluminum alloys. GRA

**N86-21686\*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

**AMINOPHENOXCYCLOTRIPHOSPHAZENE CURED EPOXY RESINS AND THE COMPOSITES, LAMINATES AND STRUCTURES THEREOF Patent Application**

D. KUMAR (NRC-NAS), G. M. FOHLEN, and J. A. PARKER, inventors (to NASA) 21 Nov. 1985 22 p  
(NASA-CASE-ARC-11548-1; NAS 1.71:ARC-11548-1; US-PATENT-APPL-SN-806572) Avail: NTIS HC A02/MF A01 CSCL 11B

Aminophenoxycyclotriphosphazenes such as hexakis(4-aminophenoxy)cyclotriphosphazene and tris(4-aminophenoxy)-tris phenoxy-cyclotriphosphazene are used as curing agents for epoxy resins. These 1,2-epoxy resins are selected from di- or polyepoxide containing organic moieties of the formula  $(CH_2-CHO-CH_2)_m-W-R-W-(CH_2CH-CH_2O)_m$  where R is diphenyldimethylmethane, diphenylmethane, bis(dibromophenyl)dimethylmethane. W is a nitrogen or oxygen atom; and m is 1 when W is oxygen and 2 when W is nitrogen. The resins are cured thermally in stages at between about 110 to 135 C for between about 1 and 10 min, then at between about 175 to 185 C for between about 0.5 to 10 hr and post-cured at between about 215 and 235 C for between about 0.1 and 2 hr. These resins are useful for making fire resistant elevated temperature stable composites, laminates (e.g., graphite fiber or fiberglass), molded parts, and adhesives and structures, usually for aircraft secondary structures and for spacecraft construction. NASA

**N86-21704\*#** Virginia Polytechnic Inst. and State Univ., Blacksburg. Dept. of Chemistry.

**DEVELOPMENT OF LC-13C NMR Final Annual Report, 10 Jan. 1984 - 9 Jan. 1985**

H. C. DORN, J. S. WANG, and T. E. GLASS 17 Mar. 1986 20 p refs  
(Contract NAG3-517)  
(NASA-CR-176656; NAS 1.26:176656) Avail: NTIS HC A02/MF A01 CSCL 21D

This study involves the development of C-13 nuclear resonance as an on-line detector for liquid chromatography (LC-C-13 NMR) for the chemical characterization of aviation fuels. The initial focus of this study was the development of a high sensitivity flow C-13 NMR probe. Since C-13 NMR sensitivity is of paramount concern, considerable effort during the first year was directed at new NMR probe designs. In particular, various toroid coil designs were examined. In addition, corresponding shim coils for correcting the main magnetic field (B sub 0) homogeneity were examined. Based on these initial probe design studies, an LC-C-13 NMR probe was built and flow C-13 NMR data was obtained for a limited number of samples. Author

**N86-21707#** Air Force Wright Aeronautical Labs., Wright-Patterson AFB, Ohio.

**F100 FUEL SAMPLING ANALYSIS Final Technical Report, May 1983 - Apr. 1984**

L. Q. MAURICE Sep. 1985 136 p  
(Contract AF PROJ. 3048)  
(AD-A161667; AFWAL-TR-85-2045) Avail: NTIS HC A07/MF A01 CSCL 21D

Fuel pump cavitation problems experienced with the F100 engine used in the F-15/F-16 aircraft have led to an extensive fuel analysis program to identify fuel properties that might be contributing to fuel pump failures. This report analyzes the chemical and physical properties of twenty-one JP-4 fuel samples obtained from United States Air Force Bases. The fuels analyzed met specifications in all but a few isolated cases, and had no unusual properties. If the fuel used is causing fuel pump failure, it must be the result of a fuel property not being measured. The fuels are as good or better than the specification prescribes. It is concluded that the F100 fuel pump cavitation problems are most likely associated with the mechanical complexity built into the design, rather than the result of the fuel used. GRA

## 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.

**A86-26336**

**THE THERMO-MECHANICAL PROCESSING DURING CLOSED DIE FORGING - A METHOD OF IMPROVING AERONAUTICAL MATERIALS [LE TRAITEMENT THERMOMECHANIQUE PAR MATRICAGE - FACTEUR D'AUGMENTATION DES PERFORMANCES DES MATERIAUX AERONAUTIQUES]**

F. CHEVET and A. GAVART (Compagnie Francaise de Forges et Fonderies, Paris-la-Defense, France) (Colloque sur les Aciers et les Alliages Speciaux dans l'Aeronautique, 11th, Le Bourget, France, June 6, 1985) *Materiaux et Techniques* (ISSN 0032-6895), Oct.-Nov. 1985, p. 611-617. In English and French.

In closed die forging, the general aim of thermomechanical processing, which is to improve mechanical properties through the control of structure by hot working, is extended to the control of local strains; difficulties arise, however, in that closed die hot forming does not yield homogeneous strain throughout the volume of the metal being worked. The development of simulation techniques that can 'visioplastically' determine local strain at every location has accordingly been undertaken. These techniques have yielded the ability to forge aircraft gas turbine elements requiring precise structural contour control, such as superalloy gas turbine disks. These techniques may also be applied to titanium, steel, etc. O.C.

**A86-26544**

**RELIABLE NONDESTRUCTIVE TESTING - THE KEY TO USING WELDMENTS IN CRITICAL FIGHTER AIRCRAFT STRUCTURE**

R. J. LORD and P. J. RAMSEY (McDonnell Aircraft Co., St. Louis, MO) *Materials Evaluation* (ISSN 0025-5327), vol. 44, Feb. 1986, p. 209-214, 208. refs

A nondestructive testing (NDT) procedure was developed for the purpose of controlling the weld quality of electron beam welds in critical fighter aircraft structures subjected to complex load patterns. The weldment is inspected using liquid penetrant, ultrasonic, and X-ray techniques designed specifically for the part configuration. The primary considerations of the NDT are: (1) the importance of X-ray beam alignment for detection of lack of fusion, (2) the effect of surface finish on ultrasonic inspection, and (3) the importance of pickling prior to penetrant inspection. An X-ray technique for confirming proper alloy usage was developed, together with a unique X-ray beam alignment indicator and a special sound beam reflection mirror to facilitate the X-ray and ultrasonic inspections. I.S.

**A86-26682\*** Virginia Polytechnic Inst. and State Univ., Blacksburg.

**EFFICIENT IDENTIFICATION OF CRITICAL STRESSES IN STRUCTURES SUBJECT TO DYNAMIC LOADS**

R. T. HAFTKA, L. T. WATSON (Virginia Polytechnic Institute and State University, Blacksburg), and R. V. GRANDHI *Computers and Structures* (ISSN 0045-7949), vol. 22, no. 3, 1986, p. 373-386. refs

(Contract NAG1-224; NSF MCS-82-07217)

Optimum structural design problems generally employ constraints which are parametric in terms of space and time variables. A parametric constraint may be replaced by equivalent critical point constraints at its local minima for optimization applications. In complex structures, accurate identification of such critical points is computationally expensive due to the cost of finite element analyses. Three techniques are described for efficiently and accurately identifying critical points for space- and

time-dependent parametric constraints. An adaptive search technique and a spline interpolation technique are developed for exactly known response. A least squares spline approximation is suggested for noisy behavior. A helicopter tail-boom structure subjected to transient loading is used as an example to demonstrate the techniques described. All three techniques are shown to be computationally efficient for critical point identification and the least squares approximation also removes noise from the data. The case of multiple constraints per element is shown to be particularly suited to the use of spline techniques. Author

**A86-26717**

**TITANIUM NEAR NET SHAPE COMPONENTS FOR DEMANDING AIRFRAME APPLICATIONS**

R. H. WITT and A. L. FERRERI (Grumman Aerospace Corp., Bethpage, NY) *SAMPE Journal* (ISSN 0091-1062), vol. 22, Jan.-Feb. 1986, p. 13-18. refs

This paper deals with the viability of Hot Isostatic Pressing (HIP) Near Net Shape (NNS) titanium parts in competition with forged or cast components. The paper summarizes NNS and advanced alloy capability and experience for each process, and includes economic assessments for specific parts varying in size and complexity. Overall results show that HIP offers greatest near-term potential for producing the complex parts considered in this study. Author

**A86-26876**

**COMBINED EXPERIMENTAL/ANALYTICAL MODELING OF DYNAMIC STRUCTURAL SYSTEMS; PROCEEDINGS OF THE JOINT MECHANICS CONFERENCE, ALBUQUERQUE, NM, JUNE 24-26, 1985**

D. R. MARTINEZ, ED. and A. K. MILLER, ED. (Sandia National Laboratories, Albuquerque, NM) Conference sponsored by ASCE and ASME. New York, American Society of Mechanical Engineers, 1985, 235 p. For individual items see A86-26877 to A86-26885.

It is pointed out that modern structural analysis involves the use of both analytical and experimental techniques. The presented papers have the objective to report the state-of-the-art in combined experimental/analytical modeling, including the substructure synthesis techniques and experimental procedures required to apply these techniques in practical applications. An overview of analytical synthesis techniques is provided, taking into account a review of the time-domain and frequency-domain component mode synthesis method. In connection with an overview of modal testing and measurement, modal test requirements for coupled structure analysis using experimentally-derived component models are examined along with excitation, measurement, and analysis methods for model testing. Hybrid experimental/analytical dynamic models of aerospace structures are considered, and structural analysis model validation using modal test data is discussed. A description of case histories and applications is also given. G.R.

**A86-26878#**

**MODAL TEST REQUIREMENTS FOR COUPLED STRUCTURE ANALYSIS USING EXPERIMENTALLY-DERIVED COMPONENT MODELS**

D. J. EWINS (Imperial College of Science and Technology, London, England) IN: Combined experimental/analytical modeling of dynamic structural systems; Proceedings of the Joint Mechanics Conference, Albuquerque, NM, June 24-26, 1985. New York, American Society of Mechanical Engineers, 1985, p. 31-47. refs

A review is made of some of the methods available for making vibration analyses of complex structures where one or more of the component substructures is modelled from experimental, rather than theoretical, data. These methods are discussed with particular reference to the implications for the test procedures which must be used and attention is focussed on the methods of analysis which are based on response properties. A number of practical problems encountered in typical applications are considered and recommendations made to aid successful implementation of the method. Author

A86-26883#

**EXPERIMENTAL SYSTEM IDENTIFICATION FOR  
EXPERIMENTAL/ANALYTICAL CORRELATION AND  
MODELLING**

N. NIEDBAL (DFVLR, Institut fuer Aeroelastik, Goettingen, West Germany) IN: Combined experimental/analytical modeling of dynamic structural systems; Proceedings of the Joint Mechanics Conference, Albuquerque, NM, June 24-26, 1985. New York, American Society of Mechanical Engineers, 1985, p. 195-204. refs

The dynamic qualification of spacecraft structures is considered, taking into account the use of modal survey tests to verify normal mode parameters. A survey is conducted of the state of the art of the classical sine-dwell methods and of some experimental modal analysis methods. The advantage of the new methods is that appropriated exciter forces, in the sense of the sine-dwell method are unnecessary. It is pointed out that in Europe the classical sine-dwell method is preferred to measure the normal mode parameters of the undamped structure for correlation and modelling of experimental and analytical results. Because of its superior flexibility, the model survey test concept is expected to attract increasing interest for purposes of dynamic qualification of future spacecraft structures. G.R.

A86-26937#

**RELIABILITY AND FAILURE PREVENTION THROUGH ESA IN  
THE 80'S AND BEYOND**

S. R. KATZ (Measurements Group, Inc., Raleigh, NC) IN: Failure prevention and reliability - 1985; Proceedings of the Conference, Cincinnati, OH, September 10-13, 1985. New York, American Society of Mechanical Engineers, 1985, p. 123-126.

Experimental stress analysis (ESA) involves the measurement of strains due to the stresses to which a structure or element is subjected, and is applied where there is a risk of structural failure in service. Practical ESA techniques fall into the two broad categories of electronic and optical methods. Strain gage technology, which exemplifies the former category, has been extensively used in the aircraft industry to record the behavior of structural elements under stress. Optical ESA methods include photoelastic coatings and models that operate on the basis of patterns generated by polarized light. O.C.

A86-27076

**ENERGY DISSIPATION CONNECTED WITH VIBRATIONS OF  
MECHANICAL SYSTEMS [RASSEIANIE ENERGII PRI  
KOLEBANIYAKH MEKHANICHESKIKH SISTEM]**

G. S. PISARENKO, ED. Kiev, Izdatel'stvo Naukova Dumka, 1985, 312 p. In Russian. For individual items see A86-27077 to A86-27086.

Results of analytical and experimental studies of the vibrations of various elastic systems under both steady-state and transient conditions are presented, with particular attention given to the effect of energy dissipation. Topics discussed include dissipative properties of cyclically deformed materials, vibrations of machine parts and components, and aerodynamic damping of the vibrations of various mechanical systems. In particular, papers are presented on the nonlinear vibrations of rectangular plates with allowance for energy dissipation; vibrations of shells of imperfectly elastic materials with allowance for geometrical nonlinearity; mathematical models for studying aircraft vibrations with allowance for structural hysteresis; and the effect of a periodic aerodynamic load on the dynamic stress level of the rotor blades of a turbomachine. V.L.

A86-27126

**INTERNATIONAL SYMPOSIUM ON ELECTROMAGNETIC  
COMPATIBILITY, WAKEFIELD, MA, AUGUST 20-22, 1985,  
RECORD**

Symposium sponsored by IEEE. New York, Institute of Electrical and Electronics Engineers, 1985, 651 p. For individual items see A86-27127 to A86-27157

Various papers on electromagnetic compatibility are presented. The general topics addressed include: EMI transient/impulsive disturbances, electromagnetic shielding, antennas and propagation,

measurement technology, anechoic chamber/open site measurements, communications systems, electrostatic discharge, cables/transmission lines. Also considered are: electromagnetic environments, antennas, electromagnetic pulse, nonlinear effect, computer/data transmission systems, EMI standards and requirements, enclosures/TEM cells, systems EMC, and test site measurements. C.D.

A86-27146

**THE PARALLEL-PLATE AND RHOMBIC EMP SIMULATORS -  
A SUMMARIZING REVIEW**

R. W. P. KING (Harvard University, Cambridge, MA) IN: International Symposium on Electromagnetic Compatibility, Wakefield, MA, August 20-22, 1985, Record. New York, Institute of Electrical and Electronics Engineers, 1985, p. 381-384. refs

Tests of the vulnerability of aircraft and missiles to electromagnetic pulses (EMP) similar to those emanating from a nuclear explosion in the atmosphere are being conducted with the aid of large parallel-plate structures with tapered input and output ends. This paper provides a final report of research conducted regarding the employed EMP simulators. The induced surface currents on obstacles are considered along with CW operation of the metal-plate simulator, CW operation of a rhombic simulator, the rhombic simulator under pulse excitation, an experimental study of the metal-plate simulator, supplementary studies, and aspects of simulator-obstacle interaction. G.R.

A86-27151

**METHODOLOGY FOR DETERMINATION OF CIRCUIT SAFETY  
MARGINS FOR MIL-E-6051 EMC SYSTEM TEST**

G. LEE and S. D. ELLERSICK (Boeing Military Airplane Co., Seattle, WA) IN: International Symposium on Electromagnetic Compatibility, Wakefield, MA, August 20-22, 1985, Record. New York, Institute of Electrical and Electronics Engineers, 1985, p. 502-510. refs

(Contract F33657-81-C-0212)

The MIL-E-6051 electromagnetic compatibility (EMC) system test is concerned with the establishment of safety margins for avionics mission critical circuits. The safety margin (SM) of a circuit is the comparison of the circuit threshold to the electromagnetic (EM) energy coupled into that circuit. In the case of the B-1B Avionics system certain difficulties were related to the complexity of the system with over 100 subsystem elements called line replaceable units (LRUs). A description is provided of the approaches taken and the analyses performed in selection of B-1B Avionics mission critical circuits to be sensitized or instrumented for test. Attention is given to aspects of methodology, mission critical LRU identification, interface circuit identification, circuit analysis, and wire-to-wire coupling analysis. G.R.

A86-27157

**AN OVERVIEW OF THE INTRASYSTEM EMC ANALYSIS  
PROGRAM WITH GRAPHICS**

G. L. BROCK, T. L. BEDFORD, and G. M. GRANGE (Kaman Sciences Corp., Colorado Springs, CO) IN: International Symposium on Electromagnetic Compatibility, Wakefield, MA, August 20-22, 1985, Record. New York, Institute of Electrical and Electronics Engineers, 1985, p. 585-592.

The Intrasystem Electromagnetic Compatibility Analysis Program (IEMCAP) represents a computer program which was designed to perform EMC analyses of ground, aircraft, spacecraft, and missile systems. A number of improvements for IEMCAP are discussed. The resulting analysis tool with improved capabilities is called the Intrasystem Electromagnetic Compatibility Analysis Program with Graphics (IEMCAP-G). It is pointed out that the improvements help the EMC engineer in evaluating a system for compatibility. Thus, matrices, antenna plots, and line graphs make it possible to tell at a glance the severity of the potential EMI problems. Attention is given to an IEMCAP overview, available options for positive electromagnetic interference (EMI) point margins, detailed interference matrices, the extraction of data, geometry graphics, antenna position graphics, antenna gain patterns, line plots, and an analysis culling technique. G.R.

A86-27203

**ENGINEER'S GUIDE TO TITANIUM CASTINGS**

R.H. COLLEY IN: *Titanium: Science and technology; Proceedings of the Fifth International Conference on Titanium*, Munich, West Germany, September 10-14, 1984. Volume 1 . Oberursel, West Germany, Deutsche Gesellschaft fuer Metallkunde, 1985, p. 151-156.

The main features of the *Engineer's Guide to Titanium Castings* are summarized. The Guide was developed to supply the essential data for cost-effective designs with Ti alloys. The Guide delineates the special properties of molten Ti in casting processes, particularly the high reactivity of Ti with other elements. Centrifuged molds and investment shell molds and their applications are described, along with the criteria which should be considered when judging whether or not to go to a cast Ti part instead of a wrought part. Design principles to avoid porosity, tooling complexity and shrinkage cavities are reviewed. Minimal stress values are provided for cast Ti alloys (Ti-6Al-4V), and factors to assess when comparing the costs of Ti alloys, which have long lifetimes, with other materials are discussed. M.S.K.

A86-27204

**TITANIUM INVESTMENT CASTING - PRODUCTION, PROPERTIES AND APPLICATIONS**

CH. LIESNER (Titan-Aluminum-Feinguss GmbH, Bestwig, West Germany) IN: *Titanium: Science and technology; Proceedings of the Fifth International Conference on Titanium*, Munich, West Germany, September 10-14, 1984. Volume 1 . Oberursel, West Germany, Deutsche Gesellschaft fuer Metallkunde, 1985, p. 157-162. refs

Ti alloy casting techniques, repair welding of castings, and areas of applications are discussed. Investment casting by the lost wax method represents a cost savings compared to machining. Ti alloys are preferred for highly stressed aircraft parts, impellers and medical implants. Melting is performed in one of two ways for casting: in electron beam furnaces or in a vacuum arc furnace with a consumable electrode. The latter method offers superior heat distribution and less evaporative loss of alloy elements. Casts are lined with resin-bound graphite, thermodynamic high solid oxides/oxide binders such as ThO<sub>2</sub>, Y<sub>2</sub>O<sub>3</sub> or CaO, or high melting metals/oxide binders to prevent the intrusion of liner material into the surface of the cast part. Gas holes are prevented by centrifuging the cast with the melt in it. Weld repairs to fractured parts have exhibited mechanical properties similar to the parent material. Cast Ti alloy parts find their greatest applications where a high mechanical strength/specific gravity ratio or a high solidity/low specific gravity ratio is required. Author

A86-27211

**RECYCLING OF TITANIUM SCRAP FOR THE PRODUCTION OF HIGH-DUTY AEROSPACE COMPONENTS**

H. JAEGER, J. MAYERHOFER, R. TARMANN, J. NEUHOLD, and J. FLADISCHER (Vereinigte Edelstahlwerke AG, Kapfenberg, Austria) IN: *Titanium: Science and technology; Proceedings of the Fifth International Conference on Titanium*, Munich, West Germany, September 10-14, 1984. Volume 1 . Oberursel, West Germany, Deutsche Gesellschaft fuer Metallkunde, 1985, p. 257-264. refs

The production of Ti for aerospace applications can consume up to 50 MWh for a ton of Ti ingot, while machining practices can leave up to 90 percent of the original metal as scrap. Recycling reduces the costs of Ti feedstock, and accounts for 30 percent of all Ti used in the U.S. The non-consumable arc furnace (NAF) offers several advantages for recycling operations when compared with the consumable melting furnace (CMF). The benefits include ingots that are 100 percent scrap, control of the loss of alloying trace elements, tailored heating of the melt and no combustibles in the furnace. NAF plants are more expensive than CMF operations, and feature either a skull melting procedure or use of a ceramic-lined crucible. Both methods require a power input of 4.4 MW for a melting rate of 500-600 kg/hr at pressures of 50-100 Pa. The scrap is cut up, pickled and sandblasted, then inspected visually to remove casting, instead of milling or machining, of high

performance Ti alloy components of jet aircraft is being developed as an acceptable forming technique which has a significantly lower scrap generation rate. M.S.K.

A86-27227

**TEN YEARS OF FRONT-FAN BLADE FORGING**

O. VOIGTLAENDER and G. GUENTHER (Thyssen Schmiedetechnik, Remscheid, West Germany) IN: *Titanium: Science and technology; Proceedings of the Fifth International Conference on Titanium*, Munich, West Germany, September 10-14, 1984. Volume 1 . Oberursel, West Germany, Deutsche Gesellschaft fuer Metallkunde, 1985, p. 477-481. refs

The drop forge processes employed to shape the front turbofan blades for the RB 211-554 engine are described. About 70,000 of the blades have been delivered since the beginning of the 1970s, each designed to withstand a tangential speed of Mach 1.4 and 780 KN force at the root. The blades were designed using CAD techniques which helped define a die shape that accounted for heat shrinkage, the distribution of contact stresses at the die interface, the elastic contact strains of the die and the mass distributions for preform, intermediate and finish forged shapes. Drop forging is used to alter a rod of machined material into the blade shape after successive twisting and coining operations to produce the desired shape. The transformation stages are balanced to ensure a smooth grain flow along the blade contour. M.S.K.

A86-27247

**ISOTHERMAL FORGING SYSTEM FOR THE PRODUCTION OF LARGE ROTATING COMPONENTS FROM TITANIUM ALLOYS OR SUPERALLOYS**

F. HUGO (Leybold-Heraeus Technologies, Inc., Enfield, CT), A. HENN, R. DEBES, D. SCHWARZ, F. ANDERLE (Leybold-Heraeus GmbH, Hanau, West Germany) et al. IN: *Titanium: Science and technology; Proceedings of the Fifth International Conference on Titanium*, Munich, West Germany, September 10-14, 1984. Volume 2 . Oberursel, West Germany, Deutsche Gesellschaft fuer Metallkunde, 1985, p. 741-744.

A86-27272

**PRODUCIBILITY OF AIRCRAFT STRUCTURAL PARTS BY SUPERPLASTIC FORMING AND DIFFUSION BONDING**

R. HOLBEIN and K.-F. SAHM (Dornier GmbH, Friedrichshafen, West Germany) IN: *Titanium: Science and technology; Proceedings of the Fifth International Conference on Titanium*, Munich, West Germany, September 10-14, 1984. Volume 2 . Oberursel, West Germany, Deutsche Gesellschaft fuer Metallkunde, 1985, p. 1237-1244. refs

Weight and cost reduction assessments are made for a variety of aircraft structural components fabricated by superplastic forming/diffusion bonding (SPF/DB) of Ti alloys, with attention to component development management on the basis of experimental efforts. Two-, three-, and four- sheet (as well as single-sheet) basic structural forms from which aircraft structural elements can be compounded by SPF/DB are discussed, and fin, engine mount and fire wall structures produced by these means are evaluated. O.C.

A86-27278

**EB REPAIR WELDING OF A CRITICAL AIRCRAFT PART MADE FROM THE NONWELDABLE TITANIUM ALLOY 3.7184.7 (Ti-AL4-MO4-SN2-SI)**

G. NEYE and A. KOLLEY (Messerschmitt-Boelkow-Blohm GmbH, Bremen, West Germany) IN: *Titanium: Science and technology; Proceedings of the Fifth International Conference on Titanium*, Munich, West Germany, September 10-14, 1984. Volume 2 . Oberursel, West Germany, Deutsche Gesellschaft fuer Metallkunde, 1985, p. 1291-1298. refs

Attention is given to the electron beam welding-based repair method used for the Ti alloy flap carriage torsion cell of the A300 airliner, which cost only about 28 percent as much as the fabrication of a new component. Electron beam welding yielded no distortion due to thermal loads, and no embrittlement of the weld area due to gas absorption. It is noted that such welding-based repair



operations make possible the restoration of defective or damaged items for unrestricted subsequent use, at economical cost. O.C.

**A86-27371**

**FRETTING FATIGUE TESTING WITH A FRETTING BRIDGE EQUIPMENT STRESS ANALYSIS, AMPLITUDES OF SLIP, RELIABILITY**

E. BROSZEIT, K. H. KLOOS, and B. O. SCHWEIGHOFER (Darmstadt, Technische Hochschule, West Germany) IN: Titanium: Science and technology; Proceedings of the Fifth International Conference on Titanium, Munich, West Germany, September 10-14, 1984. Volume 4. Oberursel, West Germany, Deutsche Gesellschaft fuer Metallkunde, 1985, p. 2179-2186.

In aircraft engines, titanium alloys are used as material for turbine blades in the fan area, on the basis of weight considerations. In such cases, fretting can lead to macrocracks which represent serious component defects. The present paper is concerned with a study of the fretting fatigue behavior of the alloy Ti-6Al-4V with the aid of a model apparatus. The approach employed in the study is based on the fretting bridge test principle. Attention is given to the fretting bridge arrangement, typical damage observed in the case of a specimen fractured in a fretting fatigue test, and the significance of the stress distribution in the system of specimen and fretting bridge. The investigation of the stress and slip distribution in the contact system specimen-fretting bridge is discussed, taking into account the finite element structure and stress distribution, the stress profile in the contact area of specimen and fretting bridge during a cycle of load, the distribution of slip between specimen and fretting bridge, and the material stressing in the contact area. G.R.

**A86-27492**

**NOISE IMMUNITY OF SIGNALS WITH MINIMUM FSK [POMEKHOUSTOICHIVOST' SIGNALOV S MINIMAL'NOI CHASTOTNOI MANIPULIATSIEI]**

A. I. LOGVIN and S. V. NEBUSEV Radiotekhnika (ISSN 0033-8486), Jan. 1986, p. 49-54. In Russian. refs

The Markov theory of optimal nonlinear filtering is used to synthesize a receiver scheme for minimum-FSK signals with random changes of the HF phase and signal delay. Formulas for estimating the noise immunity of the synthesized scheme are presented, and numerical-integration results are given. It is noted that the proposed scheme is suitable for satellite and aircraft communications systems. B.J.

**A86-27653#**

**A STUDY OF THE STATIC POST BUCKLING BEHAVIOR OF COMPOSITE SANDWICH PLATES**

S. HANAGUD, H. P. CHEN, and P. SRIRAM (Georgia Institute of Technology, Atlanta) IN: International Conference on Rotorcraft Basic Research, Research Triangle Park, NC, February 19-21, 1985, Proceedings. Alexandria, VA, American Helicopter Society, 1985, 13 p. refs

A static post buckling behavior of composite sandwich plates has been analyzed in this paper. A consistent and general three dimensional approach to the formulation has been presented. Finite deformations have been considered and a total Lagrangian approach has been used. Numerical solutions have been obtained by a discrete penalty function based finite element technique. A constant arc-length method has been used for equilibrium iterations to achieve faster convergence needed in post buckling studies. Author

**A86-27703**

**MECHANICAL DESIGN AND EVALUATION OF A SLOTTED CFRP WAVEGUIDE ANTENNA**

L. KNUSSON, S. BRUNZELL, and H. MAGNUSSON (Ericsson Radio Systems, AB, Moelndal, Sweden) IN: ICCM - V; Proceedings of the Fifth International Conference on Composite Materials, San Diego, CA, July 29-August 1, 1985. Warrendale, PA, Metallurgical Society, Inc., 1985, p. 475-481.

A development program for a slotted waveguide array antenna made of metallized CFRP was carried out. The main objective

was to minimize the weight of the structure without degrading the electrical and mechanical performance. This paper focuses on mechanical design aspects and manufacturing methods of metallized CFRP waveguides and assembly of an antenna array. A weight saving of approximately 40 percent was accomplished by the CFRP structure compared to a corresponding aluminum structure. Electrical properties and cost were essentially equal for the two concepts. Author

**A86-27741**

**AEROELASTIC TAILORING STUDY IN AIRCRAFT DESIGN**

T. UGAI, H. KIKUKAWA, J. TAKAKI (Fuji Heavy Industries, Ltd., Utsunomiya, Japan), M. SUNAKAWA, and Y. HIRANO (Tokyo, University, Japan) IN: ICCM - V; Proceedings of the Fifth International Conference on Composite Materials, San Diego, CA, July 29-August 1, 1985. Warrendale, PA, Metallurgical Society, Inc., 1985, p. 1221-1232. Research sponsored by the Agency of Industrial Science and Technology.

A computer program to assist the tailoring of aeroelastic composite aircraft wing designs, the Composite Structure Multi-constrained Optimization System (COSMOS), is described. The program makes it possible to perform automatically repeated calculations of design constraints with respect to composite strength, deflection, flutter velocity, and vibration frequency. The main objective of the COSMOS program is the optimization of composite laminated structures, but the optimization of metal structures is also possible. In addition to the four main optimization criteria provided by COSMOS, future constraints on buckling, thermal stress, and fatigue will be incorporated in the future. In order to correlate the design constraints of the COSMOS program, a test prototype laminate structure was built and rigidity and vibration tests were carried out. The test results for strain and twist angle of the model structure are compared with COSMOS estimates in a table. I.H.

**A86-28276**

**STRUCTURAL IMPACT AND CRASHWORTHINESS; PROCEEDINGS OF THE INTERNATIONAL CONFERENCE, IMPERIAL COLLEGE OF SCIENCE AND TECHNOLOGY, LONDON, ENGLAND, JULY 16-20, 1984. VOLUME 1 KEYNOTE LECTURES. VOLUME 2 - CONFERENCE PAPERS**

G. A. O. DAVIES, ED. and J. MORTON, ED. (Imperial College of Science and Technology, London, England) Conference sponsored by USAF, U.S. Army, Westland Helicopters, Ltd., and Imperial College of Science and Technology. London and New York, Elsevier Applied Science Publishers, 1984. Vol. 1, 269 p.; vol. 2, 578 p. No individual items are abstracted in these volumes.

In the present treatment, 'crashworthiness' is understood to mean the ability of land, sea and air vehicles to survive collision without unacceptable damage to payloads; the problem is therefore one of low-to-moderate velocity, and the amount of energy to be absorbed is a major parameter. 'Structural impact' is construed, however, as a more general term, encompassing many cases of high or low velocity impact between objects that may be vehicles, projectiles, ground installations, body armor, etc. Among the topics discussed are NASA research on crash dynamics, the scaling of inelastic structures, vehicle impacts and fire hazards, ballistic deformation, and impact and crashworthiness of composite structures. Also treated are topics in automobile and rail transport, concrete structures, aircraft impacts, fluid-structure interaction, composites, energy absorption, and blast and ballistic effects. O.C.

**A86-28303**

**PROBLEMS OF AIRCRAFT RELIABILITY [PROBLEMY NADEZHNOСТИ LETATEL'NYKH APPARATOV]**

I. F. OBRAZTSOV, ED. and A. S. VOLMIR, ED. Moscow, Izdatel'stvo Mashinostroenie, 1985, 280 p. In Russian. For individual items see A86-28304 to A86-28322.

The papers presented in this volume provide an overview of current theoretical and experimental research in the field of aircraft reliability. Topics discussed include accelerated testing as a means

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of ensuring the reliability of aircraft equipment, reliability and maintenance of aircraft, optimum maintenance of aircraft systems on the basis of their condition with allowance for measurement errors, and deterministic and statistical models of durability. Papers are also presented on problems in the dynamics of aircraft structures exposed to intensive acoustic loading, optimal frequency of the periodic tests of on-board digital computers, and a combined optimal algorithm for filtering and calculating navigation coordinates. V.L.

**A86-28309**  
**RELIABILITY AND MAINTENANCE OF AIRCRAFT [NADEZHNOST' I TEKHNICHESKAIA EKSPLUATATSIIA AVIATSIONNOI TEKHNIKI]**

V. V. FILIPPOV IN: Problems in aircraft reliability . Moscow, Izdatel'stvo Mashinostroenie, 1985, p. 48-62. In Russian. refs

The relationship between the reliability of aircraft systems and the approach to their maintenance is examined, and various maintenance strategies are discussed. In particular, attention is given to maintenance programs based on the remaining life criterion, on the actual condition of the equipment, and on the level of reliability. The problem of determining the optimum periodicity of maintenance is also discussed. V.L.

**A86-28314**  
**RELIABILITY OF THE PLATES AND SHELLS OF AIRCRAFT [NADEZHNOST' PLASTINOK I OBOLOCHEK LETATEL'NYKH APPARATOV]**

A. S. VOLMIR and S. A. TIMASHEV IN: Problems in aircraft reliability . Moscow, Izdatel'stvo Mashinostroenie, 1985, p. 151-170. In Russian.

The reliability of the plate and shell structures of aircraft that are subjected during service to various types of loading, including axial compression, torque, and transverse loading, is investigated using a systems approach. The principal schemes for calculating the reliability of deformable systems are presented, and ways to control the reliability of mechanical systems are discussed. Particular attention is given to cases involving a decrease in the cross-sectional area of thin-walled aircraft structures or a deterioration of the physicomaterial properties of a structural material during service. V.L.

**A86-28315**  
**APPLYING I. G. BUBNOV'S METHOD TO THE SOLUTION OF THE NATURAL VIBRATION PROBLEM FOR A CONICAL SANDWICH PANEL [PRIMENENIE METODA I. G. BUBNOVA K RESHENIIU ZADACHI O SVOBODNYKH KOLEBANIYAKH TREKHSLOINNOI KONICHESKOI PANELI]**

E. I. GRIGOLIUK and E. A. LOPANITSYN IN: Problems in aircraft reliability . Moscow, Izdatel'stvo Mashinostroenie, 1985, p. 171-187. In Russian. refs

A direct variational approach is proposed for solving a problem concerning the natural vibrations of a conical sandwich panel with a stiff core loaded in shear. The eigenvalue problem is solved through simultaneous iteration; the convergence of the method is evaluated. V.L.

**A86-28316**  
**PROBLEMS IN THE DYNAMICS OF AIRCRAFT STRUCTURES EXPOSED TO INTENSIVE ACOUSTIC LOADING [ZADACHI DINAMIKI KONSTRUKTSII LETATEL'NYKH APPARATOV PRI INTENSIVNYKH AKUSTICHESKIKH VOZDEISTVIIAKH]**

A. V. KARMISHIN and I. G. KILDIKOV IN: Problems in aircraft reliability . Moscow, Izdatel'stvo Mashinostroenie, 1985, p. 188-203. In Russian. refs

The current theoretical and experimental research related to the strength of aircraft structures subjected to acoustic loading is briefly reviewed. In particular, attention is given to characteristics of the behavior of thin-walled structural elements under intensive acoustic loading, nonlinear characteristics of panels, and the effect of acoustic loading on the fatigue life and the bearing capacity of structural elements. The importance of considering acoustic loading

in evaluating the reliability of aircraft structures is emphasized.

V.L.

**A86-28318**  
**DYNAMIC STABILITY OF ELASTIC STRUCTURES UNDER RANDOM INFLUENCES [DINAMICHESKAIA USTOICHIVOST' UPRUGIKH KONSTRUKTSII PRI SLUCHAINYKH VOZDEISTVIIAKH]**

B. P. MAKAROV IN: Problems in aircraft reliability . Moscow, Izdatel'stvo Mashinostroenie, 1985, p. 223-235. In Russian. refs

The paper is concerned with problems of the stability and stochastic parametric oscillations of elastic structures that are represented as discrete systems. In particular, the spectra of the critical parameters are analyzed for the case of wide-band and narrow-band effects, and their asymptotic properties are determined. The flutter of a panel in the presence of fluctuations is analyzed as an example. V.L.

**A86-28319**  
**THE LIFE OF REINFORCED THIN-WALLED STRUCTURES IN A RANDOM FORCE FIELD [DOLGOVECHNOST' TONKOSTENNYKH PODKREPLENNYKH KONSTRUKTSII V POLE SLUCHAINYKH SIL]**

V. N. MOSKALENKO IN: Problems in aircraft reliability . Moscow, Izdatel'stvo Mashinostroenie, 1985, p. 236-245. In Russian.

Solutions are presented for problems of the natural vibrations of periodic and quasi-periodic systems in gas flow, as well as problems concerned with the determination of the life of reinforced structures. The properties of the frequency spectra and of the modes of the natural vibrations of periodic and quasi-periodic systems are discussed. It is noted that excitation generally occurs at the frequencies corresponding to the pass band of the elastic skin and at the frequencies corresponding to the preferred vibrations of the acoustic volume. V.L.

**A86-28321**  
**PROBLEMS IN THE STABILITY AND DYNAMICS OF AIRCRAFT STRUCTURES WITH PHYSICOMECHANICAL SINGULARITIES [ZADACHI USTOICHIVOSTI I DINAMIKI ELEMENTOV LETATEL'NYKH APPARATOV S FIZIKO-MEKHANICHESKIMI OSOBENNOSTIAMII]**

I. N. PREOBRAZHENSKI IN: Problems in aircraft reliability . Moscow, Izdatel'stvo Mashinostroenie, 1985, p. 252-262. In Russian.

A method for solving stability problems for stiffened structures is proposed which is based on the formalism of generalized, or impulsive functions. The method is illustrated for a hinged stiffened cylindrical panel with a damaged stiffening element and for a stiffened cylindrical shell. It is shown that in certain cases, the inhomogeneity of the stressed state due to a damage can be neglected in the general stability analysis of a structure. V.L.

**A86-28322**  
**THE EFFECT OF CHANGES IN THE STATIC STRENGTH OF A STRUCTURE DURING SERVICE ON THE RELIABILITY OF AIRCRAFT [VLIYANIE IZMENENIIA STATICHESKOI PROCHNOСТИ KONSTRUKTSII V PROTSESSE EKSPLUATATSII NA NADEZHNOST' LETATEL'NYKH APPARATOV]**

O. I. TEREKUSHKO IN: Problems in aircraft reliability . Moscow, Izdatel'stvo Mashinostroenie, 1985, p. 262-270. In Russian.

An approximate method is proposed for evaluating the effect of changes in the static strength of a structure during service on its reliability. Numerical calculations are presented which show that even a relatively small reduction in static strength can multiply the probability of failure. The effect of the variance coefficients of the initial strength and safety on the reliability is illustrated by examples. V.L.

**A86-28330****A FLEXIBLE PROGRAMMABLE SIGNAL PROCESSOR FOR NEXT GENERATION FIGHTER AIRCRAFT**

R. ROWLETT, C. STEWART, and M. MAYOR (Sperry Corporate Technology Center, Reston, VA) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 1. New York, Institute of Electrical and Electronics Engineers, 1985, p. 22-27. refs

The performance requirements of next generation Programmable Signal Processors (PSP) military radar applications are examined. Consideration is given to processor performance criteria (throughput rate, parameter changes, mode changes) in connection with several air-to-air radar modes including long range search, single target tracking, track-while-scan, and ECCM. Air-to-ground radar modes are also examined, with emphasis given to Moving Target Indication (MTI), Doppler mode, SAR, and terrain following/avoidance. It is shown that next-generation PSP will require processing speeds on the order of 1 billion complex operations per second. It is pointed out that conventional array processor architectures similar to those in current PSPs will need significantly larger memory bandwidths to achieve the required throughput rates. However, the use of parallel architectures such as systolic arrays and wavefront arrays can achieve such speeds with much lower memory bandwidth requirements. I.H.

**A86-28332****DIGITAL CHIRP DEMODULATION**

C. F. ANDREN and M. A. KOMARA (Harris Corp., Melbourne, FL) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 1. New York, Institute of Electrical and Electronics Engineers, 1985, p. 35-40.

The results of computer simulations of process of the digital chirp demodulation are presented. It is shown that digital chirp demodulation can be accomplished using 4-bit signal quantization provided that Gaussian-distributed dither is injected 15 dB below the full-scale level of the quantizer. Comparative results obtained with ramp-type dither showed unacceptable performance, as well as those using less than 4 bits of quantization and more or less dither. Functional block diagrams of analog and digital chirp demodulation processes are provided. I.H.

**A86-28338****FIBER OPTIC HIGH SPEED DATA BUS**

R. MONING and G. HILL (Boeing Military Airplane Co., Wichita, KS) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 1. New York, Institute of Electrical and Electronics Engineers, 1985, p. 88-90.

R&D activity is discussed in connection with a fiber optic data bus architecture having 48 channels for transmission of 64 Kbps PCM voice data. The system consists of three remote terminals, a gateway terminal, and a 4-port star-coupled fiber optic data bus. Each terminal consists of an 8086 processor card which controls the terminal or gateway; a digital-to-analog converter; and an interface card which controls the fiber optic data bus. The data bus protocol for the system is described and a detailed schematic diagram of the protocol initialization sequence is provided. I.H.

**A86-28340****IMAGING CONNECTOR INTERCONNECT SYSTEM FOR A PARALLEL FIBER OPTIC DATA BUS**

R. W. UHLHORN (Harris Corp., Government Aerospace Systems Div., Melbourne, FL) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 1. New York, Institute of Electrical and Electronics Engineers, 1985, p. 95-102. Research supported by the Harris Corporation Independent Research and Development Fund.

A fiber optic data transfer system capable of transmitting high-speed parallel digital data is being developed. This system is part of a total network concept, known as the Distributed Memory

Network (DMN), which has numerous aerospace applications and is directly applicable to bus networking requirements specified in the Advanced Systems Avionics (ASA) baseline. The data transfer system, which utilizes a new optical imaging connector, a multi-fiber transmission medium, and highly reliable electronic and electro-optic components is the heart of the DMN. Because of the very high data rates involved in future avionics systems, fiber optics is the only viable transmission medium, and the connector concept is the only practical way of achieving the required high-speed, high-density parallel interface. The present design is capable of transmitting 64-bit parallel data at word rates up to 128 megawords per second for an equivalent serial data rate of 8.192 Gbps. Author

**A86-28341****A ROBUST 100 MBPS NETWORK FOR AVIONICS APPLICATIONS**

M. P. VARGA (Sperry Corp., Space Systems Div., Phoenix, AZ) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 1. New York, Institute of Electrical and Electronics Engineers, 1985, p. 103-111.

A fiber-optic Local Area Network that operates at a transmission rate of 100 MBPS is designed to feature advantages of random access (contention) networks and deterministic (token) networks. This LAN implements a contention access protocol that dynamically adjusts its performance to that of a token network as the data traffic increases. The statistical relationship between collisions and data traffic load is used to achieve this adjustment in performance. The network and bus interface units (BIUs) incorporate message fault recovery, system statistical monitor, built-in test, low power, high reliability, and radiation resistant features. The network and BIUs were designed to incorporate redundancy with cross-strapping at the physical media, and because the media is a broadcast media with simultaneous transmission over both fiber buses, immediate recovery or many physical layer failures is possible. System level redundancy is supported with BIU internal checks and an automatic switchover to redundant units. Author

**A86-28342****HIGH SPEED FIBER OPTIC DATA BUS FOR AVIONICS INTEGRATION**

P. R. COUCH and K. D. FERRIS (FiberCom, Inc., Roanoke, VA) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 1. New York, Institute of Electrical and Electronics Engineers, 1985, p. 114-121.

(Contract F33615-83-C-1036)

A review of the state-of-the-art of the various elements of a fiber optic data bus has been conducted. Based on the characteristics of the various components, an analysis of data bus system performance in an avionics integration application was performed. Technology/performance limits of the fiber optic data bus elements were combined with the avionics integration requirements to define the tradeoffs between topology, data rate, and number of terminals. The study concluded that fiber optic technology has matured to the point that, optical data buses supporting up to 128 terminals are feasible at data rates up to 300 Mb/s and that such buses will be key to avionics integration with future VHSIC computers and avionic sensors. Author

**A86-28343****HIGH SPEED BUS FOR PAVE PILLAR APPLICATIONS**

M. T. LUDVIGSON and K. L. MILTON (Rockwell International Corp., Collins Government Avionics Div., Cedar Rapids, IA) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 1. New York, Institute of Electrical and Electronics Engineers, 1985, p. 122-129.

The status of development activity in connection with the USAF High Speed Bus Technology program is reviewed. Emphasis is given to wire bus designs with applications in Pave Pillar systems. The basic design requirements of a digital data bus are discussed

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with respect to optimum throughput rate; the optimum number of terminals; message length; and compatibility with fiber-optic media. Network topologies for the bus are described, with attention given to linear networks, active rings, and switched networks. Optimum protocols and message formats for the linear bus topology of the bus are discussed in detail. Functional block diagrams of the wire bus coupler, terminal, and control interfaces of the bus system are provided. I.H.

**A86-28344#**

### **A DUAL CHANNEL HIGH SPEED FIBER OPTICS MULTIPLEX DATA BUS SYSTEM**

H. J. ALBER and W. A. THOMAS (USAF, Systems Aeronautical Systems Div., Wright-Patterson AFB, OH) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 1. New York, Institute of Electrical and Electronics Engineers, 1985, p. 130-135.

This paper provides the framework for a candidate high speed data bus. The high speed data bus is intended for use with the next generation fighter and bomber aircraft. The bus system minimizes the transport delays, optimizes the efficiency of transporting data, and minimizes the control overhead. Manchester coding plus unique start and stop identifiers are used to minimize the complexity of the encoding and decoding electronics. The token passing and centralized bus management concepts provide a deterministic system that can rapidly respond to system faults. Fiber optic point-to-point links are used to minimize the risk in connector and transceiver development, while providing for a large number of users and relatively long distances between devices.

Author

**A86-28372**

### **CONTROL OF A HIGH-SPEED, BRUSHLESS DC MOTOR DRIVEN THROUGH A CYCLOCONVERTER LINE**

J. J. CATHEY, D. B. REESOR (Kentucky, University, Lexington), and J. A. WEIMER (USAF, Aero Propulsion Laboratory, Wright-Patterson AFB, OH) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 1. New York, Institute of Electrical and Electronics Engineers, 1985, p. 376-382. refs (Contract F33615-81-C-201)

Feasibility and concept of designing a high-speed, permanent magnet, brushless dc motor aircraft fuel pump drive using a cycloconverter link is examined. Analytical methods are developed to model the behavior of a three-phase permanent magnetic machine when operated as a self-synchronous motor supplied from a polyphase, variable voltage, variable frequency source through a midpoint cycloconverter link under circulating current free mode of control. A hybrid combination of sinusoidal and dc steady-state analysis methods is utilized to obtain a suitable equivalent circuit of the motor. Study of the motor model is made to establish the nature of the no load MMF angle as a function of current to give a minimum value while assuring proper thyristor commutation. Then, a closed loop control system with an outer loop on speed and an inner loop on current is postulated wherein a proportional plus integral controller is placed in the forward path to assure minimum speed error. A numerical study of performance is presented for speed runup and rundown conditions. Author

**A86-28373**

### **POWER THYRISTOR STARTER FOR AIRCRAFT ENGINE**

Z. CAI (Purdue University, West Lafayette, IN) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 1. New York, Institute of Electrical and Electronics Engineers, 1985, p. 383-390.

A power thyristor starter for powerful aircraft engine is introduced. Some problems which appeared during the industrial testing are analyzed. The technology-economy indices of this device were verified by the experimental curves and by comparing with those of the internal-combustion engine-dc generator power-supply vehicle. Author

**A86-28376**

### **MULTIVOLTAGE HIGH POWER ELECTRICAL POWER SYSTEM**

W. E. HYVARINEN (Westinghouse Electric Corp., Pittsburgh, PA) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 1. New York, Institute of Electrical and Electronics Engineers, 1985, p. 407-412.

Applications are being identified where the optimum aircraft electrical system may not be the conventional 400 Hz approach. The requirements for a multivoltage high power airborne electrical system are presented. The methodology used to define and evaluate operating parameters, system configuration and control philosophy are presented. The approach recommended for this application is described. Author

**A86-28479**

### **IMPROVED RELIABILITY OF ELECTRONIC CIRCUITS THROUGH THE USE OF HEAT PIPES**

A. BASIULIS and C. P. MINNING (Hughes Aircraft Co., Culver, City, CA) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 2. New York, Institute of Electrical and Electronics Engineers, 1985, p. 1244-1247.

The increase in power dissipation of new avionic circuits is applying ever higher demands on the ability of conventional cooling systems to maintain circuit temperatures at acceptable levels. Since the failure rate of an electronic component is strongly temperature dependent, the design of avionics systems is often times limited by thermal considerations. In a sidewall cooled avionics chassis such as that described in MIL-STD-XXX, temperatures of PWB mounted electronic components can be reduced significantly if heat pipes instead of solid metal plates are used to transport electronic-component generated heat to the cooled sidewalls. To demonstrate this results, experimental testing of heat pipe cooled PWBs was combined with thermal analysis to show that the mean time between failure (MTBF) of an advanced bulk memory can be increased by up to 60 percent if heat pipes are used in place of solid metal plates. Author

**A86-28492#**

### **DIAGNOSIS - USING AUTOMATIC TEST EQUIPMENT AND ARTIFICIAL INTELLIGENCE EXPERT SYSTEMS**

J. E. RAMSEY, JR. (USAF, Institute of Technology, Wright-Patterson AFB, OH) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 2. New York, Institute of Electrical and Electronics Engineers, 1985, p. 1369-1374. USAF-supported research.

Three expert systems (ATEOPS, ATEFEXPERTS, and ATEFATLAS), which were created to direct automatic test equipment (ATE), are reviewed. The purpose of the project was to develop an expert system to troubleshoot the converter-programmer power supply card for the F-15 aircraft and have that expert system direct the automatic test equipment. Each expert system uses a different knowledge base or inference engine, basing the testing on the circuit schematic, test requirements document, or ATLAS code. Implementing generalized modules allows the expert systems to be used for any different unit under test. Using converted ATLAS to LISP code allows the expert system to direct any ATE using ATLAS. The constraint propagated frame system allows for the expansion of control by creating the ATLAS code, checking the code for good software engineering techniques, directing the ATE, and changing the test sequence as needed (planning). D.H.

A86-28551#

**CONTACT HEAT TRANSFER - THE LAST DECADE**

C. V. MADHUSUDANA (New South Wales, University, Kensington, Australia) and L. S. FLETCHER (Texas A&M University, College Station) AIAA Journal (ISSN 0001-1452), vol. 24, March 1986, p. 510-523. refs

Thermal contact conductance should be high in such applications as nuclear reactors, gas turbines, aircraft structural joints, etc.; when mechanically strong insulation is required, by contrast, as in the storage of cryogenic liquids, contact resistance must be as high as possible. Attention is presently given to the results obtained since 1970 by theoretical and experimental studies of conduction through contact spots and through interstitial materials. Special problems that are introduced by the geometry of contact, load cycling, and heat flux, are also discussed. Recommendations are made concerning the most fruitful directions for future investigation. O.C.

A86-28553#

**MATERIAL CONTRAVARIANT COMPONENTS - VORTICITY TRANSPORT AND VORTEX THEOREMS**

L. MORINO (Boston University, MA) AIAA Journal (ISSN 0001-1452), vol. 24, March 1986, p. 526-528. refs  
(Contract DAAG26-83-K-0050)

The concept of material contravariant components of the vorticity in a convected curvilinear coordinate system is introduced in order to interpret classical vortex theorems. For the case of inviscid isentropic flows, the material contravariant components of the vorticity divided by the density are constant, following a material point. This result simplifies the proof and the kinematic interpretation of classical results. The present result is then extended to general viscous nonisentropic flows, and used to obtain a simple but powerful computational scheme for the solution of Beltrami's vorticity equation. O.C.

A86-28570\*# Virginia Polytechnic Inst. and State Univ., Blacksburg.

**CRYOGENIC TUNNEL MEASUREMENT OF TOTAL TEMPERATURE AND PRESSURE**

W.-F. NG and J. C. ROSSON (Virginia Polytechnic Institute and State University, Blacksburg) Journal of Aircraft (ISSN 0021-8669), vol. 23, March 1986, p. 244-249. Research supported by George Washington University and NASA. refs

A newly developed, 3-mm-diam, dual hot-wire aspirating probe was used to measure the time-resolved stagnation temperature and pressure in a transonic cryogenic wind tunnel. Measurements were taken in the freestream of the settling chamber and test section. Data were also obtained in the unsteady wake shed from an airfoil oscillating at 5 Hz. The investigation revealed the presence of large fluctuations in the settling chamber occurring at the blade passing frequency of the driving fan of the tunnel. These fluctuations decrease at the test section. The rms value of the fluctuating stagnation pressure decreased from 17.5 percent in the settling chamber to 3.7 percent in the test section. Fluctuating stagnation temperature decreased from 12.3 percent to 8.4 percent. Measurements in the wake of the oscillating airfoil showed a fluctuating stagnation temperature of as much as 42 K in rms value. Author

A86-28651

**ADVANCES IN AEROSPACE STRUCTURAL ANALYSIS; PROCEEDINGS OF THE WINTER ANNUAL MEETING, MIAMI BEACH, FL, NOVEMBER 17-22, 1985**

O. H. BURNSIDE, ED. and C. H. PARR, ED. (Southwest Research Institute, San Antonio, TX) Meeting sponsored by ASME. New York, American Society of Mechanical Engineers, 1985, 152 p. For individual items see A86-28652 to A86-28663.

The present conference considers the uncertain eigenvalue analysis of composite laminated plates by stochastic FEM, probabilistic finite elements for transient analysis in nonlinear continua, the numerical synthesis of trivariate velocity realizations of turbulence, efficient algorithms applicable to probabilistic finite element analysis, a stochastic model for fatigue crack growth rate,

and the demonstration of a novel fast probability integration method for reliability analysis. Also discussed are advanced reliability methods for structural evaluation, probabilistic structural analysis for spacecraft propulsion system components, the prediction of micromechanical properties in flexible matrix composites, the limitations of finite elements in orthotropic laminated beam analysis, a case study of cure cycle shrinkage deformations, and mixed finite element models for laminated composite plates. O.C.

A86-28654\*# Rice Univ., Houston, Tex.

**NUMERICAL SYNTHESIS OF TRI-VARIATE VELOCITY REALIZATIONS OF TURBULENCE**

P.-T. D. SPANOS (Rice University, Houston, TX) and K. P. SCHULTZ (Lockheed Engineering and Management Services Co., Houston, TX) IN: Advances in aerospace structural analysis; Proceedings of the Winter Annual Meeting, Miami Beach, FL, November 17-22, 1985. New York, American Society of Mechanical Engineers, 1985, p. 25-35. refs  
(Contract NAG3-210)

An approach for synthesizing trivariate turbulence velocity field spatial realizations is presented. Some of the spatial frequency characteristics of the random velocity field are described by the von Karman spectrum. The simulation algorithm is based on an efficient autoregressive-moving average (ARMA) scheme involving coefficient square matrices of order three. The determination of the efficient low order ARMA algorithm is preceded by the determination of a suitable high order autoregressive (AR) simulation algorithm. The numerical results are presented in a dimensionless form. Thus, they are applicable for any scale of turbulence. Author

A86-28666#

**TAIL PROFILE EFFECTS ON UNSTEADY LARGE SCALE FLOW STRUCTURE IN THE WING AND PLATE JUNCTION**

E. P. ROOD and D. G. ANTHONY (David W. Taylor Naval Ship Research and Development Center, Bethesda, MD) IN: Forum on unsteady flow - 1985; Proceedings of the Winter Annual Meeting, Miami Beach, FL, November 17-22, 1985. New York, American Society of Mechanical Engineers, 1985, p. 30-32. Navy-sponsored research.

Mean velocity contours and flow separation patterns for two tail profiles, a 28 degree circular arc and an NACA 0020, are measured to determine the characteristics of the unsteady large scale flow structure associated with the wing and plate junction. Data indicate that the pressure recovery at the tail of the wing, immersed in the otherwise steady boundary layer, is especially significant in determining the downstream dynamic vortex-wake-boundary layer interaction. It is found that adverse pressure gradients produce rapid growth of the across-stream spatial extent of the vortex legs, and that vortex rollup, which contributes to the spatial extent of the unsteadiness of the vortex legs, is indicated by the curved separation line along the wing trailing edge inside the boundary layer. R.R.

A86-28742

**LINEAR AND NONLINEAR MODAL ANALYSIS OF AEROELASTIC STRUCTURAL SYSTEMS**

R. A. IBRAHIM (Texas Tech University, Lubbock) and T. D. WOODALL (Sandia National Laboratories, Albuquerque, NM) Computers and Structures (ISSN 0045-7949), vol. 22, no. 4, 1986, p. 699-707. refs

This paper deals with the investigation of linear modal analysis and the autoparametric interaction of aeroelastic systems. The normal-mode frequencies and the associated mode shapes are obtained in terms of the system parameters. The main objective of the linear analysis is to explore the critical regions of autoparametric (or internal) resonance conditions,  $\sum(k-i\omega) = 0$  (where  $k-i$  are integers and  $\omega-i$  are the normal-mode frequencies). The results show that for certain system parameters the condition of internal resonance is satisfied. The dynamic behavior of the structure in the neighborhood of internal-resonance conditions is obtained by considering the nonlinear coupling of the normal modes. Under certain conditions

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the steady-state response is derived analytically for the sum internal-resonance condition. It is concluded that the nonlinear modal analysis reveals certain types of response characteristics which cannot be interpreted within the framework of the linear theory of small oscillations. Author

**A86-29011\*** Bettis Atomic Power Lab., West Mifflin, Pa.  
**REFERENCES AND CONFERENCE PROCEEDINGS TOWARDS THE UNDERSTANDING OF FRACTURE MECHANICS**

P. M. TOOR (Bettis Atomic Power Laboratory, West Mifflin, PA) and C. M. HUDSON (NASA, Langley Research Center, Hampton, VA) *Journal of Testing and Evaluation* (ISSN 0090-3973), vol. 14, March 1986, p. 61-75. refs

A list of books, reports, periodicals, and conference proceedings, as well as individual papers, centered on specific aspects of fracture phenomenon has been compiled by the ASTM Committee E-24 on Fracture Testing. A list of basic references includes the articles on the development of fracture toughness, evaluation of stress intensity factors, fatigue crack growth, fracture testing, fracture of brittle materials, and fractography. Special attention is given to the references on application of fracture mechanics to new designs and on reevaluation of failed designs, many of them concerned with naval and aircraft structures. I.S.

**A86-29471**  
**NUMERICAL METHODS IN FLUID DYNAMICS**

F. BREZZI, ED. (Pavia, Universita, Italy) Berlin and New York, Springer-Verlag (Lecture Notes in Mathematics. Volume 1127), 1985, 341 p. For individual items see A86-29472 to A86-29475.

The present conference on fluid dynamics applications of numerical methods considers finite element, least squares and domains-decomposition methods for the numerical solution of nonlinear fluid dynamics problems, as well as the Galerkin, Chebyshev and Legendre spectral approximation methods. Also discussed are recent advancements in computational aerodynamics for transonic flow aircraft calculations, and the particle method's approximation of the Euler equations as well as its application to two- and three-dimensional vortex methods. O.C.

**N86-20658#** Analytic Sciences Corp., Reading, Mass.  
**INTEGRATED COMMUNICATION, NAVIGATION, AND IDENTIFICATION AVIONICS: IMPACT ANALYSIS. EXECUTIVE SUMMARY Final Report, Mar. 1982 - Mar. 1984**

M. H. VEATCH and J. C. MCMANUS Oct. 1985 16 p (Contract F33615-82-C-0002) (AD-A161799; AFHRL-TP-85-20) Avail: NTIS HC A02/MF A01 CSCL 17B

This paper summarizes the approach and findings of research into reliability, supportability, and survivability prediction techniques for fault-tolerant avionics systems. Since no technique existed to analyze the fault tolerance of reconfigurable systems, a new method was developed and implemented in the Mission Reliability Model (MIREM). The supportability analysis was completed by using the Simulation of Operational Availability/Readiness (SOAR) model. Both the Computation of Vulnerable Area and Repair Time (COVART) model and FASTGEN, a survivability model, proved valuable for the survivability research. Sample results are presented and several recommendations are also given for each of the three areas investigated under this study: reliability, supportability and survivability. GRA

**N86-20671\*** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.  
**PIEZOELECTRIC DEICING DEVICE Patent**

R. C. FINKE and B. A. BANKS, inventors (to NASA) 8 Oct. 1985 5 p Filed 7 Aug. 1984 Continuation of abandoned US-Patent-Appl-SN-469867, filed 25 Feb. 1983

(NASA-CASE-LEW-13773-2; US-PATENT-4,545,553; US-PATENT-APPL-SN-638541; US-PATENT-CLASS-244-134-D; US-PATENT-CLASS-39-25.35; US-PATENT-CLASS-310-324) Avail: US Patent and Trademark Office CSCL 09A

A fast voltage pulse is applied to a transducer which comprises a composite of multiple layers of alternately polarized piezoelectric

material. These layers are bonded together and positioned over the curved leading edge of an aircraft wing structure. Each layer is relatively thin and metallized on both sides. The strain produced in the transducer causes the composite to push forward resulting in detachment and breakup of ice on the leading edge of the aircraft wing.

Official Gazette of the U.S. Patent and Trademark Office

**N86-20677#** National Aerospace Lab., Tokyo (Japan).  
**COVARIANCE SPECIFICATION FOR THE LINEAR TIME-INVARIANT OUTPUT-FEEDBACK CONTROL SYSTEMS USING A KALMAN FILTER**

M. NAGAYASU 1985 16 p refs In JAPANESE; ENGLISH summary (NAL-TR-882; ISSN-0389-4010) Avail: NTIS HC A02/MF A01

The covariance specification problem using a Kalman filter for the linear time-invariant output-feedback control system contaminated by observation and system noise is described. The optimal output-feedback control using a Kalman filter with which the stationary state covariance matrix coincides with the prescribed matrix is discussed. The system is disturbed by additive white/color system noise and the output signal is contaminated by white observation noise. Using a Kalman filter, the dynamic output feedback control system was obtained. The covariance specification problem, i.e., to obtain the optimal feedback gains under the requirements of the state covariance coinciding with the prescribed covariance for minimizing the control effort, is solved. The control problem of an aircraft in the atmospheric turbulence is discussed as a numerical example. Author

**N86-20759#** National Aerospace Lab., Tokyo (Japan).  
**STUDY ON THE DIGITAL POSITION TRANSDUCER WITH OPTICAL TIME-DELAY PULSE**

M. MAYANAGI 1985 40 p refs In JAPANESE; ENGLISH summary (NAL-TR-878; ISSN-0389-4010) Avail: NTIS HC A03/MF A01

A rotary optical position transducer employing a pulse technique time delay multiplexor was studied during the development of a Fly-By-Light (FBL) for the aircraft control system, the aim of which is to offer inherent resistance to environments of electromagnetic interference (EMI), electromagnetic pulse (EMP) and lightning. The conventional absolute type optical digital transducer causes difficulty in the interface technique between the transducer and other devices such as a computer. The transducer system described consisting of a rotary position transducer unit, fiber optic cable, light source unit, and electronics interface unit, can improve this interface technique. The rotary transducer unit is an electrically passive device connected through optical fibers to the light source unit and electronics interface unit, and has many advantages of fiber optic techniques. Basic problems in the development of the rotary transducer system were studied. In particular, a basis for optimizing illumination irradiance and photodetector characteristics is given, and the intrinsic performance of the transducer is quantitatively examined. Author

**N86-20797\*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

**SEGMENTED TUBULAR CUSHION SPRINGS AND SPRING ASSEMBLY Patent Application**

L. A. HASLIM, inventor (to NASA) 18 Jun. 1985 39 p (NASA-CASE-ARC-11349-1; NAS 1.71:ARC-11349-1; US-PATENT-APPL-SN-746160) Avail: NTIS HC A03/MF A01 CSCL 13E

A spring which includes a tube with an elliptical cross section, with the greater axial dimension extending laterally and the lesser axial dimension extending vertically is disclosed. A plurality of cuts in the form of slots passing through most of a wall of the tube extend perpendicular to a longitudinal axis extending along the tube. An uncut portion of the tube wall extends along the tube for bonding or fastening the tube to a suitable base, such as a bottom of a seat cushion. NASA

**N86-20813\*#** Naval Postgraduate School, Monterey, Calif.  
**PROCEEDINGS OF THE 1985 ONR/NAVAIR WAVE ROTOR RESEARCH AND TECHNOLOGY WORKSHOP Final Report, 1 Jan. - 31 Mar. 1985**

R. P. SHREEVE and A. MATHUR May 1985 425 p Workshop held in Monterey, Calif., 26-27 Mar. 1985 (Contract RR0-2403) (AD-A161539; NPS67-85-008) Avail: NTIS HC A18/MF A01 CSCL 21E

The purpose of this workshop was to bring together an international group who are, or who have been, involved in research studies or applications of gas-gas, or gas-shaft, energy exchange through wave propagation in rotor passages. It is intended that the workshop serve to define the current levels of understanding, capability and interest in the field, and to provide the input necessary for an assessment of the prospects for the useful exploitation of wave rotors in gas turbine engines. GRA

**N86-20864#** National Aerospace Lab., Tokyo (Japan).  
**FUNDAMENTAL INVESTIGATION ON THE IMPACT STRENGTH OF HOLLOW FAN BLADES**

T. IKEDA, T. MIYACHI, and Y. SOFUE 1985 23 p refs In JAPANESE; ENGLISH summary (NAL-TR-879; ISSN-0389-4010) Avail: NTIS HC A02/MF A01

Models of hollow fan blades were made and tested to prove that their strength is sufficient for use in real engines. The hollow blades were fabricated by diffusion bonding of two titanium alloy (6Al-4V-Ti) plates, one of which had three spanwise stiffeners and the other being flat plate. The model as a nontwisted tapered blade. Impact tests were carried out on the hollow fan blade models in which the ingestion of a 1.5 pounds bird was simulated. Solid blades with the same external form were also tested by similar methods for comparison. The results of these tests show that properly designed hollow blades have sufficient stiffness and strength for use as fan blades in the turbo-fan engine. Author

**N86-21723#** Joint Publications Research Service, Arlington, Va.  
**JAPAN REPORT: SCIENCE AND TECHNOLOGY**

10 Jan. 1986 59 p refs Transl. into ENGLISH from various Japanese articles (JPRS-JST-86-001) Avail: NTIS HC A04/MF A01

Progress in Japanese science and technology is reported. Topics discussed include: aerospace sciences, chemical engineering, energy, nuclear development, and science and technology policies.

**N86-21755\*#** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

**PROGRAMMABLE, AUTOMATED TRANSISTOR TEST SYSTEM**  
 L. V. TRUONG and G. R. SUNDBURG 1986 25 p refs Presented at the 3rd Symposium on Space Nuclear Power Systems, Albuquerque, N. Mex., 13-16 Jan. 1986 (NASA-TP-2554; E-2768; NAS 1.60:2554) Avail: NTIS HC A02/MF A01 CSCL 09A

A programmable, automated transistor test system was built to supply experimental data on new and advanced power semiconductors. The data will be used for analytical models and by engineers in designing space and aircraft electric power systems. A pulsed power technique was used at low duty cycles in a nondestructive test to examine the dynamic switching characteristic curves of power transistors in the 500 to 1000 V, 10 to 100 A range. Data collection, manipulation, storage, and output are operator interactive but are guided and controlled by the system software. Author

**N86-21916#** LTV Aerospace Corp., Dallas, Tex.

**LAMINATED DAMPED FUSELAGE STRUCTURES**

R. A. ELY *In* AFWAL Vibration Damping 1984 Workshop Proceedings 32 p Nov. 1984 refs Avail: NTIS HC A99/MF A01 CSCL 20K

The application of constrained layer damping, in the form of laminated skins, frames, and equipment racks, to control acoustic fatigue of structures and vibration of equipment in the aft fuselage

sections of large aircraft is discussed. It is shown that the influence of constrained layer damping on the response of a honeycomb panel at its critical frequency is very different from the influences on its resonant responses. The discussed baseline data and background methodology include: laboratory characterization of materials, acoustical fatigue tests of baseline and laminated structures, peculiarities of structures with high damping, influences of various boundary conditions on damped panels, dynamic versus static stiffness of damped panels, and comparisons of predicted and measured stresses in damped and undamped panels that are representative of aircraft structures. Advanced metallic technology and constrained layer damping are utilized to redesign the A-7 center section leading edge flap and the F-111 outboard spoiler to achieve large increases in their acoustical fatigue lives. E.A.K.

**N86-21917#** Boeing Co., Seattle, Wash.

**BEAM DAMPERS FOR SKIN VIBRATION AND NOISE REDUCTION IN THE 747**

R. N. MILES *In* AFWAL Vibration Damping 1984 Workshop Proceedings 17 p Nov. 1984 refs Avail: NTIS HC A99/MF A01 CSCL 20K

A special constrained layer damper was incorporated into the Boeing 747 upper deck fuselage structure. The damper replaces a rivetted stiffener which was installed to reduce noise levels inside the cabin. It was found that the damper installation produced a noise reduction equal to that achieved by the stiffener and resulted in an \$8000 per airplane cost savings and a 130 pound per airplane weight savings. The analysis and test that led to this design are reviewed. E.A.K.

**N86-21918#** Boeing Military Airplane Development, Seattle, Wash.

**INTEGRATED DAMPED FUSELAGE STRUCTURE**

L. M. BUTZEL *In* AFWAL Vibration Damping 1984 Workshop Proceedings 29 p Nov. 1984 (Contract F33615-79-C-3206) Avail: NTIS HC A99/MF A01 CSCL 20K

A program aimed at developing design guidelines for viscoelastic damping applied to skin-stringer-frame type aerospace structure is described. Periodic structure type response models were developed. Two procedures for assigning values of the damping parameters required in these models are presented. Results of test to develop and verify the damping parameter assignment procedure and response prediction models are discussed. The current status of these efforts is: (1) response models are yielding predictions in agreement with test results; (2) the damping parameter assignment procedures are working, however, more work is needed to bring them up to the confidence level of the response models. E.A.K.

**N86-21919#** Cabot Corp., Indianapolis, Ind. E-A-R Div.

**USE OF SKIN DAMPING TREATMENTS TO CONTROL AIRFRAME DYNAMIC RESPONSE FOR INTERIOR NOISE CONTROL**

C. I. HOLMER *In* AFWAL Vibration Damping 1984 Workshop Proceedings 19 p Nov. 1984 refs Avail: NTIS HC A99/MF A01 CSCL 20K

A conceptual model for airframe and interior trim dynamic response. The model suggests that skin response in the frequency range may be affected by skin damping treatments. It is suggested that this motion is of significance in producing interior noise. Laboratory data of system loss factors for a new constrained layer, skin damping treatment show improved damping performance at lighter weight than other commercially available skin damping materials. Experimental data on an effective skin damping treatment which produces system loss factors which contribute significantly to total losses in the airframe in the presence of other loss mechanisms associated with the outfitted airframe are presented. The effective skin damping treatment reduces airframe motion at representative trim panel attachment points, suggesting role in the reduction of aircraft interior noise. E.A.K.

## 12 ENGINEERING

**N86-21923#** Lockheed-California Co., Burbank.  
**A DESIGN GUIDE FOR DAMPING OF AEROSPACE STRUCTURES**

J. SOOVERE, M. L. DRAKE (Dayton Univ., Ohio), and V. R. MILLER (Air Force Wright Aeronautical Lab., Wright-Patterson AFB, Ohio)  
*In* AFWAL Vibration Damping 1984 Workshop Proceedings 9 p Nov. 1984 refs

Avail: NTIS HC A99/MF A01 CSCL 20K

The effectiveness of polymeric damping materials in controlling resonant vibration problems has been established through many successful applications. The area of these applications range from aircraft structures to jet engine structures. The development of a viscoelastic damping design guide for use by designers is outlined. A brief outline of this effort is presented. E.A.K.

**N86-21933\*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**FULL-SCALE TRANSPORT CONTROLLED IMPACT DEMONSTRATION**

R. J. HAYDUK, comp. Jan. 1986 356 p refs Workshop held in Hampton, Va., 10 Apr. 1985; sponsored by NASA. Langley Research Center and FAA (NASA-CP-2395; L-16048; NAS 1.55:2395) Avail: NTIS HC A16/MF A01 CSCL 20K

The controlled impact demonstration (CID) test of a transport aircraft took place on December 1, 1984, crashing at a prepared site on Rogers Dry Lakebed, Edwards Air Force Base, California. The demonstration was a setback for the antimisting kerosene (AMK) researchers. The impact conditions, considerably different from the planned scenario, exposed large quantities of degraded AMK and hydraulic fluid and caused unexpectedly hot ignition sources, bulk loss of fuel from the right wing, airflow patterns over the wings and fuselage that were untested on AMK, and fuel intrusion into the lower fuselage. The test was much more severe than planned and is generally considered to be unrepresentative of the type of survivable crash that would benefit from AMK. Ninety-seven percent of the sensors on the fuselage and wing structure, seats, dummies, restraint systems, galley, and bins were active at impact. A wealth of sensor data was collected from this once-in-a-lifetime research test. The flight data recorder experiments on board were also generally successful.

**N86-21934\*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**CID OVERVIEW**

R. J. HAYDUK *In its* Full-Scale Transport Controlled Impact Demonstration p 1-16 Jan. 1986 refs  
Avail: NTIS HC A16/MF A01 CSCL 20K

On December 1, 1984, NASA and the Federal Aviation Administration (FAA) conducted the first remotely piloted air-to-ground crash test of a transport category aircraft. The Full-Scale Transport Controlled Impact Demonstration (CID) was the culmination of 4 years of effort by the two agencies. NASA and the FAA had many objectives during the joint planning and execution of the Controlled Impact Demonstration. The structural loads experiment was very successful. Ninety-seven percent of the channels were active at impact. The data is still being assessed. Only a portion of the data is presented here; approximately 80 channels of data are available. Analysis of the remaining data is in progress. Interior photography was also very successful. One hundred percent of the cameras functioned. The film contains unique information on the development of fire and smoke in the interior of the aircraft. From a human tolerance point of view, the CID was simulation of a survivable crash. R.J.F.

**N86-21935\*#** National Aeronautics and Space Administration. Dryden (Hugh L.) Flight Research Center, Edwards, Calif.

**CID FLIGHT/IMPACT**

R. BARBER *In* NASA. Langley Research Center Full-Scale Transport Controlled Impact Demonstration p 17-28 Jan. 1986  
Avail: NTIS HC A16/MF A01 CSCL 20K

The planned versus the actual results of the controlled impact demonstration of a transport aircraft are discussed. Remote control

systems, site selection, manned flight tests, and wreckage distribution are discussed. R.J.F.

**N86-21936\*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**NASA EXPERIMENTS ON THE B-720 STRUCTURE AND SEATS**

E. ALFARO-BOU *In its* Full-Scale Transport Controlled Impact Demonstration p 29-47 Jan. 1986

Avail: NTIS HC A16/MF A01 CSCL 20K

Two experiments onboard a remotely piloted transport aircraft that was crashed on landing are discussed. The structural experiment deals with the location and distribution of the instrumentation throughout the airplane structure. In the seat experiment, the development and testing of an energy absorbing seat are discussed. The objective of the structural experiment was to obtain a data base of structural crash loads for use in the advancement of crashworthy technology of materials (such as composites) in structural design and for use in the comparison between computer and experimental results. The objective of the seat experiment was to compare the performance of an energy absorbing transport seat and a standard seat when subjected to similar crash pulses. Details are given on the location of instrumentation, on the dynamic seat test pulse and headward acceleration limits. R.J.F.

**N86-21937\*#** Federal Aviation Agency, Atlantic City, N.J. Technical Center.

**CONTROLLED IMPACT DEMONSTRATION SEAT/CABIN RESTRAINT SYSTEMS: FAA**

R. A. JOHNSON *In* NASA. Langley Research Center Full-Scale Transport Controlled Impact Demonstration p 49-60 Jan. 1986  
Avail: NTIS HC A16/MF A01 CSCL 20K

The FAA restraint system experiments consisted of 24 standard and modified seats, 2 standard galleys and 2 standard overhead compartments. Under the controlled impact demonstration (CID) program, the experimental objective was to demonstrate the effectiveness of individual restraint system designs when exposed to a survivable air-to-ground impact condition. What researchers were looking for was the performance exhibited by standard and modified designs, performance differences resulting from their installed cabin location, and interrelating performance demonstrated by test article and attaching floor and/or fuselage structure. The other restraint system experiment consisted of 2 standard overhead stowage compartments and 2 galley modules. Again, researchers were concerned with the retention of stowed equipment and carry-on articles. The overhead compartments were loaded with test weights up to their maximum capacity, and each of the galleys was filled with test articles: aft with normal galley equipment, forward with hazardous material test packages. A breakdown of instrumentation and distribution is given beginning with 11 instrumented type anthropomorphic dummies and 185 sensors which provided for acceleration and load measurements at the various experiment and associated structure locations. The onboard cameras provided additional coverage of these experiments, including the areas of cabin which were not instrumented. Test results showing the window-side leg forces versus pulse duration are given. R.J.F.

**N86-21939\*#** PRC Kentron, Inc., Hampton, Va.

**NASA SEAT EXPERIMENT AND OCCUPANT RESPONSES**

E. L. FASANELLA *In* NASA. Langley Research Center Full-Scale Transport Controlled Impact Demonstration p 79-89 Jan. 1986 refs

Avail: NTIS HC A16/MF A01 CSCL 20K

Results of the crash test of a remotely piloted transport aircraft instrumented to measure a NASA energy-absorbing transport seat are given. Human tolerance limits to acceleration and a dynamic response index model are discussed. It was found that the acceleration levels at the rear of the airplane were quite low and were below the stroking threshold of the NASA EA-seat. Therefore, dummies in the standard and EA-seat responded approximately the same. All longitudinal accelerations were quite low for the



primary impact with very low forces measured in the lap belts. The vertical (spinward) acceleration levels measured in the dummies were also relatively low and very survivable from an impact tolerance standpoint. The pilot with an 18 G peak acceleration received by far the highest vertical acceleration and could have possibly received slight spinal injury. R.J.F.

**N86-21940\*#** National Aeronautics and Space Administration, Langley Research Center, Hampton, Va.

**STRUCTURAL LOADS PRELIMINARY RESULTS**

E. ALFARO-BOU *In its* Full-Scale Transport Controlled Impact Demonstration p 91-102 Jan. 1986

Avail: NTIS HC A16/MF A01 CSCL 20K

From a total of 351 instrumentation channels, 341 channels (97%) were in operation during the initial impact of the airplane. Both NASA seats, the energy absorbing seat and the standard seat, maintained their integrity during the impact. The floor accelerations at the seat locations were lower than the accelerations required for the energy absorbers to stroke; consequently, the energy absorbing seat did not stroke. The two seats remained firm in place during the crash and no seat attachment failures were observed. Due to the low accelerations experienced during the crash, both seats performed as standard seats. In the airplane structure, the accelerations were higher at both the point of impact in the left wing and at the forward end of the fuselage. The accelerations on the floor were higher toward the front than toward the rear and the floor accelerations on the left side were higher than on the right side at the front of the fuselage, but toward the rear they evened out. Author

**N86-21942\*#** Simula, Inc., Phoenix, Ariz.

**PRELIMINARY FLOOR, SEAT, AND DUMMY DATA**

M. R. CANNON and R. E. ZIMMERMAN *In* NASA, Langley Research Center Full-Scale Transport Controlled Impact Demonstration p 125-155 Jan. 1986 refs

Avail: NTIS HC A16/MF A01 CSCL 20K

According to preliminary examination of the data, out of 179 data channels that were onboard the aircraft in support of the seat experiments, there is data from 168. There was somewhat more severe environment imposed in the structure of the obstacles than by the ground impact. Therefore, both ground impact and obstacle impact are of interest for crashworthiness experiments. Most of the data channels that were studied are fairly consistent with the physical evidence: they show acceleration levels that are reasonable, and in many cases these integrate out to a reasonable velocity change. Finally, from observation thus far, the ground impact did not fail or significantly damage any seat. Nor did any of the energy absorbers in the modified seats extend. The accelerations do not appear high enough and/or energetic enough to cause this to happen. At this time, the onboard films have not been studied; only some videotape have been viewed. Some of the seats were so badly damaged by the fire that any failures which might have occurred were obscured. A close examination of the onboard films using a stop-action projector will allow a more thorough evaluation. Author

**N86-21943\*#** Federal Aviation Administration, Long Beach, Calif.

**CONTROLLED IMPACT DEMONSTRATION AIRFRAME BENDING BRIDGES**

S. J. SOLTIS *In* NASA, Langley Research Center Full-Scale Transport Controlled Impact Demonstration p 157-179 Jan. 1986

Avail: NTIS HC A16/MF A01 CSCL 20K

The calibration of the KRASH and DYCAST models for transport aircraft is discussed. The FAA uses computer analysis techniques to predict the response of controlled impact demonstration (CID) during impact. The moment bridges can provide a direct correlation between the predictive loads or moments that the models will predict and what was experienced during the actual impact. Another goal is to examine structural failure mechanisms and correlate with analytical predictions. The bending bridges did achieve their goals and objectives. The data traces do provide some insight

with respect to airframe loads and structural response. They demonstrate quite clearly what's happening to the airframe. A direct quantification of metal airframe loads was measured by the moment bridges. The measured moments can be correlated with the KRASH and DYCAST computer models. The bending bridge data support airframe failure mechanisms analysis and provide residual airframe strength estimation. It did not appear as if any of the bending bridges on the airframe exceeded limit loads. (The observed airframe fracture was due to the fuselage encounter with the tomahawk which tore out the keel beam.) The airframe bridges can be used to estimate the impact conditions and those estimates are correlating with some of the other data measurements. Structural response, frequency and structural damping are readily measured by the moment bridges. R.J.F.

**N86-21944\*#** Federal Aviation Agency, Atlantic City, N.J. Technical Center.

**CONTROLLED IMPACT DEMONSTRATION FLIGHT DATA RECORDERS/COCKPIT VOICE RECORDERS**

L. J. GARODZ *In* NASA, Langley Research Center Full-Scale Transport Controlled Impact Demonstration p 181-193 Jan. 1986 refs

Avail: NTIS HC A16/MF A01 CSCL 20K

It was found that the sampling rates from flight recorders on a remotely piloted transport aircraft that crashed into the ground were too low, although they were higher than those required now by regulations. For example, the sampling rate for roll angle was one per second. The sampling rate for normal acceleration was also fairly low. Existing regulations require only 4 samples per second; researchers had 16 samples per second. Some data was lost during the initial impact. The frequency response data was adequate. R.J.F.

**N86-21945\*#** Naval Air Test Center, Patuxent River, Md.

**UNITED STATES NAVY - CANADIAN FORCES SOLID STATE FLIGHT DATA RECORDER/CRASH POSITION LOCATOR EXPERIMENT ON THE B-720 CONTROLLED IMPACT DEMONSTRATION**

D. M. WATTERS *In* NASA, Langley Research Center Full-Scale Transport Controlled Impact Demonstration p 195-208 Jan. 1986

Avail: NTIS HC A16/MF A01 CSCL 20K

The operation of a radio beacon position locator during and after the remotely controlled transport aircraft is discussed. The radio beacon transmission was actuated and was picked up by the Navy P-3A chase aircraft for a short time, after which reception was lost. The pilot reported that he received a signal on both 121.5 MHz and 243 MHz for a period of approximately 5 seconds. Five minutes after the crash a portable direction finding unit located on the roof of the NASA Dryden Flight Research Facility, 4 miles distant from the crash, was unable to pick up the beacon transmission. The fire crews started fighting the fires approximately 90 seconds after the time of impact. Navy personnel access to the crash site was allowed on the morning of December 2, 1984. Radio beacon locator was found resting top side up, 15 feet forward and 13 feet perpendicular from the tray location the starboard side of the aircraft. An immediate inspection indicated the airfoil suffered moderate fire damage with paint peeling but not intumescent. The visual marker strobe lamp housings were intact but extensively burned such that it was impossible to see if the lamps had survived. The airfoil suffered minor structural damage, with assorted dents, etc. The extended plunger on the ARU-21 release unit indicated that the pyrotechnic deployment system operated. The radio beacon base (tray) suffered some heat and fire damage, and was charred and blackened by smoke. The frangible switch in the nose survived and the switch in the belly was recovered and found to have actuated. It is assumed that this switch fired the ARU-21 squib. There were no other release switches installed in the normally open system in the aircraft. R.J.F.

**N86-21946\*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**CONTROLLED IMPACT DEMONSTRATION ON-BOARD (INTERIOR) PHOTOGRAPHIC SYSTEM**

C. J. MAY *In its* Full-Scale Transport Controlled Impact Demonstration p 209-239 Jan. 1986 refs  
Avail: NTIS HC A03/MF A01 CSCL 20K

Langley Research Center (LaRC) was responsible for the design, manufacture, and integration of all hardware required for the photographic system used to film the interior of the controlled impact demonstration (CID) B-720 aircraft during actual crash conditions. Four independent power supplies were constructed to operate the ten high-speed 16 mm cameras and twenty-four floodlights. An up-link command system, furnished by Ames Dryden Flight Research Facility (ADFRF), was necessary to activate the power supplies and start the cameras. These events were accomplished by initiation of relays located on each of the photo power pallets. The photographic system performed beyond expectations. All four power distribution pallets with their 20 year old Minuteman batteries performed flawlessly. All 24 lamps worked. All ten on-board high speed (400 fps) 16 mm cameras containing good resolution film data were recovered. R.J.F.

**N86-21947\*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**CID-720 AIRCRAFT HIGH-ENVIRONMENT FLIGHT INSTRUMENTATION SYSTEM**

R. S. CALLOWAY *In its* Full-Scale Transport Controlled Impact Demonstration p 241-287 Jan. 1986  
Avail: NTIS HC A16/MF A01 CSCL 20K

The high-environment flight instrumentation system was designed to acquire Langley's structural response data during the full scale transport-controlled impact demonstration test. There was only one opportunity for data acquisition. Thus, a high reliability and crashworthy design approach was implemented. The approach featured multi-level redundancy and a vigorous quality assurance testing program. Complying with an accelerated schedule, the instrumentation system was developed, tested and shipped within 18 months to Dryden Flight Research Facility. The flight instrumentation system consists of two autonomous data systems, DAS #1 and #2, and an excellent checkout subsystem. Each data system is partitioned into four pallets. The system was designed to operate on manned and unmanned flights. There are 176 data channels per data system. These channels are sequentially sampled and encoded into 1 megabit/sec pulse code modulation (PCM) data signal. To increase the probability of success, a special PCM distribution subsystem was developed. This subsystem distributes the PCM signal to two transmitters, one delay memory, and eight recorder tracks. The data on four of these tracks was digitally delayed approximately 300 msec to maximize data acquisition during impact. Therefore each data system's data is redundantly recorded onboard and on the ground. There are two time code generators. Parallel time from each is encoded into both data systems. Serial time from each is redundantly recorded on both onboard recorders. Instrumentation power is independent of aircraft power and self-contained. R.J.F.

**N86-21948\*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**IMPACT DYNAMICS INSTRUMENTATION**

R. F. MCCORMACK *In its* Full-Scale Transport Controlled Impact Demonstration p 289-301 Jan. 1986  
Avail: NTIS HC A16/MF A01 CSCL 20K

One of the tasks specified in the NASA Langley controlled impact demonstration (CID) work package was to furnish dynamic instrumentation sensors. The types of instrumentation sensors required were accelerometers for aircraft structural loads measurements, seat belt load cells to measure anthropomorphic dummy responses to the aircraft impact, and strain gage bending bridges to measure the aircraft fuselage and wing bending during impact. The objective in the selection of dynamic instrumentation for the CID was to provide 352 of the highest quality transducers

and remain within budget allocation. The transducers that were selected for the CID evaluation process were each subjected to rigorous laboratory acceptance tests and to aircraft fuselage section drop tests at the LaRC Impact Dynamics Research Facility. Data compiled from this series of tests showed the selected transducers to be best suited for the CID mission requirement. The transducers installation technique on the airframe proved successful. The transducer quality assurance was guaranteed through rigorous acceptance testing. Data acquired was 97.0%. R.J.F.

**N86-21949\*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**CID-720 AIRCRAFT LANGLEY RESEARCH CENTER PREFLIGHT HARDWARE TESTS: DEVELOPMENT, FLIGHT ACCEPTANCE AND QUALIFICATION**

J. D. PRIDE *In its* Full-Scale Transport Controlled Impact Demonstration p 303-328 Jan. 1986 refs  
Avail: NTIS HC A16/MF A01 CSCL 20K

The testing conducted on LaRC-developed hardware for the controlled impact demonstration transport aircraft is discussed. To properly develop flight qualified crash systems, two environments were considered: the aircraft flight environment with the focus on vibration and temperature effects, and the crash environment with the long pulse shock effects. Also with the large quantity of fuel in the wing tanks the possibility of fire was considered to be a threat to data retrieval and thus fire tests were included in the development test process. The aircraft test successfully demonstrated the performance of the LaRC developed heat shields. Good telemetered data (S-band) was received during the impact and slide-out phase, and even after the aircraft came to rest. The two onboard DAS tape recorders were protected from the intense fire and high quality tape data was recovered. The complete photographic system performed as planned throughout the 40.0 sec of film supply. The four photo power distribution pallets remained in good condition and all ten onboard 16 mm high speed (400 frames/sec) cameras produced good film data. R.J.F.

**N86-21954\*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**EQUIVALENT PLATE ANALYSIS OF AIRCRAFT WING BOX STRUCTURES WITH GENERAL PLANFORM GEOMETRY**

G. L. GILES Mar. 1986 12 p refs Proposed for presentation at the 27th AIAA/ASME/ASCE/ANS Structures, Structural Dynamics and Materials Conference, San Antonio, Tex., 19-21 May 1986  
(NASA-TM-87697; NAS 1.15:87697; AIAA-86-0940-CP) Avail: NTIS HC A02/MF A01 CSCL 20K

A new equivalent plate analysis formulation is described which is capable of modeling aircraft wing structures with a general planform such as cranked wing boxes. Multiple trapezoidal segments are used to represent such planforms. A Ritz solution technique is used in conjunction with global displacement functions which encompass all the segments. This Ritz solution procedure is implemented efficiently into a computer program so that it can be used by rigorous optimization algorithms for application in early preliminary design. A direct method to interface this structural analysis procedure with aerodynamic programs for use in aeroelastic calculations is described. This equivalent plate analysis procedure is used to calculate the static deflections and stresses and vibration frequencies and modes of an example wing configuration. The numerical results are compared with results from a finite element model of the same configuration to illustrate typical levels of accuracy and computation times resulting from use of this procedure. Author

## GEOSCIENCES

Includes geosciences (general); earth resources; energy production and conversion; environment pollution; geophysics; meteorology and climatology; and oceanography.

**A86-28065\*** National Aeronautics and Space Administration. National Space Technology Labs., Bay Saint Louis, Miss.

**CHARACTERIZATION OF SHALLOW OCEAN SEDIMENTS USING THE AIRBORNE ELECTROMAGNETIC METHOD**

I. J. WON (National Space Technology Laboratory, Bay St. Louis, MS; North Carolina State University, Raleigh) and K. SMITS (National Space Technology Laboratory, Bay St. Louis, MS) IEEE Journal of Oceanic Engineering (ISSN 0364-9059), vol. OE-11, Jan. 1986, p. 113-122. refs

Experimental airborne electromagnetic (AEM) survey data collected in Cape Cod Bay are used to derive continuous profiles of water depth, electrical depth, water conductivity, and bottom sediment conductivity. Through a few well-known empirical relationships, the conductivities are used, in turn, to derive density, porosity, sound speed, and acoustic reflectivity of the ocean bottom. A commercially available Dighem III AEM system was used for the survey without any significant modification. The helicopter-borne system operated at 385 and 7200 Hz; both were in a horizontal coplanar configuration. The interpreted profiles show good agreement with available ground truth data. Where no such data are available, the results appear to be very reasonable. Compared with the shipborne electrode array method, the AEM method can determine the necessary parameters at a much higher speed with a better lateral resolution over a wide range of water depths from 0 to perhaps 100 m. The bottom sediment conductivity that can be measured by the AEM method is closely related to physical properties of sediments, such as porosity, density, sound speed, and, indirectly, sediment types that might carry broad implications for various offshore activities. Author

**A86-28568#**  
**A RING-VORTEX DOWNBURST MODEL FOR FLIGHT SIMULATIONS**

M. IVAN (Boeing Computer Services Co., Seattle, WA) (Flight Simulation Technologies Conference, St. Louis, MO, July 22-24, 1985, Technical Papers, p. 57-61) Journal of Aircraft (ISSN 0021-8669), vol. 23, March 1986, p. 232-236. Previously cited in issue 19, p. 2843, Accession no. A85-40561. refs

**A86-28618\*** Hofstra Univ., Hempstead, N. Y.  
**MEASUREMENTS OF OCEAN WAVE SPECTRA AND MODULATION TRANSFER FUNCTION WITH THE AIRBORNE TWO-FREQUENCY SCATTEROMETER**

D. E. WEISSMAN (Hofstra University, Hempstead, NY) and J. W. JOHNSON (NASA, Langley Research Center, Hampton, VA) Journal of Geophysical Research (ISSN 0148-0227), vol. 91, Feb. 15, 1986, p. 2450-2460. Previously announced in STAR as N84-27282. refs  
(Contract NAGW-468)

The directional spectrum and the microwave modulation transfer function of ocean waves can be measured with the airborne two frequency scatterometer technique. Similar to tower based observations, the aircraft measurements of the Modulation Transfer Function (MTF) show that it is strongly affected by both wind speed and sea state. Also detected are small differences in the magnitudes of the MTF between downwind and upwind radar look directions, and variations with ocean wavenumber. The MTF inferred from the two frequency radar is larger than that measured using single frequency, wave orbital velocity techniques such as tower based radars or ROWS measurements from low altitude aircraft. Possible reasons for this are discussed. The ability to measure the ocean directional spectrum with the two frequency

scatterometer, with supporting MTF data, is demonstrated.

M.A.C.

**A86-29002**  
**FORECASTING FOR CIVIL AVIATION. I**

L. DENT (Meteorological Office, Bracknell, England) Weather (ISSN 0043-1656), vol. 41, Feb. 1986, p. 42-48.

The development of forecasts for civil aviation is described. The International Civil Aviation Organization has developed a two-tiered system to provide airlines with the forecast information they require. The procedure involves utilizing global forecast models to forecast grid point data for upper winds and temperatures up to 45,000 ft. These data are supplied to regional forecast centers where wind and temperature charts with tropopause data are prepared; terminal airport forecasts are developed from these charts and applied to landings and take-offs and flight planning. The need to have current information available on surface wind on the runway, surface pressure, weather cloudbase and visibility, upper winds, and turbulence is examined. I.F.

**N86-20888#** Joint Publications Research Service, Arlington, Va.  
**AN-30 PHOTOGRAPHY AIRPLANE OUTFITTED FOR CLOUD-SEEDING MISSIONS**

T. KUZNETSOVA and A. PIMENOV *In its* USSR Report: Earth Sciences (JPRS-UES-86-001) p 1-2 10 Jan. 1986 Transl. into ENGLISH from Pravda Ukrainy (Kiev, USSR), 15 Aug. 1985 p 4

Avail: NTIS HC A04

The development of the AN-30M airplane mode, which can modify the weather is discussed. It has excellent flight qualities, high reliability, and modern pilotage-and-navigation equipment that permits flight routes and course changes in the semiautomatic mode and takeoffs during daytime and nighttime, in difficult weather conditions. Ammunition against precipitation (crystalline and other reagents) is loaded into containers placed inside and outside the aircraft on external mounts with a streamlined shape. The instruments evaluate weather conditions outside the airplane and decide at what altitude the cloud cover should be seeded and on the methods to be used. The AN-30M seeds clouds with frozen carbon dioxide granules. The plane can induce additional rainfall on farmlands, increase snow cover, and extinguish forest fires. E.A.K.

**N86-21069\*#** FWG Associates, Inc., Tullahoma, Tenn.  
**ANALYSIS OF AERODYNAMIC COEFFICIENTS USING GRADIENT DATA: SPANWISE TURBULENCE EFFECTS ON AIRPLANE RESPONSE Report, 3 Jun. 1983 - 2 Jun. 1985**

E. A. RINGNES and W. FROST Washington NASA Feb. 1986 70 p refs  
(Contract NAS8-35186)  
(NASA-CR-3961; NAS 1.26:3961) Avail: NTIS HC A04/MF A01 CSDL 04B

The influence of spanwise turbulence on airplane dynamic behavior is determined. Calculations are based on data collected from test flights with the NASA B-57 research aircraft. The approach is to first compute aerodynamic forces and moments due to a spanwise distribution of angle of attack and airspeed. Secondly, these quantities are incorporated into the equations of motion. Simulation of flights done with the effects of spanwise turbulence included are compared to simulations without any spanwise turbulence. The findings of the study are that the moments developed by turbulence along the span are significant and that more realistic flight simulation can be achieved by including the spanwise turbulence terms. Author

## 13 GEOSCIENCES

**N86-21078#** Transportation Systems Center, Cambridge, Mass.  
**THE STAPLETON MICROBURST ADVISORY SERVICE PROJECT: AN OPERATIONAL VIEWPOINT Final Report, Jun. 1984 - Sep. 1985**

L. STEVENSON Sep. 1985 80 p  
(AD-A161543; DOT-TSC-FAA-85-8; DOT/FAA/PM-85/21) Avail:  
NTIS HC A05/MF A01 CSCL 04B

A microburst advisory service project was conducted at Stapleton International Airport for a six week period during the summer of 1984. This report describes what took place during the project and what was learned from an operational, air traffic control viewpoint. Specifically, the report describes: (1) The operational, Doppler weather radar-based, microburst advisory service provided to pilots; (2) An unplanned and informal, Doppler radar-based, gust front advisory service initiated partway through the project and used by the FAA for runway management purposes; (3) The operational impact on runway operations of an unexpected, low-altitude, wind shear feature in which individual microbursts form a relatively long-lived line structure; and (4) The low-altitude wind shear environment faced by Stapleton controllers and pilots during the six week project, which took place at the peak of the Denver thunderstorm season. A microburst is a small, short-lived, low-altitude, thunderstorm-related, wind shear feature that can exhibit an intense, complex wind shear pattern that can be particularly hazardous to landing and departing aircraft. GRA

**N86-21084#** Technische Hochschule, Aachen (West Germany).  
Dept. of Aerospace Engineering.  
**WIND SHEAR MEASUREMENT ON BOARD A MORANE 893**  
H. NELLES 1985 21 p refs  
Avail: NTIS HC A02/MF A01

To investigate wind shear during flight, a pneumatic sensing device was developed and installed on board a single engine light aircraft. The device measures the difference in total pressure between two positions vertically displaced from the airplane. The mass flow rate created by the difference in pressure is measured by a hot-wire probe. The signal of this probe is a function of the wind shear. Results compare favorably with those of a ground based sensing system and a D028 research aircraft.

Author (ESA)

**N86-21982\*#** National Aeronautics and Space Administration.  
Ames Research Center, Moffett Field, Calif.  
**AIRBORNE TRACKING SUN PHOTOMETER APPARATUS AND SYSTEM Patent Application**  
T. MATSUMOTO, C. MINA, P. RUSSELL, and W. VANARK,  
inventors (to NASA) 29 Jan. 1986 17 p  
(NASA-CASE-ARC-11622-1; NAS 1.71:ARC-11622-1;  
US-PATENT-APPL-SN-823712) Avail: NTIS HC A02/MF A01  
CSCL 10A

An airborne tracking Sun photometer apparatus has a rotatable dome. An azimuth drive motor is connected to rotate the dome. The dome has an equatorial slot. A cylindrical housing is pivotally mounted inside the dome at the equatorial slot. A photometer is mounted in the housing to move in the equatorial slot as the housing pivots. The photometer has an end facing outward from the slot with an optical flat transparent window. An elevation drive motor is connected to pivot the cylindrical housing. The rotatable dome is mounted in bulkhead of an aircraft to extend from the interior of the aircraft. A Sun sensor causes the photometer to track the Sun automatically. Alternatively, the photometer may be oriented manually (by voltages or by computer). NASA

**N86-22061#** Massachusetts Inst. of Tech., Lexington.  
**WEATHER RADAR STUDIES Quarterly Technical Summary Report, 1 Jan. - 31 Mar. 1985**  
J. E. EVANS 31 Mar. 1985 42 p  
(Contract DT-FA01-80-Y-10546)  
(AD-A161622; DOT/FAA/PM-85-16) Avail: NTIS HC A03/MF  
A01 CSCL 04B

FAA-funded Doppler weather radar activities during the period 1 January to 31 March 1985 are reported. The test-bed Doppler weather radar system measurements in Olive Branch, Mississippi,

commenced following the installation of an improved lightning protection system. Clutter suppression testing showed that the objective of 50-dB suppression was obtained in the field against appropriate fixed targets. Weather measurements were conducted on a number of cold front passages with attendant prefrontal lines of showers and thunderstorms. The Lincoln mesonet was recalibrated at Lincoln in January and February and then installed at the site in late February. The mesonet was fully operational in March. The 1984 peak wind speed data from the mesonet and the Memphis International Airport LLWAS data were analyzed preliminarily to determine wind shear characteristics in the Memphis area. Doppler weather radar data from the National Center for Atmospheric Research JAWS program and the National Severe Storms Laboratory are being analyzed to develop low-altitude wind shear detection algorithms. GRA

**N86-22064#** Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Oberpfaffenhofen (West Germany). Abteilung Wolkenphysik.  
**THE ICING RESEARCH AIRCRAFT D028, D-IFMP OF DFVLR, AND ITS MEASURING EQUIPMENT**  
H. E. HOFFMANN and J. DEMMEL Aug. 1985 72 p refs In GERMAN; ENGLISH summary Report will also be announced as translation (ESA-TT-972)  
(DFVLR-MITT-85-12; ISSN-0176-7739) Avail: NTIS HC A04/MF A01; DFVLR, Cologne DM 25.50

A Dornier Do28 D-IFMP, equipped as an icing research aircraft, is described. Ice accretion is measured on three metal cylinders and at the tip of one wing. The icing-relevant, cloud-physical parameters measured include air temperature, liquid water content, particle size (0.5 to 600 micron), particle concentration, particle phase (qualitative), visibility in and outside clouds, relative humidity, and absolute humidity. The measured data are recorded on two analog and one digital recorder. Author (ESA)

**N86-22067#** National Center for Atmospheric Research, Boulder, Colo.

**RELATIVE ACCURACY OF ALPEX AIRCRAFT DATA: AN EVALUATION OF THE ALPEX INTERCOMPARISON FLIGHT WITH THE NCAR (NATIONAL CENTER FOR ATMOSPHERIC RESEARCH) ELECTRA, THE NOAA (NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION P3 AND THE DFVLR (DEUTSCHE FORSCHUNGS- UND VERSUCHSANSTALT FUER LUFT-UND RAUMFAHRT) FALCON**

H. RICHNER Jul. 1985 90 p  
(PB86-100823; NCAR/TN-238+STR) Avail: NTIS HC A05/MF A01 CSCL 04B

During the ALPEX program, three participating large research aircraft--the NCAR Electra, the NOAA P3, and the DFVLR Falcon--joined for an intercomparison flight. Using the data from this flight, this report lists the relative accuracies for position, pressure, temperature, humidity, horizontal and vertical winds, radio altitude, and radiation (some of these quantities were measured by two aircraft only). The results are presented in form of basic statistical data such as mean differences, standard deviations, and correlation coefficients, as well as in form of power, coherence and--for some quantities--phase spectra. GRA

## LIFE SCIENCES

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

**A86-28442****AUDITORY SIGNALS IN MILITARY AIRCRAFT - ERGONOMIC PRINCIPLES VERSUS PRACTICE**

T. J. DOLL and D. J. FOLDS (Georgia Institute of Technology, Atlanta) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 2. New York, Institute of Electrical and Electronics Engineers, 1985, p. 958-965. refs  
(Contract F33615-82-D-0601)

The complete ensembles of auditory signals in selected USAF aircraft (the F-4D, F-15, two models of the F-16, the C-5, and the C-141) are described and evaluated. Human factors research related to the design of speech and non-speech auditory signals is reviewed. Major findings are: that auditory signals are not well standardized among the aircraft, even between those with similar combat roles; that a relatively large number of non-speech auditory signals are used, which may make it difficult for the aircrew to recall the meanings of all the signals; that some non-speech signals are sufficiently similar that they may be confused, particularly in high workload and stressful conditions; and that the criticality of the warnings is not reliably indicated by any characteristics of the signals. Four problem areas requiring further research are discussed: reduction of signal loudness, enhancement of the distinctiveness and masking resistance of non-speech signals, effects of concurrent warning signals on aircrew performance, and additional uses of auditory information. Author

**A86-28444****DYNAMIC RETRAINING APPROACHES FOR AN AIRBORNE SPEECH RECOGNITION SYSTEM**

R. A. NORTH and K. GRAFFUNDER (Honeywell Systems and Research Center, Minneapolis, MN) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 2. New York, Institute of Electrical and Electronics Engineers, 1985, p. 970-974.  
(Contract F33615-83-C-3608)

Results of a preliminary investigation of the viability of dynamic updating of a word recognizer are reported. An isolated word recognizer was used to capture original templates and task oriented utterances for an aircraft cockpit radio frequency selection task performed by a group of student pilots. The task-oriented utterances were produced in low and high workload conditions to represent differing operational stress. Match scores between original templates and real-time utterances were compared with match scores between real-time vs. real-time utterances. Two strategies were formulated for improvement of match scores using certain real-time utterances as new templates, and one is demonstrated with laboratory data. Author

**A86-28446\*** Psycho-Linguistic Research Associates, Menlo Park, Calif.

**SELECTING COCKPIT FUNCTIONS FOR SPEECH I/O TECHNOLOGY**

C. A. SIMPSON (Psycho-Linguistic Research Associates, Menlo Park, CA) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 2. New York, Institute of Electrical and Electronics Engineers, 1985, p. 979-986. Army-supported research. refs  
(Contract NAS2-11341)

A general methodology for the initial selection of functions for speech generation and speech recognition technology is discussed. The SCR (Stimulus/Central-Processing/Response) compatibility

model of Wickens et al. (1983) is examined, and its application is demonstrated for a particular cockpit display problem. Some limits of the applicability of that model are illustrated in the context of predicting overall pilot-aircraft system performance. A program of system performance measurement is recommended for the evaluation of candidate systems. It is suggested that no one measure of system performance can necessarily be depended upon to the exclusion of others. Systems response time, system accuracy, and pilot ratings are all important measures. Finally, these measures must be collected in the context of the total flight task environment. D.H.

**A86-28453****WICKENS' RESOURCE ALLOCATION MODEL - IMPLICATIONS FOR THE DESIGN OF HUMAN-MACHINE SYSTEMS**

L. A. WHITAKER (Missouri-St. Louis, University, St. Louis) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 2. New York, Institute of Electrical and Electronics Engineers, 1985, p. 1040-1044. refs

A fundamental question of systems design is examined: can one person operate a given system or will it take two? The answer depends on the load that the system imposes on the operator. The model of Wickens, Sandry and Vidulich (1983) suggests that a single operator can draw from a number of separate internal resources to perform a complex task (such as fly an aircraft, provide air traffic control, or execute underwater maintenance tasks). If this model is correct, then systems can be designed to make optimal use of these separate resources within a single operator. The model is discussed and available evidence tending to support or refute it is examined. Implications for the design of air traffic control communications are noted. D.H.

**A86-28513****IMPROVING INTELLIGIBILITY IN AUDIO DISTRIBUTION SYSTEMS**

P. J. GRECO (Telephonics Corp., Huntington, NY) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 2. New York, Institute of Electrical and Electronics Engineers, 1985, p. 1564-1569. refs

Some of the most current techniques for increasing intelligibility in audio distribution systems operating in high ambient noise environments (engine noise, weapons launch, helicopter rotor slap, etc.) are examined. As part of a program to develop the new Tri-Service Digital Audio Distribution System (DADS), a systems approach has been taken to improving intelligibility. The solutions include better noise canceling microphones, active signal enhancement at the audio input, and both passive and active noise canceling devices as the headset. Initial data show that intelligibility scores of better than 75 percent in pink noise environments greater than 115 dB SPL have been achieved. D.H.

**A86-28864\*** Virginia Polytechnic Inst. and State Univ., Blacksburg.

**EVALUATION OF 16 MEASURES OF MENTAL WORKLOAD USING A SIMULATED FLIGHT TASK EMPHASIZING MEDIATIONAL ACTIVITY**

W. W. WIERWILLE, M. RAHIMI, and J. G. CASALI (Virginia Polytechnic Institute and State University, Blacksburg) Human Factors (ISSN 0018-7208), vol. 27, Oct. 1985, p. 489-502. Research supported by the Virginia Polytechnic Institute and State University. refs  
(Contract NAG2-17)

As aircraft and other systems become more automated, a shift is occurring in human operator participation in these systems. This shift is away from manual control and toward activities that tap the higher mental functioning of human operators. Therefore, an experiment was performed in a moving-base flight simulator to assess mediational (cognitive) workload measurement. Specifically, 16 workload estimation techniques were evaluated as to their sensitivity and intrusion in a flight task emphasizing mediational

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behavior. Task loading, using navigation problems presented on a display, was treated as an independent variable, and workload-measure values were treated as dependent variables. Results indicate that two mediational task measures, two rating scale measures, time estimation, and two eye behavior measures were reliably sensitive to mediational loading. The time estimation measure did, however, intrude on mediational task performance. Several of the remaining measures were completely insensitive to mediational load. Author

**A86-29092**

### **HEAD-UP/HEAD-DOWN TRANSITION - MEASUREMENT OF TRANSITION TIMES**

J.-P. R. MENU (Centre d'Etudes et de Recherches de Medecine Aerospatiale, Paris, France) Aviation, Space, and Environmental Medicine (ISSN 0095-6562), vol. 57, March 1986, p. 218-222. DRET-supported research. refs

A method to measure transition times between a head-up display (HUD) signal and a response given to a head-down display (HDD) was developed, using a three-segmented paradigm and testing various vocal and manual arrangements in a fighter aircraft mock-up. The shortest transition times were obtained for voice responses (1600 msec between a HUD signal and a simple response to the HDD). A comparison of the perception and transition times of a 'positive' contrast (green symbols on black background) with a 'negative' contrast (black symbols on green) has indicated both shorter perception and shorter transition times for the positive contrast. This method permits of the effects evaluation of changes in psychological conditions (such as heavier information processing) and physiological conditions (changing accommodation, gaze axis, and convergence) of a dynamic aeronautical environment on the speeds of acquisition and processing of information. I.S.

**A86-29100**

### **SHIP/RIG PERSONNEL ABANDONMENT AND HELICOPTER CREW/PASSENGER IMMERSION SUITS - THE REQUIREMENTS IN THE NORTH ATLANTIC**

C. J. BROOKS (Department of National Defence, Maritime Command, Halifax, Canada) Aviation, Space, and Environmental Medicine (ISSN 0095-6562), vol. 57, March 1986, p. 276-282. refs

**N86-22110#** Army Construction Engineering Research Lab., Champaign, Ill.

### **THE ROLE OF VIBRATION AND RATTLE IN HUMAN RESPONSE TO HELICOPTER NOISE Final Report**

P. D. SCHOMER and R. D. NEATHAMMER Sep. 1985 161 p (AD-A162486; CERL-TR-N-85/14) Avail: NTIS HC A08/MF A01 CSCL 05J

Our understanding of community reaction to helicopter noise remains incomplete. A technique called A-weighting appears to produce realistic data outdoors and at modest noise levels, and the community response in terms of percentage of population highly annoyed can be correlated with respect to the Day/Night Average Sound Level (DNL) descriptor. However, questions remain as to the effect of perceived building vibrations and rattle in human response to helicopter noise. To answer these questions, this study examined the role of vibration and rattle in human response to helicopter noise. Many volunteer subjects were tested under real noise conditions. The helicopter noise was generated by an Army UH-1H (Huey) helicopter. Subjects were located either in the living room of a new mobile home, outdoors, or in the living room or dining room of an old frame farmhouse near Champaign IL. The control or comparison sound was generated electronically through loudspeakers at each location using a 500-Hz octave band of white noise. By performing paired comparison tests between the helicopter and control noises, it was possible to establish equivalency between these two stimuli. Author (GRA)

**N86-22113\*#** Jet Propulsion Lab., California Inst. of Tech., Pasadena.

### **DIRECT MODEL REFERENCE ADAPTIVE CONTROL OF A FLEXIBLE ROBOTIC MANIPULATOR**

D. R. MELDRUM 15 Dec. 1985 90 p refs

(Contract NAS7-918)

(NASA-CR-176659; JPL-PUB-85-100; NAS 1.26:176659) Avail: NTIS HC A05/MF A01 CSCL 05H

Quick, precise control of a flexible manipulator in a space environment is essential for future Space Station repair and satellite servicing. Numerous control algorithms have proven successful in controlling rigid manipulators with collocated sensors and actuators; however, few have been tested on a flexible manipulator with noncollocated sensors and actuators. In this thesis, a model reference adaptive control (MRAC) scheme based on command generator tracker theory is designed for a flexible manipulator. Quicker, more precise tracking results are expected over nonadaptive control laws for this MRAC approach. Equations of motion in modal coordinates are derived for a single-link, flexible manipulator with an actuator at the pinned-end and a sensor at the free end. An MRAC is designed with the objective of controlling the torquing actuator so that the tip position follows a trajectory that is prescribed by the reference model. An appealing feature of this direct MRAC law is that it allows the reference model to have fewer states than the plant itself. Direct adaptive control also adjusts the controller parameters directly with knowledge of only the plant output and input signals. Author

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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.

**A86-26577**

### **NUMERICAL FIXED-POINT SOLUTION FOR NEAR-OPTIMUM REGULATORS OF LINEAR QUADRATIC GAUSSIAN CONTROL PROBLEMS FOR SINGULARLY PERTURBED SYSTEMS**

Z. GAJIC (Rutgers University, Piscataway, NJ) International Journal of Control (ISSN 0020-7179), vol. 43, Feb. 1986, p. 373-387. refs

(Contract NSF ECF-82-05337)

The fixed-point method is developed for obtaining an efficient numerical solution of the linear quadratic Gaussian problem for singularly perturbed systems. It is shown that each iteration step improves the accuracy by an order of magnitude, that is, the accuracy  $O(\epsilon^k)$  can be obtained by performing only  $k - 1$  iterations. In addition, only low-order systems are involved in algebraic manipulations and no analyticity requirements are imposed on the system coefficients. Author

**A86-27472**

### **APPLICATION OF FUZZY LOGIC TO THE ESTIMATION OF SOFTWARE RELIABILITY FOR COMPUTER SYSTEMS [PRIMENENIE NECHETKOI LOGIKI DLIA OTSENKI NADEZHSTI PROGRAMMNOGO OBESPECHENIA VYCHISLITEL'NYKH SISTEM]**

IU. N. MINAEV (Kievskii Institut Inzhenerov Grazhdanskoi Aviatcii, Kiev, Ukrainian SSR) Elektronnoe Modelirovanie (ISSN 0204-3572), vol. 8, Jan.-Feb. 1986, p. 52-56. In Russian. refs

Various aspects of the synthesis of algorithms for the estimation of software reliability in computer systems are examined. Fuzzy logic (specifically fuzzy deductibility schemes) is suggested as the basis for the algorithms. Models for the operation of computer systems when a failure state appears are considered. The operation of the Censor-932 computer system (part of an air traffic control system) is considered as an example. B.J.

A86-28280

**MODELING AND SIMULATION. VOLUME 15 - PROCEEDINGS OF THE FIFTEENTH ANNUAL PITTSBURGH CONFERENCE, UNIVERSITY OF PITTSBURGH, PA, APRIL 19, 20, 1984. PART 5 - GENERAL MODELING AND SIMULATION**

W. G. VOGT, ED. and M. H. MICKLE, ED. Research Triangle Park, NC, Instrument Society of America, 1984, 317 p. No individual items are abstracted in this volume.

Consideration is given to the general modeling and simulation problems which were addressed at the Fifteenth Annual Pittsburgh Conference on Modeling and Simulation. Among the specific problems discussed are: air-traffic control simulation; the influence of sampling rate on a pilot's assessment of the handling characteristics of a simulated aircraft; and the application of job simulation in evaluating alternative layout plans. Consideration is also given to: modeling of real systems; analysis of cracking reactions in structures; polymerization simulations; and modeling of a flight operations manual for the International Ultraviolet Explorer (IUE) spacecraft. Additional topics discussed include: analog simulation of Josephson effects; simulation and optimization models for integrated production planning; and hierarchical multilevel interactive systems simulators. Author

A86-28307

**CONTROL OF THE FLIGHT TESTING OF AIRCRAFT AS A MEANS OF INCREASING THEIR RELIABILITY [UPRAVLENIE LETNYMI ISPYTANIAMI LETATEL'NYKH APPARATOV KAK SREDSTVO POVYSHENIIA IKH NADEZHNOSTI]**

V. S. PUGACHEV IN: Problems in aircraft reliability. Moscow, Izdatel'stvo Mashinostroenie, 1985, p. 25-38. In Russian. refs

The problem of flight test optimization is reduced to an analysis of stochastic differential equations, and methods for estimating the parameters and variables of these equations are proposed. The same approach is also proposed for estimating the variables and parameters of discrete systems in the case where difference equations are used. V.L.

A86-28348#

**DATA-DRIVEN OPERATING CONCEPTS FOR REAL-TIME SIMULATION SYSTEMS**

R. A. WALLACE, D. O. HAGUE, and J. E. MCDONALD (USAF, Avionics Laboratory, Wright-Patterson AFB, OH) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 1. New York, Institute of Electrical and Electronics Engineers, 1985, p. 156-163.

Distributed computer architectures are widely applied to the design of real-time simulation systems for military use. The paper discusses one such architecture. It is for employment in modular and computationally expandable flight simulators and embedded computer system integration support facilities. The architecture is designed to combine and replace shared memory systems and packet switched networks for real-time use. The advantages and implementation of the combination is normally obscure. Shared memory systems are easy to program but limited in network utility. Packet switched networks are easy to configure but difficult to efficiently manage for an intensive real-time environment. Laboratory designs and simple experimental tests illustrate the details and the utility of the new architecture. Author

A86-28368

**STATE ESTIMATION ERRORS IN DIGITAL KALMAN FILTERS CAUSED BY MEASUREMENT DELAYS AND NUMERICAL INTEGRATION**

E. J. BAUMAN and C. E. FOSHA (Colorado, University, Colorado Springs) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 1. New York, Institute of Electrical and Electronics Engineers, 1985, p. 336-342. (Contract F33615-84-K-3602)

Continuing analysis of state estimator errors in director weapon control systems has led to isolating several error sources. Numerically integrated measurements, data delays and data

pre-filtering all cause Kalman filter state estimation errors. A simple tracking scenario shows tutorially both analytically and by simulation that these errors can be very significant. The analysis shows that these errors can be reduced by reducing the sampling period, increasing the order of the numerical integrator and/or appropriately delaying or filtering other measurements. Author

A86-28388

**REAL TIME OPTIMAL FLIGHT PATH GENERATION BY STORAGE OF MASSIVE DATA BASES**

Y. K. CHAN and M. FODDY (Boeing Co., Seattle, WA) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 1. New York, Institute of Electrical and Electronics Engineers, 1985, p. 516-521.

Dynamic programming is traditionally considered too time consuming for real time applications in a fine scale. The storage of a massive precomputed data base of intermediate results in the dynamic programming process is proposed. The numerical processing in real time is then reduced to a manageable updating of this data base to account for new information in the vicinity of the airplane. Thus the full benefit of the optimization by dynamic programming can be realized even in a real time environment. Author

A86-28403

**A MODELING STRUCTURE FOR COMPUTER AIDED DESIGN**

C. A. HARVEY, D. P. JOHNSON, D. J. LOWRY, and T. D. PIERCE (Honeywell Systems and Research Center, Minneapolis, MN) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 1. New York, Institute of Electrical and Electronics Engineers, 1985, p. 642-646.

A structure is described for the representation of analytical design models of aircraft. This structure is motivated by the desire for automated data transmittal of a model that may be used by all design groups. Such a structure could lead to model standardization and better interdisciplinary communication. An illustrative example is also described to demonstrate some of the features in a specific environment. The example vehicle is the B-1A, and the model was used for the design of integrated flight control commands for terrain following/terrain avoidance using multivariable control technology. The dynamics of the engine and flexible aircraft with unsteady aerodynamics are included in the model. For this example, the modeling software is based on Honeyx routines and the UNIX operating system, but the general structure described should be appropriate for other operating systems and software packages. Author

A86-28413

**AVOIDING PROBE TO MODEL COLLISIONS IN WIND TUNNEL TESTING**

G. W. WILLIAMS, JR. (USAF, Wright-Patterson AFB, OH) and K. K. GOROWARA (Wright State University, Dayton, OH) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 1. New York, Institute of Electrical and Electronics Engineers, 1985, p. 720-727. refs

A set of programs has been developed whose ultimate function is to detect potential collisions between a moving probe and a movable model in the finite work space of a wind tunnel test section. This task is accomplished in a two step process. The first step incorporates an interactive 'three-dimensional object' editor, and the second step performs axis transformations and collision detection in real time. An object is defined by a set of faces, edges, and vertices. The collision detection routines transform the probe survey stations, probe 'three-dimensional object' and the model 'three-dimensional object' to world coordinates. The collision detection routines can then analytically determine if two objects in the work space have intersected by testing edges of one object for intersection with a face of another object. If no potential collision is found, the probe drive system is then allowed to move the probe. Author

A86-28419

**A NEW APPROACH TO ENSURING DETERMINISTIC PROCESSING IN AN INTEGRATED AVIONICS SOFTWARE SYSTEM**

J. R. ELLIS (Harris Corp., Government Aerospace Systems Div., Melbourne, FL) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 1. New York, Institute of Electrical and Electronics Engineers, 1985, p. 756-763.

A software architecture providing mechanisms for highly reliable avionics systems which must integrate a variety of task execution rates and criticalities is presented. The executive supports single and multiprocessor systems for both cyclic and event driven tasks; foreground and background tasking with task suspension are implemented. Also covered are built-in-test features which ensure reliability. The architecture supports the use of high-level programming languages and is compatible with such advanced language features as 'tasking' and 'rendezvous' as defined for Ada. The architecture described here has been implemented in an integrated avionics software system for the Agusta A-129 Light Attack Helicopter. V.L.

A86-28420

**DESIGNING INTO THE UNKNOWN**

M. HACKMAN (Boeing Military Airplane Co., Seattle, WA) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 1. New York, Institute of Electrical and Electronics Engineers, 1985, p. 764-769.

The concept of 'configurable software', i.e., software generically constructed and table-driven to suit special contexts from tables read in at program initialization, is examined. Such an approach makes it possible to bypass many of the rigidities created by attempting to design from top down and many of the uncertainties involved in designing from bottom up. General guidelines for developing configurable software are discussed with reference to an effort to design track-file software to form the core of a battle-management system intended for the next generation of tactical fighters. V.L.

A86-28421

**A FORTRAN ALGORITHM FOR TERRAIN PERSPECTIVE AND PLAN VIEW DISPLAY**

B. RICHARDSON and W. LIM (Northrop Corp., Aircraft Div., Hawthorne, CA) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 1. New York, Institute of Electrical and Electronics Engineers, 1985, p. 770-775.

A FORTRAN algorithm has been developed which will generate a three-dimensional perspective terrain display and a two-dimensional plan view. Each of these displays are generated from a patch of terrain which is stored in digital format. This paper describes the algorithm, its memory and computational requirements as well as its development and potential utilization. Author

A86-28430

**IV&V FOR THE AUTOMATIC TEST CONTROL SYSTEM IN THE USAF AEROPROPULSION SYSTEMS TEST FACILITY**

R. M. VINING (USAF, Arnold Engineering Development Center, Arnold Air Force Station, TN) and W. ALBANES (Associated Technology Co., Estill Springs, TN) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 1. New York, Institute of Electrical and Electronics Engineers, 1985, p. 843-850.

This paper documents Independent Verification and Validation (IV&V) methods and tools used during development of an Automatic Test Control System for the Aeropropulsion Systems Test Facility at the USAF Arnold Engineering Development Center, Arnold AFS, TN. The V&V effort was applied to the control algorithms, the computer system hardware, and the interface support equipment. Author

A86-28456#

**A CASE STUDY IN SIMULATION VS. STIMULATION - THE B-1 WEAPON SYSTEM TRAINER**

M. H. TAINT (USAF, Aeronautical Systems Div., Wright-Patterson AFB, OH) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 2. New York, Institute of Electrical and Electronics Engineers, 1985, p. 1062-1067.

A topic of controversy in the training technology area is discussed, namely the relative merits of functional simulation (software modeling) as opposed to stimulation (using aircraft processors and software) to simulate avionics processors and their associated software. A case study in the 'stim vs. sim' debate is examined by comparing the design approaches to simulating the offensive and defensive avionics processors on the original B-1 (the B-1A) and B-1B weapon system trainers. For the B-1A, both stations were to be functionally simulated, while the B-1B approach is a mixture of functional simulation of the defensive station with stimulation of the offensive station. Alternate approaches to avionics processor/software simulation is also discussed. D.H.

A86-28483#

**DATA SYSTEMS FOR LOGISTICS EVALUATION DURING OPERATIONAL TEST**

J. R. FINCH and W. T. MAULDIN (USAF, Operational Test and Evaluation Center, Kirtland AFB, NM) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 2. New York, Institute of Electrical and Electronics Engineers, 1985, p. 1286-1288.

Data collection and processing systems used by the Operational Test Center to support its suitability evaluations are addressed. The Center uses the System Effectiveness Data System (SEDS) and OMNIVORE (which accepts data from standard Air Force data collection systems) to support its evaluations of aircraft, munitions, and command, control and communications systems. These two systems are flexible and user-oriented and provide the data necessary to assess system reliability, maintainability, and availability. Additionally, Test Center personnel have developed microcomputer tools to assist in data projection and analysis. Efforts are under way to expand the capability for remote data input and analysis via microcomputer, to develop data systems appropriate to space systems, and to estimate the maturity of system software. D.H.

A86-28486

**EXPERT SYSTEMS FOR REAL TIME APPLICATIONS**

J. K. CLEMA (IIT Research Institute, Annapolis, MD), R. WERLING (Technion International, Wilmington, DE), and A. CHANDE (Systems and Applied Sciences Corp., Vienna, VA) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 2. New York, Institute of Electrical and Electronics Engineers, 1985, p. 1322-1329. refs

The problems of using and building on the methodology employed in today's 'expert systems' in a real-time laboratory-environment approach to demonstrate machine learning are discussed. Artificial intelligence and cognitive techniques applicable to dynamic, real-time, rapidly changing combat situations are examined. Expert systems which use modeling and simulation systems (such an AVSAIL models), off-the-shelf operations research tools, fuzzy logic, control theory, and decision theoretics are recommended as the approach DARPA should use in attaining the Pilot's Associate System goal of employing emerging machine intelligence technology to assist the combat pilot in advanced aircraft in the 1995 time period. A model of a dynamic, real-time, adaptive expert system is provided. D.H.



A86-28487

**EXPERT SYSTEM APPLICATIONS TO THE COCKPIT OF THE '90S**

K. FRANKOVICH (USAF, Washington, DC), K. PEDERSEN, and S. BERNSTEIN IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 2. New York, Institute of Electrical and Electronics Engineers, 1985, p. 1330-1335.

The requirements, enabling technologies, and potential structure of the next generation of avionics - employing expert systems - are addressed. Two examples of the potential of future avionics expert systems are considered: a navigation and route planning expert and a threat assessment and threat reaction expert. D.H.

**N86-21168#** National Aeronautical Lab., Bangalore (India). Aerodynamics Div.

**PARAMETRIC BI-CUBIC SURFACE PATCH FOR COMPUTER AIDED GEOMETRIC DESIGN OF AIRCRAFT AND/OR OTHER THREE-DIMENSIONAL GEOMETRIES**

H. N. V. DUTT Sep. 1985 58 p refs  
(NAL-TM-AE-8505) Avail: NTIS HC A04/MF A01

A FORTRAN program was developed to fit smooth surfaces to the component parts of an arbitrary aircraft configuration or any three dimensional geometry. The basic surface element used for this fit is a bicubic surface patch. Once the geometry was replaced by a set of patch equations, various kinds of calculations which require a three dimensional mathematical description of the surface can be performed easily. The second part of the code generates orthographic views of the given geometry on a calcomp drum plotter or on a Tektronix screen. The last part of the program generates cross sectional plots at any desired orientation through the given configuration. Also this module can be used to generate cross sectional areas, intermediate sections and other geometric details of the given configuration. The input data is oriented mainly towards aircraft geometry. But the code can be efficiently used for representing any arbitrary surface or a combination of both.

Author

**N86-21219# National Aerospace Lab., Tokyo (Japan). COVARIANCE SPECIFICATION FOR THE LINEAR TIME-INVARIANT OUTPUT-FEEDBACK CONTROL SYSTEMS USING A KALMAN FILTER**

M. NAGAYASU Oct. 1985 16 p refs In JAPANESE; ENGLISH summary  
(NAL-TR-882; ISSN-0389-4010) Avail: NTIS HC A02/MF A01

The covariance specification problem using a Kalman filter for the linear time-invariant output-feedback control system contaminated by observation and system noise is described. Linear stochastic control problems based on the quadratic performance criteria were studied. However, the relationships between the criteria and the behavior of the resultant closed loop system are still in question today. The optimal output-feedback control using a Kalman filter with which the stationary state covariance matrix coincides with the prescribed matrix is described. The system is disturbed by additive white/color system noise and the output signal is contaminated by white observation noise. The dynamic output feedback control system is obtained by using a Kalman filter. The covariance specification problem, i.e., to obtain the optimal feedback gains under the requirement of the state covariance coinciding with the prescribed covariance for minimizing the control effort, is solved. The control problem of an aircraft in atmospheric turbulence is numerically discussed. E.A.K.

**N86-21232#** National Aeronautical Lab., Bangalore (India). Systems Engineering Div.

**COMPUTATION OF TRANSFER FUNCTION MATRICES**

J. K. SRIDHAR and B. SATYABHAGAVAN Aug. 1985 30 p refs  
(NAL-TM-SE-8509) Avail: NTIS HC A03/MF A01

Control systems design in frequency domain involves the computation of transfer function matrices. Details of the software developed on UNIVAC-1100/60 to compute transfer function matrices and hence zeros and poles of numerator and denominator

polynomials respectively are given. The software developed here is intended to form an integral part of a package available in the division to study longitudinal and lateral dynamics of an aircraft. Numerical algorithm and schematic flow chart is presented along with an example on a fighter aircraft model. The software is documented and validated. A user manual is provided. Author

**N86-21233#** National Aeronautical Lab., Bangalore (India). Aerodynamics Div.

**A PRELIMINARY NOTE ON THE DEVELOPMENT OF A THREE DIMENSIONAL POTENTIAL CODE IN CARTESIAN COORDINATES**

S. S. DESAI, R. RANGARAJAN, and K. S. RAVICHANDRAN Jul. 1985 53 p refs  
(NAL-TM-AE-8504) Avail: NTIS HC A04/MF A01

An existing two dimensional transonic code TRADE1 was extended in Cartesian coordinates to three dimensions. A code was developed using Cartesian coordinates, instead of the more involved body fitting coordinates, so that the incorporation of a fuselage in the code developed for wing alone case becomes straight forward. The preliminary studies show encouraging results, but also bring into focus areas in a flow field where more needs to be done for a good resolution of the flow details, particularly for swept, tapered wings. Author

**N86-21260#** Lawrence Livermore National Lab., Calif.

**APPLICATION OF PRA TO HEMP VULNERABILITY ANALYSIS**

R. W. MENSING Sep. 1985 57 p  
(Contract W-7405-ENG-48)

(DE86-001781; UCID-20553) Avail: NTIS HC A04/MF A01

Vulnerability analyses of large systems, e.g., control and communication centers, aircraft, ships, are subject to many uncertainties. A basic source of uncertainty is the random variation inherent in the physical world. Thus, vulnerability is appropriately described by an estimate of the probability of survival (or failure). The estimate of the probability of survival is not a single value but a range of values. Probabilistic risk analysis (PRA) is a methodology which deals with these uncertainty issues. This report discusses the application of PRA to HEMP vulnerability analyses. Vulnerability analysis and PRA are briefly outlined and the need to distinguish between random variation and modeling uncertainty is discussed. Then a sequence of steps appropriate for applying PRA to vulnerability problems is outlined. Finally, methods for handling modeling uncertainty are identified and discussed. DOE

**N86-21938\*#** Space Development Corp., Hampton, Va.

**DATA REDUCTION, MANAGEMENT, AND ANALYSIS SOFTWARE FOR CID**

C. W. DAVIS /n NASA. Langley Research Center Full-Scale Transport Controlled Impact Demonstration p 61-77 Jan. 1986 refs

Avail: NTIS HC A16/MF A01 CSCL 20K

In an overview of the Data Reduction System, three major steps are examined. First, the raw data tapes were selected from the onboard recorders. These tapes should provide the best quality data for the data reduction software system. These tapes contained 352 channels of data, plus the monitor channels recorded in 8 bit Pulsed Coded Modulation (PCM) words. The next step consists of transcribing the PCM tapes from 8 bit serial digital data to 8 bit parallel digital data. This puts the data in the correct format for processing. The transcription process was accomplished here at LaRC in the Central Data Transportation Facility (CDTF). The last step in this 3 step process is to process the data through the reduction system developed for the Impact Dynamic Research Facility in the early part of 1980. Processing system criteria, system interface routines, and engineering units program that reads digitized data from tapes, and file management programs are discussed. R.J.F.

**N86-21941\*#** PRC Kentron, Inc., Hampton, Va.  
**DIGITAL FILTERING AND ACCELERATION PULSE INTERPRETATION**

E. L. PASANELLA /n NASA. Langley Research Center Full-Scale Transport Controlled Impact Demonstration p 103-123 Jan. 1986 refs

Avail: NTIS HC A16/MF A01 CSCL 12A

It was concluded that the post processing digital filter is quite effective for removing unwanted high frequency and noise without distorting the signal. In addition, digital filtering is effective for smoothing low-level low resolution digital data where the digital staircase phenomena are pronounced. Integrating the acceleration data to obtain velocity traces is quite useful. The velocity change provides a check on the validity of the acceleration trace. (Zero offsets in acceleration must be removed before integrating.) Average accelerations can be obtained from the velocity trace by dividing the change in velocity for an acceleration pulse by the pulse duration. One can obtain the peak of an equivalent triangular pulse by doubling the average acceleration. Author

**N86-22159#** Defence and Civil Inst. of Environmental Medicine, Downsview (Ontario).

**SELECTION OF A MAN-MODELLING CAD (COMPUTER-AIDED DESIGN)**

P. L. ROTHWELL Sep. 1985 22 p  
 (AD-A161342; DCIEM-85-C-36) Avail: NTIS HC A02/MF A01 CSCL 09B

DCEIM has been tasked to review Canadian Forces (CF) aircrew/cockpit compatibility and to make recommendations regarding future aircrew selection standards. Computer man-modelling has been proposed as the method to address the evaluation. In this report, three potential computer-aided design, man-modelling programs (CAR, COMBIMAN and SAMMIE) are evaluated. The ELECTRE multi-criteria decision making process was used to select the most appropriate program. The criteria were based on man-modelling and workspace-modelling features, and the capabilities to address the problems of reach, clearance and vision in aircraft crew stations. The results of the analysis support the recommendation to procure SAMMIE. SAMMIE was also found to be suitable to other work station design applications. GRA

**N86-22208#** Harvard Univ., Cambridge, Mass. Center for Research in Computer Technology.  
**MOTION PLANNING IN THE PRESENCE OF MOVING OBSTACLES**

J. H. REIF and M. SHARIR 1985 30 p  
 (Contract N00014-80-C-0647)  
 (AD-A161374; TR-06-85) Avail: NTIS HC A03/MF A01 CSCL 12A

This paper investigates the computational complexity of planning the motion of a body B in 2-D or 3-D space, so as to avoid collision with moving obstacles of known, easily computed, trajectories. Dynamic movement problems are of fundamental importance to robotics, but their computational complexity has not previously been investigated. We provide evidence that the 3-D dynamic movement problem is intractable even if B has only a constant number of degrees of freedom of movement. In particular, we prove the problem is PSPACE-hard if B is given a velocity modulus bound on its movements and is NP hard even if B has no velocity modulus bound, where in both cases B has 6 degrees of freedom. To prove these results we use a unique method of simulation of a Turing machine which uses time to encode configurations (whereas previous lower bound proofs in robotics used the system position to encode configurations and so required unbounded number of degrees of freedom). We also investigate a natural class of dynamic problems which we call asteroid avoidance problems: B, the object we wish to move, is a convex polyhedron which is free to move by translation with bounded velocity modulus and the polyhedral obstacles have known translational trajectories but cannot rotate. This problem has many applications to robot, automobile, and aircraft collision avoidance. GRA

## 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.

**A86-26888\*#** Missouri Univ., Rolla.  
**APPLICATION OF THE FINITE ELEMENT METHOD IN THE CALCULATION OF TRANSMISSION LOSS OF FLAT AND CURVED PANELS**

L. R. KOVAL, S. MOTAMEDI, and J. V. RAMAKRISHNAN (Missouri-Rolla, University, Rolla) IN: Fluid-structure interaction and aerodynamics damping; Proceedings of the Tenth Biennial Conference on Mechanical Vibration and Noise, Cincinnati, OH, September 10-13, 1985. New York, American Society of Mechanical Engineers, 1985, p. 19-28. refs  
 (Contract NAG1-240)

This investigation represents an extension of a study of Roussos (1985) who considered the noise transmission loss of a rectangular plate in an infinite baffle. Roussos, who employed an analytical formulation, considered an unstiffened plate. While it is difficult to consider stiffeners by means of analytical methods, the difficulties can be avoided by employing a finite element procedure. For this reason, the present study is concerned with the implementation of a finite element method. The representation of the panel transmission loss is discussed, and the determination of the panel motion by means of the finite element technique is described, taking into account an isotropic flat panel, the exciting force, an eigenvalue problem, the radiation pressure, a plate element, and a cylindrical shell element. Numerical results are considered for a flat panel, a curved panel, and a stiffened flat panel. G.R.

**A86-27658\*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

**HELICOPTER MODEL ROTOR-BLADE VORTEX INTERACTION IMPULSIVE NOISE - SCALABILITY AND PARAMETRIC VARIATIONS**

D. A. BOXWELL, F. H. SCHMITZ (NASA, Ames Research Center, U.S. Army, Aeromechanics Laboratory, Moffett Field, CA), W. R. SPLETTSTOESSER, and K. J. SCHULTZ (DFVLR, Institut fuer Entwurfsaerodynamik, Brunswick, West Germany) (Netherlands Association of Aeronautical Engineers and Technische Hogeschool te Delft, European Rotorcraft Forum, 10th, The Hague, Netherlands, Aug. 28-31, 1984) IN: International Conference on Rotorcraft Basic Research, Research Triangle Park, NC, February 19-21, 1985, Proceedings. Alexandria, VA, American Helicopter Society, 1985, 19 p. Previously announced in STAR as N85-16826. refs

Acoustic data taken in the anechoic Deutsch-Niederlaendischer Windkanal (DNW) have documented the blade vortex interaction (BVI) impulsive noise radiated from a 1/7-scale model main rotor of the AH-1 series helicopter. Averaged model scale data were compared with averaged full scale, inflight acoustic data under similar nondimensional test conditions. At low advance ratios ( $\mu = 0.164$  to  $0.194$ ), the data scale remarkable well in level and waveform shape, and also duplicate the directivity pattern of BVI impulsive noise. At moderate advance ratios ( $\mu = 0.224$  to  $0.270$ ), the scaling deteriorates, suggesting that the model scale rotor is not adequately simulating the full scale BVI noise; presently, no proved explanation of this discrepancy exists. Carefully performed parametric variations over a complete matrix of testing conditions have shown that all of the four governing nondimensional parameters - tip Mach number at hover, advance ratio, local inflow ratio, and thrust coefficient - are highly sensitive to BVI noise radiation. Author

**N86-21279#** Federal Aviation Administration, Washington, D.C.  
**NOISE LEVELS FOR US CERTIFICATED AND FOREIGN AIRCRAFT**

4 Nov. 1985 101 p

(FAA-AC-36-1D) Avail: NTIS HC A06/MF A01

U.S. Department of Transportation Advisory Circular No. 36-1D (11/4/85) provides noise level data for airplanes certificated under FAR Part 36. Noise level data for foreign airplanes certificated to ICAO Annex 16 standards are also provided in a separate appendix for informational purposes. New appendices have been added to represent selected configurations of U.S. certificated aircraft and to provide listings of noise levels ranked in descending order.

Author

**N86-21280\*#** National Aeronautics and Space Administration.  
 Langley Research Center, Hampton, Va.

**NEW TECHNIQUES FOR EXPERIMENTAL GENERATION OF TWO-DIMENSIONAL BLADE-VORTEX INTERACTION AT LOW REYNOLDS NUMBERS**

E. BOOTH, JR. and J. C. YU Mar. 1986 27 p refs

(NASA-TP-2551; L-15981; NAS 1.60:2551) Avail: NTIS HC A03/MF A01 CSCL 20A

An experimental investigation of two dimensional blade vortex interaction was held at NASA Langley Research Center. The first phase was a flow visualization study to document the approach process of a two dimensional vortex as it encountered a loaded blade model. To accomplish the flow visualization study, a method for generating two dimensional vortex filaments was required. The numerical study used to define a new vortex generation process and the use of this process in the flow visualization study were documented. Additionally, photographic techniques and data analysis methods used in the flow visualization study are examined.

Author

**N86-21287#** Royal Netherlands Aircraft Factories Fokker,  
 Schiphol-Oost.

**RECENT EXPERIENCES IN THE ANALYSIS OF AIRCRAFT CABIN NOISE**

R. F. C. KRIENS 1985 5 p refs Presented at Inter-Noise 85, Munich, West Germany, 18-20 Sep. 1985

Avail: NTIS HC A02/MF A01

Reduction of cabin noise in propeller driven aircraft is discussed. Separation of cabin noise into left and right hand components is described. Acoustic finite element analysis and airborne acoustic intensity measurements are reviewed.

Author (ESA)

**N86-22302** National Physical Lab., Teddington (England). Div.  
 of Radiation Science and Acoustics.

**AN EXPERIMENTAL APPRAISAL OF THE USE OF GROUND-PLANE MICROPHONES FOR AIRCRAFT NOISE MEASUREMENT**

R. C. PAYNE Aug. 1985 50 p refs

(NPL-AC-104; ISSN-0143-7143) Avail: Issuing Activity

Sound pressure levels measured using ground-plane microphone configurations are compared with pressure-doubled spectra derived from measurements using a conventional 1.2 m microphone location. Experimental data were obtained under laboratory conditions and in the field using a stationary sound source producing pure tone signals or shaped white noise. An arrangement involving a half-inch condenser microphone inverted over a circular baffle gives a close approximation to a pressure-doubled spectrum. Field trials using over-flights of light propeller-driven aircraft confirm the validity of the arrangement.

Author (ESA)

**N86-22304\*#** National Aeronautics and Space Administration.  
 Langley Research Center, Hampton, Va.

**AIRPORT-NOISE LEVELS AND ANNOYANCE MODEL (ALAMO) USER'S GUIDE**

R. DELOACH, J. L. DONALDSON, and M. J. JOHNSON Jan. 1986 129 p Prepared in cooperation with Computer Sciences Corp., Hampton, Va.

(NASA-TM-87695; NAS 1.15:87695) Avail: NTIS HC A07/MF A01 CSCL 20A

A guide for the use of the Airport-Noise Level and Annoyance Model (ALAMO) at the Langley Research Center computer complex is provided. This document is divided into 5 primary sections, the introduction, the purpose of the model, and an in-depth description of the following subsystems: baseline, noise reduction simulation and track analysis. For each subsystem, the user is provided with a description of architecture, an explanation of subsystem use, sample results, and a case runner's check list. It is assumed that the user is familiar with the operations at the Langley Research Center (LaRC) computer complex, the Network Operating System (NOS 1.4) and CYBER Control Language. Incorporated within the ALAMO model is a census database system called SITE II.

Author

**N86-22305\*#** National Aeronautics and Space Administration.  
 Langley Research Center, Hampton, Va.

**AIRPORT-NOISE LEVELS AND ANNOYANCE MODEL (ALAMO) SYSTEM'S REFERENCE MANUAL**

R. DELOACH, J. L. DONALDSON, and M. J. JOHNSON Jan. 1986 129 p refs Prepared in cooperation with Computer Sciences Corp., Hampton, Va.

(NASA-TM-87694; NAS 1.15:87694) Avail: NTIS HC A06/MF A01 CSCL 20A

The airport-noise levels and annoyance model (ALAMO) is described in terms of the constituent modules, the execution of ALAMO procedure files, necessary for system execution, and the source code documentation associated with code development at Langley Research Center. The modules constituting ALAMO are presented both in flow graph form, and through a description of the subroutines and functions that comprise them.

Author

**N86-22306\*#** Bionetics Corp., Hampton, Va.

**AN EVALUATION OF STUDY DESIGN FOR ESTIMATING A TIME-OF-DAY NOISE WEIGHTING**

J. M. FIELDS Mar. 1986 30 p refs

(Contract NAS1-16978)

(NASA-CR-178062; NAS 1.26:178062) Avail: NTIS HC A03/MF A01 CSCL 20A

The relative importance of daytime and nighttime noise of the same noise level is represented by a time-of-day weight in noise annoyance models. The high correlations between daytime and nighttime noise were regarded as a major reason that previous social surveys of noise annoyance could not accurately estimate the value of the time-of-day weight. Study designs which would reduce the correlation between daytime and nighttime noise are described. It is concluded that designs based on short term variations in nighttime noise levels would not be able to provide valid measures of response to nighttime noise. The accuracy of the estimate of the time-of-day weight is predicted for designs which are based on long term variations in nighttime noise levels. For these designs it is predicted that it is not possible to form satisfactorily precise estimates of the time-of-day weighting.

Author

**N86-22312#** Aeronautical Research Inst. of Sweden, Stockholm.  
 Aerodynamics Dept.

**MEASUREMENT OF NOISE FROM AIRPLANES TRAVELING AT HEIGHTS 3500 TO 6000M**

M. LINDE and S. MEIJER Sep. 1985 19 p refs

(Contract STU-AU-2168)

(FFA-TI-AU-2168) Avail: NTIS HC A02/MF A01

The noise on the ground produced by overflights of jet and propeller airplanes, at different flight levels, was studied to provide a basis for the estimation of the noise from future propeller

## 17 SOCIAL SCIENCES

airplanes. The noise on the ground from airplanes at heights 3500 to 6000m was measured. Author (ESA)

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### 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.

#### A86-26427#

##### RADIONAVIGATION PLANNING IN THE FAA

N. A. BLAKE and J. W. BRADLEY (FAA, Washington, DC) IN: Institute of Navigation, National Technical Meeting, San Diego, CA, January 15-17, 1985, Proceedings. Washington, DC, Institute of Navigation, 1985, p. 5-17.

A review of the development and automation of the FAA's air traffic control process, in addition to its program for the future, is presented. The very high frequency omnidirectional radio range (VOR) in use since 1946 and updated to solid-state capability, and its distance measuring equipment (DME), constitute the primary civil air radio navigation systems today, and are projected to remain so into the next century. The system is supplemented by LORAN-C for low altitudes and offshore areas, and OMEGA and INS for oceanic and domestic high altitude airspace to meet all current user requirements including direct and random fuel efficient operation throughout much of the upper airspace. The Global Positioning System (GPS) may meet the requirements either as a sole-means or a supplementary navigation system in the future, accompanied by the possible phasing-out of existing supplementary systems. The military, however, plan to replace their tactical air navigation system (TACAN) with the GPS during the 1990s.

R.R.

#### A86-27834#

##### PRODUCTION-THEORETICAL STUDY OF AIR TRAFFIC OUTPUT PRODUCTION [PRODUKTIONSTHEORETISCHE UNTERSUCHUNG DER FLUGBETRIEBLICHEN LEISTUNGSERSTELLUNG]

C. WEILER Koeln, Universitaet, Wirtschafts- und sozialwissenschaftliche Fakultae, Doktor Dissertation, 1983, 239 p. In German. refs

The theory and application of production theory to air traffic is addressed. The formalities and systematics of the theory are discussed and applied to the characterization and differentiation of combined aircraft operations. The empirical determination of the technical-economic use function for fuel and maintenance work is studied and formulated for the singular process. The combined usage function is applied to models of aircraft usage, and the factor-output relationship is characterized.

C.D.

#### A86-28425

##### SOFTWARE MANAGEMENT FOR INTEGRATED AVIONICS SYSTEMS

K. C. EDWARDS (Harris Corp., Government Aerospace Systems Div., Melbourne, FL) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 1. New York, Institute of Electrical and Electronics Engineers, 1985, p. 798-805. refs

Software engineering methodologies providing the level of control necessary to achieve cost effective software development for an integrated avionics software system are discussed with particular reference to the integrated software system for the Agusta A-129 Light Attack Helicopter. The high level of control is required to maintain the functional independence of the different software elements (e.g., Automated Flight Controls, Engine Monitor, Operator Interface, Navigation, and others) in order to avoid unnecessary couplings that will drive the cost of the system

development and maintenance up while reducing the reliability of the system. As a result of an implementation of this approach, the software development costs for the Agusta A-129 project have been comparable to less complex ground-based systems. V.L.

#### N86-21435# National Bureau of Standards, Washington, D.C. Information Resources and Services Div.

##### PUBLICATIONS OF THE NATIONAL BUREAU OF STANDARDS, 1984 CATALOG Report, Jan. - Dec. 1984

R. J. MOREHOUSE Jun. 1985 441 p (PB85-245678; NBS/SP-305-SUPPL-16) Avail: NTIS HC A19/MF A01; SOD HC \$16.00 as 003-003-02667-1 CSCL 05B

The 16th Supplement to Special Publication 305 lists the 1984 papers which reflect the results of National Bureau of Standards (NBS) programs. Also included are those NBS papers published prior to 1984 but not reported in previous supplements of SP305. In addition to bibliographic data, key words, and abstracts for each publication and/or paper, the catalog provides author, key word, title, and NTIS order/report number indexes. GRA

#### N86-21447# Committee on Science and Technology (U. S. House).

##### OVERSIGHT ON THE FEDERAL AVIATION ADMINISTRATION FISCAL YEAR 1986 RESEARCH, ENGINEERING AND DEVELOPMENT BUDGET REQUEST

Washington GPO 1985 191 p Hearings before the Subcommittee on Transportation, Aviation and Materials of the Committee on Science and Technology, 99th Congr., 1st Sess., no. 8, 19-20 Mar. 1985

(GPO-46-725) Avail: Subcommittee on Transportation, Aviation and Materials

Hearings held by the House Committee on Science and Technology on the Federal Aviation Administration fiscal year 1986 research, engineering, and development budget requests are presented. Statements in support of the implementation of R & D programs in the National Airspace System Plan are presented.

B.W.

#### N86-22441# Air Force Inst. of Tech., Wright-Patterson AFB, Ohio. School of Systems and Logistics.

##### A METHODOLOGY FOR APPLYING BAR CODE TECHNOLOGY TO AIRCRAFT MAINTENANCE UNIT SUPPORT SECTIONS M.S. Thesis

P. VALOVICIN Sep. 1985 97 p (AD-A161783; AFIT/GLM/LSM/85S-79) Avail: NTIS HC A05/MF A01 CSCL 09B

This study developed a methodology that decision makers can use as an aid to determine if bar code technology should be applied in Aircraft Maintenance Unit (AMU) Support Sections. The literature review revealed that the Logistics Applications of Automated Marking and Reading Symbols (LOGMARS) steering group recommended that bar code technology applications be aggressively pursued across the logistics spectrum due to the success of the LOGMARS test program. Since AMU support sections perform many functions similar to those that have already benefited from this technology as it applies to an AMU support sections. Worksheets were designed to help collect and analyze the necessary cost/benefit information so that decision makers will be able to properly assess the expected cost and benefits for a particular support section. GRA

#### N86-22443# Air Force Wright Aeronautical Labs., Wright-Patterson AFB, Ohio.

##### AIR FORCE TECHNICAL OBJECTIVE DOCUMENT, FLIGHT DYNAMICS LABORATORY PLANS FOR FISCAL YEAR 1987 Final Report, Aug. 1984 - Jul. 1985

Jul. 1985 75 p Supersedes AFWAL-TR-84-3000, AD-A149648 (AD-A162792; AFWAL-TR-85-3000; AFWAL-TR-84-3000) Avail: NTIS HC A04/MF A01 CSCL 01C

The document presents an overview of the Laboratory Technology Planning Objectives of the Flight Dynamics Laboratory omitting specific funding and timing information of an Official Use Only nature. Technology planning objectives are described for

Structures and Dynamics, Vehicle Equipment, Flight Control, Aeromechanics, and Technology Assessment. GRA

**N86-22450** Deutsche Lufthansa Aktiengesellschaft, Frankfurt am Main (West Germany).

**ACTIVITIES REPORT OF THE AEROSPACE INDUSTRY IN WEST GERMANY Annual Report, 1985 [LUFTHANSA JAHRBUCH 85]**

H. J. ALLGAIER, ed. 31 May 1985 360 p In GERMAN (ISSN-0176-5086) Avail: Issuing Activity

Air traffic, air traffic market, efficiency, costs, Lufthansa national role and independence, and rates and regulation in civil aviation are discussed. The Airbus A320 program, the development of a propeller, the role of Lufthansa in aircraft development and in technical services, German cargo services, and aviation fuel are treated. Author (ESA)

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### GENERAL

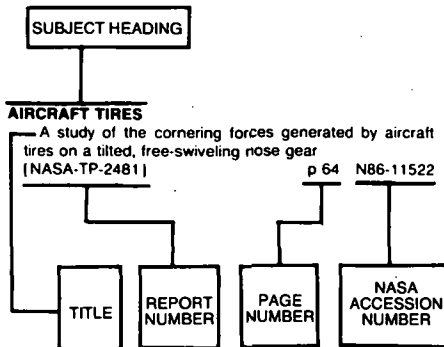
**A86-27648**

**THE GOLDEN AGE OF THE GREAT PASSENGER AIRSHIPS: GRAF ZEPPELIN AND HINDENBURG**

H. G. DICK and D. H. ROBINSON Washington, DC, Smithsonian Institution Press, 1985, 226 p. refs

The history of commercial airship operations in Germany during the 1920s and 1930s is reviewed, in an anecdotal style. Emphasis is given to the personal reminiscences of an American airship designer on board the Graf Zeppelin and the Hindenburg during several transatlantic crossings. A description of the Hindenburg disaster at Lakehurst, New Jersey, on May 6, 1937, is presented. Some of the political and economic factors which led to the abandonment of commercial airship transportation are discussed in detail. Original black and white photographs of the Hindenburg and the Graf Zeppelin are provided, as well as a glossary of airship terms and a verbatim reproduction of a German airship crew manual. I.H.

### Typical Subject Index Listing



The subject heading is a key to the subject content of the document. The title is used to provide a description of the subject matter. When the title is insufficiently descriptive of the document content, the title extension is added, separated from the title by three hyphens. The (NASA or AIAA) accession number and the page number are included in each entry to assist the user in locating the abstract in the abstract section. If applicable, a report number is also included as an aid in identifying the document. Under any one subject heading, the accession numbers are arranged in sequence with the AIAA accession numbers appearing first.

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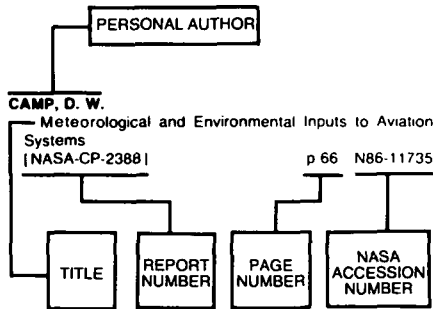
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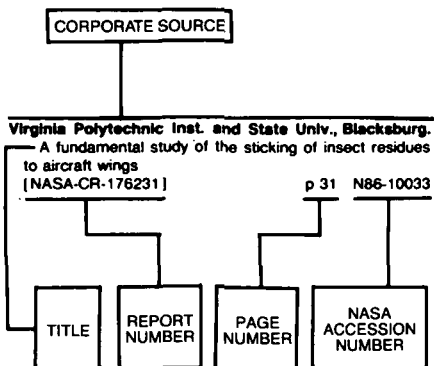
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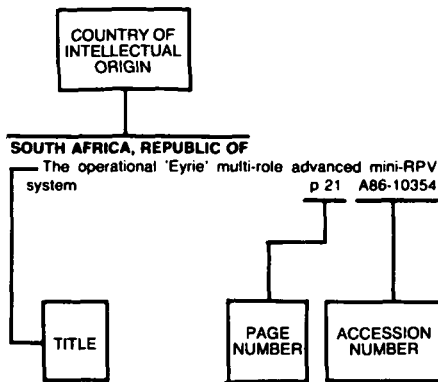
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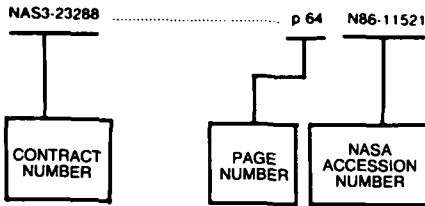
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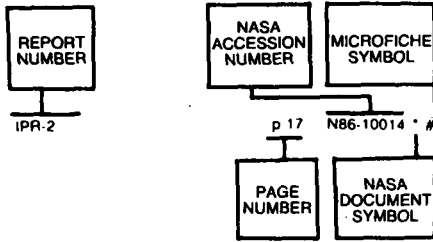


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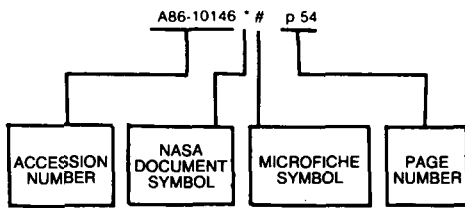
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