



## ACCESSION NUMBER RANGES

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# AERONAUTICAL ENGINEERING

## A CONTINUING BIBLIOGRAPHY WITH INDEXES

(Supplement 207)

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 November 1986 in

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



Scientific and Technical Information Branch

**National Aeronautics and Space Administration**

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# INTRODUCTION

This issue of *Aeronautical Engineering -- A Continuing Bibliography* (NASA SP-7037) lists 484 reports, journal articles and other documents originally announced in November 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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# TYPICAL REPORT CITATION AND ABSTRACT

**NASA SPONSORED**

↓  
ON MICROFICHE

**ACCESSION NUMBER** → **N86-10033\***# Virginia Polytechnic Inst. and State Univ., Blacksburg. Dept. of Chemistry. ← **CORPORATE SOURCE**

**TITLE** → **A FUNDAMENTAL STUDY OF THE STICKING OF INSECT RESIDUES TO AIRCRAFT WINGS Annual Technical Report**

**AUTHORS** → **N. S. EISS, JR., J. P. WIGHTMAN, D. R. GILLIAM, and E. J. SIOCHI** Apr. 1985 191 p refs ← **PUBLICATION DATE**

**CONTRACT NUMBER** → (Contract NAG1-300) ← **AVAILABILITY SOURCE**

**REPORT NUMBERS** → (NASA-CR-176231; NAS 1.26:176231) Avail: NTIS HC A09/MF ← **PRICE CODE**

**COSATI CODE** → A01 CSCL 01C

The aircraft industry has long been concerned with the increase of drag on airplanes due to fouling of the wings by insects. The present research studied the effects of surface energy and surface roughness on the phenomenon of insect sticking. Aluminum plates of different roughnesses were coated with thin films of polymers with varying surface energies. The coated plates were attached to a custom jig and mounted on top of an automobile for insect collection. Contact angle measurements, X-ray photoelectron spectroscopy and specular reflectance infrared spectroscopy were used to characterize the surface before and after the insect impact experiments. Scanning electron microscopy showed the topography of insect residues on the exposed plates. Moments were calculated in order to find a correlation between the parameters studied and the amount of bugs collected on the plates. An effect of surface energy on the sticking of insect residues was demonstrated.

Author

# TYPICAL JOURNAL ARTICLE CITATION AND ABSTRACT

**NASA SPONSORED**

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ON MICROFICHE

**ACCESSION NUMBER** → **A86-11041\***# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va. ← **TITLE**

**AUTHOR** → **D. S. MILLER and R. M. WOOD** (NASA, Langley Research Center, Hampton, VA) ← **AUTHOR'S AFFILIATION**

**CONFERENCE TITLE** → **AIAA Applied Aerodynamics Conference, 3rd, Colorado Springs, CO, Oct. 14-16, 1985. 9 p. refs** ← **CONFERENCE DATE**

(AIAA PAPER 85-4076)

A previously developed technique for selecting a design space for efficient supersonic wings is reviewed; this design-space concept is expanded to include thickness and camber effects and is evaluated for cambered wings at high-lift conditions. The original design-space formulation was based on experimental upper-surface and lower-surface normal-force characteristics for flat, uncambered delta wings; it is shown that these general characteristics hold for various thickness distributions and for various amounts of leading-edge camber. The original design-space formulation was also based on the assumption that the combination of Mach number and leading-edge sweep which would produce an equal division of flat-wing lift between the upper and lower surface would also be the proper combination to give the best cambered-wing performance. Using drag-due-to-lift factor as a measure of performance, for high-lift conditions cambered-wing performance is shown to significantly increase as conditions approach the design space; this correlation is demonstrated for both subcritical and supercritical flows.

Author

# AERONAUTICAL ENGINEERING

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DECEMBER 1986

01

## AERONAUTICS (GENERAL)

**A86-43890#**

### **LINE REPLACEABLE MODULES - THE NEXT GENERATION OF AVIONICS**

D. H. WEISS (USAF, Washington, DC) IN: AUTOTESTCON '85; Proceedings of the International Automatic Testing Conference, Uniondale, NY, October 22-24, 1985. New York, Institute of Electrical and Electronics Engineers, 1985, p. 187-190.

New trends in avionics, their impact on test equipment, and third generation avionics capabilities are considered. An improved modular automatic test equipment concept is discussed, and an evolution towards third generation Line Replacement Modules instead of Line Replaceable Units and Shop Replaceable Units is indicated. Improved reliability and maintainability is the goal for Air Force second generation avionics, with a more-than 1300 hour mean time between failures required for new systems. It is suggested that new technologies would permit evolution of the USAF test philosophy from an avionics fly-to-failure policy to an avionics integrity program of preemptive removals. Other issues considered are changes due to material and human resource related issues. R.R.

**A86-43906**

### **BUILT IN TEST (BIT) UTILIZATION FOR IMPROVED SUPPORTABILITY OF THE F-20 AIRCRAFT**

R. K. WALKER (Northrop Corp., Aircraft Div., Hawthorne, CA) IN: AUTOTESTCON '85; Proceedings of the International Automatic Testing Conference, Uniondale, NY, October 22-24, 1985. New York, Institute of Electrical and Electronics Engineers, 1985, p. 446-449.

The use of avionics built-in test (BIT) as a fundamental part of off-aircraft support is demonstrated using F-20 avionics systems. The F-20 avionics systems briefly described here include the head-up display, the digital display indicator, the display processor, the data entry panel, the armament control panel, the mission computer, the multimode radar, the inertial navigation set, the pylon interface unit, the AIM-9 missile interface unit, and the communications, navigation identification interface unit. The equipment manufacturers are named and the projected mean time between failures is given. The application of BIT to these systems is described, and the improved reliability of this new generation of avionics is compared with that of the complex and expensive Avionics Intermediate Shops of the present. C.D.

**A86-44006#**

### **DOUBLING THE AIR FORCE THROUGH GREATER RELIABILITY**

R. T. RODENROTH (USAF, Advanced Tactical Fighter Office, Wright-Patterson AFB, OH) Aerospace America (ISSN 0740-722X), vol. 24, June 1986, p. 44-46.

The U.S. Air Force, in studies conducted in anticipation of Advanced Tactical Fighter (ATF) design and performance requirements, has determined that greater attention to reliability

and maintenance considerations should result not merely in cost reductions but in force-multiplying effects. At any given time, 90-92 percent of the ATF force will be available for use; half the aircraft grounded for maintenance should be ready to fly again in two hours, 75 percent in four hours, and fully 85 percent in eight hours. The ATF should also require only 8.7 maintainers per aircraft, which is less than half as many as those servicing current fighter aircraft. O.C.

**A86-44284**

### **METHODS OF THE ASSEMBLY OF AIRCRAFT INSTRUMENTATION AND SYSTEMS [TEKHNOLOGIYA MONTAZHA PRIBORNOGO OBORUDOVANIYA LETATEL'NYKH APPARATOV]**

V. A. NEGREBA and L. V. MARKIN Moscow, Izdatel'stvo Mashinostroenie, 1985, 312 p. In Russian. refs

The book is concerned with methods, tools, and special techniques used in the assembly of on-board instrumentation and various aircraft systems. In particular, attention is given to general metal working and assembly techniques, assembly of electrical equipment and wiring, electric measurements and electric testing equipment, and assembly of navigation and control systems. The discussion also covers the assembly of high-altitude and oxygen systems, television and photographic equipment, and safety engineering. V.L.

**A86-44291**

### **FUNDAMENTALS OF AVIATION TECHNOLOGY AND AIRPORT EQUIPMENT [OSNOVY AVIATIONNOI TEKHNIKI I OBORUDOVANIE AEROPORTOV]**

V. I. BLOKHIN, ED. Moscow, Izdatel'stvo Transport, 1985, 256 p. In Russian. No individual items are abstracted in this volume.

The fundamental of aerodynamics, flight dynamics, and general aircraft design are presented, as are the basic principles of aircraft service and maintenance and characteristics of the main types of airfield equipment. In particular, attention is given to ground power supply sources, compressed air supply, towing and cleaning machines, and equipment for the storage and handling of fuels and lubricants. The discussion also covers navigation and ranging equipment, light signals, and the electric power supply system of airfields. V.L.

**A86-44422#**

### **GENERIC INTEGRATED MAINTENANCE DIAGNOSTICS**

H. M. SEAMAN (USAF, Directorate of Support Systems Engineering, Wright-Patterson AFB, OH) IEEE Aerospace and Electronic Systems Magazine (ISSN 0885-8985), vol. 1, June 1986, p. 9-12.

An Air Force program designated GiMADS (Generic Integrated Maintenance Diagnostics) has been initiated to pursue a systems approach to weapon system maintenance using both prognostics and diagnostics. The program is an outgrowth of a study by the Air Force Operational Test and Evaluation Command of field maintenance effectiveness for the E-3A, EF-111 and F-16 aircraft. The 1984 directive initiating GiMADS stressed the requirement for 100 percent fault detection and isolation of weapon system faults by an optimized combination of testing techniques. Over a five-year period, the program will utilize a combination of ASD in-house engineering and contracted engineering support to gather data, perform studies and analyses, prepare technical and management

## 01 AERONAUTICS (GENERAL)

documentation, and develop hardware and software tools needed to implement an integrated diagnostics approach to maintenance for both electronic and nonelectronic systems. Technical integration will be accomplished by ASD engineering, and will consider and utilize on-going integrated diagnostics efforts in industry and government. D.H.

### **A86-44442** **LAUNCHING THE AEROSPACE PLANE**

T. A. HEPPENHEIMER High Technology (ISSN 0277-2981), vol. 6, July 1986, p. 46-51.

A discussion is presented concerning the performance requirements, the possible configurational, structural, and propulsion system features, and the R&D program management aspects, of the proposed 'aerospace plane'. Attention is given to the tradeoffs that must be considered in the use of airbreathing rather than rocket engines, as well as to the advanced refractory materials and fabrication techniques called for by high friction temperature, hypersonic flight, and the comparative advantages of various proposed fuels and engine multiple cycle schemes. NASA, DARPA, and British Aerospace are noted to be the most prominent research institutions in the development of aerospace plane designs. O.C.

### **A86-44919** **WORLD AEROSPACE PROFILE 1986**

London, Sterling Publications, Ltd., 1986, 352 p. No individual items are abstracted in this volume.

A comprehensive evaluation is made of state-of-the-art achievement and development trends for numerous fields in aerospace technology throughout the industrial world, with attention to airframe, engine and avionics manufacturers in the U.S., U.K., France, West Germany, and Japan. Both civilian and military programs are discussed in articles covering composite airframes for materials, anticorrosion design practices, tilt-rotor aircraft design, next-generation SSTs, supersonic STOL and V/STOL development trends, Unducted Fan engine design evolution, propeller design trends, and novel aviation fueling methods. Also discussed are avionics for all glass cockpits, HUDs, future ATC developments, RPVs, flight simulators, advanced components, safety systems, commercial aircraft interior design, airport and airline planning, and financial management. O.C.

### **A86-44935** **THE SELECTION AND ACQUISITION OF COMMERCIAL AIRCRAFT FLEETS**

W. PETERS (South African Airways, Johannesburg, Republic of South Africa) Aeronautica Meridiana (ISSN 0257-8573), vol. 6, no. 1, 1985, p. 43-50.

Fleet planning, aircraft selection and aircraft acquisition processes must be constantly undertaken by airlines irrespective of their size, and will have as their primary concern the matching of aircraft performance characteristics with market route networks, on the one hand, and on the other the large amounts and high cost of capital for fleet refurbishment. Other considerations encompass market analyses, the purchase of new or used aircraft, aircraft performance suitability for certain route sectors, and the guarantee of engine and airframe manufacturers' performance specifications. O.C.

### **A86-45063** **NEW TECHNOLOGIES OFFER QUANTUM LEAP IN FUTURE FIGHTER CAPABILITIES**

R. R. ROPELEWSKI Aviation Week and Space Technology (ISSN 0005-2175), vol. 124, June 23, 1986, p. 48, 49, 51, 52.

A new generation of airframe, engine, materials, and avionics technologies which will provide substantial performance, reliability, and survivability gains in future fighter aircraft is discussed. The expected advances in structures and materials, propulsion, avionics, and stealth are examined, including the contributions of the USAF advanced tactical fighter (ATF) the USN advanced tactical aircraft (ATA), and the multinational European fighter aircraft (EFA) programs. The characteristics of the super cockpits now under

development, the first of which will enter full-scale development around 1990, are briefly addressed. C.D.

### **A86-45065** **NASA'S LANGLEY CENTER MAKING GAINS IN ADVANCED TECHNOLOGY PROJECTS**

D. M. NORTH Aviation Week and Space Technology (ISSN 0005-2175), vol. 124, June 23, 1986, p. 85, 87, 89.

Research projects at NASA's Langley Research Center aimed at achieving increased maneuverability in high angle of attack flight using multi-axis thrust vectoring in future fighter aircraft are discussed. Development programs to establish generic technology for aircraft beyond the USAF advanced tactical fighter and the USN advanced tactical aircraft are considered. The F/A-18 prototype acquired from the Navy will be used as a test bed. Wind tunnel testing of pylon, tangent, and semisubmerged pallet weapon mounting concepts on a generic aircraft wing is described, as is a leading edge flap vortex research program for fighter and attack aircraft. Future flight control systems for new technology aircraft which will accommodate the expanded flight envelopes permitted by thrust vectoring are discussed. C.D.

### **A86-45704#** **LHX TARGETS DOLLARS AS WELL AS BOGEYS**

G. K. ANDRESON (U.S. Army, Aviation Systems Command, Saint Louis, MO) Aerospace America (ISSN 0740-722X), vol. 24, July 1986, p. 24-27.

The Army is reported to be working on the initial stages to develop a Light Helicopter family (LHX) to supplant its aging fleet of light rotorcraft. Affordability will be a key concern. Mission gross weight for the single-pilot scout and attack version called SCAT must be only 7500-8500 lb. Its flyaway cost must not exceed \$6 million in 1984 dollars, and that of the utility version must be held to \$4 million. Instead of the usual array of instruments and switches requiring pilot attention and physical actions, the SCAT cockpit will be simplified, integrated, and largely automated. SCAT will include a Mission Equipment Package (a sort of central nervous system) with sensors, processors, displays, controls and flight management interconnections. The helmet-mounted display approach is being considered. Considerable work will be required to develop workable software and assure that sufficient mission reliability is achieved. Prospective contractors include Boeing-Vertol/Sikorski, Bell, and Hughes; Hughes has been acquired by McDonnell Douglas, which has teamed with Bell. All have developed technology test beds. The request-for-proposals point is expected to be reached in March 1987. D.H.

### **A86-46199#** **CFRP-WING FOR THE ALPHA JET**

D. ROSER Dornier Post (English Edition) (ISSN 0012-5563), no. 2, 1986, p. 21-24.

Carbon-fiber reinforced plastic (CFRP) wings were developed for the Alpha jet to control production costs while providing structural strength as high as that available from metals. The wings were required to satisfy the mission, operational range and flight envelope of the aircraft. The CFRP mixture selected was chosen on the basis of the environmental and external forces it would encounter, weight and optimal design constraints, the ability to handle complex loads, and the readiness of suitable quality control technologies. The wings have aluminum ribs and attachment fittings which were already qualified for the aircraft. Sample coupons of the CFRP material met the mechanical properties test criteria and a multi-rib configuration was selected as an additional weight saving measure. The manufacturing techniques for producing the complex composite components are outlined. M.S.K.

**N86-29762\*#** National Aeronautics and Space Administration, Langley Research Center, Hampton, Va.

**MOTION AND INTERACTION OF DECAYING TRAILING VORTICES IN SPANWISE SHEAR WIND**

C. H. LIU and T. LU (New York Univ., New York.) Sep. 1986 26 p  
(NASA-TP-2599; L-16040; NAS 1.60:2599) Avail: NTIS HC A03/MF A01 CSCL 01B

A simulation is presented of the drift of trailing vortices in a cross-wind near the ground by an unsteady, two-dimensional, rotational flow field with a concentration of large vorticity in vortical spots (having a finite but small effective size and finite total strength). The problem is analyzed by a combination of the method of matched asymptotic analyses for the decay of the vortical spots and the Euler solution for the unsteady rotational flow. Using the method of averaging, a special numerical method is developed in which the grid size and time step depend only on the length and velocity scales of the background flow and are independent of the effective core size of a vortical spot. The core size can be much smaller than the grid size, whereas the peak velocity in the core is inversely proportional to the spot size. Numerical results are presented to demonstrate the strong interaction between the trajectories of the vortical spots and the change of the vorticity distribution in the background flow field. Author

**N86-29763#** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.

**INTRODUCTION TO THE RECENT DEVELOPMENTS OF CHINA'S CIVIL AVIATION**

11 Mar. 1986 10 p Transl. into ENGLISH from Hangkong Zhishi (China), no. 1, 1985 p 11-12  
(AD-A166194; FTD-ID(RS)T-1165-85) Avail: NTIS HC A02/MF A01 CSCL 01B

The Civil Aviation Administration of China, abbreviated CAAC, is in charge of the whole China civil aviation system. It is different from ordinary airline companies but similar to the Traffic Administration of the Japan Transportation Ministry. Its responsibility includes making policy and regulations for civil aviation, aviation traffic, operation and maintenance of civil airlines, selling of airline tickets and other commodities, management of airports, passenger lounges and anything related to civil aviation. GRA

**N86-29764#** Air Command and Staff Coll., Maxwell AFB, Ala.  
**THE SEARCH FOR AN ADVANCED FIGHTER: A HISTORY FROM THE XF-108 TO THE ADVANCED TACTICAL FIGHTER**

R. P. LYONS, JR. Apr. 1986 101 p  
(AD-A166724; ACSC-86-1575) Avail: NTIS HC A06/MF A01 CSCL 05A

This report traces the Air Force's progress in developing advanced fighters from the XF-108 and the YF-12A for long-range supersonic interception; through the F-111 with its goal of multi-mission commonality through the F-15 air superiority fighter; then to the Lightweight Fighter Prototypes (YF-16 and YF-17) and the Air Combat Fighter competition won by the F-16. The report also covers the technology and fighter enhancement programs (such as AFTI, HiMAT, X-29A, and MSIP) which build the base for the Advanced Tactical Fighter now in Concept Development. GRA

**N86-30627#** Deutsche Gesellschaft fuer Luft- und Raumfahrt, Bonn (West Germany).

**THE SECOND INTERNATIONAL SYMPOSIUM ON AEROELASTICITY AND STRUCTURAL DYNAMICS**

1985 713 p Symposium held in Aachen, West Germany, 1-3 Apr. 1985; sponsored in cooperation with DFVLR, NLR and ONERA  
(DGLR-85-02; ISBN-3-922010-28-8; ESA-86-97411) Avail: NTIS HC A99/MF E03

Unsteady aerodynamics and aeroelastic characteristics; active control technology; structural modeling and optimization; structural system identification; and structural dynamics design verification

of space structures were discussed.

ESA

**N86-30661#** Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick (West Germany). Inst. for Structural Mechanics.

**EFFECTS OF ANISOTROPIC DESIGN ON THE STATIC AEROELASTICITY OF A SWEEP WING**

M. PIENING In DGLR The 2nd International Symposium on Aeroelasticity and Structural Dynamics p 451-456 1985  
Avail: NTIS HC A99/MF E03

A simple structural idealization is adopted to model an arbitrary swept anisotropic wing of moderate to high aspect ratio. The related differential equations are solved for the deformations and internal forces by multiple shooting. The divergence speed is calculated by searching the lowest eigenvalue of the structural matrix formed from the transfer matrices of the wing sections and the according boundary conditions. Parametric evaluations are performed. ESA

**N86-30690#** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.

**INTERNATIONAL AVIATION (SELECTED ARTICLES)**

T. SHEY-SHI, K. M. HSU, I. T. KUO, and C. HUANG 14 Mar. 1986 35 p Transl. into ENGLISH from Guoji Hangkong (China), no. 2(264), Feb. 1985 p 24-26; 27-29; 45-46  
(AD-A166748; FTD-ID(RS)T-0843-85) Avail: NTIS HC A03/MF A01 CSCL 01C

Following are the partial contents of a report on international aviation: A few points on longitudinal jet ejection techniques; Foreign technology studies on external store separation; Stealth aircraft technology Current development and future prospects. GRA

## 02

### AERODYNAMICS

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

**A86-43485#**

**A SECOND-ORDER THEORY FOR THREE-DIMENSIONAL UNSTEADY FLOWS AND ITS APPLICATION TO THIN WINGS WITH ANGLE OF ATTACK AT SUPERSONIC AND HYPERSONIC SPEEDS**

L. HE, Y. HAN, and F. QIAN (Chinese Academy of Sciences, Institute of Mechanics, Beijing, People's Republic of China) Acta Aeronautica et Astronautica Sinica, vol. 6, Dec. 1985, p. 585-589. In Chinese, with abstract in English.

**A86-43501#**

**SOME PROBLEMS IN THE FINITE-DIFFERENCE COMPUTATION OF THREE-DIMENSIONAL TRANSONIC FLOWS**

T. CHEN (Beijing Institute of Aerodynamics, People's Republic of China) Acta Aeronautica et Astronautica Sinica, vol. 7, Feb. 1986, p. 104-107. In Chinese, with abstract in English.

The mixed finite-difference relaxation iteration method is applied to the calculation of the wing-body combination with rectangular wings. It is based on the three-dimensional transonic small-disturbance potential equation in the cylinder coordinates. The effect of different computation regions and relaxation parameters (on subsonic points) on the ranges of the computed Mach numbers, angles of attack and calculated results is also studied. It is shown that extending the computation limits brings an increase in the convergence rates of the small-disturbance equation. The convergence rate and computation accuracy are enhanced if the subsonic relaxation parameter is supposed to be 1.9. It is also demonstrated that the calculated results differ when the finite or infinite regions are taken as the computation region of the r-direction. Particularly the distribution of the pressure

coefficients near the wingtip varies as the incident Mach number becomes larger. Author

**A86-43512#**

**MEASUREMENTS OF FLUCTUATIONS OF SURFACE HEAT TRANSFER RATE IN THE INTERACTING REGION OF OBLIQUE SHOCK WAVE AND TURBULENT BOUNDARY LAYER**

M. HAYASHI, S. ASO, and A. TAN (Kyushu University, Fukuoka, Japan) Kyushu University, Technology Reports (ISSN 0023-2718), vol. 58, Dec. 1985, p. 1001-1006. In Japanese, with abstract in English. refs

Fluctuations of surface heat-transfer rate have been measured in the regions of interaction between an oblique shock wave and a turbulent boundary layer. A new type of heat-transfer-rate gage with high spatial resolution and fast response is used. Experiments were made at a nominal Mach number of 4, wall temperature condition  $T_w/T_0$  of 0.56, and Reynolds number of  $1.26 \times 10$  to the 7th based on the distance from the flat-plate leading edge. Measurements were made under separated and unseparated boundary-layer conditions, depending on different incident shock-wave strength. When the boundary layer is separated, significant fluctuations of the heat-transfer rate are observed throughout the interaction region, particularly near the separation point, at the end of the wall pressure plateau, and near the reattachment point. Near the separation point, intermittency is observed in the heat-transfer rate. It changes remarkably with a small length scale. When the boundary layer is unseparated, fluctuations of the heat-transfer rate get strong near the impinging point of the incident shock, but no intermittency is observed. The fluctuations are nearly Gaussian throughout the interaction.

Author

**A86-43514#**

**FLUCTUATIONS OF WALL PRESSURE IN THE INTERACTING REGION OF OBLIQUE SHOCK WAVE AND TURBULENT BOUNDARY LAYER**

M. HAYASHI, S. ASO, and A. TAN (Kyushu University, Fukuoka, Japan) Kyushu University, Technology Reports (ISSN 0023-2718), vol. 59, Jan. 1986, p. 75-82. In Japanese, with abstract in English. refs

Fluctuations of wall pressure have been measured in the region of interaction between an oblique shock wave and a turbulent boundary layer. Experiments were made at a nominal Mach number of 4, wall temperature condition  $T_w/T_0$  of 0.56, and Reynolds number of  $1.26 \times 10$  to the 7th based on the distance from the flat plate leading edge. When boundary layer is separated, significant fluctuations of wall pressure are observed throughout the interaction region. Near the separation point, intermittency is observed in wall pressure signals. The fluctuations change remarkably with a small length scale. The distribution of intensity of wall pressure fluctuations shows the same tendency as that of the surface heat transfer rate fluctuations. Both of them have a sharp peak near separation point. When the boundary layer is unseparated, the fluctuations of wall pressure show a peak near the impinging point of the incident shock wave, but no intermittency is observed.

Author

**A86-43533#**

**FLOWS PAST A ROTATING CIRCULAR CYLINDER AT HIGH REYNOLDS NUMBER**

T. KIMURA and M. TSUTAHARA (Kobe University, Japan) Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 34, April 1986, p. 188-194. In Japanese, with abstract in English. refs

Flows past a rotating circular cylinder at high Reynolds number are investigated by a discrete vortex method. The nascent vortices are introduced to the flowfield at each time step from several points uniformly distributed around and near the surface of the circular cylinder. Calculations are performed for  $\omega = 0.5$ , and 1.0, where  $\omega$  is the angular velocity of rotation, and equals the specific speed, i.e., in this case, the ratio of the peripheral velocity to the uniform flow. The results agree qualitatively with experimental results. The reverse Magnus effect,

however, due to the transitions of the boundary layers on the upper side and the lower side of the circular cylinder, did not appear, and the simulation for this by the present method seems to be difficult. Author

**A86-43938#**

**THE EFFECT OF RAIN AND CONTAMINATION OF THE FRONT SURFACE ON THE IN-FLIGHT BEHAVIOR OF AIRCRAFT DURING ROLL. II [WPLYW DESZCZU I ZANIECZYSZCZEN POWIERZCHNI NOSNEJ NA ZACHOWANIE W LOCIE SAMOLOTOW O UKLADZIE KACZKI. II]**

Technika Lotnicza i Astronautyczna (ISSN 0040-1145), vol. 41, Jan. 1986, p. 16-18. In Polish.

**A86-44238**

**APPLICATION OF UNSTEADY AERODYNAMICS TO LARGE-EDDY BREAKUP DEVICES IN A TURBULENT FLOW**

P. BALAKUMAR and S. E. WIDNALL (MIT, Cambridge, MA) Physics of Fluids (ISSN 0031-9171), vol. 29, June 1986, p. 1779-1787. refs

(Contract F49620-83-C-0019)

The modifications to the vertical velocity of a turbulent flow by the large-eddy breakup devices (LEBU) were analyzed using linear three-dimensional unsteady aerodynamics. A Fourier component of the input turbulence convected over these devices was considered and the modified vertical velocity in the far downstream wake was solved. It is shown that the amplitude of the vertical velocity behind the device is reduced, the effect increasing with increasing stream and spanwise wavenumber. Two plates placed far apart in series produce a reduction that is the square of that for a single plate. The presence of the ground plane decreases the effectiveness of the LEBU in reducing the amplitude of the vertical velocity in the far wake. Author

**A86-44802**

**THE REVERSE-FLOW THEOREM FOR TRANSONIC FLOW**

G. SCHNERR and J. ZIEREP (Karlsruhe, Universitaet, West Germany) IN: Flow of real fluids. Berlin and New York, Springer-Verlag, 1985, p. 17-27. refs

A generalized form of the reverse flow theorem (RFT) is developed for airfoils with contours symmetrical to the maximum thickness in transonic flows and considered for its range of applicability. The prime concern with the RFT is that the pressure drag of the body remain constant even if the flow is reversed, i.e., the drag freezing criterion. The use of the RFT is validated for the hodograph method for double-wedge profiles. A parabolic method is formulated for applying the RFT to a Guderley cusped nose profile. The calculations are extended to supersonic flows. Comparisons with experimental data and Schlieren photographs from a Guderley profile in a shocked wind tunnel illustrate the accuracy of the RFT calculations when the freezing criterion is satisfied. M.S.K.

**A86-44803**

**ON AERODYNAMIC SOUND GENERATION BY AIRFOIL-VORTEX INTERACTION**

F. OBEMEIER (Max-Planck-Institut fuer Stroemungsforschung, Goettingen, West Germany) IN: Flow of real fluids. Berlin and New York, Springer-Verlag, 1985, p. 41-50. refs

An analytical examination is carried out of aerodynamic sound generation by blade vortex interaction, such as happens with helicopter blades, to demonstrate the difficulties in accurately modeling the sound field. The discussion covers the Mach numbers up to transonic flows, concentrating on a single line vortex sweeping past the leading edge of a semi-infinite solid plate in a flow parallel to the plate. Sound field properties dominate in the outer region, away from the leading edge, while hydrodynamical incompressibility effects are most important in the inner region near the leading edge. Models are developed for both fields and approximate expressions are defined for acoustic effects in the far field. A Hamiltonian formalism is used for the vortex path. Compressibility effects in the inner region are considered to extend the model to transonic flows. Further investigations required to characterize the



leading edge flow and to equate unsteady vortex motion with sound wave propagation are indicated. M.S.K.

**A86-44810**

**ON SLENDER VORTICES**

E. KRAUSE (Aachen, Rheinisch-Westfaelische Technische Hochschule, West Germany) IN: Flow of real fluids. Berlin and New York, Springer-Verlag, 1985, p. 211-218.

A numerical model is developed for the breakdown of slender vortices. The model considers the conditions which will permit the vortices to remain slender, noting the necessity of maintaining small axial pressure gradients and limitations on the magnitude of circumferential velocity variations. Local accelerations of the axial velocity components are also permitted. Inviscid theory shows that breakdown is controlled by an axial pressure gradient imposed by the external flow and on a swirl component which causes the flow to become unsteady. Viscosity, although significant in core dissipation, does not have a significant impact on breakdown.

M.S.K.

**A86-44855\*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**FAR-FIELD BOUNDARY CONDITIONS FOR TRANSONIC LIFTING SOLUTIONS TO THE EULER EQUATIONS**

J. L. THOMAS and M. D. SALAS (NASA, Langley Research Center, Hampton, VA) AIAA Journal (ISSN 0001-1452), vol. 24, July 1986, p. 1074-1080. refs

Far-field boundary conditions for the Euler equations are formulated and applied to transonic lifting flow over an airfoil in an unbounded domain. An expansion of the linearized small-disturbance equation in the far field is developed and the leading-order term, corresponding to a point vortex representation for the airfoil, is retained. A comprehensive evaluation across the Mach number range of the procedure's effectiveness in eliminating dependence of the numerical results on the boundary extent is presented. Extension of the method to three dimensions is also outlined.

Author

**A86-44874#**

**LIFTING-LINE SOLUTION FOR A SYMMETRICAL THIN WING IN GROUND EFFECT**

A. PLOTKIN (San Diego State University, CA) and C. H. TAN AIAA Journal (ISSN 0001-1452), vol. 24, July 1986, p. 1193, 1194. refs

A lifting-line solution is presented for the problem of the aerodynamic characteristics of a thin wing in ground effect which is easier to obtain than previous numerical solutions, while furnishing reasonable accuracy for the cases of large aspect ratio wings. The effect of thickness on lift is considered in both the lifting line and vortex lattice formulations. O.C.

**A86-44875#**

**INTEGRATION OF SINGULAR FUNCTIONS ASSOCIATED WITH LIFTING SURFACE THEORY**

B. VAN NIEKERK (Stanford University, CA) AIAA Journal (ISSN 0001-1452), vol. 24, July 1986, p. 1194-1196. refs (Contract AF-AFOSR-84-0099)

A simple quadrature rule directly applicable to subsonic aerodynamic problems is presented whose main advantage is that it allows kernel function applications to be as conceptually simple as the vortex panel method; this is due to the fact that careful identification and treatment of singularities is unnecessary. The technique may be used to compute time-accurate transient aerodynamic loads on wings. O.C.

**A86-44879\*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

**TRANSIENT INDUCED DRAG**

D. WEIHS and J. KATZ (NASA, Ames Research Center, Moffett Field, CA) AIAA Journal (ISSN 0001-1452), vol. 24, July 1986, p. 1203-1205. refs

In the present treatment of the calculation of forces on a wing that is suddenly brought into motion at a constant speed, attention

is given to the unsteady potential's contribution to the force balance. Total bound vorticity is produced at the initial impulse. The results obtained are independent of wing aspect ratio; as time increases, this effect on the drag force becomes smaller as the vortex emanating from the trailing edge is left behind. The second contributor to induced drag is the spanwise vorticity shedding that results from the spanwise load distribution of three-dimensional wings. This contribution grows with time as the length of the wake grows. O.C.

**A86-44880#**

**UNIFIED SUPERSONIC/HYPERSONIC SIMILITUDE FOR OSCILLATING WEDGES AND PLANE OGIVES**

K. GHOSH (Indian Institute of Technology, Kanpur, India) AIAA Journal (ISSN 0001-1452), vol. 24, July 1986, p. 1205-1207. refs

The unified supersonic/hypersonic similitude for a wedge and quasi-wedge first reported in abstract form by Ghosh (1983) is presented under the tentative assumption that streamlines are straight. For a steady wedge, the present similitude applies in a plane normal to the shock with exactitude for freestream Mach numbers greater than 1. For a quasi-wedge or an oscillating wedge, another constraint in addition to the Mach number restriction is required. In the hypersonic domain, both similitudes are valid.

O.C.

**A86-44889\*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**AN APPROXIMATE MODEL OF VORTEX DECAY IN THE ATMOSPHERE**

G. C. GREENE (NASA, Langley Research Center, Hampton, VA) Journal of Aircraft (ISSN 0021-8669), vol. 23, July 1986, p. 566-573. Previously cited in issue 22, p. 3223, Accession no. A85-47034. refs

**A86-44890#**

**PRESSURE LOADING ON CURVED LEADING EDGE WINGS IN SUPERSONIC FLOW**

M. E. VAUGHN, JR. (U.S. Army, Missile Command, Huntsville, AL) and J. E. BURKHALTER (Auburn University, AL) Journal of Aircraft (ISSN 0021-8669), vol. 23, July 1986, p. 574-581. Research sponsored by Auburn University. Previously cited in issue 06, p. 801, Accession no. A82-17934. refs (Contract DAAG29-78-G-0036)

**A86-44891#**

**COMPUTATION OF ROTOR BLADE FLOWS USING THE EULER EQUATIONS**

N. L. SANKAR, S. G. LEKOUKIS (Georgia Institute of Technology, Atlanta), and B. E. WAKE Journal of Aircraft (ISSN 0021-8669), vol. 23, July 1986, p. 582-588. Army-supported research. Previously cited in issue 03, p. 242, Accession no. A86-14455. refs

**A86-44979**

**CALCULATION OF THE POTENTIAL FLOW AROUND WING PROFILES WITH THE AID OF A CONTINUOUSLY DIFFERENTIABLE VORTEX DISTRIBUTION [BERECHNUNG DER POTENTIALSTROEMUNG UM TRAGFLUEGELPROFILE MIT HILFE EINER STETIG DIFFERENZIERBAREN WIRBELBELEGUNG]**

H. JAEGER (Stuttgart, Universitaet, West Germany) (Gesellschaft fuer angewandte Mathematik und Mechanik, Wissenschaftliche Jahrestagung, Dubrovnik, Yugoslavia, April 1-4, 1985) Zeitschrift fuer angewandte Mathematik und Mechanik (ISSN 0044-2267), vol. 66, no. 4, 1986, p. T 228, T 229. In German.

The numerical calculation of the compressible potential flow by means of the field panel procedure involves a combination of a panel procedure with a source distribution of the flow region. The derivatives have to be determined by numerical differentiation. A description is provided of a panel procedure which makes it possible to calculate also the derivatives by a direct approach. The steady flow around a wing profile is considered for the case of an incompressible flow, taking into account a procedure

discussed by Jaeger (1984). The occurring curvilinear integrals can be approximated by integrals which can be evaluated analytically. The results provided by the described procedure, involving the case of a continuously differentiable vorticity distribution, are compared with the results of a panel procedure of a higher order. G.R.

A86-45054

**NUMERICAL SOLUTION OF THE SUPERSONIC LAMINAR FLOW OVER A TWO-DIMENSIONAL COMPRESSION CORNER USING AN IMPLICIT APPROACH**

N. S. MADHAVAN and V. SWAMINATHAN (Indian Space Research Organization, Vikram Sarabhai Space Centre, Trivandrum, India) International Journal for Numerical Methods in Fluids (ISSN 0271-2091), vol. 6, June 1986, p. 387-393. refs

Using an implicit numerical scheme similar to MacCormack's (1982), the unsteady Navier-Stokes equations are successfully solved for the supersonic laminar two-dimensional compression corner flow problem. A 70 percent reduction in computational time is demonstrated for a Courant-Friedrichs-Lewy (CFL) number of 5, and CFL numbers up to 15 could be used without loss of accuracy. An increase in memory requirement for the implicit scheme of the order of 20 percent was also found. R.R.

A86-45189

**THE CLASSICAL STREAMLINE CURVATURE METHOD IN THE SUPERSONIC RANGE - A NUMERICALLY ILL-POSED BOUNDARY VALUE PROBLEM**

G. SPINDLER (DFVLR, Institut fuer technische Physik, Stuttgart, West Germany) and H. PAETZOLD (Brown Boveri et Cie AG, Baden, Switzerland) Zeitschrift fuer Flugwissenschaften und Weltraumforschung (ISSN 0342-068X), vol. 10, Mar.-Apr. 1986, p. 107-115. refs

A linear stability analysis of the streamline curvature method using a homogeneous (isentropic) flow model, produces a numerical stability condition, first encountered by Wilkinson. It sets an upper limit on the (relative) Mach number in the supersonic range depending on streamline curve fitting and aspect ratio of the computational grid. Numerical test calculations of the flow in an axially parallel annular duct show that beyond this limit small perturbations of the streamline positions grow. This indicates that convergence to the homogeneous solution can no longer be achieved. Analytical considerations yield infinitely many neighboring solutions in certain cases, proving that the underlying hyperbolic boundary value problem is not properly posed. It is demonstrated that the numerical instability is strongly related to the non-uniqueness of the supersonic flow field. The application of backward differences for the approximation of the streamline curvature is discussed from a mathematical point of view.

Author

A86-45190

**THE WING TIP VORTEX SYSTEM IN A STARTING FLOW**

P. FREYMUTH, F. FINAISH, and W. BANK (Colorado, University, Boulder) Zeitschrift fuer Flugwissenschaften und Weltraumforschung (ISSN 0342-068X), vol. 10, Mar.-Apr. 1986, p. 116-118. refs

(Contract AF-AFOSR-81-0037)

The vortex system of a rectangular wing tip is visualized in a starting flow of constant acceleration. The system consists of a pair of vortices: one is fed from pressure side vorticity, the other from suction side vorticity. The vortices connect to each other at the corner between leading edge and tip. Author

A86-45345

**SCHEME FOR CALCULATING AN ALMOST-ASYMMETRIC GAS FLOW AND SUPERSONIC FLOW PAST THE END OF A CYLINDER AT A SMALL ANGLE OF ATTACK [SKHEMA RASCHETA BLIZKOGO K OSESIMMETRICHNOMU TECHENIIA GAZA I SVERKHZVUKOVOE OBTEKANIE TORTSA TSILINDRA POD NEBOL'SHIM UGLOM ATAKI]**

E. F. ZHIGALKO Zhurnal Vychislitel'noi Matematiki i Matematicheskoi Fiziki (ISSN 0044-4669), vol. 26, June 1986, p. 951-954. In Russian.

A finite-difference scheme is developed for the approximate calculation of almost-asymmetric flows. The scheme is based on the large-particle method with trigonometric interpolation with respect to the meridional angle. The effectiveness of the scheme is demonstrated on the example of supersonic flow past the end of a circular cylinder at a small angle of attack. B.J.

A86-45410\*# Massachusetts Inst. of Tech., Cambridge.

**ACTIVE SUPPRESSION OF COMPRESSOR INSTABILITIES**

A. H. EPSTEIN, J. E. FLOWERS WILLIAMS, and E. M. GREITZER (MIT, Cambridge, MA) AIAA, Aeroacoustics Conference, 10th, Seattle, WA, July 9-11, 1986. 13 p. NASA-supported research. refs

(AIAA PAPER 86-1914)

A strategy is proposed for controlling aerodynamic instabilities which limit the useful range of both axial and centrifugal turbomachines. Both local and global instabilities (incipient rotating stall and surge) are analyzed. A theory is developed which shows how an additional disturbance, driven from real time data measured within the machine, can be generated so as to realize a device with characteristics fundamentally different from those of the turbomachine without control; for the particular compressor analyzed, the control led to a 20 percent increase in the extent of the stable operating range. The use of structural dynamics to enhance stability is also discussed. K.K.

A86-45411#

**CONTROL OF THE DISCRETE VORTICES FROM A DELTA WING**

M. GAD-EL-HAK and R. F. BLACKWELDER (Flow Research Co., Kent, WA) AIAA, Aeroacoustics Conference, 10th, Seattle, WA, July 9-11, 1986. 12 p. refs  
(Contract F49620-85-C-0131)  
(AIAA PAPER 86-1915)

The modulation of shedding and pairing of discrete vortices is examined. The injection of a secondary fluid is utilized to control the development and strength of the bound-leading-edge vortices on delta wings. Flow visualization and wind tunnel tests were conducted in order to characterize the flow field around a delta wing. A delta wing with a sharp leading edge and a sweep of 60 deg was used in the towing tank and a delta-wing model with a root chord of 40 cm, a 60 deg sweep angle, and a sharp leading edge was employed in the wind tunnel tests. The procedure for perturbing the shear layer at the leading edge of the delta wing is described. The rms, spectral distribution, auto- and cross-correlations, and the probability density function of the velocity field are calculated using the instantaneous velocity signal. The effects of the leading edge on the excitations of the shear layer are investigated. The data reveal that the maximum amount of variations in the leading edge vortices occurs when the perturbation frequency is a subharmonic of the natural shedding frequency of the unperturbed wing and when the injection/suction speed is about the same order of magnitude as the ambient velocity. I.F.

**A86-45413\*#** California Univ., Los Angeles.

**AN EXPERIMENTAL INVESTIGATION OF WING TIP TURBULENCE WITH APPLICATIONS TO AEROSOUND**

S. A. MCINERNEY, W. C. MEECHAM (California, University, Los Angeles), and P. T. SODERMAN (NASA, Ames Research Center, Moffett Field, CA) AIAA, Aeroacoustics Conference, 10th, Seattle, WA, July 9-11, 1986. 21 p. refs (AIAA PAPER 86-1918)

Wind tunnel tests were carried out to measure the turbulence characteristics of flow in the wing tip region of a blunt tipped NACA 0012 airfoil at 16-, 12-, and 6-deg angles of attack and 75-, 55-, and 35-m/s flow speeds. Results suggest the presence of a well organized turbulence structure with a peak Strouhal number 0.8 to 1.1 based on the wing thickness. At positions near the primary tip vortex on the upper wing surface, high frequency turbulence of lesser intensity was measured. Near-far field correlations reveal that the well-ordered tip turbulence and the separation region surface on the upper surface both radiate significant levels of far field sound. K.K.

**A86-45428\*#** Lockheed-Georgia Co., Marietta.

**COHERENT LARGE-SCALE STRUCTURES IN HIGH REYNOLDS NUMBER SUPERSONIC JET OF MACH NUMBER 1.4**

J. LEPICOVSKY, K. K. AHUJA, W. H. BROWN, and R. H. BURRIN (Lockheed-Georgia Co., Marietta) AIAA, Aeroacoustics Conference, 10th, Seattle, WA, July 9-11, 1986. 9 p. refs (Contract NAS1-17442) (AIAA PAPER 86-1941)

Large-scale coherent structures are found to exist in fully expanded shock free supersonic jets with Reynolds number 1.6 million and Mach number 1.4. The jet was excited by a weak upstream tone to extract the large-scale structures from the random turbulence. The most preferential excitation Strouhal number is found to be in the vicinity of 0.4, and the dependence of the large-scale structure phase velocity on the excitation Strouhal number shows a similar trend to that found for subsonic acoustically excited jets. R.R.

**A86-45485#**

**FEATURES OF DISCRETE TONES GENERATED BY JET FLOWS OVER COANDA SURFACES**

P. W. CARPENTER, D. W. BRIDSON, and P. N. GREEN (Exeter, University, England) AIAA, Aeroacoustics Conference, 10th, Seattle, WA, July 9-11, 1986. 11 p. Research supported by the British Petroleum Co., PLC and SERC. refs (AIAA PAPER 86-1865)

The paper presents the results of an experimental investigation of supersonic jet flows over axisymmetric Coanda surfaces. A description of the principal features of the flow fields is given based on extensive flow-visualization studies. Acoustic measurements were carried out both in the near and far field; typical results are presented and discussed. Simple computer simulations of the acoustic near field have been carried out for three different theoretical models in an attempt to identify the dominant mechanism for the generation of discrete tones in such flows. Author

**A86-45494\*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**AERODYNAMICS VIA ACOUSTICS - APPLICATION OF ACOUSTIC FORMULAS FOR AERODYNAMIC CALCULATIONS**

F. FARASSAT (NASA, Langley Research Center, Hampton, VA) and M. K. MYERS (George Washington University, Hampton, VA) AIAA, Aeroacoustics Conference, 10th, Seattle, WA, July 9-11, 1986. 10 p. refs (AIAA PAPER 86-1877)

Prediction of aerodynamic loads on bodies in arbitrary motion is considered from an acoustic point of view, i.e., in a frame of reference fixed in the undisturbed medium. An inhomogeneous wave equation which governs the disturbance pressure is constructed and solved formally using generalized function theory. When the observer is located on the moving body surface there results a singular linear integral equation for surface pressure.

Two different methods for obtaining such equations are discussed. Both steady and unsteady aerodynamic calculations are considered. Two examples are presented, the more important being an application to propeller aerodynamics. Of particular interest for numerical applications is the analytical behavior of the kernel functions in the various integral equations. Author

**A86-45702#**

**MORE ACCURATE SIMULATIONS OF WHOLE AIRCRAFT**

E. J. LERNER Aerospace America (ISSN 0740-722X), vol. 24, July 1986, p. 12, 13.

A full, exact Euler equation simulation of an entire aircraft has been demonstrated for the first time. Previously tradeoffs had to be made: accurate simulation of only a wing for example or greatly simplified simulation of the whole aircraft; in either case, validating wind-tunnel tests of models were required with the incumbent problems of choosing appropriate scaling factors. The new method, by Princeton scientists T. J. Baker, A. Jameson, and N. P. Wetherhill, uses an unstructured grid - one without a set of coordinates. A set of points is built, working outward from each aircraft surface, the points being in the form of an array of tetrahedra (four triangles joined together). A new algorithm was devised to work well without coordinates, so that the grid is defined by each edge of a triangle and the two points opposite it. The simulation program balances energy flow into and out of the two triangles so defined. Bookkeeping is minimized and the program runs just as fast as more approximate methods. In the first demonstration of the program, pressures were calculated on a Boeing 747 airframe, based on 12,000 points; adequate accuracy would require taking 500,000 points and this simulation would require several hours on a Cray MXMP computer (comparable with run times of other simulations). Such simulations will permit engineers not only to develop more intelligent designs prior to wind-tunnel testing but also to focus on problem areas revealed by simulations. D.H.

**A86-46004**

**SPIRAL VORTEX FLOW OVER A SWEEPED-BACK WING**

D. I. A. POLL (Cranfield Institute of Technology, England) Aeronautical Journal (ISSN 0001-9240), vol. 90, May 1986, p. 185-199. Research supported by the Ministry of Defence (Procurement Executive). refs

An experimental investigation has been performed to study the formation and development of spiral vortex flow over a swept-back wing. An aerofoil section with three alternative leading edge shapes was tested at sweep angles ranging from 0 to 56 deg for unit Reynolds numbers of 1,000,000/m and 2,000,000/m. The principal diagnostic tool was the surface oil-flow visualization technique supplemented by pressure distribution measurements in certain cases. No spiral vortex flow was observed for sweep angles of 0 and 15 deg but at higher sweep angles the oil-flows indicated that there were three different mechanisms for the formation of spiral vortices. The angle of incidence at the onset of vortex flow, and the mechanism responsible for its formation, were found to depend upon the sweep angle, the leading edge shape and the Reynolds number. It was also noted that the larger the leading edge radius, the greater the dependence upon Reynolds number. However, comparison with other work suggests that Reynolds number, incidence and sweep angle alone are insufficient to determine the type of spiral vortex flow occurring on a given wing. Author

**A86-46152#**

**VISCOUS-INVISCID INTERACTION SOLVERS AND COMPUTATION OF HIGHLY SEPARATED FLOWS**

J. C. LE BALLEUR (ONERA, Chatillon-sous-Bagneux, France) (NASA Institute for Computer Applications in Science and Engineering, Conference on Vortex Dominated Flows, Hampton, VA, July 9, 10, 1985) ONERA, TP, no. 1986-4, 1986, 35 p. refs (ONERA, TP NO. 1986-4)

The use of indirect viscous-inviscid solvers based on interacting-defect integral equations to calculate flows with massive separation at the viscous or inviscid scale is examined, summarizing

the results of the author's recent numerical investigations. The derivation of the model equations is explained, and results for steady shock-wave/boundary-layer interactions, transonic unsteady separation, high-lift and stalled airfoils, and airfoils with deflected spoilers are presented graphically. T.K.

**A86-46171#**

**MODELING THREE-DIMENSIONAL FLOWS IN TERMS OF VISCOUS-INVISCID INTERACTION BY MEANS OF THE MSZ METHOD [CALCUL D'ECOULEMENTS TRIDIMENSIONNELS PAR INTERACTION VISQUEUX-NON VISQUEUX UTILISANT LA METHODE 'MZM']**

M. LAZAREFF and J. C. LE BALLEUR (ONERA, Chatillon-sous-Bagneux, France) (NATO, AGARD, Symposium on Applications of Computational Fluid Dynamics in Aeronautics, Aix-en-Provence, France, Apr. 7-11, 1986) ONERA, TP, no. 1986-29, 1986, 16 p. In French. refs (ONERA, TP NO. 1986-29)

A multi-zonal marching (MZM) method for solving systems of hyperbolic equations governing viscous fluid layers and modeling turbulent velocity profiles is extended to modeling three-dimensional separated flows over swept wings. The flow equations for a viscous fluid are decomposed into two-dimensional deficit equations for the viscous layer, equations for a perfect fluid, and equations for strong coupling. The concept of thin layers is applied in decomposing the numerical operators before coupling. Defining the viscous deficit equations in closed integral form permits retaining the hyperbolic form of the set of equations and generating a MacCormack space marching solution. Sample results are provided from modeling viscosity by coupling on a transonic wing, the boundary layer on an ellipsoid of revolution and a flattened ellipsoid at 60 deg angles of attack, and of the boundary layer on a glider geometry at a 30 deg angle of attack and 10 deg of sideslip. M.S.K.

**A86-46185#**

**10 YEARS OF ROTOR FLOWS STUDIES AT ONERA - STATE OF THE ART AND FUTURE STUDIES**

A. DESOPPER, P. LAFON, P. CERONI, and J. J. PHILIPPE (ONERA, Chatillon-sous-Bagneux, France) ONERA, TP, no. 1986-49, 1986, 12 p. refs (ONERA, TP NO. 1986-49)

For about 10 years now, at the Aerodynamics Department of ONERA, experimental and theoretical studies have been performed in order to improve the capability to perform accurate measurements as well as to predict the characteristics of the flow around a helicopter blade. The different phases of the experimental work and analytical studies concerning blade tip planform effects are presented and the main results are analyzed. The results demonstrate that it is possible for high speed rotor blades to define new blade tip shapes that minimize some of the problems due to transonic flows such as the increase of power required, of vibration level or of impulsive noise generated by the rotor. Finally, future studies planned to study the difficult problem of aeroelastic optimization are outlined. Author

**A86-46316\*#** United Technologies Research Center, East Hartford, Conn.

**THREE-DIMENSIONAL INVISCID FLOW IN MIXERS. II - ANALYSIS OF TURBOFAN FORCED MIXERS**

T. J. BARBER (United Technologies Research Center, East Hartford, CT), G. L. MULLER, S. M. RAMSAY (Pratt and Whitney, East Hartford, CT), and E. M. MURMAN (MIT, Cambridge, MA) Journal of Propulsion and Power (ISSN 0748-4658), vol. 2, July-Aug. 1986, p. 339-344. refs (Contract NAS3-23039)

A small disturbance formulation for the three-dimensional potential analysis of the inviscid flow over a turbofan forced mixer configuration in which the governing equations are reduced by means of a flux volume formulation along a Cartesian grid is presently extended to include the effects of power addition within the potential formulation. Calculations are presented for practical turbofan mixer designs, and comparison calculations are also given

with measured surface pressure distributions and measured axial velocity profiles. O.C.

**A86-46415#**

**NUMERICAL CALCULATIONS OF INVISCID TRANSONIC FLOWS OVER WINGS**

Z. CHEN, F. YAO, and Y. ZHANG (China Aerodynamics Research and Development Center, People's Republic of China) Acta Aerodynamica Sinica (ISSN 0258-1825), vol. 4, June 1986, p. 184-192. In Chinese, with abstract in English. refs

A numerical method for calculating steady inviscid transonic flows over wings is introduced. The full potential equation is chosen as the mathematical model. The infinite physical domain is transformed to a finite computing domain, and the swept wing is transformed to a rectangular wing using proper mathematical transformation. The equation is discretized in the computing domain using a mixed finite scheme, and the line-relaxation method is used for solving the resulting nonlinear algebraic equation. Successively refining, the mesh makes the calculation very economical. Author

**A86-46793\*** Massachusetts Inst. of Tech., Cambridge.

**HIGH RESOLUTION SOLUTIONS OF THE EULER EQUATIONS FOR VORTEX FLOWS**

E. M. MURMAN, K. G. POWELL (MIT, Cambridge, MA), and A. RIZZI (Flygtekniska Forsoksanstalten, Bromma, Sweden) IN: Progress and supercomputing in computational fluid dynamics; Proceedings of U.S.-Israel Workshop, Jerusalem, Israel, December 1984. Boston, MA, Birkhaeuser, 1985, p. 93-113. Research supported by Flygtekniska Forsoksanstalten. refs (Contract NAG1-358)

Solutions of the Euler equations are presented for  $M = 1.5$  flow past a 70-degree-swept delta wing. At an angle of attack of 10 degrees, strong leading-edge vortices are produced. Two computational approaches are taken, based upon fully three-dimensional and conical flow theory. Both methods utilize a finite-volume discretization solved by a pseudounsteady multistage scheme. Results from the two approaches are in good agreement. Computations have been done on a 16-million-word CYBER 205 using  $196 \times 56 \times 96$  and  $128 \times 128$  cells for the two methods. A sizable data base is generated, and some of the practical aspects of manipulating it are mentioned. The results reveal many interesting physical features of the compressible vortical flow field and also suggest new areas needing research. Author

**N86-29765\*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

**TRANSONIC NAVIER-STOKES WING SOLUTION USING A ZONAL APPROACH. PART 1: SOLUTION METHODOLOGY AND CODE VALIDATION**

J. FLORES, T. L. HOLST, U. KAYNAK (Sterling Software, Palo Alto, Calif.), K. GUNDY, and S. D. THOMAS Apr. 1986 2 p Presented at the AGARD Symposium on Applications of Computational Fluid Dynamics in Aeronautics, Aix En Provence, France, 7-10 Apr. 1986 (NASA-TM-88248; A-86206; NAS 1.15:88248) Avail: NTIS HC A02/MF A01 CSCL 01A

A fast diagonalized Beam-Warming algorithm is coupled with a zonal approach to solve the three-dimensional Euler/Navier-Stokes equations. The computer code, called Transonic Navier-Stokes (TNS), uses a total of four zones for wing configurations (or can be extended to complete aircraft configurations by adding zones). In the inner blocks near the wing surface, the thin-layer Navier-Stokes equations are solved, while in the outer two blocks the Euler equations are solved. The diagonal algorithm yields a speedup of as much as a factor of 40 over the original algorithm/zonal method code. The TNS code, in addition, has the capability to model wind tunnel walls. Transonic viscous solutions are obtained on a 150,000-point mesh for a NACA 0012 wing. A three-order-of-magnitude drop in the L2-norm of the residual requires approximately 500 iterations, which takes about 45 min of CPU time on a Cray-XMP processor. Simulations are also

conducted for a different geometrical wing called WING C. All cases show good agreement with experimental data. Author

**N86-29766\*#** Kansas Univ. Center for Research, Inc., Lawrence.

**AN INVESTIGATION OF TIP PLANFORM INFLUENCE ON THE AERODYNAMIC LOAD CHARACTERISTICS OF A SEMI-SPAN, UNSWEPT WING AND WING-TIP Final Technical Report**

J. M. VANAKEN Dec. 1985 83 p

(Contract NCC2-112)

(NASA-CR-177110; NAS 1.26:177110; CRINC-5171-1) Avail: NTIS HC A05/MF A01 CSCL 01A

A semi-span wing, equipped with an interchangeable tip, which was varied in planform and size was examined. Total wing aerodynamic loading was obtained from the wind tunnel scale system. The wing tip was mounted on a separate six-component strain gauge balance, which provided the aerodynamic loads on the tip. The tests were accomplished in the NASA Ames 7 x 10 foot Wind Tunnel at a Mach number of 0.178. The aerodynamic load characteristics of the wing and of the tip were presented with the tip at several incidence angles relative to the wing inboard section. B.G.

**N86-29768\*#** Massachusetts Inst. of Tech., Cambridge. Dept. of Aeronautics and Astronautics.

**ANALYTICAL INVESTIGATION OF ROTOR WAKE FORMATION AND GEOMETRY Progress Report, 15 Apr. - 15 Oct. 1985**

R. MILLER and E. M. MURMAN 16 Jan. 1986 21 p

(Contract NAG2-275)

(NASA-CR-177032; NAS 1.26:177032) Avail: NTIS HC A02/MF A01 CSCL 01A

A number of refinements in the computer code were worked out and tested. Three codes have been written to date. One program is for an isolated wing and is being used to compare with data for the vortex wake (Weston). The second code is for an isolated wing with a streamwise vortex passing above it. This program is being used to validate the computational procedure for incorporating the vortex into the Euler equation calculations. The third program is the hovering rotor code which is the overall objective of the research. The optimization calculations for a hovering helicopter rotor have been completed. Author

**N86-29769\*#** California Polytechnic State Univ., San Luis Obispo. Dept. of Aeronautical Engineering.

**AN EXPERIMENTAL AND ANALYTICAL METHOD FOR APPROXIMATE DETERMINATION OF THE TILT ROTOR RESEARCH AIRCRAFT ROTOR/WING DOWNLOAD Final Report, 30 May 1984 - 30 Nov. 1985**

D. E. JORDON, W. PATTERSON, and D. R. SANDLIN Nov. 1985 116 p

(Contract NCC2-259)

(NASA-CR-176970; NAS 1.26:176970) Avail: NTIS HC A06/MF A01 CSCL 01A

The XV-15 Tilt Rotor Research Aircraft download phenomenon was analyzed. This phenomenon is a direct result of the two rotor wakes impinging on the wing upper surface when the aircraft is in the hover configuration. For this study the analysis proceeded along tow lines. First was a method whereby results from actual hover tests of the XV-15 aircraft were combined with drag coefficient results from wind tunnel tests of a wing that was representative of the aircraft wing. Second, an analytical method was used that modeled that airflow caused by the two rotors. Formulas were developed in such a way that a computer program could be used to calculate the axial velocities were then used in conjunction with the aforementioned wind tunnel drag coefficient results to produce download values. An attempt was made to validate the analytical results by modeling a model rotor system for which direct download values were determined. Author

**N86-29770\*#** Iowa State Univ. of Science and Technology, Ames. Coll. of Engineering.

**VORTEX SHEET MODELING WITH HIGHER ORDER CURVED PANELS Ph.D Thesis Final Technical Report**

M. G. NAGATI 1985 115 p

(Contract NCC2-19)

(NASA-CR-176971; NAS 1.26:176971) Avail: NTIS HC A06/MF A01 CSCL 01A

A numerical technique is presented for modeling the vortex sheet with a deformable surface definition, along which a continuous vortex strength distribution in the spanwise direction is applied, so that by repeatedly modifying its shape, its true configuration is approached, in the proximity of its generating wing. Design problems requiring the inclusion of a realistic configuration of the vortex sheet are numerous. Examples discussed include: control effectiveness and stability derivatives, longitudinal stability, lateral stability, canards, propellers and helicopter rotors, and trailing vortex hazards. B.G.

**N86-29771\*#** Oklahoma State Univ., Stillwater. School of Mechanical and Aerospace Engineering.

**CORRELATION OF TRANSONIC-CONE PRESTON-TUBE DATA AND SKIN FRICTION Final Report, Nov. 1980 - May 1984**

A. S. ABU-MOSTAFA and T. D. REED May 1984 104 p

(Contract NAG2-76)

(NASA-CR-176902; NAS 1.26:176902) Avail: NTIS HC A06/MF A01 CSCL 01A

Preston-tube measurements obtained on the Arnold Engineering Development Center (AEDC) Transition Cone have been correlated with theoretical skin friction coefficients in transitional and turbulent flow. This has been done for the NASA Ames 11-Ft Transonic Wind Tunnel (11 TWT) and flight tests. The developed semi-empirical correlations of Preston-tube data have been used to derive a calibration procedure for the 11 TWT flow quality. This procedure has been applied to the corrected laminar data, and an effective freestream unit Reynolds number is defined by requiring a matching of the average Preston-tube pressure in flight and in the tunnel. This study finds that the operating Reynolds number is below the effective value required for a match in laminar Preston-tube data. The distribution of this effective Reynolds number with Mach number correlates well with the freestream noise level in this tunnel. Analyses of transitional and turbulent data, however, did not result in effective Reynolds numbers that can be correlated with background noise. This is a result of the fact that vorticity fluctuations present in transitional and turbulent boundary layers dominate Preston-tube pressure fluctuations and, therefore, mask the tunnel noise effects. So, in order to calibrate the effects of noise on transonic wind tunnel tests only laminar data should be used, preferably at flow conditions similar to those in flight tests. To calibrate the effects of transonic wind-tunnel noise on drag measurements, however, the Preston-tube data must be supplemented with direct measurements of skin friction. M.G.

**N86-29772\*#** Iowa State Univ. of Science and Technology, Ames. Dept. of Aerospace Engineering.

**NUMERICAL COMPUTATION OF VISCOUS FLOW AROUND BODIES AND WINGS MOVING AT SUPERSONIC SPEEDS Final Report, 15 Nov. 1971- 31 Mar. 1984**

J. C. TANNEHILL Apr. 1984 21 p

(Contract NGR-16-002-038)

(NASA-CR-176903; NAS 1.26:176903; ISU-ERI-AMES-84483;

CFD-9) Avail: NTIS HC A02/MF A01 CSCL 01A

Research in aerodynamics is discussed. The development of equilibrium air curve fits; computation of hypersonic rarefield leading edge flows; computation of 2-D and 3-D blunt body laminar flows with an impinging shock; development of a two-dimensional or axisymmetric real gas blunt body code; a study of an over-relaxation procedure for the MacCormack finite-difference scheme; computation of 2-D blunt body turbulent flows with an impinging shock; computation of supersonic viscous flow over delta wings at high angles of attack; and computation of the Space Shuttle Orbiter flowfield are discussed. Author

## 02 AERODYNAMICS

**N86-29773\*#** Texas A&M Univ., College Station. Dept. of Aerospace Engineering.  
**EXPERIMENTAL AND THEORETICAL STUDY OF PROPELLER SPINNER/SHANK INTERFERENCE M.S. Thesis**  
C. C. CORNELL May 1986 143 p  
(Contract NAS3-272)  
(NASA-CR-176954; NAS 1.26:176954) Avail: NTIS HC A07/MF A01 CSCL 01A

A fundamental experimental and theoretical investigation into the aerodynamic interference associated with propeller spinner and shank regions was conducted. The research program involved a theoretical assessment of solutions previously proposed, followed by a systematic experimental study to supplement the existing data base. As a result, a refined computational procedure was established for prediction of interference effects in terms of interference drag and resolved into propeller thrust and torque components. These quantities were examined with attention to engineering parameters such as two spinner finess ratios, three blade shank forms, and two/three/four/six/eight blades. Consideration of the physics of the phenomena aided in the logical deduction of two individual interference quantities (cascade effects and spinner/shank juncture interference). These interference effects were semi-empirically modeled using existing theories and placed into a compatible form with an existing propeller performance scheme which provided the basis for examples of application. Author

**N86-29776\*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.  
**PSEUDO-TIME ALGORITHMS FOR THE NAVIER-STOKES EQUATIONS**  
R. C. SWANSON and E. TURKEL (Tel-Aviv Univ. (Israel).) May 1986 33 p  
(Contract NAS1-17070; NAS1-18107)  
(NASA-CR-178127; ICASE-86-37; NAS 1.26:178127) Avail: NTIS HC A03/MF A01 CSCL 01A

A pseudo-time method is introduced to integrate the compressible Navier-Stokes equations to a steady state. This method is a generalization of a method used by Crocco and also by Allen and Cheng. We show that for a simple heat equation that this is just a renormalization of the time. For a convection-diffusion equation the renormalization is dependent only on the viscous terms. We implement the method for the Navier-Stokes equations using a Runge-Kutta type algorithm. This permits the time step to be chosen based on the inviscid model only. We also discuss the use of residual smoothing when viscous terms are present. Author

**N86-29777\*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.  
**AN ENTROPY CORRECTION METHOD FOR UNSTEADY FULL POTENTIAL FLOWS WITH STRONG SHOCKS**  
W. WHITLOW, JR., M. M. HAFEZ (California Univ., Davis.), and S. J. OSHER (California Univ., Los Angeles.) Jun. 1986 14 p  
(NASA-TM-87769; NAS 1.15:87769) Avail: NTIS HC A02/MF A01 CSCL 01A

An entropy correction method for the unsteady full potential equation is presented. The unsteady potential equation is modified to account for entropy jumps across shock waves. The conservative form of the modified equation is solved in generalized coordinates using an implicit, approximate factorization method. A flux-biasing differencing method, which generates the proper amounts of artificial viscosity in supersonic regions, is used to discretize the flow equations in space. Comparisons between the present method and solutions of the Euler equations and between the present method and experimental data are presented. The comparisons show that the present method more accurately models solutions of the Euler equations and experiment than does the isentropic potential formulation. Author

**N86-29778#** Montana State Univ., Missoula. Supersonic Wind Tunnel Lab.  
**BOUNDARY LAYER STABILITY MEASUREMENTS OVER A FLAT PLATE AT MACH 3 Final Report**  
A. DEMETRIADES Nov. 1985 203 p  
(Contract AF-AFOSR-0267-80)  
(AD-A166188; SWT-TR-85-1; AFOSR-86-0056TR) Avail: NTIS HC A10/MF A01 CSCL 20D

Amplification of natural disturbances in a flat plate laminar boundary layer at edge Mach number 3 have been measured in a supersonic wind tunnel with and without turbulent sidewall boundary layers. Detailed flowfield measurements were made to define the self-similar region and the point where the velocity profile first departs from the Blasius theory. The first instability mode was detected with a minimum critical momentum Reynolds number of 190 and a maximum amplified frequency of 0.000225. Amplification rates for this mode agree with the available theoretical predictions, and its low-frequency, low-R region is not as distorted by monotonic amplification as previously thought. A second, very prominent and extensive instability was found which extends to much higher frequencies beyond  $F = 0.00035$  and which dominates the pretransitional flow. The neutral branch location of this mode associates it with the second instability mode found in hypersonic flow and serves to clarify and present a stability diagram rational over the  $M = 0$  to 8 range. The overall amplitude gain before the first departure is still confined to low frequencies with the first mode contributing little net gain, the combined first-second modes contributing a gain of about 3, while an additional factor of 5 to 10 is provided by a mechanism active near the leading edge and apparently consistent with Mack's forcing-stability approach. GRA

**N86-29782#** Grumman Aerospace Corp., Bethpage, N.Y. Research and Development Center.  
**AN INVESTIGATION OF TURBULENCE MECHANISMS IN V/STOL UPWASH FLOW FIELDS Final Report, Mar. 1982 - Jun. 1985**  
B. GILBERT 15 Sep. 1985 94 p  
(Contract F49620-82-C-0025)  
(AD-A166286; RE-707; AFOSR-86-0096TR) Avail: NTIS HC A05/MF A01 CSCL 20D

This report presents results of an experimental investigation of the abnormally high turbulent mixing layer growth rate characteristics found in the upwash regions of V/STOL flows in ground effect. The fundamental turbulent V/STOL upwash mechanisms were investigated in increasingly more complex flow configurations. Most of this study uses the two-dimensional upwash formed by the collision of opposed two-dimensional wall jets. Initial parameters used to characterize the upwash formation were identified as the maximum wall jet velocity and wall jet half velocity width. Upwash measurements were taken in flows formed from equal wall jets with the same maximum velocities and equal wall jets with the same half widths. While mixing layer growth rates were larger than those found in a free two-dimensional jet, these values were less than those previously reported. An explanation based on non-similarity conditions in the flow is offered. Abnormally high turbulence levels reported by other investigators were not found. The increased growth rate seem to be a direct effect of the head-on collision process. There is an indication that in the far field the upwash growth characteristics are approaching those found in free jets which has profound implications to the turbulence modelers. GRA

**N86-29786#** Office National d'Etudes et de Recherches Aérospatiales, Paris (France). Direction Scientifique de la Résistance des Struct

**INFLUENCE OF THE ANGLE OF ATTACK AND FLUTTER ON THE LIFT OF A SUPERCRITICAL WING. COMPARISON BETWEEN THEORY AND EXPERIMENT Final Report [INFLUENCE DE L'INCIDENCE ET DU VRILLAGE SUR LE FLOTTEMENT D'UNE AILE SUPERCRITIQUE. COMPARAISON THEORIE-EXPERIENCE]**

R. DESTUYNDER and A. GRAVELLE Dec. 1985 40 p In FRENCH

(Contract STPA-84-95-015)  
(ONERA-RT-24/3064-RY-044-R; ESA-86-97276) Avail: NTIS HC A03/MF A01

Variations of the critical lift velocity in transonic flow (Mach 0.8) was studied. A first method is based on a linear computation of the corrections to perform on wind tunnel steady flow pressure measurements. A second nonlinear method is based on the analysis of small perturbations which take in account the deformations and the exact profile of the model. The comparison shows that both methods are close to the experimental results.

ESA

**N86-30628#** Arizona State Univ., Tempe. Dept. of Mechanical and Aerospace Engineering.

**TRANSONIC EQUIVALENT STRIP METHOD FOR AEROELASTIC APPLICATIONS**

D. D. LIU, Y. F. KAO, and K. Y. FUNG (Arizona Univ., Tucson) *In* DGLR The 2nd International Symposium on Aeroelasticity and Structural Dynamics p 17-32 1985 Sponsored by DTNSRDC/NAVAIR

Avail: NTIS HC A99/MF E03

For unsteady flow computations of arbitrary wing planforms including control surfaces, a method based on the transonic equivalent strip (TES) model is developed. It consists of two consecutive correction steps to a given unsteady two-dimensional code. The latter can be a time-linearized transonic code or a nonlinear one such as LTRAN2 code. The mean-flow correction step involves an equivalent airfoil design procedure; the spanwise phase correction step accounts for the effects of acoustic wave propagation in three dimensions. Computed results using the TES method are compared with those obtained by methods such as versions of XTRAN3 code, Isogai's full potential code, and measured data. Computed cases include the Northrop F-5 wing in pitching oscillation, the AGARD standard RAE wing with an oscillating flap, and the LANN wing in pitching oscillation. ESA

**N86-30629#** Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Goettingen (West Germany). Inst. fuer Aeroelastik.

**CALCULATION OF THREE-DIMENSIONAL TRANSONIC POTENTIAL FLOWS BY A FIELD PANEL METHOD**

R. VOSS *In* DGLR The 2nd International Symposium on Aeroelasticity and Structural Dynamics p 33-46 1985

Avail: NTIS HC A99/MF E03

A calculation method for three dimensional transonic flows around oscillating wings is described. It solves the time-linearized unsteady transonic small perturbation equation by an integral equation method with a field panel technique. In a computer code called PTRAN3, the field panel technique is combined with a finite difference method. Accuracy and computer costs of the code are acceptable for routine flutter applications. Results for applications to pitching motions of a rectangular wing and two swept wings (LANN wing and F5 wing) with high and low aspect ratio are shown. ESA

**N86-30631#** Fairchild Republic Div., Farmingdale, N. Y. **EXACT CLOSED-FORM SOLUTIONS FOR NONLINEAR UNSTEADY TRANSONIC AERODYNAMICS**

G. A. OYIBO *In* DGLR The 2nd International Symposium on Aeroelasticity and Structural Dynamics p 71-78 1985

Avail: NTIS HC A99/MF E03

The existence of exact closed-form solutions for nonlinear unsteady aerodynamics is established. The full nonlinear unsteady velocity potential equations for an airfoil are considered. Evidence indicating why the traditional hodograph approach is ineffective for solving these equations is provided. A mapping scheme transforms these full nonlinear equations into the hodograph plane. Examination of the resulting hodograph equations reveals that by prescribing the Jacobian of the transformation, ab initio, the exact closed-form solutions can be obtained for the nonlinear unsteady aerodynamic characteristics of an airfoil in a potential flow. The shockless transonic results for inviscid analysis show trends that agree with previous data. Dips are observed in the pressure distributions as the free stream Mach number is varied. There are finite optimum reduced frequencies (Strouhal numbers) for the pressure distributions. This suggests a solution to the transonic dip problem associated with aeroelastic stability characteristics at transonic Mach numbers. ESA

**N86-30632#** Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Goettingen (West Germany). Inst. of Aeroelasticity.

**STEADY AND UNSTEADY PRESSURE DISTRIBUTION ON VARIOUS PROFILES IN SEPARATED SUBSONIC AND TRANSONIC FLOW**

H. TRIEBSTEIN *In* DGLR The 2nd International Symposium on Aeroelasticity and Structural Dynamics p 99-119 1985

Avail: NTIS HC A99/MF E03

Steady, mean, and unsteady aerodynamic data were measured on two dimensional rectangular wings, one with a supercritical MBB-Va2 profile and one with a NACA 0012 in subsonic flow and another supercritical MBB-A3 profile in transonic flow. The measurements were performed to produce systematic results with respect to Mach number, reduced frequency, incidence (wing, spoiler, tab) and amplitude of oscillation, and for use in the development and assessment of subsonic and transonic codes. The higher harmonic parts of the unsteady pressure in the region of pressure jumps and flow separation are emphasized. The wind tunnels, test setups, wing configurations, electronic data recording and processing devices, and the measuring procedure are described. ESA

**N86-30633#** Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Goettingen (West Germany).

**AN IMPROVED POTENTIAL GRADIENT METHOD FOR THE CALCULATION OF UNSTEADY AERODYNAMIC PRESSURES ON OSCILLATING WINGS IN SUPERSONIC FLOW**

F. Q. ZHANG and H. FOERSCHING *In* DGLR The 2nd International Symposium on Aeroelasticity and Structural Dynamics p 153-162 1985

Avail: NTIS HC A99/MF E03

A method to calculate pressure distributions on harmonically oscillating wings is presented. The method uses an integral variable substitution, by which the computer time is reduced considerably together with an improvement of computation accuracy, especially for low supersonic Mach numbers and high reduced frequencies. Comparisons with other methods and experimental results show quite satisfactory agreement. ESA



## 02 AERODYNAMICS

**N86-30634#** Tel-Aviv Univ. (Israel). Dept. of Solid Mechanics, Materials and Structures.

**AN EXACT FORMULATION OF THE UNSTEADY AERODYNAMIC THEORY OF LIFTING SURFACES UNDERGOING ARBITRARY SMALL MOTIONS IN A SUPERSONIC FLOW FIELD**

L. LIBRESCU /in DGLR The 2nd International Symposium on Aeroelasticity and Structural Dynamics p 163-168 1985  
Avail: NTIS HC A99/MF E03

The indirect theory of unsteady lifting surfaces is developed. The integral equation (IE) relating a known downwash distribution to an unknown pressure distribution is derived without any restriction on the time dependence of field variables. The IE for simple harmonic motions and arbitrary small motions starting from rest at a certain time are obtained. In the latter case, the theory of generalized functions is used to derive the appropriate integral equation, by incorporating the associated initial conditions, and by highlighting properties of the aerodynamic kernel such as causality. The relationship between the aerodynamic kernels in the time and frequency domains is established. The problem analyzed is useful in the evaluation of the structural response of flight vehicles as well as in the active control problem of aeroelastic response.

ESA

**N86-30636#** Technische Univ., Brunswick (West Germany). Inst. fuer Stroemungsmechanik.

**APPLICATION OF UNSTEADY WING COLLOCATION METHODS TO CASCADES IN SUBSONIC FLOW**

A. KLOSE and B. LASCHKA /in DGLR The 2nd International Symposium on Aeroelasticity and Structural Dynamics p 180-186 1985

Avail: NTIS HC A99/MF E03

A method to calculate the pressure distribution and unsteady forces on the blades of a flat plate cascade in subsonic flow during harmonic oscillation is presented. A collocation method as used in lifting surface theories for single airfoils was adapted to solve the cascade equation. Pressure distribution and aerodynamic forces for several values of stagger, reduced frequency, space-to-chord ratio, Mach number and interblade phase angle were calculated. The results were compared to published data. Significant differences are discovered.

ESA

**N86-30638\*#** California Univ., Berkeley. Dept. of Mechanical, Aerospace and Nuclear Engineer Ring.

**A NEW LOOK AT ARBITRARY MOTION UNSTEADY AERODYNAMICS AND ITS APPLICATION TO ROTARY-WING AEROELASTICITY**

P. P. FRIEDMANN /in DGLR The 2nd International Symposium on Aeroelasticity and Structural Dynamics p 194-210 1985  
(Contract NAG2-209)

Avail: NTIS HC A99/MF E03 CSCL 01B

Research on arbitrary motion unsteady aerodynamics, emphasizing applications to rotary wing aeroelastic problems, is reviewed. Generalization of Greenberg's theory and its application to hingeless rotor aeroelastic stability; a technique for formulating finite state approximations to unsteady aerodynamic theories, suitable for fixed and rotary-wing applications, and its application to generalize Loewy's theory; comparison of fixed wing and rotary wing indicial response functions; influence of arbitrary motion aerodynamics, as represented by dynamic inflow on a helicopter in ground resonance; and comparison of dynamic inflow with arbitrary motion unsteady airfoil aerodynamics are covered.

ESA

**N86-30639#** Shenyang Aircraft Corp. (China).  
**EXPERIMENTAL TRANSONIC PRESSURE DISTRIBUTIONS OF A FLEXIBLE WING-AILERON MODEL AND COMPARISONS WITH RESULTS OF SEVERAL THEORETICAL METHODS**

D. GUAN, W. LIU, Z. GAO, and Y. ZHANG /in DGLR The 2nd International Symposium on Aeroelasticity and Structural Dynamics p 211-218 1985

Avail: NTIS HC A99/MF E03

Analytical methods for the prediction of transonic load distribution due to large aileron deflection angle on a flexible wing were investigated. A 60 deg delta wing model with representative

stiffness level and deflected aileron was tested in a high speed wind tunnel, and pressure distributions were measured. Second order transonic small disturbance theory, linearized aerodynamic theory, and an empirical method based on rigid model pressure distributions were used to calculate the load distribution. The empirical method seems more powerful.

ESA

**N86-30640#** Northwestern Polytechnical Univ., Xian (China).  
**CALCULATION OF THE LOAD DISTRIBUTION, AERODYNAMIC DERIVATIVES AND DYNAMIC CHARACTERISTICS OF QUASI-STATIC ELASTIC AIRCRAFT**

Q. LIU, C. WU, Z. JIAN, and K. WU /in DGLR The 2nd International Symposium on Aeroelasticity and Structural Dynamics p 219-228 1985

Avail: NTIS HC A99/MF E03

A numerical method for predicting the aerodynamic characteristics of quasi-static elastic aircraft is presented. The method can be used to evaluate the load distribution, control surface efficiency, aerodynamic derivatives and dynamic properties at subsonic speed. The aerodynamic calculations are based on the Green's function method. In structure deformation calculations, the free-structure influence coefficient method is used to evaluate the deformation of the elastic aircraft in free flight. The calculations are carried out for a large elastic aircraft. Results on load distribution, elevator efficiency, longitudinal aerodynamic derivatives, frequency responses to elevator input, and other dynamic properties are compared with those of the same aircraft where the elastic effect is not considered.

ESA

**N86-30659#** Fairchild Republic Div., Farmingdale, N. Y.  
**ANISOTROPIC WING AEROELASTIC THEORIES WITH WARPING EFFECTS**

G. A. OYIBO and J. H. BERMAN /in DGLR The 2nd International Symposium on Aeroelasticity and Structural Dynamics p 434-440 1985

Avail: NTIS HC A99/MF E03

The influence of warping (spanwise axial constraints on wing twist) on anisotropic wing aeroelastic oscillations is investigated using a similarity rule approach. Results show that a high aspect ratio anisotropic wing could behave aeroelastically like a low aspect ratio wing and vice-versa. Similarity parameters derived in the analysis expose conditions for which this might happen. The analysis also indicates that the parameter that is currently used in determining when warping is important (or when not to use the St Venant's torsion theory) is inaccurate for anisotropic wings. The correct parameter is presented.

ESA

**N86-30691\*#** New York Univ., New York. Courant Mathematics and Computing Lab.

**THE METHOD OF COMPLEX CHARACTERISTICS FOR DESIGN OF TRANSONIC BLADE SECTIONS Research and Development Report**

M. R. BLEDSOE Jun. 1986 203 p  
(Contract NAG2-345; DE-AC02-76ER-03077; NSF DMS-83-20430)  
(NASA-CR-176978; NAS 1.26:176978; DOE/ER-03077/273)  
Avail: NTIS HC A10/MF A01 CSCL 01A

A variety of computational methods were developed to obtain shockless or near shockless flow past two-dimensional airfoils. The approach used was the method of complex characteristics, which determines smooth solutions to the transonic flow equations based on an input speed distribution. General results from fluid mechanics are presented. An account of the method of complex characteristics is given including a description of the particular spaces and coordinates, conformal transformations, and numerical procedures that are used. The operation of the computer program COMPRES is presented along with examples of blade sections designed with the code. A user manual is included with a glossary to provide additional information which may be helpful. The computer program in Fortran, including numerous comment cards is listed.

B.G.



**N86-30693\*#** Texas A&M Univ., College Station. Dept. of Aerospace Engineering.

**AERODYNAMIC DATA BANKS FOR CLARK-Y, NACA 4-DIGIT AND NACA 16-SERIES AIRFOIL FAMILIES Final Report**

K. D. KORKAN, J. CAMBA, III, and P. M. MORRIS Jan. 1986 272 p

(Contract NAS3-272)

(NASA-CR-176883; NAS 1.26:176883) Avail: NTIS HC A12/MF A01 CSCL 01A

With the renewed interest in propellers as means of obtaining thrust and fuel efficiency in addition to the increased utilization of the computer, a significant amount of progress was made in the development of theoretical models to predict the performance of propeller systems. Inherent in the majority of the theoretical performance models to date is the need for airfoil data banks which provide lift, drag, and moment coefficient values as a function of Mach number, angle-of-attack, maximum thickness to chord ratio, and Reynolds number. Realizing the need for such data, a study was initiated to provide airfoil data banks for three commonly used airfoil families in propeller design and analysis. The families chosen consisted of the Clark-Y, NACA 16 series, and NACA 4 digit series airfoils. The various component of each computer code, the source of the data used to create the airfoil data bank, the limitations of each data bank, program listing, and a sample case with its associated input-output are described. Each airfoil data bank computer code was written to be used on the Amdahl Computer system, which is IBM compatible and uses Fortran.

Author

**N86-30694\*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**COMPARISON OF EXPERIMENTAL SURFACE PRESSURES WITH THEORETICAL PREDICTIONS ON TWIN TWO-DIMENSIONAL CONVERGENT-DIVERGENT NOZZLES**

J. R. CARLSON, O. C. PENDERGRAFT, JR., and J. R. BURLEY, II Aug. 1986 31 p Presented at the AIAA 4th Applied Aerodynamics Conference, San Diego, Calif., 9-11 Jun. 1986

(NASA-TM-87757; NAS 1.15:87757; AIAA-86-1803-CP) Avail: NTIS HC A03/MF A01 CSCL 01A

A three-dimensional subsonic aerodynamic panel code (VSAERO) was used to predict the effects of upper and lower external nozzle flap geometry on the external afterbody/nozzle pressure coefficient distributions and external nozzle drag of nonaxisymmetric convergent-divergent exhaust nozzles having parallel external sidewalls installed on a generic twin-engine high performance aircraft model. Nozzle static pressure coefficient distributions along the upper and lower surfaces near the model centerline and near the outer edges (corner) of the two surfaces were calculated, and nozzle drag was predicted using these surface pressure distributions. A comparison between the theoretical predictions and experimental wind tunnel data is made to evaluate the utility of the code in calculating the flow about these types of non-axisymmetric afterbody configurations. For free-stream Mach numbers of 0.60 and 0.90, the conditions where the flows were attached on the boattails yielded the best comparison between the theoretical predictions and the experimental data. For the Boattail terminal angles of greater than 15 deg., the experimental data for  $M = 0.60$  and  $0.90$  indicated areas of separated flow, so the theoretical predictions failed to match the experimental data. Even though calculations of regions of separated flows are within the capabilities of the theoretical method, acceptable solutions were not obtained.

Author

**N86-30695\*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**EXPERIMENTAL AND NUMERICAL RESULTS FOR A GENERIC AXISYMMETRIC SINGLE-ENGINE AFTERBODY WITH TAILS AT TRANSONIC SPEEDS**

J. R. BURLEY, II, J. R. CARLSON, and W. P. HENDERSON Aug. 1986 20 p Presented at the AIAA 4th Applied Aerodynamics Conference, San Diego, Calif., 9-11 Jun. 1986

(NASA-TM-87755; NAS 1.15:87755; AIAA-86-1797-CP) Avail: NTIS HC A02/MF A01 CSCL 01A

Static pressure measurements were made on the afterbody, nozzle and tails of a generic single-engine axisymmetric fighter configuration. Data were recorded at Mach numbers of 0.6, 0.9, and 1.2. NPR was varied from 1.0 to 8.0 and angle of attack was varied from -3 deg. to 9 deg. Experimental data were compared with numerical results from two state-of-the-art computer codes.

Author

**N86-30696\*#** Colorado Univ., Boulder. Dept. of Aerospace Engineering Sciences.

**NUMERICAL STUDIES OF POROUS AIRFOILS IN TRANSONIC FLOW Ph.D. Thesis. Final Report, 1 Jun. 1985 - 31 Aug. 1986**

C. Y. CHOW 1986 114 p

(Contract NCC2-355)

(NASA-CR-179655; NAS 1.26:179655) Avail: NTIS HC A06/MF A01 CSCL 01A

A numerical tool is constructed to examine the effects of a porous surface on transonic airfoil performance and to help understand the flow structure of passive shockwave/boundary layer interactions. The porous region is located near the shock with a cavity underneath it. This study is composed of two parts. Solved in the first part, with an inviscid-flow approach, is the transonic full-potential equation associated with transpiration boundary conditions which are obtained from porosity modeling. The numerical results indicate that a porous airfoil has a wave drag lower than that of a solid airfoil. The observed lambda-shock structure in the wind-tunnel testing can be predicted. Furthermore, the lift could be increased with an appropriate porosity distribution. In the second part of this work, the modified version of either an interactive boundary layer (IBL) algorithm or a thin-layer Navier-Stokes (TLNS) algorithm is used to study the outer flow, while a stream-function formulation is used to model the inner flow in the shallow cavity. The coupling procedure at the porous surface is based on Darcy's law and the assumption of a constant total pressure in the cavity. In addition, a modified Baldwin-Lomax turbulence model is used to describe the transpired turbulent boundary layer in the TLNS approach, while the Cebeci turbulence model is used in the IBL approach. According to the present analysis, a porous surface can reduce the wave drag appreciably, but can also increase the viscous losses. As has been observed experimentally, the numerical results indicate that the total drag is reduced at higher Mach numbers and increased at lower Mach numbers when the angles of attack are small. Furthermore, the streamline pattern of passive shock/boundary layer interaction are revealed.

Author

**N86-30697\*#** Cornell Univ., Ithaca, N.Y. School of Mechanical and Aerospace Engineering.

**AERODYNAMICS OF ENGINE-AIRFRAME INTERACTION Annual Progress Report, 1 Oct. 1985 - 30 Sep. 1986**

D. A. CAUGHEY 30 Aug. 1986 29 p

(Contract NAG2-373)

(NASA-CR-179657; NAS 1.26:179657) Avail: NTIS HC A03/MF A01 CSCL 01A

The report describes progress in research directed towards the efficient solution of the inviscid Euler and Reynolds-averaged Navier-Stokes equations for transonic flows through engine inlets, and past complete aircraft configurations, with emphasis on the flowfields in the vicinity of engine inlets. The research focusses upon the development of solution-adaptive grid procedures for these problems, and the development of multi-grid algorithms in conjunction with both, implicit and explicit time-stepping schemes for the solution of three-dimensional problems. The work includes

further development of mesh systems suitable for inlet and wing-fuselage-inlet geometries using a variational approach. Work during this reporting period concentrated upon two-dimensional problems, and has been in two general areas: (1) the development of solution-adaptive procedures to cluster the grid cells in regions of high (truncation) error; and (2) the development of a multigrid scheme for solution of the two-dimensional Euler equations using a diagonalized alternating direction implicit (ADI) smoothing algorithm. M.G.

**N86-30698\*#** Vigyan Research Associates, Inc., Hampton, Va.  
**PAN AIR APPLICATION TO THE F-106B**  
 F. GHAFARI Aug. 1986 60 p  
 (Contract NAS1-17919)  
 (NASA-CR-178165; NAS 1.26:178165) Avail: NTIS HC A04/MF A01 CSCL 01A

The PAN AIR computer code was employed in the present study to investigate the aerodynamic effects of the various geometrical changes and flow conditions on a configuration similar to the F-106B half-airplane tested in the Langley 30x60-foot wind tunnel. The various geometries studied included two forebodies (original and shortened), two inlet flow conditions (open and closed) two vortex flap situations (off and on). The attached flow theoretical solutions were obtained for Mach number of 0.08 and angle of attack of 8 deg., 10 deg., 12 deg., and 14 deg. In general this investigation revealed that the shortening of the forebody or closing of the inlet produced only a small change in the overall aerodynamic coefficients of the basic F-106B configuration throughout the examined angles of attack. However, closing the inlet of the configuration resulted in a slightly higher drag level at low angles of attack. Furthermore, at and above 10 deg. angle of attack, it was shown that the presence of the vortex flap causes an increase in the total lift and drag. Also, these theoretical results showed the expected reduction in longitudinal stability level with addition of the vortex flap to the basic F-106B configuration. Author

**N86-30700#** Arnold Engineering Development Center, Arnold Air Force Station, Tenn.  
**AIR-ON DEMONSTRATION OF THE AEDC PWT TUNNEL 16T CAPTIVE TRAJECTORY SUPPORT SYSTEM Final Report, 21 Jul. - 26 Jul. 1985**  
 L. L. ARENDT (Calspan Field Services, Inc., Arnold AFS, Tenn.) Sep. 1985 68 p Prepared in cooperation with Calspan Field Service  
 (AD-A166888; AEDC-TSR-85-P17) Avail: NTIS HC A04/MF A01 CSCL 20D

An air-on demonstration of the Captive Trajectory Support (CTS) system was conducted in the AEDC Propulsion Wind Tunnel (16T). The test objectives were: (1) to demonstrate the structural integrity of the CTS system; (2) to demonstrate the ability of the CTS system to satisfactorily obtain grid and trajectory generation data for a typical store model in free stream and relative to a simulated (flat plate) aircraft in a dynamic wind tunnel environment; (3) to obtain a Mach number calibration for the Tunnel 16T Cart 2 (Multipurpose Cart) with the CTS system installed. The 1/4-scale Maximum Volume Bomb (MVB) was used to represent a typical store. Data were obtained at free-stream numbers from 0.6 to 1.6 and at various compressor ratios. GRA

## AIR TRANSPORTATION AND SAFETY

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

### **A86-44400** **THE FIRE-HARD AIRLINER**

J. M. RAMSDEN Flight International (ISSN 0015-3710), vol. 129, May 17, 1986, p. 27-30.

The complex problems posed by airliner cabin fires are examined and the continuing search for even more fire-resistant materials is described. In 25 years the airlines have suffered about 50 cabin fires in the air, of which fewer than half have been fatal. This is a fatal cabin-fire rate of only one per 10,000,000 flights. Three tragic fires are described. At Riyadh in 1980, all 301 occupants of a Saudi TriStar died when a flashover of combustible gases ran through the cabin when engines and air conditioning were shut down after an emergency landing. In Manchester, England, British Airways 737 caught fire on takeoff; blazing fuel melted the fuelage and 55 of the 137 occupants died, most of them from hydrogen cyanide or carbon monoxide gases or 'black ash' emitted by burning cabin furnishings. Approaching Greater Cincinnati, in 1983, an Air Canada DC-9 had a fire aboard smoldering for almost 15 minutes before being discovered; during the emergency landing, acrid black smoke filled the cabin but it only ignited a minute after the doors and exits had been opened on landing; half of the 46 occupants died. A major question in fire hardening is whether to try to make cabin furnishing harder to ignite (noting that all plastics do burn) or to try to find materials that emit gases that are less toxic when they are burning. Topics covered include: plastic materials, wool, fireblockers, tests (Airbus and Boeing standards, FAA rulemaking - NPRM 85-10), and structure (aircraft skin, sidewalls, ceiling, windows, fuel tanks). D.H.

### **A86-44777** **1985 USAF EJECTION SUMMARY**

R. C. DELGADO (USAF, Directorate of Aerospace Safety, Norton AFB, CA) SAFE Journal, vol. 16, no. 2, Summer 1986, p. 16, 17.

An analysis of the USAF ejection statistics for the 58 crewmembers involved in escape-system-equipped aircraft mishaps during 1985 is presented. An 81 percent ejection survival rate from the 43 attempted ejections (the lowest number of ejections since 1950) is found. Six out of eight of the fatalities were due to out-of-envelope ejection, involving three in F-4s, two in a T-38, and one in an F-16. Specific ejection mishaps are discussed, and recommendations are made. R.R.

### **A86-44781** **AUTOMATIC INFLATION MODULATION (A.I.M.) PARACHUTE UP-DATE**

D. B. WEBB (Irvin Industries Canada, Ltd., Fort Erie) SAFE Journal, vol. 16, no. 2, Summer 1986, p. 38-45. refs

The current status of the AIM parachute and parachute system testing in each of the Martin Baker MK.12, the Stencel S4S and the McDonnell Douglas ACES II ejection seats is reviewed. The benefits of deploying the main canopy at the highest possible speed are discussed, together with the necessary structural integrity and inflation control requirements. Results of additional environmental testing of the stretch fabric used in the AIM canopy crown area (for relief of inflation loads) are included, which show that it closely follows the standard MIL-C-7020 parachute cloth results. Author

A86-45757

**SNIFFING OUT TROUBLE**

H. HOPKINS Flight International (ISSN 0015-3710), vol. 129, June 28, 1986, p. 24-26.

The "Condor" contraband detector system is a mobile explosives and illegal drugs cargo inspection apparatus for use at airports against smugglers and terrorists. The entire system is contained in two installations through which cargo vehicles pass on a conveyor belt, with an inspection capacity of around 100 tonnes/hr. Luggage does not have to be unpacked for inspection. Condor is housed in a 30-ft-long trailer, and is currently priced at over 2 million pounds sterling. Operations are conducted by two personnel, one of whom works outside it on the actual sampling manipulations while the other is inside, monitoring the analysis functions. O.C.

**N86-29790#** National Transportation Safety Board, Washington, D. C.

**SAFETY RECOMMENDATION**

J. BURNETT 28 Mar. 1986 2 p

(NTSB-A-86-22; NTSB-A-86-23; REPT-4346/1-60A) Avail: NTIS HC A02/MF A01

On June 25, 1985, a Cessna Model 150 airplane, N704ZS, sustained substantial damage after a loss of engine power in flight forced the pilot to execute an emergency landing at Rushville, Missouri. The National Transportation Safety Board's investigation of the accident disclosed that the power loss occurred because a self-locking nut became disengaged from the bolt that connects the throttle cable rod end to the carburetor throttle arm, permitting the bolt to back out of the bolt hole. Since January 1, 1980, throttle linkages have become disconnected from carburetor throttle arms for similar reasons on seven other Cessna Model 150 airplanes. Additionally, the loss of connecting hardware has caused the separation of engine throttle or mixture controls on Cessna Model 152, 172, 177RG, A188, and U206 airplanes, resulting in six accidents, one incident, and eight service difficulty reports.

Author

**N86-29791#** National Transportation Safety Board, Washington, D. C.

**NATIONAL TRANSPORTATION SAFETY BOARD SAFETY RECOMMENDATION**

7 Apr. 1986 6 p

(NTSB-4360/33) Avail: NTIS HC A02/MF A01

Problems that have been experienced by the Pratt & Whitney Aircraft JT8D-1 through -17AR engines are discussed. These problems include failures of combustion chambers, removable sleeve spacers in the high-pressure compressor, combustion chamber outer cases, second-stage low-pressure turbine disks, second-stage fan blades, and high-pressure and low-pressure turbine blades.

Author

**N86-29792#** National Transportation Safety Board, Washington, D. C.

**NATIONAL TRANSPORTATION SAFETY BOARD SAFETY RECOMMENDATION**

17 Apr. 1986 2 p

(NTSB-4357/1) Avail: NTIS HC A02/MF A01

On July 16, 1984, a Hiller Aviation UH-12E helicopter, N1043L, crashed while engaged in an agricultural spraying operation near Redmond, Oregon. The helicopter was destroyed. The pilot, the sole occupant, received minor injuries. The investigation by the National Transportation Safety Board revealed that an outboard section of main rotor blade had separated in flight. Subsequent detailed examination of the fractured surfaces of main rotor blade spar in the Safety Board's metallurgical laboratory revealed that a fatigue crack had propagated through 80 percent of the spar cross section prior to separation. The fatigue crack originated at the interface between the spar lower surface leading edge and the external spar doubler. The failed blade was manufactured by the Parsons Company, a Hiller Aviation vendor, in the 1960's. The Safety Board understands that this was the fourth such blade failure since the AD was issued. All four failures reportedly occurred when the blades had accumulated about 4,000 hours, although

the approved service life of the PN 2253-1101-04 blade is 6,600 hours. The inspection now being conducted at 100-hour intervals apparently is not adequate to identify fatigue crack propagation originating at the interface between the spar lower surface leading edge and the external spar doubler. The Safety Board concludes that a one-time inspection using ultrasonic or eddy current techniques should be imposed on the remaining Parsons main rotor blades with more than 3,000 hours of accumulated time, in addition to the existing AD requirement. Data from this one-time inspection program should be evaluated to determine if any further nondestructive tests are necessary or if the approved service life of the blades should be reduced.

Author

**N86-29793#** Federal Aviation Administration, Washington, D.C. Emergency Evacuation Task Force.

**TASK FORCE REPORT ON EMERGENCY EVACUATION OF TRANSPORT AIRPLANES, VOLUME 1 Final Summary Report**

Jul. 1986 109 p

(DOT/FAA/VS-86/1.1) Avail: NTIS HC A06/MF A01

This is one of two volumes that report on the study of the emergency evacuation of transport airplanes that was sponsored by the Federal Aviation Administration (FAA). The study included the September 1985 Public Technical Conference and the public meetings of the three technical working groups formed during the conference as part of a task force effort. The working groups are: Design and Certification, Training and Operations, and Maintenance and Reliability. The task force program focused on the reassessment of existing Federal Aviation Regulations pertaining to emergency evacuation. Topics considered in the study include: evacuation demonstrations; emergency exits; evacuation slide certification, inspection, and maintenance; emergency equipment; crewmember training and duties; passenger safety information; air carrier operations; and others. Volume I, Summary Report, summarizes the issues considered during the study and the outcome of those issues. Volume II, Supporting Documentation, contains meeting reports, formal presentation papers, and other documents on which the summary report is based.

Author

**N86-29794#** Federal Aviation Administration, Atlantic City, N.J. Technical Center.

**HALON EXTINGUISHER AGENT BEHAVIOR IN A VENTILATED SMALL AIRCRAFT Final Report, Mar. - Jul. 1984**

G. R. SLUSHER, J. WRIGHT, and J. E. DEMAREE Jun. 1986 53 p

(DOT/FAA/CT-86/5) Avail: NTIS HC A04/MF A01

Hand held fire extinguishers (Halon 1211 and Halon 1301) were evaluated in a four-passenger Cessna Model 210C aircraft. The aircraft was operated in the FAA's Technical Center airflow facility under simulated flight conditions. Extinguishers were discharged without fires to determine the dissipation rate and toxicity levels of Halon extinguishing agents. Agent concentrations dissipated rapidly. Analysis of dose calculations demonstrated that 2.5 pound Halon 1211 and 3.0 pound Halon 1301 extinguishers were safe in the four-passenger test aircraft. Dose calculations for the pilot were a maximum of 60 percent of the limit for Halon 1211, and maximum dose was 31 percent of the limit for Halon 1301. Stratification of the Halons together with cabin ventilation resulted in safe conditions for the pilot. Distribution of extinguishing agents under the instrument panel was investigated. When the extinguishers were discharged on either the pilot's or the copilot's side, four percent concentration was measured on the side opposite of the discharge of the extinguishers. Extinguisher gas stratification was determined by measuring agent levels on the cabin floor.

Author

### 03 AIR TRANSPORTATION AND SAFETY

**N86-29795#** Jet Propulsion Lab., California Inst. of Tech., Pasadena.  
**FULL-SCALE TRANSPORT CONTROLLED IMPACT DEMONSTRATION PROGRAM PHOTOGRAPHIC/VIDEO COVERAGE Final Report, May 1983 - Dec. 1984**  
J. D. GREGOIRE Apr. 1986 430 p  
(Contract DTFA03-80-A-00215)  
(DOT/FAA/CT-85/35; JPL-D-2534) Avail: NTIS HC A19/MF A01

The Full-Scale Transport Controlled Impact Demonstration Program was recorded on both film and video tape by the Photo-Duplication Section 642 of the Jet Propulsion Laboratory, California Institute of Technology. Photographic coverage was requested by the Federal Aviation Administration (FAA) on the antimisting kerosene (AMK) fuel and crashworthiness experiments. Instrumentation and documentation cinematography and videography produced a catalog of images that recorded completely the pre-/post-elements of the event. Author

**N86-29796#** Federal Aviation Administration, Washington, D.C. Program Engineering and Maintenance Service.  
**INVESTIGATION OF HAZARDS OF HELICOPTER OPERATIONS AND ROOT CAUSES OF HELICOPTER ACCIDENTS Final Report, Oct. 1983 - Sep. 1985**  
F. R. TAYLOR and R. J. ADAMS Jul. 1986 177 p  
(Contract DTFA01-80-C-10080)  
(FAA/PM-86/28) Avail: NTIS HC A09/MF A01

During 1983 and 1984, Systems Control Technology, Inc. conducted a country-wide survey of civil helicopter pilot organizations involved in a wide range of helicopter operations for the purpose of determining the hazards of the latter and the root causes of the high rate of helicopter accidents. The survey was conducted through personal interviews, meetings, and questionnaires. The questionnaire included census data, profiles of the pilot work environment and procedures, and their own perspectives on the hazards of helicopter operations and causes of helicopter accidents. These data were compared with historical National Transportation Safety Board accident reports and accident briefs to determine more specifically the causes of helicopter accidents. The results of the analysis include a list of hazards and probable causes of accidents, as well as technological, training and standardization remedies. Author

**N86-29797#** Federal Aviation Administration, Washington, D.C. Associate Administrator for Aviation Standards.  
**TASK FORCE REPORT ON EMERGENCY EVACUATION OF TRANSPORT AIRPLANES. VOLUME 2: SUPPORTING DOCUMENTATION Final Report**  
Jul. 1986 429 p  
(FAA/VS-86/1,2) Avail: NTIS HC A19/MF A01

This is one of two volumes that report on the study of the emergency evacuation of transport airplanes that was sponsored by the Federal Aviation Administration (FAA). The study included the September 1985 Public Technical Conference and the public meetings of the three technical working groups formed during the conference as part of a task force effort. The working groups are: Design and Certification, Training and Operations, and Maintenance and Reliability. The task force program focused on the reassessment of existing Federal Aviation Regulations pertaining to emergency evacuation. Topics considered in the study include: evacuation demonstrations; emergency exits; evacuation slide certification, inspection and maintenance; emergency equipment, crewmember training and duties; passenger safety information; air carrier operations, and others. Volume I, Summary Report, summarizes the issues considered during the study and the outcome of those issues. Volume II, Supporting Documentation, contains meeting reports and other documents on which the summary report is based. Author

**N86-29798#** Scientific Systems, Inc., Cambridge, Mass.  
**VECTORED THRUST DIGITAL FLIGHT CONTROL FOR CREW ESCAPE, VOLUME 1 Final Report, 1 Jun. 1982 - 28 Feb. 1985**  
J. V. CARROLL and R. F. GENDRON Dec. 1985 215 p  
(Contract F33615-C-82-3402)  
(AD-A166580; AFWAL-TR-85-3116-VOL-1) Avail: NTIS HC A10/MF A01 CSCL 01D

Work of Meyer and Cicolani was adapted for application to open seat escape systems in current Air Force fighter aircraft. The control system design is a fully self-contained system whose major on-seat components are: acceleration, rate, attitude and altitude sensors, real-time control logic imbedded on a microprocessor chip, rocket thrusters with thrust vectoring and throttling capability, and various avionics and support subsystem hardware items (e.g., power supply). The control concept is based on a comparison of measured translational and rotational accelerations with desired values; the propulsion system is then configured to provide adequate energy to follow the desired trajectory and simultaneously eliminate acceleration errors. The concept uses nonlinear models and incorporates state and control constraints. This volume contains the detailed documentation of specification development, control logic design, hardware identification, and trade study efforts. Volume II (Ad-A166 596) contains a description of the prototype design, real time breadboard simulation, and the results and analysis of the verification task. Volume III contains the supporting appendices for volumes I and II. Volume IV details the results of the real time hybrid computer simulation effort. GRA

**N86-29799#** Scientific Systems, Inc., Cambridge, Mass.  
**VECTORED THRUST DIGITAL FLIGHT CONTROL FOR CREW ESCAPE, VOLUME 2 Final Report, 1 Jun. 1982 - 28 Feb. 1985**  
J. V. CARROLL and R. F. GENDRON Dec. 1985 208 p  
(Contract F33615-82-C-3402)  
(AD-A166596; AFWAL-TR-85-3116-VOL-2) Avail: NTIS HC A10/MF A01 CSCL 01D

Work of Meyer and Cicolani was adapted for application to open seat escape systems in current Air Force fighter aircraft. The control system design is a fully self-contained system whose major on-seat components are: acceleration, rate, attitude and altitude sensors, real-time control logic imbedded on a microprocessor chip, rocket thrusters with thrust vectoring and throttling capability, and various avionics and support subsystem hardware items (e.g., power supply). The control concept is based on a comparison of measured translational and rotational accelerations with desired values; the propulsion system is then configured to provide adequate energy to follow the desired trajectory and simultaneously eliminate acceleration errors. The concept uses nonlinear models and incorporates state and control constraints. Volume I (AD-A166580) contains the detailed documentation of specification development, control logic design, hardware identification, and trade study efforts. Volume II contains a description of the prototype design, real time breadboard simulation, and the results and an alysis of the verification task. GRA

**N86-30019#** Boeing Co., Seattle, Wash.  
**CURRENT DESIGN PROCEDURES FOR MINIMIZING POST CRASH FIRE HAZARDS**  
H. SKAVDAHL In FAA Proceedings of Fuel Safety Workshop p 261-276 31 Dec. 1985  
Avail: NTIS HC A17/MF A01 CSCL 21D

In designing jet aircraft fuel systems, experience has resulted in current attention to the following considerations for fire safety: (1) elimination of ignition sources; (2) where (1) is not possible, minimizing oxygen supply, ventilating the fuel sufficiently to prevent combustible mixtures, or eliminating the fuel source with valves or drains; (3) shrouding of fuel lines in pressurized compartments; (4) impact-resistant location of fuel tanks; (5) safety features for pressure fueling; (6) strut breakaway design; and (7) fire walls, air cooling, and careful location of fuel system components to further minimize fire hazards. Airplane fuel systems are discussed in

general, and criteria which must be satisfied in the design of a new component or subsystem are described. J.P.B.

**N86-30020#** Aviation Fuel Safety Co., Chelmsford, Mass.  
**AMINE-CO<sub>2</sub> ADDUCTS AS AVIATION FUEL GELLING AGENTS**  
 W. W. BANNISTER /n FAA Proceedings of Fuel Safety Workshop  
 p 279-298 31 Dec. 1985  
 Avail: NTIS HC A17/MF A01 CSCL 21D

On addition of small amounts of cyclododecylamine (CDDN) to jet fuels, with subsequent addition of CO<sub>2</sub>, a zwitterionic carbamate forms to set up a gelling matrix within the fuel. This system is proposed for application in controlled crash landings in which the crew would have one or two second to undertake fire-prevention measures. There is also a possibility for use in very low non-gelling concentrations which may still provide antimisting kerosene (AMK) characteristics, in which case there would be no weight penalties and no reaction time would be required. Use with other additives may provide synergistic effects. Cost estimates, payload requirements, heat of combustion and NOx emission data are included. Author

**N86-30022#** Akron Univ., Ohio.  
**JET FUEL VISCOSITY AT LOW TEMPERATURES WITH NOTES ON N-ALKALINE CRYSTALS Final Report**  
 D. SCHRUBEN /n FAA Proceedings of Fuel Safety Workshop p 317-356 31 Dec. 1985  
 (Contract NAG3-488)  
 (NASA-CR-174911; NAS 1.26:174911) Avail: NTIS HC A17/MF A01 CSCL 21D

Apparatus and procedures were developed to collect jet fuel viscosity versus temperature data for temperatures down to about -60 deg C in a manner compatible with prior jet fuel data bases generated with the Brookfield viscometer. Viscosity data showed good reproducibility even at temperatures a few degrees into the two-phase region. The viscosity-temperature relationship could be correlated by two linear segments when plotted as a standard log-log type representation. The breakpoint between the high and low temperature line segments is the filter flow temperature, a fuel characteristic approximated by the freezing point. A generalized correlation appears sufficiently accurate for many design or performance calculations. In the low temperature two-phase region, wax precipitation is significant. Qualitative literature was quantitatively analyzed along with data in this study to plot crystal size versus composition for the fuel model C sub 20-C sub 24 n-alkane system in solvent. This suggested that wax mixtures tend towards smaller crystal sizes than pure wax species. Complex mixtures in jet fuels lead to two-phase states, at least in some instances, that have small enough crystals to be treated as a continuum. Author

**N86-30702#** Simula, Inc., Tempe, Ariz.  
**SEAT EXPERIMENT RESULTS OF FULL-SCALE TRANSPORT AIRCRAFT CONTROLLED IMPACT DEMONSTRATION Final Report, Jan. - Jul. 1985**  
 M. R. CANNON and R. E. ZIMMERMANN (RMS Technologies, Inc., Trevese, Pa.) Jul. 1986 248 p  
 (Contract DTFA03-81-C-00040)  
 (DOT/FAA/CT-85/25; TR-85413) Avail: NTIS HC A11/MF A01

The results of the Federal Aviation Administration (FAA) seat experiments tested in the joint FAA/NASA Controlled Impact Demonstration (CID) are described. Twenty-three seats were placed on the test aircraft. Thirteen seats were modifications of existing transport seats which were designed structurally to improve their crashworthiness. The remaining experiments were unmodified standard seats which included seven light and heavy-weight forward-facing seats, two aft-facing seats, and one flight attendant seat. Three additional seat experiments were placed onboard the test aircraft: two by NASA, and one by a private contractor. Onboard instrumentation was placed at specific locations to obtain data pertaining to airframe structural loads and seat/occupant response. Accelerometers were attached to the airframe and floor structure, the seat experiments, and the anthropomorphic dummies occupying the seats. The data base resulting from the test was intended for

validating crash prediction models and occupant/seat dynamic simulation models. Author

**N86-30703#** National Transportation Safety Board, Washington, D. C.

**AIRCRAFT ACCIDENT REPORT: PROVINCETOWN, BOSTON AIRLINES FLIGHT 1039, EMBRAER BANDEIRANTE, EMB-110P1, N96PB, JACKSONVILLE, FLORIDA, DECEMBER 6, 1984**

24 Jun. 1986 100 p  
 (PB86-910405; NTSB/AAR-86/04) Avail: NTIS HC A05/MF A01  
 Provincetown-Boston Airlines Flight 1039, an Embraer Bandeirante, was cleared from the Jacksonville International Airport, Jacksonville, Florida, to Tampa, Florida at 1805 eastern standard time on December 6, 1985, in visual flight conditions. There were 11 passengers and 2 crewmembers aboard the scheduled domestic passenger flight operating under 14 CFR 135. At 1812, flight 1039 was cleared for takeoff, and, at 1813, while over the departure end of the runway and climbing, the crew acknowledged a frequency change. Thirty seconds later, about 1814, the airplane was seen in a steep descent near the extended centerline of the runway. Flight 1039 struck the ground 7,800 feet beyond the departure end of runway 31 and 85 feet to the northeast (right) of the extended runway centerline in an inverted nose down attitude, after which it caught fire and burned. The airplane was demolished, and all 13 persons aboard were killed. Before ground impact, the horizontal stabilizer, including bulkhead No. 36, had separated from the fuselage. Both elevators and elevator tips, the tail cone assembly, and the aft portion of the ventral fin also had separated in flight. Author

**N86-30704#** Calspan Field Services, Inc., Arnold AFS, Tenn.  
**AIRCRAFT TRANSPARENCY TESTING: ARTIFICIAL BIRDS Final Report, 1 Jul. 1984 - 1 May 1985**  
 C. J. WELSH and V. CENTONZE Apr. 1986 18 p Prepared in cooperation with AEDC  
 (AD-A166832; AEDC-TR-86-2) Avail: NTIS HC A02/MF A01 CSCL 14B

An analysis was made concerning the use of artificial birds in bird impact testing of aircraft transparencies. Results of this analysis, including impact measurements at a nominal velocity of 500 fps, indicated that the use of artificial birds for impact testing at these conditions is impractical. This follows from the importance and difficulty of simulating the shear strength characteristics of real birds in transparency impacts. GRA

**N86-30705#** Weather Corp., Weston, Mass.  
**DEVELOPMENT OF AIRBORNE ELECTRIC FIELD AND LIGHTNING DETECTION INSTRUMENTATION FOR AVIATION SAFETY Final Report**  
 R. MARKSON 20 Apr. 1986 30 p  
 (Contract N00014-85-C-0707)  
 (AD-A167342) Avail: NTIS HC A03/MF A01 CSCL 01D

The objectives of Phase I were to investigate the use of simple corona current instrumentation on aircraft to measure thunderstorm electric fields and to conduct a feasibility study of a single station aircraft lightning interferometer to detect the occurrence and position of lightning. Both of these techniques have the common purpose of providing warning to aircraft crews when they are approaching potentially hazardous clouds and thunderstorms. The electric field measurement has the advantage of detecting electrified clouds which may not be producing lightning flashes but are nevertheless dangerous because an aircraft can trigger lightning; however this is a relatively short range system (on the order of 10 to 20 miles). The interferometer, which responds to RF pulses from lightning, has the advantage of long range detection (more than 100 miles) and can map the position of lightning flashes in a manner similar to the way radar maps areas of rain. Thus the systems complement each other. GRA

### 03 AIR TRANSPORTATION AND SAFETY

**N86-30706#** Koninklijk Inst. voor de Marine, Den Helder (Netherlands).

**THE BLACK BOX. SILENCE IS SILVER, SPEECH IS GOLDEN [DE ZWARTE DOOS. ZWIJGEN IS ZILVER, SPREKEN IS GOUD]**

A. W. POL Jul. 1984 151 p Partly in DUTCH and ENGLISH (ESA-86-97394) Avail: NTIS HC A08/MF A01

Requirements, design and development, and feasibility aspects of Flight Data Recorders (FDR) and Cockpit Voice Recorders (CVR) are treated. Examples of existing systems (e.g., the U.S. Navy Universal Locator Airborne Data Systems, and the solid-state FDR) are given. Installation of FDR/CVR combined crash recorders in Westland Lynx helicopters is discussed. Aircraft accident relevant information, necessary adaptations of the helicopter, and feasibility were investigated. As the present aircraft indicating instruments often contain information after accidents it is concluded that installation of only a CVR is a feasible solution. However, future aircraft instruments (e.g., digital computers, and displays) might necessitate FDRs also. ESA

**N86-30707#** General Accounting Office, Washington, D. C. Resources Community and Economic Development Div.

**AVIATION WEATHER HAZARDS: FAA (FEDERAL AVIATION ADMINISTRATION) SYSTEM FOR DISSEMINATING SEVERE WEATHER WARNINGS TO PILOTS Briefing Report**

Apr. 1986 34 p (PB86-195070; GAO/RCED-86-152BR; B-222882) Avail: NTIS HC A03/MF A01 CSCL 01B

Controllers at the nation's busiest airports sometimes do not have time to disseminate weather information to pilots. In addition, when weather information is given, it may not be given as soon as possible because controllers are too busy performing their primary duty of separating aircraft. FAA's procedure for communicating weather warnings by having controllers read them over their radio frequencies is too slow to avoid potential hazards, and some pilots may not receive any warning because of radio frequency changes. On-airport weather detection systems (LLWAS and ASR) do not provide controllers adequate detection or information about potentially hazardous weather because the radar cannot detect storm intensities, and the wind shear system cannot reliably detect the most dangerous form of wind shear, microbursts. GRA

**N86-30708#** Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).

**INTERACTION BETWEEN EMP (ELECTROMAGNETIC PULSE), LIGHTNING AND STATIC ELECTRICITY WITH AIRCRAFT AND MISSILE AVIONICS SYSTEMS**

1986 144 p Presented at a Lecture Series, Ankara, Turkey, 29-30 May 1986, Oberpfaffenhofen, West Germany, 2-3 Jun. 1986, and The Hague, The Netherlands, 5-6 Jun. 1986; sponsored by Avionics Panel and the Consultant and Exchange Programme of AGARD (AGARD-LS-144; ISBN92-835-1528-5) Avail: NTIS HC A07/MF A01

Interactions between transient electromagnetic waves with aircraft and missile avionics systems are described. Transient electromagnetic waves include electromagnetic pulses (EMP) from nuclear explosions, lightning, and static electricity. Interactions are introduced by coupling of EMP and lightning induced currents and voltages with avionics components. Shielding against these interactions is discussed with respect to induced currents and voltages from EMP and lightning, and induced voltages from static charging effects. Several examples of interactions, coupling, shielding, and measurement techniques are presented. This Lecture Series, sponsored by the Avionics Panel of AGARD, has been implemented by the Consultant and Exchange Program of AGARD. Author

**N86-30709#** Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).

**CRASHWORTHINESS OF AIRFRAMES**

1986 34 p Presented at the 61st Meeting of the Structures and Materials Panel of AGARD in Oberammergau, West Germany, 8-13 Sep. 1985 (AGARD-R-737; ISBN92-835-1525-0) Avail: NTIS HC A03/MF A01

At its 61st Meeting the AGARD Structures and Materials Panel heard three papers as a preliminary to setting up a Sub-Committee on this topic; this publication contains these papers. They survey a range of theoretical and experimental aspects of crashworthiness relating to metallic structures. For structures made of these materials theoretical methods are becoming useful design tools, but much further development is required before composite structures can be satisfactorily handled. There is a very great need for a data base of reliable experimental information (including accident data bases) on both metallic and composite structures. Author

### 04

#### AIRCRAFT COMMUNICATIONS AND NAVIGATION

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

**A86-43484#**

**AN INERTIAL NAVIGATION SYSTEM WITH SINGLE-AXIS STABILIZATION**

S. REN and Z. LI (Northwestern Polytechnical University, Xian, People's Republic of China) Acta Aeronautica et Astronautica Sinica, vol. 6, Dec. 1985, p. 578-584. In Chinese, with abstract in English.

The principles, error model and simulation results of an inertial navigation system with single-axis stabilization are addressed. The error propagation characteristics are obtained by means of covariance analysis based on the developed error model. A series iteration technique is adopted for computation. An assumed trajectory of a short range missile is used for simulating the error covariance propagation. The principle of operation of the present system is simpler than that of a pure strapdown system, and lessens the requirements of the gyro dynamic range. As a result, it is possible to utilize a cheap gyro instead of an expensive one in the execution of the same navigation and guidance missions. Author

**A86-43708**

**APPLICATIONS OF SATELLITE COMMUNICATIONS TECHNOLOGIES TO INTERNATIONAL CIVIL AVIATION**

D. W. FREER (International Civil Aviation Organization, Air Navigation Bureau, Montreal, Canada) IN: SPACECOM '85; Space and Radiocommunications Symposium, 5th, Paris and Le Bourget, France, June 5-7, 1985, Speakers' Papers. Geneva, Switzerland, International Telecommunication Union, 1985, p. 75-82.

ICAO's considerations of satellite technologies for civil aviation from 1964-1985 are reviewed. The recommendations of the Application of Space Technology Relating to Aviation panel (1969) and the Aeronautical Satellite Service (1972) for the use of satellite-communication systems in aircraft are discussed. The development of a new international civil air infrastructure by the Future Air Navigation Systems (FANS) committee is examined. The disadvantages of satellite-communications and navigation systems, which include line-of-sight propagation constraints, limited flight routing flexibility, and the absence of air-ground data interchange capability, are studied. The infrastructure proposed by the FANS committee includes a satellite-based communications system with digital data and voice transmissions, nonsatellite ground-based communication capability in airport areas, global satellite navigation service, coverage from the earth surface to

the 21,336 m range, and the integration of satellite-based communications, navigation, and surveillance systems. Policy issues affecting the implementation of the proposal are analyzed. I.F.

**A86-43862****A COMPUTER MODEL TO EVALUATE AIRBORNE RECEIVER PERFORMANCE IN INTERFERENCE ENVIRONMENTS**

D. P. KOESTER, L. E. SMITH, R. R. STEVENS, JR., and C. E. COOK (MITRE Corp., Bedford, MA) IEEE Transactions on Communications (ISSN 0090-6778), vol. COM-34, May 1986, p. 462-474. refs  
(Contract F19628-84-C-0001)

A computer model is described to evaluate airborne radio performance in a mixed environment of friendly and hostile emitters. A new performance criterion, the communications operability volume, is introduced. This criterion permits operational, scenario-based comparisons of various radio designs over a range of interference environments. Communications operability volumes can be calculated for different waveforms, receiver antenna patterns (including adaptive arrays), and detection thresholds. An empirical propagation algorithm is used to calculate path losses and/or maximum communications range. The computer model provides several types of graphic outputs that are used to compare anti-jam or electromagnetic compatibility performance for different radio designs at various locations relative to the sources of interference in a scenario. Author

**A86-44279****VLF RADIO NAVIGATION SYSTEMS [RADIONAVIGATSIONNYE SISTEMY SVERKHDLINNOVOLNOVOGO DIAPAZONA]**

S. B. BOLOSHIN, G. A. SEMENOV, A. S. GUZMAN, G. V. GOLOVUSHKIN, and P. V. OLIANIUK Moscow, Izdatel'stvo Radio i Sviaz', 1985, 264 p. In Russian. refs

The book presents the fundamentals of the theory, operation, and implementation of VLF navigation systems commonly used for the long-range navigation of aircraft and ships. Topics discussed include the effect of propagation conditions on the operation of VLF navigation systems, methods of coordinate estimation under conditions on incomplete information on the correction model parameters, and system characteristic predictions. The discussion also covers methods of resolving the ambiguity of phase measurements, ground transmitting stations, and combining VLF navigation systems with other means of navigation. V.L.

**A86-44399****A GRAPHIC TERMINAL FOR AIR TRAFFIC CONTROL OF CANADIAN MILITARY AIRPORTS [LA REALISATION D'UN TERMINAL GRAPHIQUE POUR LE CONTROLE DU TRAFIC AERIEN D'AEROPORTS MILITAIRES CANADIENS]**

C. Y. LAPORTE and J. L. HOULE (Montreal, Universite, Montreal, Canada) Control and Computers (ISSN 0315-8934), vol. 14, no. 2, 1986, p. 38-43. In French. refs

As part of the Terminal Aids Replacement Program, a terminal for the real-time display of up to 60 targets within a 32 nautical mile radius, with a lag of no more than 22.5 degrees with respect to the radar antenna position, was developed. Specifications were for compatibility with NOVA 3 minicomputer transmission rates, graphic translator and CRT display, 0.5 s command reaction time, and the ability to distinguish targets from other objects. Software and different processor architectures are described, and cost and reliability are considered to evaluate the advantages and disadvantages of monoprocessor versus multiprocessor structures. R.R.

**A86-46140****DME/P - A NECESSARY MLS COMPONENT FOR THE FUTURE**

G. K. ROMREL (E-Systems, Inc., Montek Div., Salt Lake City, UT) ICAO Bulletin, vol. 41, March 1986, p. 18-21.

The design and capabilities of the precision distance measuring equipment (DME/P) of the microwave landing system (MLS) are analyzed. The DME/P is a landing aid used to guide an aircraft

throughout the coverage volume of the MLS to a safe landing. The DME/P operates with a fast-rise-time pulse and coverage in the 2.4-6,100 m altitude range is provided by initial and final approach modes; the initial approach mode performs in the 13 km range and final approach mode operates from 13 km to landing. The detection accuracy possible due to the cos/cos-squared pulse-shaped signal and the Delay-Attenuation-Compare detection of the DME/P is discussed. The use of dynamic automatic delay correction circuits to eliminate potential false detection is examined. The transponder integrity design and the installation of the DME/P into aircraft are described. I.F.

**A86-46142****ILS GOAL - AUTOMATIC LANDINGS, SAFETY**

P. LAUX (Thomson-CSF, Division Systemes Defense et Controle, Bagnaux, France) ICAO Bulletin, vol. 41, March 1986, p. 27-29.

The design and functions of the instrument landing system (ILS) 381 T are described. The ILS allows for interaction between the pilot, aircraft, and the ground controller. The reliability and stability provided by the transmission chain of the IRS (VHF or UHF signal generator, amplifier and phase feedback loop of the signal, and a linear wideband amplifier) are analyzed. The use of a two-frequency array with 13-radiating elements, a 25-element, wide-aperture array, and a Thomson-CSF 'M' array to reduce the interference from reflecting objects is discussed. The monitor channels and transfer logic employed by the ILS 381 T are examined. The capabilities of the remote maintenance monitoring of the IRS 381 are considered. I.F.

**A86-46146****THE PROTECTED VOLUME OF AIRSPACE GENERATED BY AN AIRBORNE COLLISION AVOIDANCE SYSTEM**

R. L. FORD (Royal Signals and Radar Establishment, Malvern, England) Journal of Navigation (ISSN 0020-3009), vol. 39, May 1986, p. 139-158. Research supported by the Civil Aviation Authority. refs

The features of the Traffic Alert and Collision Avoidance System (TCAS) II are described, and the operational principles of the system are explained. The shape, size, and orientation of the protected volume of the airspace are derived, showing how the threat detection logic used by TCAS II generates a volume of protected airspace enclosing own aircraft. It is also shown how the essential features of the protected volume may be used to calculate alarm rates for some simple traffic patterns. The TCAS III version, still under development, is intended to provide both horizontal and vertical escape maneuvers. I.S.

**A86-46457#****GRAVITY-INDUCED ERRORS IN AIRBORNE INERTIAL NAVIGATION**

D. W. HARRIMAN and J. C. HARRISON (Geodynamics Corp., Santa Barbara, CA) (Guidance and Control Conference, Seattle, WA, August 20-22, 1984, Technical Papers, p. 285-295) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 9, July-Aug. 1986, p. 419-426. Previously cited in issue 21, p. 2991, Accession no. A84-43433. refs

**N86-29800\*#** University of Southern Colorado, Pueblo. School of Applied Science and Engineering Technolo

**TECHNOLOGY RESEARCH FOR STRAPDOWN INERTIAL EXPERIMENT AND DIGITAL FLIGHT CONTROL AND GUIDANCE Final Technical Report, 1 Oct. 1979 - 31 Dec. 1984**

R. A. CARESTIA and D. E. COTTRELL 1985 113 p  
(Contract NCC2-41)  
(NASA-CR-176907; NAS 1.26:176907) Avail: NTIS HC A06/MF A01 CSCL 17G

A helicopter flight-test program to evaluate the performance of Honeywell's Tetrad - a strapdown, laser gyro, inertial navigation system is discussed. The results of 34 flights showed a mean final navigational velocity error of 5.06 knots, with a standard deviation of 3.84 knots; a corresponding mean final position error of 2.66 n.mi., with a standard deviation of 1.48 n.mi.; and a modeled mean-position-error growth rate for the 34 tests of 1.96 knots,



## 04 AIRCRAFT COMMUNICATIONS AND NAVIGATION

with a standard deviation of 1.09 knots. Tetrad's four-ring laser gyros provided reliable and accurate angular rate sensing during the test program and on sensor failures were detected during the evaluation. Criteria suitable for investigating cockpit systems in rotorcraft were developed. This criteria led to the development of two basic simulators. The first was a standard simulator which could be used to obtain baseline information for studying pilot workload and interactions. The second was an advanced simulator which integrated the RODAAS developed by Honeywell into this simulator. The second area also included surveying the aerospace industry to determine the level of use and impact of microcomputers and related components on avionics systems. M.G.

**N86-29801#** Ohio Univ., Athens. Dept. of Electrical and Computer Engineering.

### **INVESTIGATIONS FOR IMPROVING OPERATIONAL RELIABILITY AND MAINTAINABILITY OF INSTRUMENT LANDING SYSTEM COMPONENTS. VOLUME 1: TEXT AND APPENDICES Final Report, Feb. 1983 - Feb. 1986**

R. H. MCFARLAND, W. D. PHIPPS, L. D. BRADY, J. DENNIS, and J. D. LONGWORTH Feb. 1986 272 p  
(Contract DTFA01-83-C-20025)  
(DOT/FAA/PM-86/7,1-VOL-1; OU/AEC/EER-79-1-VOL-1) Avail: NTIS HC A12/MF A01

An investigation of anomalous performance of the glide slope at Lambert-St. Louis is reported. An analysis of the Instrument Landing System (ILS) Reference Datum Heights (RDH) is reported, as well as the results of an investigation of glide slope critical areas. The feasibility of developing ground bases checking techniques for validating the Sideband Reference (SBR) glide slope is presented as well as an assessment of the current standards and tolerances used to qualify glide slope structure. In addition, a proposed methodology for mathematical model validation is discussed. Author

### **N86-29802#** Federal Aviation Administration, Washington, D.C. **ENGINEERING PERFORMANCE EVALUATION OF SMALL COMMUNITY AIRPORT MICROWAVE LANDING SYSTEM (TI-MODEL) AT PHILADELPHIA INTERNATIONAL AIRPORT RUNWAY 17 Final Report**

G. D. ADAMS and C. E. RICHARDSON Aug. 1986 68 p  
(Contract DTFA01-82-Y-10521)  
(FAA/PM-86/24) Avail: NTIS HC A04/MF A01

The Microwave Landing System (MLS) program is designed to meet both civil and military operational needs. It will eventually replace the Instrument Landing System (ILS). After a system/equipment development phase, the Federal Aviation Administration in 1979 began a Service Test And Evaluation Program (STEP) to obtain experience for developing criteria for siting, installation and preliminary operational procedures. Feasibility demo ground equipment from the development phase was used and user aircraft were equipped with MLS receivers. This report contains engineering evaluation of the FAA Technical Center flight test data taken on the Texas Instruments' manufactured Small Community MLS, as installed for STEP at Philadelphia International Airport Runway 17. The equipment performance was found to generally meet the FAA-STD-022b Path Following Error and Control Motion Noise requirement, but not the linearity requirement. Apparent aircraft propeller induced noise effects were identified. Author

### **N86-29804#** Mitre Corp., McLean, Va. **THE CONCEPT OF ALMOST-PARALLEL IFR (INSTRUMENT FLIGHT RULES) APPROACHES TO PARALLEL RUNWAYS**

A. C. SILVA Mar. 1986 52 p  
(Contract DTFA01-84-C-00001)  
(AD-A166485; MTR-86W11; FAA-DL5-86-1) Avail: NTIS HC A04/MF A01 CSCL 01B

Under today's rules independent parallel approaches are restricted to runways separated by at least 4300 feet. Currently the FAA is investigating a proposal to achieve reductions down to 3000 feet with the use of an improved surveillance system (1 milliradian accuracy/1 second update). This paper proposes new

procedures to achieve such reduction, using existing radars, by executing almost-parallel MLS or ILS approaches. Almost-parallel approaches include curved paths where very shallow rates of turn are required and offset straight paths where the angle of offset with respect to the extended runway centerline is less than 3 degrees. Some issues of concern that arise, such as blunder resolution and pilot's loss of sight of other approach course during curved approaches, are discussed in this paper. Alternatives for an early implementation and site-specific sample applications are presented. The objective of this paper is to present in a concise manner this preliminary concept that has already generated some interest as a solution to reduced parallel operations. As with any new concept, analysis by all concerned parties have to be performed followed by simulations and/or demonstrations before the concept can be considered implementable. Author (GRA)

### **N86-29805#** Air Command and Staff Coll., Maxwell AFB, Ala. **WILL THE USAF NEED GROUND-BASED AIR TRAFFIC CONTROL RADAR IN THE YEAR 2000?**

G. L. VARN Apr. 1986 49 p  
(AD-A166504; AD-E750871; ACSC-86-2585) Avail: NTIS HC A03/MF A01 CSCL 17G

Advanced technology in military aviation is developing rapidly. The Global Positioning System (GPS) and Microwave Landing System (MLS) will give the pilot precision navigation capability when fully deployed in the 1990s. The Joint Tactical Information Distribution System (JTIDS) will give the pilot the capability to display enemy and friendly aircraft in his area in his cockpit. At the same time, our mobile air traffic control (ATC) radars are aging and need to be replaced. But, with the new technology in the cockpit, it may be more feasible to eliminate ground-based ATC radar and let the pilot do his own ATC from the cockpit. This study examines the feasibility of a cockpit-based ATC system by looking at the requirement for military ATC, specific capabilities that new technologies give the pilot, and human considerations in a cockpit-based ATC system. The study concludes that a cockpit-based ATC system is not feasible and that there will be a need for ground-based ATC radar, at least through the year 2000. Author (GRA)

### **N86-29806#** Lear Siegler, Inc., Grand Rapids, Mich. Inst. Div. **OPERATING AND SUPPORT HAZARD ANALYSIS FOR THE SELF-CONTAINED NAVIGATION SYSTEM LSI MODEL 6216A, B AND C GROUP A**

J. T. REEVES 13 Mar. 1986 20 p  
(Contract F09603-85-C-1224)  
(AD-A166815; GRR-6216-014) Avail: NTIS HC A02/MF A01 CSCL 17G

This document constitutes the Operating and Support Hazard Analysis (O&SHA) for the C-130 Self-Contained Navigation System (SCNS) installation. It provides a hazard assessment of use and maintenance of the SCNS installation. The purpose of an O&SHA is to identify and control hazards to personnel and to the system, or related to production, installation, maintenance, test, operation, etc. This O&SHA is limited to installation and checkout of the A-kits and system and to the safety of personnel working in or around the equipment, including ground and flight crews. The scope of this analysis for Data Item 0103 is limited to the SCNS installation task 'A-kit' components (viz. wiring harness, brackets, racks, control panels, relay boxes, circuit breakers), B-kit components (viz. ICDUS, BICU, DVS, INU), and the physical interfaces with existing equipment (viz. CACD or Sensors, Radar, Air Data Sensors). These items will be analyzed in respect to safe installation, safe hardware, and safe usage (viz. installation, removal, in-place test, and handling). GRA



**N86-29807#** Lear Siegler, Inc., Grand Rapids, Mich. Inst. Div.  
**SUBSYSTEM HAZARD ANALYSIS FOR THE LSI MODELS 6216A, B AND C SELF-CONTAINED NAVIGATION SYSGEM GROUP A**

J. T. REEVES 13 Mar. 1986 19 p  
 (Contract F09603-85-C-1224)  
 (AD-A166816; GRR-6216-013) Avail: NTIS HC A02/MF A01  
 CSCL 09E

This document constitutes the Subsystem Hazard Analysis (SSHA) for the C-130 Self-Contained Navigation System (SCNS) installation. It provides a safety assessment of the SCNS installation. The purpose of an SSH is to evaluate the parts making up a system for items that could adversely affect the system safety through component failure, performance degradation, functional failure and inadvertent operation. The scope of this analysis for Data Item 0103 is limited to the SCNS installation task A kit components (viz. wiring harness, brackets, racks control panels, relay boxes, circuit breakers), B-kit components (viz., ICDUs, BICU, DVS, INU), and the physical interfaces with existing equipment (viz., CADC or Sensors, Radar, Air Data Sensors). These items will be analyzed in respect to safe installation, safe hardware, and safe usage (viz. installation, removal, in-place test, and handling). GRA

**N86-30711#** Radio Technical Commission for Aeronautics, Washington, D. C.

**MINIMUM OPERATIONAL PERFORMANCE STANDARDS FOR AIRBORNE AREA NAVIGATION EQUIPMENT USING OMEGA/VLF INPUTS**

May 1986 187 p Supersedes RTCA/DO-140  
 (RTCA/DO-190; RTCA/DO-140) Avail: NTIS HC A09/MF A01

Minimum operational performance standards for airborne area navigation equipment (2D and 3D) operated in the National Airspace System (NAS) using Omega/Very Low Frequency (VLF) signals are presented. Incorporated within these standards are equipment characteristics that should be useful to users, designers, manufacturers, and installers of the equipment. The performance functions and features are defined for a 2D system which performs both lateral and vertical guidance. Equipment may be manufactured and tested to meet 2D or 3D requirements (or both) in the in route mode. Author

**N86-30712#** Federal Aviation Agency, Atlantic City, N.J. Technical Center.

**COMPREHENSIVE TEST AND EVALUATION OF THE DALMO VICTOR TCAS 2 INDUSTRY PROTOTYPES Final Report, Feb. 1986**

A. REHMANN Feb. 1986 245 p  
 (FAA/PM-862; FAA/CT-86/2) Avail: NTIS HC A11/MF A01

The test procedure and results of a five-part comprehensive evaluation of two prototype minimum Traffic Alert and Collision Avoidance System (TCAS) II units are described. The five parts include: (1) hardware and software verification, (2) cockpit display and operational procedure verification, (3) pilot and inflight observer training, (4) TCAS II demonstration to the aviation community, and (5) readiness for airworthiness certification testing. Overall, the minimum TCAS II prototype has matured into an acceptable test-bed for the 8-month inservice evaluation in a commercial airliner. System reliability has improved and pilot acceptance was generally good. It is expected that minimum TCAS II will provide a valuable service to airline pilots. Author

**N86-30714#** Computer Technology Associates, Inc., Englewood, Colo.

**OPERATIONS CONCEPT FOR THE TCCC (TOWER CONTROL COMPUTER COMPLEX) MAN-MACHINE INTERFACE Final Report**

H. L. AMMERMAN, E. S. BECKER, L. J. BERGEN, D. K. DAVIES, and E. E. INMAN 28 Mar. 1986 771 p  
 (Contract DTFA01-85-Y-01034)  
 (AD-A166899; FAA/AP-86/02) Avail: NTIS HC A99/MF A02  
 CSCL 17G

Operations Concept for the TCCC Man-Machine Interface analyzes the tower Air Traffic Controller's job in the Tower Control Computer Complex (TCCC) environment. It considers the operations in today's towers and the automated capabilities planned for the TCCC, to reach an understanding of the Controller's job after TCCC implementation. Three separate positions are analyzed: Local Control, Ground Control, and Clearance Delivery/Flight Data. Analysis results include composition graphs and narratives showing the logical flow through the sub-activities of the three positions; task analysis, presenting the tasks of each position; task characterizations, including information requirements, cognitive/sensory attributes, and performance criteria associated with each task; and a top-level dialogue description summarizing the interaction between controller and TCCC. Traceability between tasks and system level specification requirements is also provided. GRA

**N86-30715#** Federal Aviation Agency, Atlantic City, N.J.

**HARDWARE PERFORMANCE ANALYSIS OF THE BASIC NARROW MICROWAVE LANDING SYSTEM (MLS) AT WASHINGTON NATIONAL AIRPORT (DCA) IN THE SERVICE TEST AND EVALUATION PROGRAM (STEP) Final Technical Note, 1 Jan. 1981 - 30 Jun. 1983**

M. S. PLOTKA Sep. 1985 141 p  
 (AD-A166916; FAA/CT-TN85/19) Avail: NTIS HC A07/MF A01  
 CSCL 17G

This is the final technical note for the Hardware Performance Analysis of the Basic Narrow Microwave Landing System (MLS) at Washington National Airport (DCA) in the Service Test and Evaluation Program (STEP) for the period January 1, 1981 through June 30, 1983. The MLS configuration, limits of signal operation, system and subsystem operation, data collection and analysis are described. Equipment and environmental problem areas uncovered during the test and evaluation are discussed in the Results section of this report. Chargeable failures are identified and listed and engineering investigations are discussed. Remote Maintenance Monitoring System (RMMS) data analysis are presented. Conclusions and recommendations are listed. GRA

## 05

**AIRCRAFT DESIGN, TESTING AND PERFORMANCE**

Includes aircraft simulation technology.

**A86-43477#**

**APPLICATION OF ROTOR INDUCED VELOCITY FIELD OF THE VORTEX THEORY TO THE STUDY OF STABILITY AND CONTROLLABILITY OF HELICOPTER WITH HINGELESS ROTOR**

Z. XIN (Air Force Research Institute, People's Republic of China) and S. WANG (Nanjing Aeronautical Institute, People's Republic of China) Acta Aeronautica et Astronautica Sinica, vol. 6, Dec. 1985, p. 521-529. In Chinese, with abstract in English. refs

With the aim of developing a new rotor system, a method is presented for calculation of stability and controllability of helicopter with a hingeless rotor. The effects of nonuniformity in rotor-induced velocity distribution and blade flapping elasticity are taken into account and investigated in detail. This is the first time that the

first harmonic term of rotor-induced velocity distribution derived from the generalized vortex theory of rotor is employed, and a close form of equation for the induced velocity and circulation is established. Finally, analytic formulae suitable to engineering applications are given which consider the effects of the motion parameter, control parameter, blade flapping elasticity, and so on. Also, the effect of the second flapping mode on stability and controllability of helicopter with hingeless rotor is discussed. The calculations show that only the first flapping bending mode should be taken into account in stability and controllability calculation of helicopter with hingeless rotor in the range of  $\mu$  less than 0.3. Finally, a typical Bo-105 helicopter is taken as a numerical example, and it is found that the results are in good agreement with its flight-test data. Author

**A86-43487#  
IMPROVEMENT OF SERVO SYSTEMS FOR FLIGHT SIMULATOR**

D. SUN (China Precision Engineering Institute for Aircraft Industry, People's Republic of China) Acta Aeronautica et Astronautica Sinica, vol. 6, Dec. 1985, p. 597-601. In Chinese, with abstract in English.

A great deal of experimental research was done on simulator servo systems during the development of the YMT-S1 type simulator. A modification of its design was accomplished by improving a 'double velocity' servo system, a velocity or position servo system with velocity differential feedback, and an 'integral control' servo system. The experiments have proved that these three types of servo system have tangible results in improving performances of the simulator. Their formation, working principles and results are presented. Author

**A86-43490#  
APPLICATION OF HARMONIC ANALYSIS METHOD TO RESEARCH ON ROTOR AIRLOADS**

Z. QIU (Chinese Helicopter Research and Development Institute, People's Republic of China) Acta Aeronautica et Astronautica Sinica, vol. 7, Feb. 1986, p. 11-18. In Chinese, with abstract in English.

Using the rotor vortex theory, the rotor airflow and the rotor induced velocity are developed into Fourier series. The flow distribution along the blade spanwise is expressed in terms of segment-by-segment linear functions and the induced velocity equations and the flow equations are derived. The engineering application of the rotor vortex theory is provided. Then the induced velocity and its harmonic components are obtained to provide a quantitative basis for the vortex model. To calculate each order harmonic components of the induced velocity a simplified method is forwarded which considers the effects of each order flow while neglecting those of a higher order. The method saves computer time and is of significant benefit. Author

**A86-43776  
DURABILITY AND DAMAGE TOLERANCE IN AIRCRAFT DESIGN; PROCEEDINGS OF THE THIRTEENTH SYMPOSIUM, PISA, ITALY, MAY 22-24, 1985**

A. SALVETTI, ED. and G. CAVALLINI, ED. (Pisa, Universita, Italy) Symposium sponsored by the International Committee on Aeronautical Fatigue; Organized by the Italian Association for Aeronautical Fatigue. Warley, England, Engineering Materials Advisory Services, Ltd., 1985, 684 p. For individual items see A86-43777 to A86-43798.

The conference presents papers on fatigue and damage tolerance work during the aircraft design process, fatigue life prediction in the crack initiation and crack propagation stages, the significance of flight-simulation fatigue tests, fatigue life under compression-dominated spectra, fatigue cracking of aluminum under spectrum loading at various humidities, increasing fatigue and crack growth lives of short-edge-margin holes and the evaluation of materials degradation due to cyclic loading in composites. Also considered are U.S. Army requirements for damage tolerance of composite helicopter structure, the damage tolerance test program of the Fokker 100, a continuing structural

integrity program for transport aircraft, a maintenance system by means of the damage tolerance principle and a rationale for the safe operation of an aircraft fleet having known cracks in its primary structure. Papers are also presented on the residual strength characterization of jet transport structures, a simple crack closure model for predicting fatigue crack growth under flight simulation loading, the effect of residual stress fields at notches on fatigue crack growth and the certification of airframes and components in metals and components. K.K.

**A86-43777  
FATIGUE AND DAMAGE TOLERANCE WORK DURING THE AIRCRAFT DESIGN PROCESS**

L. JARFALL (SAAB-Scania AB, Linkoping, Sweden) IN: Durability and damage tolerance in aircraft design; Proceedings of the Thirteenth Symposium, Pisa, Italy, May 22-24, 1985. Warley, England, Engineering Materials Advisory Services, Ltd., 1985, p. 1-31. refs

Stress office routine procedures for the handling of fatigue life and damage tolerance work during the design process are reviewed and discussed. Four main tasks are identified: Handling of spectra, Planning of tests, Fatigue life and Crack growth predictions. Examples of procedures and experiences are taken from an actual fighter aircraft project. Author

**A86-43779  
THE SIGNIFICANCE OF FLIGHT-SIMULATION FATIGUE TESTS**

J. SCHIJVE (Delft, Technische Hogeschool, Netherlands) IN: Durability and damage tolerance in aircraft design; Proceedings of the Thirteenth Symposium, Pisa, Italy, May 22-24, 1985. Warley, England, Engineering Materials Advisory Services, Ltd., 1985, p. 71-170. refs

Results of flight-simulation fatigue tests drawn from many literature sources are analyzed to reveal the effects of truncating high loads, omitting low-amplitude cycles, the minimum stress of ground-air-ground cycles, design stress levels, sequence of flights and loads within a flight and material thickness. Tests with gust-dominated wing load spectra and maneuver-dominated wing load spectra are considered separately, which is also done for results on crack initiation life and on crack growth. Special attention is paid to standard load histories TWIST and FALSTAFF. Recommendations are given for the planning of flight-simulation tests, especially for full-scale tests. Attention is paid to comparative flight-simulation tests and the meaning of such tests for fatigue prediction problems. Author

**A86-43785  
U.S. ARMY REQUIREMENTS FOR DAMAGE TOLERANCE OF COMPOSITE HELICOPTER STRUCTURE**

J. P. WALLER and R. S. MCLELLON (U.S. Army, Applied Technology Laboratory, Fort Eustis, VA) IN: Durability and damage tolerance in aircraft design; Proceedings of the Thirteenth Symposium, Pisa, Italy, May 22-24, 1985. Warley, England, Engineering Materials Advisory Services, Ltd., 1985, p. 297-316.

Preliminary U.S. Army damage tolerance design criteria are presented with a rationale for their development. A brief description of previous Army experience in the application of composites on military helicopters is included with a discussion of relevant technology and future applications. Author

**A86-43786  
DAMAGE TOLERANCE TEST PROGRAM OF THE FOKKER 100**

A. A. JONGEBREUR, E. P. LOUWAARD, and R. V. VAN DER VELDEN (Fokker, Schiphol, Netherlands) IN: Durability and damage tolerance in aircraft design; Proceedings of the Thirteenth Symposium, Pisa, Italy, May 22-24, 1985. Warley, England, Engineering Materials Advisory Services, Ltd., 1985, p. 317-349. refs

The Fokker 100 is an advanced new twin turbofan aircraft with a redesigned super critical wing and increased utilization of composites. The objective with regard to damage tolerance is to

satisfy the latest requirements. During the decision making process of how this is accomplished in terms of analysis and supporting tests, several special aspects were considered, e.g., the availability of test- and operational experience of the F28 'Fellowship', with which the Fokker 100 has much in common, and the time schedule of the Fokker 100 program. The test program as finally adopted, comprises full scale flight simulation testing for a large part of the aircraft. Author

A86-43787

**AIRBUS INDUSTRIE A310 AND A300-600 EXPERIENCE WITH PRACTICAL APPLICATIONS OF DAMAGE TOLERANCE DESIGN IN FUSELAGE PRIMARY STRUCTURE**

H.-J. SCHMIDT and C. L. HAMMOND (Messerschmitt-Boelkow-Blohm GmbH, Hamburg, West Germany) IN: Durability and damage tolerance in aircraft design; Proceedings of the Thirteenth Symposium, Pisa, Italy, May 22-24, 1985. Warley, England, Engineering Materials Advisory Services, Ltd., 1985, p. 351-382. refs

A brief description of the current damage tolerance requirements for a civil aircraft primary structure is given as well as examples of application to the A310 and A300-600 fuselage structure. Comparisons between analysis and full-scale test results for selected points are presented along with resulting repercussions for future design and for the development of the required inspection programs. Finally, conclusions and recommendations are given for the future application of a damage tolerance design and for additional work required to better understand the damage tolerance behavior of complex structures. Author

A86-43788

**CONTINUED AIRWORTHINESS OF DAMAGE TOLERANT AIRCRAFT**

D. R. TURNER, R. BANISTER, and P. TO IN: Durability and damage tolerance in aircraft design; Proceedings of the Thirteenth Symposium, Pisa, Italy, May 22-24, 1985. Warley, England, Engineering Materials Advisory Services, Ltd., 1985, p. 383-393.

The CL-600 was the first aircraft to address the damage tolerance evaluation of FAR 25.571 amendment 45. Compliance was shown and FAA type approval was granted in February 1983. This paper discusses some of the certification activities which occurred after this time due to a reevaluation of the CL-600 by Transport Canada and also the introduction of the CL-601 version with a General Electric Engine. The impact on the maintenance and repair manuals is discussed. Author

A86-43790

**DAMAGE TOLERANCE AND DURABILITY IN THE DESIGN OF A SHORT-HAUL TURBOPROP AIRCRAFT**

A. GALASSO, A. DEL CORE (Aeritalia S.p.A., Gruppo Velivoli Trasporto, Pomigliano d'Arco, Italy), G. CAVALLINI, and A. LANCIOTTI (Pisa, Universita, Italy) IN: Durability and damage tolerance in aircraft design; Proceedings of the Thirteenth Symposium, Pisa, Italy, May 22-24, 1985. Warley, England, Engineering Materials Advisory Services, Ltd., 1985, p. 423-472.

The fatigue design of the ATR 42 aircraft is presented from the point of view of its durability and damage tolerance. An account is given of the durability tests carried out on joint specimens and of the damage tolerance tests carried out on both standard specimens and stiffened panels. The various aspects of full-scale fatigue tests are described, and included in test objectives are the following: (1) the verification of the fatigue life objectives of the ATR 42 airframe, (2) the identification of fatigue critical areas by means of a test program that represents service loading conditions, and (3) the examination of crack propagation as well as inspection and repair methods in an effort to define inspection intervals and repair methods. It is noted that this test is presently running successfully and has reached 12,000 simulated flights. K.K.

A86-43795

**RESIDUAL STRENGTH CHARACTERIZATION OF JET TRANSPORT STRUCTURES**

U. G. GORANSON, C. K. GUNTHER, and W. T. HARDRATH (Boeing Commercial Airplane Co., Seattle, WA) IN: Durability and damage tolerance in aircraft design; Proceedings of the Thirteenth Symposium, Pisa, Italy, May 22-24, 1985. Warley, England, Engineering Materials Advisory Services, Ltd., 1985, p. 585-603. refs

The principles of residual strength analysis procedures developed to account for local redistribution and component failures are outlined and their applicability to damaged jet transport structures is assessed. A model which predicts maximum load and stable crack growth for stiffened panels is described. It operates on the basis of compatibility of displacements at the fastener location, considers elastic-plastic behavior for the fasteners and stingers, takes any elemental failure into account and is capable of analyzing stable crack growth in the skin panel material. A residual strength analysis procedure which takes the transition between linear elastic fracture mechanics failure and net section yield into consideration is also developed. K.K.

A86-43930

**THE OPTIMIZATION OF SEAPLANES - NEW CHANCES AND REQUIREMENTS REGARDING FLYING BOATS [ZUR OPTIMIERUNG VON SEEFLUGZEUGEN - NEUE CHANCEN UND ANFORDERUNGEN AN FLUGBOOTE]**

RWTH-Themen, no. 2, 1986, p. 52-56. In German.

The present situation concerning a demand for seaplanes is considered. It is found that aircraft which are designed to take off from and land on water would be very useful for a number of countries. Thus, in countries consisting of many islands, such as the Philippines and Indonesia, such aircraft could provide a very convenient means of transportation for people, freight, and mail. Other countries which could profit from a use of such aircraft are those having suitable bodies of water in their interior, taking into account Canada, Brazil, Finland, and countries which can utilize lake and river systems in Africa. The aircraft considered could also be very useful for surveillance and rescue operations, and in operations against forest fires it would be easier to take up water by landing on a body of water. The requirements which the aircraft would have to satisfy to perform their prospective functions are discussed along with suitable aircraft design features. G.R.

A86-44001

**X-WING ROTOR SYSTEMS TEST VEHICLE SCHEDULED FOR FLIGHT IN OCTOBER**

S. W. KANDEBO Aviation Week and Space Technology (ISSN 0005-2175), vol. 124, June 16, 1986, p. 52, 57.

The X-wing configured S-72 rotor systems research aircraft is scheduled to fly in October 1986 to test the X-wing's start/stop characteristics in the 180-200 kt range. This X-wing VTOL vehicle uses two forward- and two aft-swept wings to fly, but can rotate these in the manner of a helicopter rotor for hover. Rotor blade lift control is furnished by air ingested and expelled through leading and trailing edge slots. In fixed-wing flight, rotor airfoil pitch control is achieved through variable fore and aft air blowing and the use of a horizontal stabilizer. O.C.

A86-44003#

**RAFALE WILL KEEP TRICOLOR FLYING**

P. LANGEREUX Aerospace America (ISSN 0740-722X), vol. 24, June 1986, p. 26-28, 30.

An evaluation is made of the design features and prospective performance levels of France's Rafale experimental fighter aircraft, with reference to the European Fighter Aircraft technology demonstration work that is being simultaneously undertaken by a consortium of European manufacturers. Rafale is envisioned in two variants, for attack and air defense; both versions will have 12 external hardpoints, evenly divided between the wings and fuselage. The configuration of Rafale is of the canard-delta type, with two engines and single seat cockpit. High lift devices are employed on both the leading and trailing edges of the wings,

facilitating maneuvers at currently unachievable angles of attack. The Rafale's structural mass comprises 25 percent composites.

O.C.

**A86-44004#  
NEW TECHNOLOGIES FOR A EUROPEAN FIGHTER**

J. VINCENT (British Aerospace, PLC, Weybridge, England) Aerospace America (ISSN 0740-722X), vol. 24, June 1986, p. 34-36.

The state-of-the-art technologies that will be integrated into the European Experimental Aircraft Program (EAP) fighter aircraft are discussed, and their prospective performance levels are assessed. EAP's configuration is of the canard-delta type, and a full authority digital fly-by-wire system is employed to maximize this inherently unstable configuration's agility with minimum pilot workload. The large wing area employed is prompted by both high turn rate and low speed/short landing run requirements. Stealth technology features are incorporated to maintain low radar signature. Extensive use is made of carbon fiber-reinforced composite structures.

O.C.

**A86-44283  
FLIGHT TESTING OF THE NAVIGATION AND FLIGHT CONTROL COMPLEXES OF AIRCRAFT AND HELICOPTERS [LETNYE ISPYTANIYA PILOTAZHNO-NAVIGATSIONNYYKH KOMPLEKSOV SAMOLETOV I VERTOLETOV]**

E. G. KHARIN, ED. Moscow, Izdatel'stvo Mashinostroenie, 1985, 128 p. In Russian. No individual items are abstracted in this volume.

Methods for testing and evaluating the performance characteristics of the navigation and flight control complexes of flight vehicles are presented. In particular, attention is given to the theory and methods of evaluating the accuracy of navigation and flight control, assessing the performance of the algorithms of on-board navigation systems, and identifying models of errors characteristic of the navigation and flight control equipment. The discussion also covers methods of evaluating flight safety in relation to the reliability of the navigation and flight control systems.

V.L.

**A86-44386\* Rice Univ., Houston, Tex.  
OPTIMAL TAKE-OFF TRAJECTORIES IN THE PRESENCE OF WINDSHEAR**

A. MIELE, T. WANG (Rice University, Houston, TX), and W. W. MELVIN (Delta Air Lines, Atlanta, GA) Journal of Optimization Theory and Applications (ISSN 0022-3239), vol. 49, April 1986, p. 1-45. refs

(Contract NAG1-516)

The present consideration of takeoff trajectory optimization in eight different fundamental problems involving wind shears assumes that the power setting is held at the maximum value, and that the aircraft is controlled with respect to angle-of-attack. While the first three problems are least-squares ones of the Bolza type, the remaining five are minimax problems of the Chebyshev type which can be converted to Bolza type by means of suitable transformations. All problems are solved on the basis of the dual sequential gradient-restoration algorithm for optimal control problems. The trajectory solutions obtained are superior to constant angle-of-attack trajectories.

O.C.

**A86-44460  
OPTIMIZING THE NOTAR DESIGN**

Aerospace Engineering (ISSN 0736-2536), vol. 6, June 1986, p. 52-57.

The operating principles and design history of NOTAR, a no-tail-rotor antitorque system for single-main-rotor helicopters, are reviewed and illustrated with drawings, diagrams, and photographs. The primary components of NOTAR include a vertical fin, a tail boom, and an engine-driven variable-pitch fan (at the rear of the fuselage), circulation-control slots, and a direct jet thruster at the rear of the tail boom. Consideration is given to preliminary design concepts; the use of computer models to improve the design; wind-tunnel, flow-visualization, water-tank-LDV, whirl-stand, and

flight testing; and the development of a specialized advanced-design tail fan.

T.K.

**A86-44776  
THE BOEING CREW ESCAPE TECHNOLOGIES (CREST) PROGRAM**

R. F. YURCZYK (Boeing Military Airplane Co., Seattle, WA) SAFE Journal, vol. 16, no. 2, Summer 1986, p. 6-12.

Boeing completed Phase I of the CREST program and was recently awarded a contract for the next phase, IIA. The first phase consisted of requirements analysis and subsystem trade studies concluding with a System Design Review. Work included establishment of a performance baseline; development of a system specification and preliminary development specifications for the hardware and software subsystems; initial system design; and cockpit integration. Phase IIA consists of subsystem preliminary design and detail test planning concluding with a Preliminary Design Review of each configuration item. This paper describes the Boeing approach to the requirements of the CREST program with an overview of the system initial design.

Author

**A86-44853\*# Virginia Polytechnic Inst. and State Univ., Blacksburg.  
NOISE CONTROL CHARACTERISTICS OF SYNCHROPHASING. I ANALYTICAL INVESTIGATION**

C. R. FULLER (Virginia Polytechnic Institute and State University, Blacksburg) AIAA Journal (ISSN 0001-1452), vol. 24, July 1986, p. 1063-1068. Previously cited in issue 01, p. 4, Accession no. A85-10898. refs

(Contract NAG1-390)

**A86-44886\*# Informatics General Corp., Palo Alto, Calif.  
TRANSONIC AEROELASTIC ANALYSIS OF THE B-1 WING**

G. P. GURUSWAMY (Sterling Software/Informatics, Palo Alto, CA), P. M. GOORJIAN (NASA, Ames Research Center, Moffett Field, CA), H. IDE, and G. D. MILLER (Rockwell International Corp., Los Angeles, CA) Journal of Aircraft (ISSN 0021-8669), vol. 23, July 1986, p. 547-553. refs (AIAA PAPER 85-0690)

The flow over the B-1 wing is studied computationally, including the aeroelastic response of the wing. Computed results are compared with results from wind tunnel and flight tests for both low- and high-sweep cases, at 25.0 and 67.5 deg, respectively, for selected transonic Mach numbers. The aerodynamic and aeroelastic computations are made by using the transonic unsteady code ATRAN3S. Steady aerodynamic computations compare well with wind tunnel results for the 25.0 deg sweep case and also for small angles of attack at 67.5 deg sweep case. The aeroelastic response results show that the wing is stable at the low-sweep angle for the calculation at the Mach number at which there is a shock wave. In the higher-sweep case, for the higher angle of attack at which oscillations were observed in the flight and wind tunnel tests, the calculations do not show any shock waves. Their absence lends support to the hypothesis that the observed oscillations are due to the presence of leading-edge separation vortices and not to shock wave motion, as was previously proposed.

Author

**A86-44887#  
RAPID SIZING METHOD FOR AIRPLANES**

J. ROSKAM (Kansas, University, Lawrence) Journal of Aircraft (ISSN 0021-8669), vol. 23, July 1986, p. 554-560. Previously cited in issue 01, p. 9, Accession no. A86-10960.

**A86-44894#  
THE ROLE OF STRUCTURAL AND AERODYNAMIC DAMPING ON THE AEROELASTIC BEHAVIOR OF WINGS**

I. LOTTATI (Technion - Israel Institute of Technology, Haifa) Journal of Aircraft (ISSN 0021-8669), vol. 23, July 1986, p. 606-608. refs

The significant influence of the unsteadiness of a wake on flutter speed is presently demonstrated for a high aspect ratio rectangular wing that is idealized in terms of a box beam. Attention

is also given to the influence of structural damping on the flutter speed, as related to the aerodynamic damping modeled by the aerodynamic air forces that are incorporated in the analysis. Many useful conclusions are drawn from close examination of the concept of computing the critical velocity of the system by frequency coalescence. O.C.

**A86-44936****SOCIETY OF EXPERIMENTAL TEST PILOTS, SYMPOSIUM, 29TH, BEVERLY HILLS, CA, SEPTEMBER 25-28, 1985, PROCEEDINGS**

Lancaster, CA, Society of Experimental Test Pilots, 1985, 292 p. For individual items see A86-44937 to A86-44950.

The present conference on recent achievements in flight testing methodology considers F-14A engine air intake icing conditions, the XV-15 tilt-rotor aircraft flight test program history, naval aircraft weapons system integration experience in the U.S. Navy, flight test and early service performance of the B 737-300 airliner, a high technology training simulator for cost reduction, initial flight test results from the X-29 program, and data from the AV-8B's high angle-of-attack/spin test program. Also discussed are metrics for advanced fighter agility performance, F-14 departure/spin and air combat maneuvering evaluation using a NASA FCS, Tornado high speed terrain-following performance testing in mountainous terrain and bad weather, A320 airliner flight controls, flight tests of the Voyager unrefueled circumnavigation aircraft, the orbital salvage operations conducted by STS mission 51-A, and aerobatic testing of the BK-117 helicopter. O.C.

**A86-44937****F-14A INLET ICING**

G. FREEMAN and B. M. PICARD (U.S. Navy, Naval Air Test Center, Patuxent River, MD) IN: Society of Experimental Test Pilots, Symposium, 29th, Beverly Hills, CA, September 25-28, 1985, Proceedings . Lancaster, CA, Society of Experimental Test Pilots, 1985, p. 3-23.

The problem of ice forming on F-14A engine inlet surfaces and on certain conditions being shed into the engine, with resulting FOD (foreign-object-damage) is examined. The F-14A Tomcat is more susceptible to inlet icing problems than any other operational Navy airplane. The problem ice forms in the number three ramp area and normally sheds out the bleed door on the top of the fuselage with little probability of FOD. If substantial ice exists, however, when the aircraft is arrested on landing, the ice can dislodge with severe FOD a serious possibility. The Navy has designated the F-14A icing a Category IA hazard, defined as having catastrophic potential with frequent occurrence. Wind-tunnel tests, validated by flight tests, indicated that ice on the back wall of ramp three had been shed from the leading edge of ramp three. The test aircraft and instrumentation are described along with an inlet airflow survey, icing tests, and maneuvering tests. A modified 'anti-ice' inlet was developed which will effectively reduce ice accumulation on the leading edge of ramp three and eliminate ice accumulation above ramp three, thus minimizing the potential for engine FOD. The new inlet has demonstrated stall free engine/inlet compatibility during flight maneuvering up to 35 Kft and 0.9 indicated Mach number and is satisfactory for the fighter mission. D.H.

**A86-44938\*** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

**THE XV-15 TILT-ROTOR FLIGHT-TEST PROGRAM**

D. C. DUGAN (NASA, Ames Research Center, Moffett Field, CA) IN: Society of Experimental Test Pilots, Symposium, 29th, Beverly Hills, CA, September 25-28, 1985, Proceedings . Lancaster, CA, Society of Experimental Test Pilots, 1985, p. 24-41. refs

The XV-15 Tilt-Rotor flight research program is described; it has resulted in the full-scale development of the Navy's MV-22A Osprey which will be the world's first operational tilt rotor aircraft. Proof-of-concept flight test objectives have been completed along with military service tests and demonstrations. NASA Ames and Bell Helicopter Textron are currently engaged in advanced flight research programs. The government flight test activity is discussed. It includes hover tests both in ground effect (IGE) and out of

ground effect (OGE) for performance, downwash and noise measurements, short-field takeoff and landing (STOL) evaluations, aeroelastic stability investigations, dynamic stability tests, and three-axis sidestick-controller development and evaluation. Advanced Technology Blades will be installed and evaluated under all flight conditions. D.H.

**A86-44940****BOEING 737-300 FLIGHT TEST AND THE FIRST NINE MONTHS SERVICE EXPERIENCE**

J. C. MCROBERTS (Boeing Commercial Airplane Co., Seattle, WA) IN: Society of Experimental Test Pilots, Symposium, 29th, Beverly Hills, CA, September 25-28, 1985, Proceedings . Lancaster, CA, Society of Experimental Test Pilots, 1985, p. 51-66.

**A86-44941****NORTHROP'S SURROGATE TRAINER**

F. S. DOTEN (Northrop Corp., Electro-Mechanical Div., Anaheim, CA) IN: Society of Experimental Test Pilots, Symposium, 29th, Beverly Hills, CA, September 25-28, 1985, Proceedings . Lancaster, CA, Society of Experimental Test Pilots, 1985, p. 67-92.

The Surrogate Trainer, developed specifically to ensure that the new Apache attack helicopter is fielded with fully trained crews, is described. The Apache helicopter itself was developed with a full complement of weapons to include the standard mini-guns and rockets but enhanced with a chaingun and laser-guided missiles. It has a target acquisition/designation system capable of day and night operations, allowing the crew to fly nap-of-the-earth (NOE) as freely by night as by day. The particular Apache subsystem described is called the Pilot Night Vision Sensor (PNVS); it provides the pilot with the capability of flying night NOE with infrared video as the sole external visual reference. The surrogate Trainer is the name given to the TH-1S helicopter after the PNVS is installed. Topics covered include: PNVS How it works; the integrated helmet and display sight system; symbology generation; subsystem integration; design implementation; aft cockpit; front cockpit; data entry and display panel; blackout curtains; videotape recorder; fault detection and location system; power; ammunition bay pallet; subsystems integration; and flight testing. D.H.

**A86-44942\*** National Aeronautics and Space Administration. Flight Research Center, Edwards, Calif.

**X-29 INITIAL FLIGHT TEST RESULTS**

S. D. ISHMAEL (NASA, Flight Research Center, Edwards, CA) and T. WIERZBANOWSKI (USAF, Flight Test Center, Edwards AFB, CA) IN: Society of Experimental Test Pilots, Symposium, 29th, Beverly Hills, CA, September 25-28, 1985, Proceedings . Lancaster, CA, Society of Experimental Test Pilots, 1985, p. 95-113.

It is announced that the X-29 forward-swept-wing (FSW) aircraft has been built, with flight testing under way and proceeding smoothly. The X-29 is a single-seat, single-engine supersonic aircraft that blends an optimized FSW, a close-coupled near-coplar canard, an F-5A forward fuselage module employing two side-mounted engine inlets, and a new aft fuselage. An F404-GE-400 engine with afterburner provides about 16,000 lb of thrust. The X-29 was designed to be near neutrally stable in the supersonic region to minimize drag; it becomes highly unstable transonically and subsonically, which dictates the use of a computerized fly-by-wire flight control system capable of stabilizing the aircraft. The X-29 advanced technology demonstrator began flight testing on Dec. 14, 1984; by Sept. 26, 1985, its envelope had been expanded to 0.75 Mach, 350 knots estimated airspeed, and 30,000 feet altitude. The aircraft has flown with very few problems and aerodynamic, structural, and control system results have correlated well with predictions. Areas where prediction and performance are not so well correlated are noted. D.H.

**A86-44943**

**AV-8B HIGH ANGLE OF ATTACK/SPIN PROGRAM**

W. W. LOWE (McDonnell Aircraft Co., St. Louis, MO) IN: Society of Experimental Test Pilots, Symposium, 29th, Beverly Hills, CA, September 25-28, 1985, Proceedings . Lancaster, CA, Society of Experimental Test Pilots, 1985, p. 114-133.

Program commitments and accomplishments are noted with regard to the AV-8B (Harrier II) high angle of attack test program. The program was originally structured to define boundaries of controllable flight, to explore departure dynamics and recovery, and to investigate spins if encountered. However, since earlier Harrier II testing had uncovered undesirable departure tendencies, an additional program commitment was made to correct this problem. Hardware changes made during the pre-program layout included: modifying the rudder actuator relief valve to give 15 percent more hinge moment to resist sideslip; reworking the aileron actuators to allow 6 degrees of servo authority (with new servo authority increased to 34 percent of total surface travel); adding an additional lateral accelerometer and roll rate gyro forward of the CG to provide feedback loop stability; and providing a lateral stick position sensor to implement a roll/yaw interconnect. Resistance to spin is extreme for the Harrier II. Even for lateral asymmetries to 7500 ft lb, aggravated with other than neutral controls to trigger a spin. If a spin is ever encountered, aerodynamic controls are powerful enough to effect recovery. Procedures are given for both inverted and upright spin recovery. D.H.

**A86-44945**

**TORNADO HIGH SPEED TERRAIN FOLLOWING TESTING IN MOUNTAINOUS TERRAIN AND BAD WEATHER**

P. WEGER (Messerschmitt-Boelkow-Blom GmbH, Munich, West Germany) IN: Society of Experimental Test Pilots, Symposium, 29th, Beverly Hills, CA, September 25-28, 1985, Proceedings . Lancaster, CA, Society of Experimental Test Pilots, 1985, p. 180-195.

The development and flight testing of a terrain-following system for the West German jet fighter Tornado are described. After more than 200 developmental flights, it has been possible to achieve final clearance for flying the aircraft at the lowest clearance height at 600 knots in mountainous terrain under full instrumental meteorological conditions. Equipment, the test area in the Schwarzwald of southwest Germany, crewing, aircraft system considerations, the O-G problem, flight control system considerations, the EMI problem, flight envelope, flight director use, terrain-following-system changes, system set-up, the warning system, weather, Category II landing capability, and open loop pull-up training are among the topics covered. The dynamics of flight at 600 knots over rough terrain in the hard-ride mode in frontal weather areas was described as 'breathtaking'. Advice is given for the pilot making use of the terrain following system. D.H.

**A86-44947**

**CERTIFICATION FLIGHT TESTING OF CIVILIAN HELICOPTERS IN THE UNITED KINGDOM**

P. J. G. HARPER (Civil Aviation Authority, London, England) IN: Society of Experimental Test Pilots, Symposium, 29th, Beverly Hills, CA, September 25-28, 1985, Proceedings . Lancaster, CA, Society of Experimental Test Pilots, 1985, p. 211-222.

**A86-44948**

**FLIGHT TESTING THE VOYAGER - A NON-STOP, UNREFUELED, AROUND-THE-WORLD AIRCRAFT**

R. G. RUTAN and J. L. YEAGER (Voyager Aircraft, Inc., Mojave, CA) IN: Society of Experimental Test Pilots, Symposium, 29th, Beverly Hills, CA, September 25-28, 1985, Proceedings . Lancaster, CA, Society of Experimental Test Pilots, 1985, p. 226-235.

Attention is given to the design features, mission requirements, performance characteristics, and flight test program accomplishments of the 'Voyager' long distance aircraft, which has been designed to circumnavigate the globe without refueling. The flight test program is divided into two phases that are respectively dedicated to verify performance predictions and to

refine stability and control systems. Attention is presently given to lateral stability and control, bank-recovery deficiency at low speed, autopilot and avionics performance criteria, and aeroelastic airframe behavior. Flight test results are also presented. O.C.

**A86-44950**

**AEROBATIC TESTING OF THE BK-117 HELICOPTER**

G. A. SHARON and E. TAVARES (U.S. Army, Aviation Engineering Flight Activity, Edwards AFB, CA) IN: Society of Experimental Test Pilots, Symposium, 29th, Beverly Hills, CA, September 25-28, 1985, Proceedings . Lancaster, CA, Society of Experimental Test Pilots, 1985, p. 262-283.

An evaluation is made of the results obtained in aerobatic flight tests of a BK-117 helicopter, with a view of such maneuvering capabilities' applicability to increasingly important helicopter air-to-air combat. Attention is given to the performance envelope of the BK-117 test helicopter, test conditions, and helicopter behavior in the standard aerobatic/combats maneuvers known as 'modified lazy-eight', 'hammerhead', roll, loop, 'one-half Cuban eight', 'reverse one-half Cuban eight', and 'pushover'. O.C.

**A86-45064**

**BRITISH EXPERIMENTAL AIRCRAFT PROGRAM PROVIDING INSIGHT INTO NEW TECHNOLOGY**

D. A. BROWN Aviation Week and Space Technology (ISSN 0005-2175), vol. 124, June 23, 1986, p. 71, 73, 76.

The British Experimental Aircraft Program (EAP) technology demonstrator aircraft program is discussed. This aircraft is not a prototype, but rather serves to provide in-flight technical evaluation of a number of different emerging technologies, all of which are combined in the design. Six performance objectives for the aircraft are summarized along with seven project objectives intended to demonstrate that the aircraft can meet its performance objectives. The system has four flight control computers rather than the six used on the Jaguar, and uses software different from that for the Jaguar because of the different flight characteristics of the EAP. The drives for the aircraft control surfaces and for the instruments are described, and the functioning of the control system is summarized. C.D.

**A86-45406\*** Cambridge Acoustical Associates, Inc., Mass.

**STRUCTUREBORNE NOISE INVESTIGATIONS OF A TWIN ENGINE AIRCRAFT**

J. M. GARRELICK, J. E. COLE, III, and K. MARTINI (Cambridge Acoustical Associates, Inc., MA) AIAA, Aeroacoustics Conference, 10th, Seattle, WA, July 9-11, 1986. 9 p. refs (Contract NAS1-18020) (AIAA PAPER 86-1905)

The interior noise of aircraft powered by advanced turbo-prop concepts is likely to have nonnegligible contributions from structureborne paths, these paths being those involving propeller loads transmitted to the structures of the lifting surfaces. As a means of examining these paths, structural measurements have been performed on a small twin-engine aircraft, and in addition analytical models of the structure have been developed. In this paper results from both portions of this study are presented. Author

**A86-45407\***

**CABIN NOISE CHARACTERISTICS OF A SMALL PROPELLER POWERED AIRCRAFT**

H. V. L. PATRICK (North Carolina State University, Raleigh) AIAA, Aeroacoustics Conference, 10th, Seattle, WA, July 9-11, 1986. 11 p. refs (AIAA PAPER 86-1906)

A transfer function between engine vibrations and cabin noise of a Cessna 172 'Skyhawk' airplane was obtained by shaking the static engine. During flight conditions, the same parameters were measured recorded, and analyzed. Cabin noise was predicted based upon the transfer function and compared with actual cabin noise measurements obtained at 5000 ft altitude and engine rotation speed of 2400 rpm. It was concluded that engine vibrations do not appreciably contribute to cabin noise via a structure borne



path at 2,400 rpm. Other conclusions obtained were that the cabin noise is dominated by propeller rotation noise at the blade-passing frequency and that wind screen vibrations contribute significantly to cabin noise at 2,400 rpm. At an engine rotational speed of 2,100 rpm the cabin noise spectrum was noticeably different than at 2,400 RPM and there was strong evidence of structure-borne noise. Author

**A86-45426\*#** Virginia Polytechnic Inst. and State Univ., Blacksburg.

**EFFECTS OF AN INTERNAL FLOOR ON LOW FREQUENCY SOUND TRANSMISSION INTO AIRCRAFT CABINS - AN EXPERIMENTAL INVESTIGATION**

J. D. JONES and C. R. FULLER (Virginia Polytechnic Institute and State University, Blacksburg) AIAA, Aeroacoustics Conference, 10th, Seattle, WA, July 9-11, 1986. 9 p. refs (Contract NAG1-390) (AIAA PAPER 86-1939)

A simplified cylindrical model of an aircraft fuselage is used to experimentally study the effects of an internal floor on low frequency sound transmission into aircraft cabins. A scaled-down lattice floor support and floor skin are designed based upon selected characteristics of a business aircraft. Thus, the model provides a simplified procedure for studying the effects of various structural modifications as well as other important effects. Modal decomposition of the shell response and the corresponding pressure response at various interior locations are presented. Results indicate that the main effect of the floor on interior pressure levels is due to modification of the interior acoustic mode shape and not due to the structural modification of the fuselage caused by the lattice floor support. Author

**A86-45427\*#** Virginia Polytechnic Inst. and State Univ., Blacksburg.

**STRUCTURAL INFLUENCE OF CABIN FLOOR ON SOUND TRANSMISSION INTO PROPELLER AIRCRAFT - ANALYTICAL INVESTIGATIONS**

C. R. FULLER (Virginia Polytechnic Institute and State University, Blacksburg) AIAA, Aeroacoustics Conference, 10th, Seattle, WA, July 9-11, 1986. 9 p. refs (Contract NAG1-390) (AIAA PAPER 86-1940)

The structural influence of the cabin floor on the transmission of low frequency propeller noise into aircraft interiors has been examined using a simplified analytical model. The response amplitudes and distributions of shell displacement and internal acoustic pressure are examined for various frequencies and floor configurations. In general, at lower frequencies the floor exerts little structural influence on the transmission of acoustic energy to the interior. However, as the frequency nears half the cylinder ring frequency the floor can be seen to significantly alter the internal pressure distributions and response. Author

**A86-45442\*#** National Aeronautics and Space Administration, Langley Research Center, Hampton, Va.

**ACTIVE CONTROL OF PROPELLER INDUCED NOISE FIELDS INSIDE A FLEXIBLE CYLINDER**

H. C. LESTER (NASA, Langley Research Center, Hampton, VA) and C. R. FULLER (Virginia Polytechnic Institute and State University, Blacksburg) AIAA, Aeroacoustics Conference, 10th, Seattle, WA, July 9-11, 1986. 18 p. refs (AIAA PAPER 86-1957)

An active noise control model has been evaluated for reducing aircraft interior noise. The structural noise transmission properties of an aircraft fuselage were modelled as a flexible cylinder excited by external acoustic dipoles simulating the noise produced by twin propellers. The amplitudes of an internal distribution of monopole control sources were determined such that the area-weighted mean square acoustic pressure was minimized in the propeller plane. The noise control model was evaluated at low frequencies corresponding to the blade passage frequency and first few harmonics of a typical turbo-prop aircraft. Interior noise reductions of 20-25 dB were achieved, over a substantial region of the

cylindrical cross-section, with just a few monopole control sources. The most favorable interior noise reductions were achieved when the active noise control model was used in combination with propeller source phasing. Author

**A86-45449\*#** National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

**AN EXPERIMENTAL INVESTIGATION OF REDUCING ADVANCED TURBOPROP CABIN NOISE BY WING SHIELDING**

J. H. DITTMAR (NASA, Lewis Research Center, Cleveland, OH) AIAA, Aeroacoustics Conference, 10th, Seattle, WA, July 9-11, 1986. 18 p. Previously announced in STAR as N86-25218. refs (AIAA PAPER 86-1966)

An experimental investigation was undertaken to determine if wing shielding could reduce the noise impacting the fuselage of an advanced turboprop airplane. Four wings were tested behind two eight-bladed propeller models. Significant shielding of the propeller noise was observed and a particular wing-propeller geometry was identified to provide the most shielding. Specifically, an up-inboard rotation would be needed for a low-wing airplane and a down-inboard rotation for a high-wing airplane. As the axial Mach number was increased, the position where the shielding starts moved farther downstream. This shift in the start of shielding was roughly a straight line with respect to Mach number between  $M = 0.7$  and  $M = 0.8$ . At  $M = 0.85$  the start of shielding does not shift any farther downstream. A simple barrier noise-reduction model gave the same trends with transducer positions as did the data, and, if corrected for Mach number shift, the model might be used to provide estimates of the wing shielding. Besides providing a barrier to the noise reaching the shielded area, the wing also reflects some of the noise back onto the unshielded area. This can make the noise difference between the unshielded and shielded areas of the fuselage larger than would be expected by simple wind shielding. Author

**A86-45450\*#** Kentron International, Inc., Hampton, Va.

**WING LOADS INDUCED BY A PROPELLER WAKE**

D. S. WEIR (Kentron International, Inc., Hampton, VA) AIAA, Aeroacoustics Conference, 10th, Seattle, WA, July 9-11, 1986. 10 p. (Contract NAS1-18000) (AIAA PAPER 86-1967)

A wing located in the wake of a propeller sustains unsteady loading. This loading can generate components of structureborne noise which are transmitted to the interior of the aircraft. The vibration of the wing can also contribute to reradiation of propeller noise. An analysis system for the evaluation of wing unsteady loads is presented. The propeller wake is modeled as a potential helical tip vortex and unsteady airfoil theory is used to determine the wing response. The result is the forcing function for determining the structureborne noise. The wing response is evaluated as a function of propeller thrust coefficient, advance ratio, and propeller installation geometry. The system capabilities are demonstrated by application to three significantly different aircraft. Author

**A86-45483\*#** Missouri Univ., Rolla.

**A COMPARISON OF THE STRUCTUREBORNE AND AIRBORNE PATHS FOR PROPFAN INTERIOR NOISE**

W. EVERSMAN, J. V. RAMAKRISHNAN, and L. R. KOVAL (Missouri-Rolla, University, Rolla) AIAA, Aeroacoustics Conference, 10th, Seattle, WA, July 9-11, 1986. 13 p. refs (Contract NAG1-394) (AIAA PAPER 86-1863)

In the present comparative study of aircraft interior noise levels due to airborne and structureborne paths for a given propeller source, a structure model is used that treats the fuselage interior as a rectangular cavity with five rigid walls; the sixth, or fuselage sidewall, is a stiffened panel. The wing is modeled as a simple beam carried into the fuselage by a large, discrete stiffener representing the carry-through structure. Comparisons are made on the basis of interior noise over a range of propeller rotational frequencies at a fixed thrust. It is found that the relative importance

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of the structural and airborne paths is highly dependent on the structural parameters. O.C.

**A86-45749#**

### **GROUND RESONANCE OF A HELICOPTER DURING THE TAKE-OFF AND LANDING RUN [REZONANS PRZYZIEMNY SMIGLOWCA PODCZAS ROZBIEGU]**

L. ZEREK and D. DYMITRUK Instytut Lotnictwa, Prace (ISSN 0509-6669), no. 102, 1985, p. 39-62. In Polish. refs

Fundamental problems of the analysis of the ground resonance of a helicopter during the takeoff and landing run are discussed, some physical and mathematical models of the phenomenon being put forward. The influence of the speed during the takeoff and landing run of a helicopter on its natural vibrations and the ground resonance is analyzed. The results of the analysis are presented in a graphical form. Author

**A86-45750#**

### **STATISTICAL ANALYSIS OF THE INFLUENCE OF SERVICE PARAMETERS ON THE AEROACOUSTIC EFFECTS [STATYSTYCZNA ANALIZA WPLYWU PARAMETROW EKSPLOATACYJNYCH NA EFEKTY AEROAKUSTYCZNE]**

A. CHYLA Instytut Lotnictwa, Prace (ISSN 0509-6669), no. 102, 1985, p. 63-90. In Polish. refs

The service parameters of light airscrew-propelled aircraft and helicopters constitute sets of multidimensional control vectors of complex dynamic objects. The present paper contains numerical data obtained for 19 types of helicopters and 265 types of airscrew-propelled aircraft which are used in various countries. The two sets of measurement results (noise levels) are treated as independent samples constituting parts of two populations. From those data it is inferred that there is an empirical dependence of the acoustic pressure, in the far acoustic field, on the service and design parameters. The models used have been verified by statistical methods, which make it possible to create an experimental model describing the noise produced irrespective of the type of the predominant source of noise, the influence of interference effects, the nonhomogeneity of flow and dynamic characteristics and the influence of the variation of velocity. Making use of the mathematical model it is possible to introduce some design modifications to reduce the noise. Author

**A86-45753**

### **CORPORATE FLYING, ITALIAN STYLE**

A. POSTLETHWAITE Flight International (ISSN 0015-3710), vol. 129, June 21, 1986, p. 42-45, 48, 49.

The P.180 Avanti 6-9 seat business aircraft, which uses a unique three-surface (canard-incorporating) configuration and highly contoured fuselage together with twin pusher turboprops for aerodynamic efficiency, is able to cruise at 400 kt, while burning half the fuel load of a comparable-payload jet. In addition, it will at \$3.1 million cost only half as much as a jet aircraft. An exceptional effort has been made to insure laminar boundary flow over the greatest possible portions of the fuselage and wing. The structure is almost entirely metallic, with composites being confined to the control surfaces. Attention is presently given to the rationale for numerous design details, and their prospective performance advantages. O.C.

**A86-45758**

### **MORE THAN A MIRAGE**

G. WARWICK Flight International (ISSN 0015-3710), vol. 129, June 28, 1986, p. 41-44.

The development status, design features, and performance capabilities of the next-generation French fighter, Rafale, are assessed. Rafale owes its distinctive appearance to a unique semiventral engine air intake design that has been optimized to allow the forward fuselage to deflect airflow into the inlets at the high-angle-of-attack regime typical of transonic combat maneuvering. Approximately 25 percent of the Rafale's structural weight is made up of composite materials, which are primarily carbon fiber-reinforced. Extensive comparisons are presently made with the Mirage 2000, to give perspective on the performance

improvements that the Rafale promises. Twelve stores stations are evenly divided between wings and fuselage; two 30-mm cannon are carried internally. The Snecma M88 engine, whose thrust/weight of 9.5-10 compares with 7.5 for the F404 turbofan, will power propulsion versions of Rafale. O.C.

**A86-46005**

### **SOVIET ATTACK HELICOPTERS**

J. W. R. TAYLOR Air International (ISSN 0306-5634), vol. 31, July 1986, p. 14-20.

The development status and future development prospects of Soviet attack helicopters are evaluated, with emphasis on the design features and performance capabilities of the Mil Mi-24 'Hind' variants currently in service with Warsaw Pact and Third World forces. More than 2300 Mi-24 helicopters are believed to have been delivered for service to date. Chemical weapons are regarded to be standard options for the latest variant, the Hind-D, which entered service in 1981. Attention is given to the variety and effectiveness of Mi-24 weapons, as well as to the results of preliminary assessments of the state-of-the-art Mi-28 'Havoc' dedicated attack helicopter and Kamov Ka-32 'Hokum' air-to-air combat helicopter. O.C.

**A86-46125**

### **A COME-BACK IN CANARDS**

R. BRAYBROOK Air International (ISSN 0306-5634), vol. 30, June 1986, p. 267-276, 304-307.

A comprehensive discussion is presented concerning the design features and performance capabilities of state-of-the-art fighter aircraft employing canard configurations. The class encompasses both single and two-engined aircraft, and includes the Swedish JAS 39 Gripen, the French Rafale-A, the Israeli Lavi, the British EAP, and the inter-European EFA that is to be based on the EAP. The design trend is noted to have been instigated by the excellent performance established for the canard configuration by the Kfir derivative of the Mirage used by the Israeli Air Force and by the Swedish Viggen. All the aircraft in question are of multimission type, capable of both low altitude ground support/interdiction missions and air superiority/interception missions at high altitudes; all are, in addition, capable of supersonic speeds. O.C.

**A86-46134**

### **THE SKYEYE RPV - AN NDI SOLUTION TO TODAY'S UNMANNED AERIAL VEHICLE REQUIREMENTS**

K. A. STANSELL (Lear Siegler, Inc., Developmental Sciences Astronics Div., Ontario, CA) Unmanned Systems, vol. 4, Spring 1986, p. 10, 11, 30.

Due to the sophistication of potential threat forces together with demands for reductions in defense spending, there is a renewed interest in the capabilities offered by unmanned aerial vehicle (UAV) systems. The development histories of the various members of the SKYEYE family are traced and their respective features are described. The SKYEYE R4E-40, the newest member of this family of unmanned aerial vehicles, offers a payload capacity of 140 pounds and a flight endurance exceeding eight hours. In late 1985, the SKYEYE was reconfigured to accommodate either a turreted daylight video or a turreted common module FLIR. It is noted that SKYEYE's success can be attributed to a great extent to its simplistic design and high degree of flexibility, both of which are reflected in the system's unique method of recovery. SKYEYE utilizes a shock-mounted centerline skid which requires no additional recovery equipment; it is also recoverable via a parachute system. The SKYEYE ground Control Station provides for command and control of the air vehicle and its payloads and accurate vehicle tracking and target positioning data. K.K.



A86-46153#

**THE METHODS IMPLEMENTED AT ONERA TO IMPROVE AIRPLANE GROUND VIBRATION TESTS**

R. DAT and P. LUBRINA (Union College, International Modal Analysis Conference, 4th, Los Angeles, CA, Feb. 3-6, 1986) ONERA, TP, no. 1986-8, 1986, 7 p. refs (ONERA, TP NO. 1986-8)

Test and data-analysis techniques developed to improve the efficiency and accuracy of aircraft ground vibration tests using the ONERA mobile test laboratory are described. The principles of the iterative algorithm of Dat and Dunoyer (1981) and Dat (1983) for the separation of modal transfer functions (SMTF), permitting vibration testing with white-noise excitation or only roughly tailored harmonic excitation, are explained, and a simplified version is applied to sample data for a Mystere 20 aircraft. The identification of weak nonlinearities by curve-fitting algorithms or by application of SMTF at different excitation levels is demonstrated, and it is shown that strong nonlinearities can be identified by vibration tests with the control surfaces disengaged, by superimposing high-frequency vibration, or by analysis of the response of the wing-driven control surface. T.K.

A86-46177#

**NEW MODAL IDENTIFICATION METHODS APPLIED TO AERONAUTICAL STRUCTURES**

G. PIAZZOLI (ONERA, Chatillon-sous-Bagneux, France) and C. HUTIN (Societe pour le Perfectionnement des Matériels et Equipements Aérospatiaux, Velizy-Villacoublay, France) (NATO, AGARD, Specialists Meeting, Oslo, Norway, Apr. 13-18, 1986) ONERA, TP, no. 1986-35, 1986, 23 p. refs (ONERA, TP NO. 1986-35)

Two ground vibration tests which are based on transfer functions analysis methods and nonappropriated excitation are presented. The first, the 'Separation of Modal Transfer Function' is based on multiexcitations which are monitored by independent coherent processes. The second, the 'multi-Excitation Method' is based on excitations monitored by noncoherent random processes. The results of tests performed on the Falcon aircraft are compared with those of the classical method and a critical analysis is made; problems such as the nonlinearities of aircraft structures are taken into consideration. K.K.

A86-46198#

**AERODYNAMIC TECHNOLOGIES FOR GENERAL AVIATION AIRCRAFT**

W. SCHMIDT Dornier Post (English Edition) (ISSN 0012-5563), no. 2, 1986, p. 18-20.

The development of the Dornier 228 aircraft is used to illustrate techniques which can ensure that new general aircraft satisfy performance and production cost goals for such aircraft. The important performance characteristics of such aircraft are range, single engine climb rate and minimum speed. The design goals are thus maximized L/D, cruise efficiency, climb parameter and high propeller efficiency. Computational fluid dynamics studies permit identification of fuselage designs that, in the case of the 228, offered a 15 percent decrease in drag from a previous generation of aircraft. The use of fiber-reinforced composites in the wings permits maintenance of laminar flow up to 60 percent of the chord. Variable camber was identified as a means to extend the shape control capability. Efficiency, i.e., fuel savings, was also realized with low drag propulsion integration, and it is expected that advanced propellers and propfans will provide even greater efficiency enhancements. M.S.K.

A86-46405

**AVANTI TO FLY SOON**

M. GRANGIER Interavia (ISSN 0020-5168), vol. 16, June 1986, p. 645-647.

An assessment is made of the development status and marketing prospects of the 'Avanti' two-crew/six to nine-passenger twin-turboprop aircraft. The Avanti features an aerodynamically contoured fuselage and canard configuration, whose aerodynamic efficiencies yield a 1000-nmi range at 400-kt maximum cruising

speed with six onboard. Cabin dimension and performance comparisons are tabulated for the Avanti and its competitors, the Starship I, Citation S/II, Cheyenne 400LS, and King Air 300. Projections are presented for the Avanti's cruising speed vs. altitude and IFR range/payload ratio performance. O.C.

A86-46458#

**PRACTICAL CONSIDERATIONS IN OPTIMAL FLIGHT MANAGEMENT COMPUTATIONS**

S. LIDEN (Sperry Corp., Aerospace and Marine Group, Phoenix, AZ) (1985 American Control Conference, 4th, Boston, MA, June 19-21, 1985, Proceedings. Volume 2, p. 675-681) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 9, July-Aug. 1986, p. 427-432. Previously cited in issue 15, p. 2128, Accession no. A86-35367. refs

A86-46461\*# 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 IN CRUISING FLIGHT**

M. B. TISCHLER (NASA, Ames Research Center; U.S. Army, Aeroflightdynamics Directorate, Moffett Field, CA), J. G. M. LEUNG, and D. C. DUGAN (NASA, Ames Research Center, Moffett Field, CA) (International Conference on Rotorcraft Basic Research, Research Triangle Park, NC, February 19-21, 1985, Proceedings. 17 p.) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 9, July-Aug. 1986, p. 446-453. Previously cited in issue 11, p. 1481, Accession no. A86-27661. refs

A86-46850

**AIRCRAFT HYDRAULIC SYSTEMS: AN INTRODUCTION TO THE ANALYSIS OF SYSTEMS AND COMPONENTS**

W. L. GREEN (Salford, University, England) Chichester, England and New York, Wiley-Interscience, 1985, 150 p. refs

The presently treated design practices associated with aircraft hydraulic systems and their components must meet the most severe constraints imposed by airworthiness requirements, environmental restrictions, and reliability criteria. Attention is given to hydraulic valves for control of flow direction and of flow speed and maximum pressure; fluid power circuits, emergency operation, and accumulator performance, servovalves, servoflying control units; fluid compressibility, liquid springs and their natural frequencies, hydraulic servos, Bode diagrams for harmonic response, electrohydraulic servos, and the relationships among stability networks, on-off servos, and nonlinearities. O.C.

A86-47096

**A COMPARISON OF METHODS FOR AIRCRAFT GROUND VIBRATION TESTING**

D. L. HUNT (SDRC, Inc., Milford, OH) IN: International Modal Analysis Conference, 3rd, Orlando, FL, January 28-31, 1985, Proceedings. Volume 1. Schenectady, NY, Union College, 1985, p. 131-137. refs

The recent advances in multiple-input techniques for experimental modal analysis have given the test engineer alternatives for performing aircraft ground vibration tests (GVT). Multiple-input random excitation is one of the methods being used instead of the traditional sine dwell approach. The relative advantages of the random and sine methods are apparent in comparisons made using data from recent aircraft GVT's. Author

A86-47128

**DYNAMIC AND FLUTTER ANALYSIS USING F.E.M. OF THE GP-180**

A. MAZZONI and M. PIZZAMIGLIO (Rinaldo Piaggio Industrie Aeronautiche e Meccaniche S.p.A., Finale Ligure, Italy) IN: International Modal Analysis Conference, 3rd, Orlando, FL, January 28-31, 1985, Proceedings. Volume 2. Schenectady, NY, Union College, 1985, p. 1162-1170.

Three steps have been followed for the GP-180 dynamic and flutter analyses. After a preliminary investigation of the GP-180 characteristics, using a simple beam finite element model, a detailed

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analysis has been performed using the static model. The last verification of the results was done in the wind tunnel, using an aeroelastic model. This was based on a simple beam model, having the same characteristic about stiffnesses, mass, inertia, and in particular about mode shapes and flutter behavior of the detailed model. Author

**N86-29809\*#** Stanford Univ., Calif.

### **OPTIMAL LANDING OF A HELICOPTER IN AUTOROTATION**

A. Y. N. LEE Jul. 1985 322 p  
(Contract NCC2-106)  
(NASA-CR-177082; NAS 1.26:177082) Avail: NTIS HC A14/MF A01 CSCL 01C

Gliding descent in autorotation is a maneuver used by helicopter pilots in case of engine failure. The landing of a helicopter in autorotation is formulated as a nonlinear optimal control problem. The OH-58A helicopter was used. Helicopter vertical and horizontal velocities, vertical and horizontal displacement, and the rotor angle speed were modeled. An empirical approximation for the induced velocity in the vortex-ring state were provided. The cost function of the optimal control problem is a weighted sum of the squared horizontal and vertical components of the helicopter velocity at touchdown. Optimal trajectories are calculated for entry conditions well within the horizontal-vertical restriction curve, with the helicopter initially in hover or forward flight. The resultant two-point boundary value problem with path equality constraints was successfully solved using the Sequential Gradient Restoration Technique. Author

**N86-29810\*#** Cincinnati Univ., Ohio. Dept. of Aerospace Engineering and Applied Mechani

### **FLAP-LAG-TORSIONAL DYNAMICS OF HELICOPTER ROTOR BLADES IN FORWARD FLIGHT Final Report, Jan. 1984 - Jun. 1986**

M. R. M. CRESPODASILVA Jun. 1986 6 p  
(Contract NAG2-274)  
(NASA-CR-176976; NAS 1.26:176976) Avail: NTIS HC A02/MF A01 CSCL 01C

A perturbation/numerical methodology to analyze the flap-lead/lag motion of a centrally hinged spring restrained rotor blade that is valid for both hover and for forward flight was developed. The derivation of the nonlinear differential equations of motion and the analysis of the stability of the steady state response of the blade were conducted entirely in a Symbolics 3670 Machine using MACSYMA to perform all the lengthy symbolic manipulations. It also includes generation of the fortran codes and plots of the results. The Floquet theory was also applied to the differential equations of motion in order to compare results with those obtained from the perturbation analysis. The results obtained from the perturbation methodology and from Floquet theory were found to be very close to each other, which demonstrates the usefulness of the perturbation methodology. Another problem under study consisted in the analysis of the influence of higher order terms in the response and stability of a flexible rotor blade in forward flight using Computerized Symbolic Manipulation and a perturbation technique to bypass the Floquet theory. The derivation of the partial differential equations of motion is presented. B.G.

**N86-29811\*#** Bio-Dynamics Research and Development Corp., Eugene, Oreg.

### **FEASIBILITY STUDY FOR ERGONOMIC ANALYSIS AND DESIGN OF FUTURE HELICOPTER COCKPIT SYSTEMS**

H. L. HAWKINS May 1985 52 p  
(Contract NAS2-12056)  
(NASA-CR-176942; NAS 1.26:176942) Avail: NTIS HC A04/MF A01 CSCL 01C

The Army's light scout-attack helicopters (LHXs), planned for deployment in the 1990's, will fly nap-of-the-earth (NOE) missions in high threat environments, often under poor visibility and adverse atmospheric conditions, and probably with a one man crew. A procedure for the analysis of pilot workload that will identify and explicate the main characteristics of those LHX mission

components holding overload potential is described. A principled, in-depth, explication of the cognitive demands of LHX piloting is essential to any effective effort to address the human factors issues. A task-analytic procedure that will yield the detail and organization needed to achieve these goals is examined. B.G.

**N86-29812\*#** Kansas Univ. Center for Research, Inc., Lawrence. Flight Research Lab.

### **STUDY OF NEW FLIGHT TEST TECHNIQUES Final Report**

D. DEAM Aug. 1984 29 p  
(Contract NSG-4019)  
(NASA-CR-176952; NAS 1.26:176952; KU-FRL-407-10) Avail: NTIS HC A03/MF A01 CSCL 01C

The modification and testing of a small electromechanical vibrator are described. The vibrator was designed for the flutter testing of aircraft wings and was built to specifications that make it compatible with the X-29 experimental aircraft. The device uses alternating electromagnetic forces to move a magnetic mass and produce vibration. Its unconventional way of producing vibration avoids the need for complex mechanisms and makes efficient use of space and weight. B.G.

**N86-29813\*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

### **FLIGHT CONTROL SYSTEM DEVELOPMENT AND FLIGHT TEST EXPERIENCE WITH THE F-111 MISSION ADAPTIVE WING AIRCRAFT**

R. R. LARSON Aug. 1986 21 p To be presented at the AIAA Guidance, Navigation, and Control Conference, Williamsburg, Va., 18-20 Aug. 1986  
(NASA-TM-88265; H-1366; NAS 1.15:88265; AIAA-86-2237-CP)  
Avail: NTIS HC A02/MF A01 CSCL 01C

The wing on the NASA F-111 transonic aircraft technology airplane was modified to provide flexible leading and trailing edge flaps. This wing is known as the mission adaptive wing (MAW) because aerodynamic efficiency can be maintained at all speeds. Unlike a conventional wing, the MAW has no spoilers, external flap hinges, or fairings to break the smooth contour. The leading edge flaps and three-segment trailing edge flaps are controlled by a redundant fly-by-wire control system that features a dual digital primary system architecture providing roll and symmetric commands to the MAW control surfaces. A segregated analog backup system is provided in the event of a primary system failure. This paper discusses the design, development, testing, qualification, and flight test experience of the MAW primary and backup flight control systems. Author

**N86-29814\*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

### **FLIGHT TEST OF A DECOUPLER PYLON FOR WING/STORE FLUTTER SUPPRESSION**

F. W. CAZIER, JR. and M. W. KEHOE (National Aeronautics and Space Administration. Dryden (Hugh L.) Flight Research Center, Edwards, Calif.) Jul. 1986 14 p Presented at the AIAA 3rd Flight Testing Conference, Las Vegas, Nev., 2-4 Apr. 1986  
(NASA-TM-87767; NAS 1.15:87767) Avail: NTIS HC A02/MF A01 CSCL 01B

The decoupler pylon is a NASA concept of passive wing-store flutter suppression achieved by providing a low store-eylon pitch frequency. Flight tests were performed on an F-16 aircraft carrying on each wing an AIM-9J wingtip missile, a GBU-8 bomb near midspan, and an external fuel tank. Baseline flights with the GBU-8 mounted on a standard pylon established that this configuration is characterized by an antisymmetric limited amplitude flutter oscillation within the operational envelope. The airplane was then flown with the GBU-8 mounted on the decoupler pylon. The decoupler pylon successfully suppressed wing-store flutter throughout the flight envelope. A 37-percent increase in flutter velocity over the standard pylon was demonstrated. Maneuvers with load factors to 4g were performed. Although the static store displacements during maneuvers were not sufficiently large to be of concern, a store pitch alignment system was tested and performed successfully. One GBU-8 was ejected demonstrating

that weapon separation from the decoupler pylon is normal. Experience with the present decoupler pylon design indicated that friction in the pivoting mechanism could affect its proper functioning as a flutter suppressor. Author

**N86-29815\*#** National Aeronautics and Space Administration, Langley Research Center, Hampton, Va.

**DESIGN AND FABRICATION OF LARGE SUCTION PANELS WITH PERFORATED SURFACES FOR LAMINAR FLOW CONTROL TESTING IN A TRANSONIC WIND TUNNEL**

D. V. MADDALON and W. A. POPPEN, JR. Aug. 1986 67 p (NASA-TM-89011; NAS 1.15:89011) Avail: NTIS HC A04/MF A01 CSCL 01C

Considerable progress has been made in the development of perforated suction surface material for laminar flow control applications. Electron-beam perforated titanium skin was used as the suction surface. Critical issues related to suction panel manufacturing were identified and largely resolved. The final product included fabrication of a 7-foot chord by 7-foot span perforated laminar flow control wind tunnel model. Techniques used can be adapted to modern aircraft production lines. The report includes details on panel instrumentation and other features required for testing in a transonic pressure tunnel. Author

**N86-30654#** Grumman Aerospace Corp., Bethpage, N.Y.  
**THE APPLICATION OF PRACTICAL OPTIMIZATION TECHNIQUES IN THE PRELIMINARY STRUCTURAL DESIGN OF A FORWARD-SWEPT WING**

E. LERNER /n DGLR The 2nd International Symposium on Aeroelasticity and Structural Dynamics p 381-392 1985  
Avail: NTIS HC A99/MF E03

The application of optimization technology in design studies that preceded the full development of the Grumman X-29, forward swept wing, demonstrator aircraft is outlined. Finite-element resizing methods were developed to satisfy optimality criteria for strength and divergence-velocity constraints. Application of the methods in an initial feasibility study of a variable sweep wing and in a more detailed, fixed wing design study are described. The usefulness of the methodology at various stages of design is demonstrated by tracing the process that led to the selection of an efficient cover-laminate configuration. ESA

**N86-30655#** Cranfield Inst. of Tech., Bedford (England). Coll. of Aeronautics.

**STRUCTURAL OPTIMIZATION PROGRAMS AND METHODS**

A. J. MORRIS /n DGLR The 2nd International Symposium on Aeroelasticity and Structural Dynamics p 393-406 1985  
Avail: NTIS HC A99/MF E03

Minimum weight design algorithms used in computer aided aircraft design are reviewed. Applications to carbon fiber composite wings, aircraft flaps, fuselages, and an automobile seat are illustrated. ESA

**N86-30656#** Dornier-Werke G.m.b.H., Friedrichshafen (West Germany).

**VARIATION OF ANISOTROPIC BEHAVIOR IN STRUCTURAL OPTIMIZATION**

G. HORNUNG, D. W. MATHIAS, and H. ROEHRLE /n DGLR The 2nd International Symposium on Aeroelasticity and Structural Dynamics p 407-414 1985  
Avail: NTIS HC A99/MF E03

Use of the gradient method to optimize carbon fiber reinforced composite airframe design is described. The optimization process consists of two major parts. The first part of the calculation is done to select the fiber orientations for a given structure under a given load. In the second part this preoptimized configuration is improved by varying the thicknesses of the layers, leading to the optimum design. This design having preoptimized compounds is compared with a corresponding quasiisotropic structure and a design having four fixed fiber directions but different thicknesses of the layers. The preoptimized design is shown to be best adapted to the load bearing requirements of the structure. ESA

**N86-30660#** Tel-Aviv Univ. (Israel). Faculty of Engineering.  
**RECENT RESULTS ON THE WEIGHT MINIMIZATION OF PANELS WITH A FLUTTER SPEED CONSTRAINT**

L. LIBRESCU and L. BEINER /n DGLR The 2nd International Symposium on Aeroelasticity and Structural Dynamics p 441-450 1985

Avail: NTIS HC A99/MF E03

Weight minimization of flat and curved panels exposed to a supersonic flow and subjected to a flutter speed constraint is described. The analysis encompasses axisymmetric circular cylindrical shells and rectangular orthotropic flat panels. Optimal control in a single variable and of distributed parameter systems is used in deriving the optimality equations. In order to ensure that the flutter speed of the optimal panel coincides with the constrained one, a flutter instability condition is employed. Galerkin's technique is used for solving the optimality equations and the influence of orthotropicity ratio, in-plane loads, aspect ratio, and boundary conditions on the optimal thickness distribution is determined. For the case of pure transverse shear panels, an aeroelastic paradox similar to the membrane paradox is revealed. The cases of 1-D type panels and isotropic 2-D panels are also considered. ESA

**N86-30662#** Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (West Germany).

**AEROELASTIC PROBLEMS AND STRUCTURAL DESIGN OF A TAILLESS CARBON FIBER COMPOSITE (CFC) SAILPLANE**

J. SCHWEIGER, O. SENSBURG, and H. J. BERNS (Technische Univ., Brunswick, West Germany) /n DGLR The 2nd International Symposium on Aeroelasticity and Structural Dynamics p 457-468 1985

Avail: NTIS HC A99/MF E03

Severe instability at low speed in a 1/3 scale model of a 15 m sailplane was studied. Flutter calculations using data from a ground resonance test show that coupling of the rigid body short period mode with the first elastic mode causes the phenomenon. The wing was redesigned with the optimization programs FASTOP and TSO to find optimum fiber orientations and stiffness distributions for aeroelastic and strength requirements. By applying these computer codes the flutter speed is increased to an acceptable level with small modifications of the wing root geometry, a new design of the main spar, and by using a high modulus fiber type. With a small weight penalty compared to the initial design the flutter speed can be doubled. ESA

**N86-30665#** Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (West Germany).

**STRUCTURAL DYNAMIC ASPECTS OF ROTOR NODAL ISOLATION**

J. STOPPEL /n DGLR The 2nd International Symposium on Aeroelasticity and Structural Dynamics p 486-494 1985  
Avail: NTIS HC A99/MF E03

An Antiresonance Isolation System (ARIS) for helicopters is described. In the passive nodal isolation system, the antiresonant frequency is tuned to the main rotor passage frequency to prevent the transmission of the oscillatory hub forces and moments to the fuselage. Analysis demonstrates that the nodal rotor isolation system may be strongly influenced by the structural dynamics of the helicopter. Due to the numerous eigenvalues the antiresonant frequency of the isolation system may be compensated by an adjacent natural frequency. In this case the desired isolating effect disappears. The complexity of the three dimensional structure aggravates the understanding and prediction of vibration system. For the BK 117 helicopter with MBB-ARIS, the structural optimization is demonstrated using finite element methods. ESA

## 05 AIRCRAFT DESIGN, TESTING AND PERFORMANCE

**N86-30678#** Northwestern Polytechnical Univ., Xian (China). Dept. of Aircraft Engineering.

### **DETERMINATION OF NATURAL VIBRATION PROPERTIES OF A WING WITH WINGLET BY EXPERIMENTAL MODE SYNTHESIS TECHNIQUE**

S. N. GU, W. J. YOU, and J. S. JIANG /in DGLR The 2nd International Symposium on Aeroelasticity and Structural Dynamics p 605-611 1985

Avail: NTIS HC A99/MF E03

Nine lowest natural frequencies and their corresponding natural modes of a wing model with winglet were determined using electric measurement and laser time-averaged holographic interferometry supplemented by sand contours. Three-dimensional quantitative analysis and orthogonalization of the three lowest natural modes of wing with winglet are carried out. Modal synthesis is used to get lower ordered natural frequencies and modes of the wing model with winglet, by using the six lowest orthogonalized modes of the wing and three lowest orthogonalized modes of the winglet. Calculated results of natural frequencies and modes of the wing with winglet and its wing by finite element method agree quite well with experimental data. ESA

### **N86-30679#** Israel Aircraft Industries Ltd., Ben-Gurion Airport. **RAPID VIBRATION MODE ANALYSIS OF AIRCRAFT WITH EXTERNAL STORES**

M. KARPEL /in DGLR The 2nd International Symposium on Aeroelasticity and Structural Dynamics p 612-616 1985

Avail: NTIS HC A99/MF E03

A method for coupling the vibration modes of a central structure to additional substructures is presented. A set of low frequency natural modes, including rigid body modes, represents the central structure. These modes are obtained by a mathematical model loaded with a set of fictitious masses at the connection to the substructures degrees of freedom. The substructures are represented by their mass properties, vibration modes with clamped boundary conditions and free-free rigid body modes. The connection of each substructure to the central structure is statically determinate. The method is applied for vibration analysis of aircraft with external stores. The coupled aircraft + stores dynamic properties may be efficiently used for flutter analysis. Comparison with vibration modes obtained by a direct (full-size) eigensolution shows very accurate coupling results with low order eigensolutions. ESA

**N86-30718\*#** California Univ., Los Angeles. Dept. of Computer Science.

### **A.I.-BASED REAL-TIME SUPPORT FOR HIGH PERFORMANCE AIRCRAFT OPERATIONS Report, 15 May 1984 - 14 May 1985**

J. VIDAL, J. 1985 52 p

(Contract NAG2-302)

(NASA-CR-176906; NAS 1.26:176906) Avail: NTIS HC A04/MF A01 CSCL 01C

Artificial intelligence (AI) based software and hardware concepts are applied to the handling system malfunctions during flight tests. A representation of malfunction procedure logic using Boolean normal forms are presented. The representation facilitates the automation of malfunction procedures and provides easy testing for the embedded rules. It also forms a potential basis for a parallel implementation in logic hardware. The extraction of logic control rules, from dynamic simulation and their adaptive revision after partial failure are examined. It uses a simplified 2-dimensional aircraft model with a controller that adaptively extracts control rules for directional thrust that satisfies a navigational goal without exceeding pre-established position and velocity limits. Failure recovery (rule adjusting) is examined after partial actuator failure. While this experiment was performed with primitive aircraft and mission models, it illustrates an important paradigm and provided complexity extrapolations for the proposed extraction of expertise from simulation, as discussed. The use of relaxation and inexact reasoning in expert systems was also investigated. Author

### **N86-30719#** Federal Aviation Administration, Washington, D.C. **ADVISORY CIRCULAR: AUXILIARY FUEL SYSTEM INSTALLATIONS**

2 May 1986 53 p

(FAA/AC-25-8) Avail: NTIS HC A04/MF A01

The advisory circular (AC) provides guidance and criteria for the installation of auxiliary fuel systems, i.e., those which supplement essential fuel systems to provide additional range, in transport category airplanes. It is intended primarily for installations in which the auxiliary fuel is carried with the fuselage, such as within cargo or baggage compartments, the main deck or other similar areas. B.G.

**N86-30720\*#** National Aeronautics and Space Administration, Washington, D.C.

### **NASA AND GENERAL AVIATION**

J. L. ETHELL 1986 140 p Original contains color illustrations (NASA-SP-485; NAS 1.19:485) Avail: NTIS HC A07/MF A01 CSCL 01C

General aviation remains the single most misunderstood sector of aeronautics in the United States. A detailed look at how general aviation functions and how NASA helps keep it on the cutting edge of technology in airfoils, airframes, commuter travel, environmental concerns, engines, propellers, air traffic control, agricultural development, electronics, and safety is given. Author

**N86-30721\*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

### **IMPACT DATA FROM A TRANSPORT AIRCRAFT DURING A CONTROLLED IMPACT DEMONSTRATION**

E. L. FASANELLA (PRC Kentron, Inc., Hampton, Va.), E. ALFARO-BOU, and R. J. HAYDUK Sep. 1986 88 p

(NASA-TP-2589; L-16125; NAS 1.60:2589) Avail: NTIS HC A05/MF A01 CSCL 01B

On December 1, 1984, the FAA and NASA conducted a remotely piloted air-to-ground crash test of a Boeing 720 transport aircraft instrumented to measure crash loads of the structure and the anthropomorphic dummy passengers. Over 330 time histories of accelerations and loads collected during the Full-Scale Transport Controlled Impact Demonstration (CID) for the 1-sec period after initial impact are presented. Although a symmetric 1 deg. nose-up attitude with a 17 ft/sec sink rate was planned, the plane was yawed and rolled 13 deg. at initial (left-wing) impact. The first fuselage impact occurred near the nose wheel well with the nose pitched down 2.5 deg. Peak normal (vertical) floor accelerations were highest in the cockpit and forward cabin near the nose wheel well and were approximately 14G. The remaining cabin floor received normal acceleration peaks of 7G or less. The peak longitudinal floor accelerations showed a similar distribution, with the highest (7G) in the cockpit and forward cabin, decreasing to 4G or less toward the rear. Peak transverse floor accelerations ranged from about 5G in the cockpit to 1G in the aft fuselage. Author

**N86-30722\*#** California Polytechnic State Univ., San Luis Obispo. Dept. of Aeronautical Engineering.

### **THE PERFORMANCE EVALUATION OF A JET FLAP ON AN ADVANCED SUPERSONIC HARRIER Final Report**

L. D. LIPERA and D. R. SANDLIN Aug. 1984 84 p

(Contract NCC2-238)

(NASA-CR-179653; NAS 1.26:179653) Avail: NTIS HC A05/MF A01 CSCL 01C

The performance concept of a supersonic vertical and short takeoff and landing (V/STOL) fighter, model 279-3, modified to utilize a jet flap was evaluated. Replacing the rear nozzles of the 279-3 with the jet flap favorably alters the pressure distribution over the airfoil and dramatically increases lift. The result is a significant decrease in takeoff distance, an increase in payload, and an improvement in combat performance. To investigate the benefit in increased payload, the 279-3 and the jet flapped 279-3JF were modeled on the NASA Aircraft Synthesis (ACSYNT) computer code and flown on a 250 feet takeoff distance interdiction mission. The increase in payload weight that the 279-3JF could carry was

converted into fuel in one case, and in another, converted to bomb load. When the fuel was increased, the 279-3JF penetrated into enemy territory almost four times the distance of 279-3, and therefore increased mission capability. When the bomb load was increased, the 279-3JF carried 14 bombs the same distance the 279-3 carried four. The increase in mission performance and improvements in turning rates was realized with only a small penalty in increased empty weight. Author

**N86-30723\*#** National Aeronautics and Space Administration. Dryden (Hugh L.) Flight Research Center, Edwards, Calif.

**MODIFIED US ARMY U-8F GROUND VIBRATION TEST**

M. W. KEHOE Aug. 1986 50 p  
(NASA-TM-86741; H-1297; NAS 1.15:86741) Avail: NTIS HC A03/MF A01 CSCL 01C

The Dryden Flight Research Facility of NASA Ames Research Center conducted a ground vibration test on a modified U.S. Army U-8F airplane. Modifications included new engines, propellers, and engine-mounted truss assemblies. The ground vibration test was conducted using sine dwell, single-point random, and impact excitations. The test was performed to determine modal frequencies, mode shapes, and structural damping coefficients of the airframe and propeller with full and empty fuel tanks. The data presented include frequency response plots, rigid-body and structural modal frequencies, and mode shapes. Author

**N86-30724#** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.

**LIQUID HYDROGEN FUELED PASSENGER AIRCRAFT**

Y. QIAN 11 Mar. 1986 11 p Transl. into ENGLISH from Hangkong Zhishi (China), no. 11, Nov. 1984 p 22-23  
(AD-A166229; FTD-ID(RS)T-0862-85) Avail: NTIS HC A02/MF A01 CSCL 01C

The idea that passenger aircraft will eventually use liquid hydrogen fuel is discussed. There is a large reserve of hydrogen and hydrogen poses no danger to the environment. Hydrogen has high calorific value, high specific heat, low density and low temperature. Aircraft will have to have a liquid fuel tank to carry the hydrogen and will have to be partially redesigned. Lockheed and NASA have considered such designs. A problem remains in the planning--the high cost of large extraction of liquid hydrogen. GRA

**N86-30725#** Air Force Wright Aeronautical Labs., Wright-Patterson AFB, Ohio.

**ELECTROSTATIC HAZARDS OF URETHANE PACKED FUEL TANKS Final Report, Mar. 1977 - Apr. 1978**

T. C. HILLMAN, J. R. MANHEIM, and G. A. SPENCER Mar. 1986 95 p  
(AD-A166803; AFWAL-TR-82-2022) Avail: NTIS HC A05/MF A01 CSCL 13L

An experiment investigation has been carried out to determine the primary factors that have contributed to recent aircraft electrostatically induced ground refueling fire incidents. It was found that the explosion suppression open pore polyurethane fuel tank foams along with the charging characteristics of the JP-4 fuel resulted in charge accumulation and electrostatic spark discharging. The polyurethane foams accumulated charge due to their highly resistive nature (blue, 10 to the 15th power ohm-cm; red, 10 to the 14th power ohm-cm; yellow, to the 14th power ohm-cm; and orange, 10 to the 13th power ohm-cm). The fuel flow rate and velocity entering the tank and impinging on the open pore polyurethane foam directly affected the magnitude of the charge separation which was occurring. The number of refuelings that had taken place also was a critical factor due to its effect on charge accumulation/discharge frequency levels. The last major variable investigated was pro-static (Gulf-178) and conductivity improving (shell ASA-3) fuel additives. The Gulf-178 additive dramatically increased the levels of charge separation and accumulation taking place along with a reversal in the polarity of charge. The Shell ASA-3 fuel additive eliminated the aircraft ground refueling electrostatic discharge hazard decreasing the level of charge accumulation. GRA

**N86-30726#** Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). Structures and Materials Panel.

**THE INFLUENCE OF LARGE-SCALE COMPUTING ON AIRCRAFT STRUCTURAL DESIGN**

Apr. 1986 67 p  
(AGARD-R-726; ISBN92-835-1522-6) Avail: NTIS HC A04/MF A01

An outcome of the AGARD Working Group on Large Scale Computing was the institution by the Structures and Materials Panel of a Sub-Committee to consider this topic in relation to Aircraft Structural design. The publication contains papers on various aspects of the topic heard by the Sub-Committee plus a summary. These cover likely developments in both soft- and hardware, and their applications to the Design process. This Report was sponsored by the Structures and Materials Panel of AGARD. Author

**N86-30727#** Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).

**STORE SEPARATION FLIGHT TESTING**

R. J. ARNOLD, C. S. EPSTEIN, and R. K. BOGUE, ed. Apr. 1986 161 p  
(AGARD-AG-300-VOL-5; ISBN92-835-1523-4) Avail: NTIS HC A08/MF A01

This volume in the AGARD Flight Test Techniques Series treats stores separation testing from the overall systems standpoint. All aspects of testing are described from the time of identification of a particular aircraft/store requirement through all steps leading to the establishment of a satisfactory employment envelope. Considerable emphasis is placed on the planning and execution of the flight test phase of the stores clearance program, including the definition of a basic structure, and a set of procedures which will maximize the safe and efficient execution of such a program. Author

## 06

## AIRCRAFT INSTRUMENTATION

Includes cockpit and cabin display devices; and flight instruments.

**A86-43481#**  
**IDENTIFICATION AND ESTIMATION OF THE RANDOM ERROR MODELS FOR INERTIAL ACCELEROMETER AND BARO-ALTIMETER**

R. WANG (Beijing Institute of Aeronautics and Astronautics, People's Republic of China) Acta Aeronautica et Astronautica Sinica, vol. 6, Dec. 1985, p. 556-564. In Chinese, with abstract in English. refs

In accordance with the 'Flight Control' (SFB-58 Flugfuehrung) national research project in West Germany, it is necessary to develop an optimal baroradiointertial hybrid altimeter for the research aircraft DO-28. For this purpose, the random error models for vertical accelerometers on inertial platform and a barometric altimeter under the conditions of landing approach are identified and estimated with the aid of two onboard data acquisition systems. The optimal estimate of the ARIMA model of the associated random error sources is obtained by the time series analysis. A number of actual problems, such as data preprocessing and effect of measurement noise on error model, are also discussed. Author

**A86-45066**  
**BOEING DEVELOPING NEW COCKPIT DISPLAYS TO EASE PILOT WORKLOAD**

J. T. MERRIFIELD Aviation Week and Space Technology (ISSN 0005-2175), vol. 124, June 23, 1986, p. 109, 110, 113.

A program being pursued to ready advanced cockpit displays and automated systems in order to manage the large volume of information that will be available to pilots of the USAF's advanced tactical fighter (ATF) is discussed. In the pictorial format cockpit

## 06 AIRCRAFT INSTRUMENTATION

concept being utilized, the ATF pilot will be assisted by an 'electronic copilot' equipped to automatically handle such tasks as flight and powerplant control, weapons management, and countermeasures. The system would also manage communications and navigation systems while informing the pilot of current tactical situations and advising him in the decision-making process. The research funding for this effort is discussed, and the simulation equipment utilized is described. The roles of the crew station information manager in the system is addressed, including his interaction with the pilot. A planned Kickoff demonstration of the system is described, and related developments in avionics are summarized. C.D.

### **A86-45067 CREW SITUATIONAL AWARENESS DRIVES AVIONICS DEVELOPMENTS**

M. A. DORNHEIM Aviation Week and Space Technology (ISSN 0005-2175), vol. 124, June 23, 1986, p. 114-116.

Avionics research being conducted to provide increased tactical situation awareness for fighter crews is discussed. The main aspects of situational awareness, finding targets while minimizing emissions, identifying targets, and displaying the information to the pilot, are discussed in terms of the display technology required. The features of a conceptual 'superc cockpit' which will provide superior situational awareness are addressed, using the visually coupled airborne systems simulator (VCASS) as an example. The use of avionics modularity to control manufacturing costs and logistics is discussed, stressing the importance of reliability. The maintainability of these avionics systems is also discussed. C.D.

### **A86-45209 THE ACCURACY OF AIR-TEMPERATURE AND FLIGHT-ALTITUDE MEASUREMENTS ABOARD METEOROLOGICAL AIRCRAFT [O TOCHNOSTI IZMERENIYA TEMPERATURY VOZDUKHA I VYSOTY POLETA NA SAMOLETAKH-METEOLABORATORIIAKH]**

V. P. BELIAEV IN: Methods and technology for experimental studies of the atmosphere. Moscow, Gidrometeoizdat, 1985, p. 113-122. In Russian. refs

Measurement errors in determinations of air temperature, air speed, and flight altitude by means of airborne meteorological instruments are discussed. Data obtained by using different instruments to determine a given parameter are compared with one other and with radio-sounding data. For temperature measurements, a thermometer with a shielded thermal element is recommended to eliminate the cloud effect. It is also advisable to use the most exact equations, rather than approximating relationships, for calculations of flight altitude and air velocity, utilizing an airborne digital computer. I.S.

### **A86-46139 WIND-SHEAR DETECTION - A REPORT ON THE FIRST SUCH AIRBORNE WARNING DEVICE TO BE COMMERCIALY CERTIFIED**

B. C. JOHNSTON (Sperry Corp., New York) ICAO Bulletin, vol. 41, March 1986, p. 14-17.

The Performance Management System (PMS) which contains an airborne wind shear detection and alert system is described. The main components of the alert system are a wind-shear computer and a detector. The system evaluates changes in the inertial and air-mass accelerations of aircraft and the annunciation of wind shear is provided to the flight crew using the PMS performance management indicator, a light on the PMS speed deviation indicator, and a flashing red lamp alert. The performance of the wind shear detection and alert system is tested using models and flight tests; it is observed that the system provides accurate and reliable wind shear data. The installation of a program into the system that will supply instructions to the crew on how to exit the wind shear is examined. I.F.

### **A86-46141**

#### **TRENDS IN CIVIL AVIONICS FOR THE NEAR FUTURE**

M. VIVET (Telecommunications Radioelectriques et Telephoniques, Paris, France) ICAO Bulletin, vol. 41, March 1986, p. 22-24.

The growth of avionics is examined. The early development of avionics equipment (1910-1940) is discussed. The use of transistors, semiconductors, and solid-state circuits in airborne equipment is described. The advantages of digital technology as compared to analog technology are studied. The present utilization of electronics and computers in integrated avionics equipment is analyzed. The digitalization of information and data processing methods, decreases in avionics maintenance costs, improvements in communication systems, and an automatic data management concept are proposed for future avionics systems. I.F.

### **A86-46150**

#### **LIQUID-CRYSTAL GOGGLES PERMIT VISUAL SIMULATIONS OF RESTRICTED VISIBILITY**

F. A. WATT, III (Instrument Flight Research, Inc., West Columbia, SC) ICAO Bulletin, vol. 41, May 1986, p. 34-36.

The present Instrument Meteorological Conditions Simulator reproduces the weather conditions seen by a pilot by means of a pair of liquid crystal lenses having electrically controllable opacity. The system encompasses a set of electronically controlled goggles worn by the trainee pilot and a controller subsystem that is operated by the instructor/safety pilot. The goggles may be worn on helicopter or aircraft helmets, or directly on the pilot's face. When simulating clouds or fog, the goggles reproduce the effect of a progressive obscuration of objects with increasing distance from the viewer. O.C.

**A86-46676\*** Georgia Inst. of Tech., Atlanta.

#### **AN UPWARD LOOKING AIRBORNE MILLIMETER WAVE RADIOMETER FOR ATMOSPHERIC WATER VAPOR SOUNDING AND RAIN DETECTION**

J. A. GAGLIANO and R. H. PLATT (Georgia Institute of Technology, Atlanta) IN: Millimeter wave technology III; Proceedings of the Meeting, Arlington, VA, April 9, 10, 1985. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1985, p. 112-117. refs

(Contract NAS5-28132; NAS5-28724)

A 90/180 GHz multichannel radiometer is currently under development for NASA's 1985 Hurricane Mission onboard the Convair 990 research aircraft. The radiometer will be a fixed beam instrument with dual corrugated horns and a common lens antenna designed to operate simultaneously at 90 and 180 GHz. The all solid state front-end will contain three double side band data channels at 90 + or - 3 GHz, 180 + or - 3 GHz, and 180 + or - 7 GHz. The airborne radiometer will mount in a window port on the CV-990 and will maintain a fixed beam view approximately 14 degrees off zenith. The radiometer design is a Dicke chopper arrangement selected to achieve maximum absolute temperature accuracy and minimum brightness temperature sensitivity. Analog outputs of the three data channels will be calibrated dc voltages representing the observed radiometric brightness temperatures over the selected integration time. Author

### **A86-46715**

#### **DECISION AIDING FOR TACTICAL AIRCRAFT**

M. BROADWELL, J. SMITH, J. BARNETTE, and C. STAROS (Lockheed-Georgia Co., Advanced Electronics Div., Marietta) IN: Applications of artificial intelligence II; Proceedings of the Meeting, Arlington, VA, April 9-11, 1985. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1985, p. 153-160. refs

Some of the tasks of the airborne mission/route planner system under development for tactical aircraft require symbolic reasoning on the basis of subjective and incomplete information. Other tasks call for precise and synchronized processing of aircraft control parameters, while others may be of a nature that is intermediate between the two extremes. Attention is given to this system's design and implementation approach, which involves the subdivision of the route planning problem into a hierarchy of reasoning abstractions reflecting the types of reasoning or



computation best suited to the various facets of the problem.

O.C.

**A86-47106**

**AN INTELLIGENT AMPLIFIER AND ITS APPLICATION TO MODAL TESTING**

R. D. TALMADGE (USAF, Flight Dynamics Laboratory, Wright-Patterson AFB, OH) IN: International Modal Analysis Conference, 3rd, Orlando, FL, January 28-31, 1985, Proceedings, Volume 1. Schenectady, NY, Union College, 1985, p. 507-510.

The design of the automatic gain ranging amplifier (AGRA) which is to provide the gain element in a data collection system is examined. The amplifier consists of a gain block, a presample filter with six poles and butterworth characteristics, a quasi-peak detector for gain control, and a line driver output. The use of a dual-tracking constant-current-circuit to supply bridge power and measure the differential IR drops across the elements is discussed. The performance characteristics and functions of the digitally controlled AGRA are described. The AGRA produces an analog signal output. The application of the amplifier to flight and ground testing of aircraft is analyzed. I.F.

**N86-29816#** Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). Flight Mechanics Panel.

**ANALOGUE SIGNAL CONDITIONING FOR FLIGHT TEST INSTRUMENTATION**

D. W. VEATCH and R. BOGUE Apr. 1986 179 p (AGARD-AG-160-VOL-17; ISBN-92-835-1520-X) Avail: NTIS HC A09/MF A01

The application of analog signal conditioning to flight-test data-acquisition systems is discussed. Emphasis is placed on practical applications of signal conditioning for the most common flight-test data-acquisition systems. A limited amount of theoretical discussion is included to assist the reader in a more complete understanding of the subject matter. Nonspecific signal conditioning, such as amplification, filtering, and multiplexing, is discussed. Signal conditioning for various specific transducers and data terminal devices is also discussed to illustrate signal conditioning that is unique to particular types of transducers. The purpose is to delineate for the reader the various signal-conditioning technique options, together with tradeoff considerations, for commonly encountered flight-test situations. Author

**N86-29817#** Air Force Inst. of Tech., Wright-Patterson AFB, Ohio.

**IMPROVING THE INTERPRETABILITY OF AN AIRCRAFT ATTITUDE INDICATOR M.S. Thesis**

M. A. DIPADUA 1986 59 p (AD-A166329; AFIT/CI/NR-86-27T) Avail: NTIS HC A04/MF A01 CSCL 01D

Two display types and four aircraft size ratios were investigated in this thesis to determine their effect on attitude display interpretability. The two display designs used were an outside-in (moving plane) and an inside-out (moving horizon) display. The four aircraft symbol lengths were measured relative to the size of the artificial horizon (33 percent, 50 percent, 67 percent, 100 percent). Twenty flight naive subjects were tested in two phases with both display types and all four size ratios. The first phase tested subjects' reaction to the sudden awareness of a change in attitude. The dependent variables measured, reaction time and error rate, indicated a preference for the outside-in display. The small size ratio was significantly better than the larger ones with reaction time as the dependent variable. A significant difference between sizes was not the case when the dependent variable error rate was measured. The second phase consisted of a dynamic flying task on an Apple PC computer. The dependent measures were the root mean square (RMS) error due to roll and the RMS error due to pitch. A significant difference in display types, favoring the outside-in type, was found with the RMS error due to roll as the dependent measure. No significant differences were found when the RMS error due to pitch was used as the dependent

measure. Sizes did, however, approach significance in this case.

GRA

**N86-30728#** Aerojet ElectroSystems Co., Azusa, Calif. **DESIGN, DEVELOPMENT AND INTEGRATE/INSTALL AN AIRBORNE REMOTE INSTRUMENTATION SYSTEM (AIREYE) Final Report**

J. J. BOMMARITO and L. E. SAYLOR Aug. 1985 79 p (Contract DTCG23-80-C-20012) (AD-A166755; REPT-7921; USCG-D-27-85) Avail: NTIS HC A05/MF A01 CSCL 01C

A prototype airborne remote instrument system, AIREYE, was developed for the U.S. Coast Guard by Aerojet ElectroSystems Company. This multisensor system permits real-time day/night, all weather detection, mapping and documentation of vessels and pollution at sea. The system was installed aboard a coast Guard Hu-25A Falcon fanjet aircraft and flight tested off the California coast. Surveillance data were obtained from natural oil seeps, known optical and radar targets, routine shipping and targets of opportunity. The AIREYE system consists of a sidelooking radar, infrared/ultraviolet line scanner, active gated television systems, aerial reconnaissance camera and a processor/display recording subsystem with real-time digital image enhancement capability. The system reliably detected and mapped oil seeps and vessel locations for environmental conditions ranging from dense undercast to clear, windspeeds from 0 to greater than 25 knots and from daytime to total darkness. The ability to read a vessel's name and determine deck activity in total darkness was demonstrated. The AIREYE real-time digital enhancement provided detection, recognition and identification of targets of interest when not otherwise possible with unenhanced imagery. Test results demonstrated that the AIREYE system will provide greatly enhanced capability in the U.S. Coast Guard missions of Marine Environmental Protection (MEP), Enforcement of Laws and Treaties and Search and Rescue. Author (GRA)

**N86-30729#** Aeronautical Systems Div., Wright-Patterson AFB, Ohio.

**AIRBORNE NAVIGATION REMOTE MAP READER EVALUATION Final Report, 1 Sep. 1984 - 30 Sep. 1985**

J. C. BYRD Mar. 1986 56 p (AD-A166976; ASD-TR-86-5004) Avail: NTIS HC A04/MF A01 CSCL 01C

The U.S. Air Force evaluated the Full-Color Remote Map Reader built by Thomson-CSF of France under the Foreign Weapons, Equipment, and Technology Evaluation program. The unit is used in a military aircraft to provide a moving map video display for the aircrew. Map data is contained in a 65-foot roll of 35mm film at 11.4:1 reduction, which allows approximately 550 sq. ft. of aeronautical charts of any standard scale to be stored in one cassette. The unit moves the film with microprocessor-controlled servo motors and performs scanning, rotation and zoom with a microprocessor-controlled flying spot scanner. It obtains navigation data from the aircraft MIL-STD-1553 data bus and presents video on a full-color, shadow-mask cathode ray tube. The evaluation determined that the moving map display is useful in several Air Force missions, and that the French map reader technology is roughly equivalent to devices recently developed in the U.S.

Author (GRA)

## 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.

**A86-43910#****PROPELLING THE AEROSPACE PLANE**

Mechanical Engineering (ISSN 0025-6501), vol. 108, June 1986, p. 32-36.

Attention is given to the design features, prospective performance levels and technology development aspects of the combined turbojet/scramjet propulsion system currently undergoing conceptual definition for the hypersonic/transatmospheric 'aerospace plane'. The scramjet engine design under intensive consideration is able to operate as a conventional ramjet from speeds of Mach 3.5 to 6, and then as a true scramjet from Mach 5 to 12. Acceleration to Mach 3.5 would be accomplished by a separate complement of turbojet engines. Attention is given to the characteristics of liquid hydrogen fuel that render it an advantageous propellant for such powerplants. O.C.

**A86-43939#****INFLUENCE OF TURBINE-ENGINE DESIGN ON FLIGHT SAFETY [WPLYW KONSTRUKCJI SILNIKOW TURBINOWYCH NA BEZPIECZENSTWO LOTU]**

M. LAGOSZ and S. SZCZECINSKI (Wojskowa Akademia Techniczna, Warsaw, Poland) Technika Lotnicza i Astronautyczna (ISSN 0040-1145), vol. 41, Jan. 1986, p. 20-22. In Polish. refs

During the operation of aircraft turbine engines, failures sometimes occur which consist in the breaking off of single rotor blades or larger parts of the rotating components. The present paper attempts to determine how engine design features can affect the extent of damage to the engine and to the fuselage during failures of this type. B.J.

**A86-44005#****THE NEXT HOT FIGHTER ENGINE**

J. S. PETTY, R. J. HILL, A. C. PICCIRILLO, and A. E. FANNING (USAF, Aeronautical Systems Div., Wright-Patterson AFB, OH) Aerospace America (ISSN 0740-722X), vol. 24, June 1986, p. 40-43.

The U.S. Air Force's projected Advanced Tactical Fighter (ATF) will be the first such vehicle to cruise over long distances at supersonic speeds, without afterburning and without compromise of subsonic range. The ATF's STOL and high maneuverability requirements have been judged to require nonaxisymmetric vectoring and reversing nozzles, contrarotating turbine spools, high throughflow compressors, and digital electronic engine controls without hydromechanical backups. Several variable geometry features are also under consideration in the two technology demonstration engines currently under development in order to furnish balanced subsonic vs supersonic operating efficiencies. O.C.

**A86-44007#****ROTARY GROWS UP**

R. DEMEIS Aerospace America (ISSN 0740-722X), vol. 24, June 1986, p. 48-51.

In conjunction with the use of composite airframes, a lightweight high power rotary engine of modest cost and gasoline or kerosene fuel rather than avgas operation could have a substantial impact on the general aviation market. Attention is presently given to the development status of engines of this type, and to configurational features they have incorporated; such features include stratified charge combustion, electronically controlled high pressure fuel injectors, friction-reduction coatings, and high temperature ceramics. specific fuel consumption ratings comparable to those of piston engines are already obtainable, with lower vibration. O.C.

**A86-44697****THE EFFECT OF DEPOSITS ON THE COOLING EFFICIENCY OF GAS-TURBINE ENGINE BLADES [VLIANIE OTLOZHENII NA EFFEKTIVNOST' OKHLAZHDENIIA LOPATOK GAZOTURBINNYKH DVIGATELEI]**

S. Z. KOPELEV and V. G. DAMASKIN Promyshlennaia Teplotekhnika (ISSN 0204-3602), vol. 8, no. 2, 1986, p. 71-73. In Russian.

A method is proposed for calculating the thermal and hydraulic characteristics of blades with deposits, and an expression relating the intensity of heat transfer from cooled blades to the thickness and thermophysical properties of the deposits is obtained. It is shown that the deposits formed on blades during service have a noticeable effect on the thermal state of the blades, which must be taken into account in designing blades and blade-cooling systems. V.L.

**A86-44872#****ROLE OF SHOCKS IN TRANSONIC/SUPERSONIC COMPRESSOR ROTOR FLUTTER**

O. O. BENDIKSEN (Princeton University, NJ) (International Symposium on Air Breathing Engines, 7th, Beijing, People's Republic of China, September 2-6, 1985, Proceedings, p. 691-701) AIAA Journal (ISSN 0001-1452), vol. 24, July 1986, p. 1179-1186. Previously cited in issue 02, p. 110, Accession no. A86-11684. refs

**A86-44925#****AXISYMMETRIC THREE-DIMENSIONAL FLOW IN THE COOLED GAS TURBINE [ROTATIONSSYMMETRISCHE RAEUMLICHE STROMUNG IN DER GERKUEHLTEN GASTURBINE]**

E. RIKLI Zuerich, Eidgenoessische Technische Hochschule, Doktor der technischen Wissenschaften Dissertation, 1984, 121 p. In German. refs

The present investigation is concerned with a computational procedure for the cooled gas turbine, taking into account the determination of state variables, velocities, and the location of the meridian streamlines. This procedure makes it possible to calculate two-dimensional flow characteristics in an effective channel. The mass flow along the path of expansion is kept variable, corresponding to the introduction of cooling air. Attention is given to a geometrical description of the meridian channel, a one-dimensional solution, the stream function in a variable mass flow, the cooling air distribution function, changes of state in the two-dimensional case, a description of the streamlines, the initial solution for the meridian streamline characteristics, the equations of motion, a local coordinate system, the solution of the equilibrium condition in a control surface, a two-dimensional solution, and selected results. G.R.

**A86-45375#****DEVELOPMENT OF IN-FLIGHT THRUST MEASUREMENT PROCEDURES FOR AN AFTERBURNING TURBOFAN ENGINE**

E. C. ROONEY and C. E. WILT (U.S. Navy, Naval Air Systems Command, Washington, DC) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 21st, Monterey, CA, July 8-11, 1985. 12 p. Navy-sponsored research. refs (AIAA PAPER 85-1405)

This paper presents a historical perspective of the development of in-flight thrust measurement procedures for a mixed-flow afterburning turbofan engine. Portions of this program were previously extracted for use in the examples used in SAE AIR-1703: 'In-Flight Thrust Determination'. The purpose of the in-flight thrust measurement program was to provide for economical definition of performance characteristics over a range of subsonic, transonic and supersonic flight conditions. Development of the in-flight thrust measurement procedures is discussed from the planning through flight phases, including: contract provisions, methodology, instrumentation, engine test cell program, thrust-drag accounting and flight validation. The initial flight results showed evidence of bias errors. Investigation of these errors ultimately led to development of alternative in-flight thrust methodology. Author



**A86-45504\*#** United Technologies Corp., Windsor Locks, Conn. **PROPELLER NOISE CAUSED BY BLADE TIP RADIAL FORCES**  
D. B. HANSON (United Technologies Corp., Hamilton Standard Div., Windsor Locks, CT) AIAA, Aeroacoustics Conference, 10th, Seattle, WA, July 9-11, 1986. 11 p. Research supported by United Technologies Corp. refs  
(Contract NAS3-23720; NAS3-23051)  
(AIAA PAPER 86-1892)

New experimental evidence which indicates the presence of leading edge and tip edge vortex flow on Prop-Fans is examined, and performance and noise consequences are addressed. It was shown that the tip edge vortex is a significant noise source, particularly for unswept Prop-Fan blades. Preliminary calculations revealed that the addition of the tip side edge source to single rotation Prop-Fans during take off conditions improved the agreement between experiment and theory at blade passing frequency. At high-speed conditions such as the Prop-Fan cruise point, the tip loading effect tends to cancel thickness noise. K.K.

**A86-45819**  
**Mechanical Design of Gas Turbine Blading in Cast Superalloys**

A. G. DODD (Rolls-Royce, Ltd., Derby, England) (Institute of Metals, Conference on Casting of Superalloys, London, England, Feb. 27, 1985) Materials Science and Technology (ISSN 0267-0836), vol. 2, May 1986, p. 476-485. refs

The mechanical design of hot turbine blading has two main phases: (1) optimization, which yields the choice of material, number of blades, and general configuration, and (2) detailed design of the particular features of the blades. The first phase makes use of the data available, which are usually limited, to provide an outline mechanical assessment of commercial viability. At this stage maximization of the lifetime to failure is considered in terms of the temperature and stress at each radial position. In the second phase, failure modes are considered in more detail. The methods used in both stages are discussed, with emphasis on material and manufacture, taking as an example the blading in civil aircraft gas turbines. Particular attention is paid to the problems of designing with single-crystal cast superalloys. Author

**A86-46024#**  
**EXPERIMENTAL STUDY OF FLIGHT EFFECT ON FAN NOISE. I - A STUDY OF INFLOW CONTROL DEVICE FOR SIMULATING IN-FLIGHT FAN NOISE IN STATIC TEST**

H. KOBAYASHI and T. TORISAKI (National Aerospace Laboratory, Chofu, Japan) JSME, Bulletin (ISSN 0021-3764), vol. 29, May 1986, p. 1536-1543. Research supported by the Agency of Industrial Science and Technology. refs

The design, development, and performance of an inflow control device (ICD) which permits (by reducing turbulence) the static-test simulation of flight test conditions when investigating the fan noise of turbofan aircraft engines are reported. Experimental tests on various candidate materials for an ICD are described along with measurements of the inflow turbulence in flight-test conditions. A prototype 4-m-diameter hemispheric ICD constructed with a combination of perforated plate, wire screen, and 6.3-mm-core aspect-ratio-8 honeycomb is found to reduce the inflow turbulence level to 1 percent at flow velocity 2-5 m/s while lowering acoustic transmission by only 1.0 dB or less. T.K.

**N86-29818\*#** Oklahoma Univ., Norman.  
**TRANSMISSION LINE DESIGN FOR A POWER DISTRIBUTION SYSTEM AT 20 KHZ FOR AIRCRAFT**

L. W. ZELBY, J. B. MATHES, and J. W. SHAWVER Washington NASA Jul. 1986 38 p  
(Contract NAG3-508)  
(NASA-CR-3987; NAS 1.26:2987) Avail: NTIS HC A03/MF A01 CSCL 21E

A low inductance, low characteristic impedance transmission line was designed for a 20 kHz power distribution system. Several different conductor configurations were considered: strip lines, interdigitated metal ribbons, and standard insulated wires in multiwire configurations (circular and rectangular cylindrical

arrangements). The final design was a rectangular arrangement of multiple wires of the same gauge with alternating polarities from wire to wire. This offered the lowest inductance per unit length (on the order of several nanohenries/meter) and the lowest characteristic impedance (on the order of one Ohm). Standard multipin connectors with gold-plated elements were recommended with this transmission line, the junction boxes to be internally connected with flat metal ribbons for low inductance, and the line to be constructed in sections of suitable length. Computer programs for the calculation of inductance of multiwire lines and of capacitances of strip lines were developed. Author

**N86-29819\*#** Massachusetts Inst. of Tech., Cambridge. Lab. for Information and Decision Systems.

**MULTI-VARIABLE CONTROL OF THE GE T700 ENGINE USING THE LQG/LTR DESIGN METHODOLOGY**

W. H. PFEIL (General Electric Co., Lynn, Mass.), M. ATHANS, and H. A. SPANG, III (General Electric Co., Schenectady, N. Y.) Apr. 1986 16 p  
(Contract NAG2-297)  
(NASA-CR-177080; NAS 1.26:177080; LIDS-P-1547) Avail: NTIS HC A02/MF A01 CSCL 21E

The design of scalar and multi-variable feedback control systems for the GET700 turboshaft engine coupled to a helicopter rotor system is examined. A series of linearized models are presented and analyzed. Robustness and performance specifications are posed in the frequency domain. The linear-quadratic-Gaussian with loop-transfer-recovery (LQG/LTR) methodology is used to obtain a sequence of three feedback designs. Even in the single-input/single-output case, comparison of the current control system with that derived from the LQG/LTR approach shows significant performance improvement. The multi-variable designs, evaluated using linear and nonlinear simulations, show even more potential for performance improvement. Author

**N86-29820\*#** Wu (Jiunn-Jenq), Sierra Madre, Calif.

**EXPERIMENTS ON HIGH SPEED EJECTORS**

J. J. WU Jul. 1986 82 p  
(Contract NASA ORDER A40174-C; F49620-81-C-0043)  
(NASA-CR-177419; NAS 1.26:177419) Avail: NTIS HC A05/MF A01 CSCL 21E

Experimental studies were conducted to investigate the flow and the performance of thrust augmenting ejectors for flight Mach numbers in the range of 0.5 to 0.8, primary air stagnation pressures up to 107 psig (738 kPa), and primary air stagnation temperatures up to 1250 F (677 C). The experiment verified the existence of the second solution ejector flow, where the flow after complete mixing is supersonic. Thrust augmentation in excess of 1.2 was demonstrated for both hot and cold primary jets. The experimental ejector performed better than the corresponding theoretical optimal first solution ejector, where the mixed flow is subsonic. Further studies are required to realize the full potential of the second solution ejector. The research program was started by the Flight Dynamics Research Corporation (FDRC) to investigate the characteristic of a high speed ejector which augments thrust of a jet at high flight speeds. Author

**N86-29822#** Department of the Air Force, Washington, D.C.  
**SELF-RETAINED PLATFORM COOLING PLATE FOR TURBINE VANE Patent Application**

S. N. FINGER, inventor (to Air Force) 13 Nov. 1985 13 p  
(AD-D012218; US-PATENT-APPL-SN-797581) Avail: NTIS HC A02/MF A01 CSCL 21E

A turbine stator vane assembly for gas turbine or turbojet engines has an improved structure for retention of a cooling impingement plate. Two inwardly directed flanges are added to the wall-like extensions extending from the bottom of the platform upon which the vane is mounted. The cooling impingement plate is resiliently snapped into place between pin fins on the bottom of the platform and the flanges. Author (GRA)

## 07 AIRCRAFT PROPULSION AND POWER

**N86-30664#** Liege Univ. (Belgium).

### **DYNAMIC ANALYSIS OF STRUCTURES WITH FLEXIBLE ROTORS**

M. GERADIN and N. KILL *In* DGLR The 2nd International Symposium on Aeroelasticity and Structural Dynamics p 477-485 1985

Avail: NTIS HC A99/MF E03

Analytical tools for the dynamic structural analysis of machines with rotating parts such as aircraft engines are described. The finite element analysis is used for discretization, and the rotating parts are described using a 3-D formalism which includes in the kinetic energy expression the gyroscopic effects induced by the local changes of angular velocity produced by the deformation. The implementation of the formalism is specialized to the modeling of flexible rotors made of shafts and disks typical of modern aircraft engines. The effectiveness of the component mode synthesis method to reduce the size of the system of equations is demonstrated in the case of systems made of rotating and fixed parts. Critical speed and stability analyses and unbalance response calculations are performed by a sweeping procedure. The concepts are applied to the dynamic analysis of a high by-pass ratio aircraft engine. ESA

**N86-30730\*#** Massachusetts Inst. of Tech., Cambridge. Dept. of Aeronautics and Astronautics.

### **UNSTEADY DESIGN-POINT FLOW PHENOMENA IN TRANSONIC COMPRESSORS Final Report**

J. B. GERTZ and A. H. EPSTEIN Aug. 1986 210 p

(Contract NGL-22-009-383)

(NASA-CR-176879; NAS 1.26:176879) Avail: NTIS HC A10/MF A01 CSCL 21E

High-frequency response probes which had previously been used exclusively in the MIT Blowdown Facility were successfully employed in two conventional steady state axial flow compressor facilities to investigate the unsteady flowfields of highly loaded transonic compressors at design point operation. Laser anemometry measurements taken simultaneously with the high response data were also analyzed. The time averaged high response data of static and total pressure agreed quite well with the conventional steady state instrumentation except for flow angle which showed a large spread in values at all radii regardless of the type of instrumentation used. In addition, the time resolved measurements confirmed earlier test results obtained in the MIT Blowdown Facility for the same compressor. The results of these tests have further revealed that the flowfields of highly loaded transonic compressors are heavily influenced by unsteady flow phenomena. The high response measurements exhibited large variations in the blade to blade flow and in the blade passage flow. The observed unsteadiness in the blade wakes is explained in terms of the rotor blades' shed vorticity in periodic vortex streets. The wakes were modeled as two-dimensional vortex streets with finite size cores. The model fit the data quite well as it was able to reproduce the average wake shape and bi-modal probability density distributions seen in the laser anemometry data. The presence of vortex streets in the blade wakes also explains the large blade to blade fluctuations seen by the high response probes which is simply due to the intermittent sampling of the vortex street as it is swept past a stationary probe. Author

**N86-30731\*#** Virginia Polytechnic Inst. and State Univ., Blacksburg. Dept. of Mechanical Engineering.

### **THERMODYNAMIC EVALUATION OF TRANSONIC COMPRESSOR ROTORS USING THE FINITE VOLUME APPROACH Status Report**

S. NICHOLSON and J. MOORE Aug. 1986 292 p

(Contract NAG3-593)

(NASA-CR-176947; NAS 1.26:176947; JM/86-6) Avail: NTIS HC A13/MF A01 CSCL 21E

A method was developed which calculates two-dimensional, transonic, viscous flow in ducts. The finite volume, time marching formulation is used to obtain steady flow solutions of the Reynolds-averaged form of the Navier Stokes equations. The entire calculation is performed in the physical domain. The method is

currently limited to the calculation of attached flows. The features of the current method can be summarized as follows. Control volumes are chosen so that smoothing of flow properties, typically required for stability, is now needed. Different time steps are used in the different governing equations to improve the convergence speed of the viscous calculations. A new pressure interpolation scheme is introduced which improves the shock capturing ability of the method. A multi-volume method for pressure changes in the boundary layer allows calculations which use very long and thin control volumes. A special discretization technique is also used to stabilize these calculations. A special formulation of the energy equation is used to provide improved transient behavior of solutions which use the full energy equation. The method is then compared with a wide variety of test cases. The freestream Mach numbers range from 0.075 to 2.8 in the calculations. Transonic viscous flow in a converging diverging nozzle is calculated with the method; the Mach number upstream of the shock is approximately 1.25. The agreement between the calculated and measured shock strength and total pressure losses is good. Essentially incompressible turbulent boundary layer flow in a adverse pressure gradient is calculated and the computed distribution of mean velocity and shear stress are in good agreement with the measurements. At the other end of the Mach number range, a flat plate turbulent boundary layer with a freestream Mach number of 2.8 is calculated using the full energy equation; the computed total temperature distribution and recovery factor agree well with the measurements when a variable Prandtl number is used through the boundary layer. Author

**N86-30732\*#** Systems Control Technology, Inc., Palo Alto, Calif.

### **ROBUST DETECTION, ISOLATION AND ACCOMMODATION FOR SENSOR FAILURES Final Report**

A. EMAMI-NAEINI, M. M. AKHTER, and S. M. ROCK Jul. 1986 164 p

(Contract NAS3-24079)

(NASA-CR-174825; NAS 1.26:174825; SCT-85-5449) Avail:

NTIS HC A08/MF A01 CSCL 21E

The objective is to extend the recent advances in robust control system design of multivariable systems to sensor failure detection, isolation, and accommodation (DIA), and estimator design. This effort provides analysis tools to quantify the trade-off between performance robustness and DIA sensitivity, which are to be used to achieve higher levels of performance robustness for given levels of DIA sensitivity. An innovations-based DIA scheme is used. Estimators, which depend upon a model of the process and process inputs and outputs, are used to generate these innovations. Thresholds used to determine failure detection are computed based on bounds on modeling errors, noise properties, and the class of failures. The applicability of the newly developed tools are demonstrated on a multivariable aircraft turbojet engine example. A new concept call the threshold selector was developed. It represents a significant and innovative tool for the analysis and synthesis of DiA algorithms. The estimators were made robust by introduction of an internal model and by frequency shaping. The internal mode provides asymptotically unbiased filter estimates. The incorporation of frequency shaping of the Linear Quadratic Gaussian cost functional modifies the estimator design to make it suitable for sensor failure DIA. The results are compared with previous studies which used thresholds that were selected empirically. Comparison of these two techniques on a nonlinear dynamic engine simulation shows improved performance of the new method compared to previous techniques Author

**N86-30733\*#** Detroit Diesel Allison, Indianapolis, Ind.

### **FEASIBILITY STUDY FOR CONVERTIBLE ENGINE TORQUE CONVERTER**

Oct. 1985 72 p

(Contract NAS3-24092)

(NASA-CR-175082; NAS 1.26:175082; EDR-12118) Avail: NTIS HC A04/MF A01 CSCL 21E

The feasibility study has shown that a dump/fill type torque converter has excellent potential for the convertible fan/shaft

engine. The torque converter space requirement permits internal housing within the normal flow path of a turbofan engine at acceptable engine weight. The unit permits operating the engine in the turboshaft mode by decoupling the fan. To convert to turbofan mode, the torque converter overdrive capability bring the fan speed up to the power turbine speed to permit engagement of a mechanical lockup device when the shaft speed are synchronized. The conversion to turbofan mode can be made without drop of power turbine speed in less than 10 sec. Total thrust delivered to the aircraft by the propotor, fan, and engine during transient can be controlled to prevent loss of air speed or altitude. Heat rejection to the oil is low, and additional oil cooling capacity is not required. The turbofan engine aerodynamic design is basically uncompromised by convertibility and allows proper fan design for quiet and efficient cruise operation. Although the results of the feasibility study are exceedingly encouraging, it must be noted that they are based on extrapolation of limited existing data on torque converters. A component test program with three trial torque converter designs and concurrent computer modeling for fluid flow, stress, and dynamics, updated with test results from each unit, is recommended. Author

**N86-30734#** Exotech, Inc., Campbell, Calif.  
**TIME RESOLVED AND TIME AVERAGED FLOW EVALUATION FOR AN ISOLATED TRANSONIC COMPRESSOR ROTOR Final Report**

F. NEUHOFF Mar. 1986 61 p  
 (Contract N00014-84-C-0766)  
 (AD-A166759; TR-8601) Avail: NTIS HC A04/MF A01 C SCL  
 20D

A 0.28-m single stage transonic fan was operated in a rotor only configuration. Overall performance was measured and radial distributions of inlet and outlet velocity were obtained using time-averaging combination temperature-pneumatic probes. These results were compared to the prediction of a finite element computer code (TURBOFEM) prediction. The blade-to-blade velocity and pressure distributions were measured using the Dual Probe Digital Sampling technique (involving two commercial semi-conductor probes of simple design). Data were obtained from hub-to-tip at both near-sonic and at supersonic inlet relative Mach numbers. The rotor losses were derived as blade-to-blade distributions and the shock losses were evaluated as components of the total loss at each radius. Based on the limited data obtained near sonic conditions, a combination of the profile loss model of Koch & Smith and shock loss model of Dunker was found to predict the measured radial loss distribution quite well. Preliminary observations of rotor shock oscillations were also reported. Compressor rotors, Compressor stators, Transonic flow, Turbomachinery flow fields, Transonic loss measurements, and Finite element codes. GRA

**N86-30735#** Doellner (O. Leonard), Tucson, Ariz.  
**JET-ENGINE COMBUSTOR SPECTRAL RADIATION MEASUREMENTS USING FIBEROPTIC INSTRUMENTATION SYSTEM. RADIANT ENERGY POWER SOURCE FOR JET AIRCRAFT Final Report**

O. L. DOELLNER Feb. 1986 121 p  
 (Contract DE-FG01-82CE-15144)  
 (DE86-007289; DOE/CE-15144/T2) Avail: NTIS HC A06/MF  
 A01

This report is a summary of spectral radiation measurements made at Williams Air Force Base, Chandler, Arizona on a General Electric J-85-5 engine. The spectral radiation measurements consisted of a complete axial profile down the combustor and are directed toward the application of Radiant Energy Power Source for Jet Aircraft. Radiant Energy Power Source for Jet Aircraft relates to the use of photovoltaic cells to generate the electrical power demands of the aircraft. The photovoltaic cells are mounted inside the casing of the jet engine, are thermally insulated from the normally hot engine casing, and are appropriately cooled. The photovoltaic cells receive their required radiant energy from the combustion flame by holes in the combustion liner. The instrumentation system used to make these measurements

employed fiberoptic probes - entering the engine by way of an existing (modified) access plate - to obtain the radiation measurements. Such an instrumentation system has the strong advantage of being able to measure radiation from all the holes running axially down the combustor without making any holes in the plenum/engine casing - as would be necessary if sapphire observation windows were used. DOE

## 08

## AIRCRAFT STABILITY AND CONTROL

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

**A86-43497#**  
**CONTROLLABILITY OF REDUNDANT FLIGHT CONTROL SYSTEM AND PRESSURE EQUALIZATION OF REDUNDANT SERVO ACTUATORS**

S. GUO (Nanjing Aeronautical Institute, People's Republic of China) Acta Aeronautica et Astronautica Sinica, vol. 7, Feb. 1986, p. 71-79. In Chinese, with abstract in English.

A study on the control behavior of a redundant flight control system is carried out. The controllability of the redundant system and the effects of bias on the dynamic response of the controllable and uncontrollable state variables is stressed. The conclusions are extended to the pressure equalization problem of redundant servo actuators. Then a type of proportional plus integral digital equalization loop is designed. The good behavior of equalization is verified through experiments. Author

**A86-43498#**  
**DESIGN AND RESEARCH OF AIRCRAFT PARAMETER-ADAPTIVE LATERAL COMMAND AUGMENTATION SYSTEMS**

S. XIAO and W. ZHANG (Northwestern Polytechnical University, Xian, People's Republic of China) Acta Aeronautica et Astronautica Sinica, vol. 7, Feb. 1986, p. 80-90. In Chinese, with abstract in English.

A scheme of parameter-adaptive command augmentation system (CAS) is designed for a supersonic-jet's lateral motions. Its digital simulation is also investigated. The purpose of the work is to provide the aircraft with superior handling qualities against rapid variation of the aircraft's lateral parameters and effect of external disturbances. The behavior of CAS during constant altitude-coordination both at constant and decreasing speed, as well as under stochastic side-gust disturbances is addressed. The time responses of the aircraft with CAS are compared with those of the free aircraft under the above conditions. It is shown that the version of the adaptive CAS is superior in anti-disturbance and adaptability to time-varying parameters. The microcomputer implementation of the parameter-adaptive lateral CAS and the choice of the microcomputer are also considered. Author

**A86-43536#**  
**AN ADAPTIVE FLIGHT CONTROL SYSTEM DESIGN FOR CCV WITH AN UNKNOWN INTERACTOR MATRIX**

K. KANAI and S. UCHIKADO Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 34, April 1986, p. 211-221. In Japanese, with abstract in English. refs

A design method for a Control Configured Vehicle adaptive flight control system with an unknown interactor matrix is proposed whose matrix is uniquely constructed from a controlled system and helps determine the control law. The system is applied to the case of small-sized and high speed aircraft with vertical canard and flap control surfaces, and its effectiveness is demonstrated by a numerical simulation. R.R.

A86-44932

**AIRCRAFT FLUTTER ANALYSIS (THE FOURTH JOHN WESTON MEMORIAL LECTURE)**

A. J. VERMEULEN (Council for Scientific and Industrial Research, National Institute for Aeronautics and Systems Technology, Pretoria, Republic of South Africa) *Aeronautica Meridiana* (ISSN 0257-8573), vol. 6, no. 1, 1985, p. 1-12.

A comprehensive account is given of current methods for the study and analysis of flutter in aircraft structures, with particular reference to such high performance aircraft cases as the oscillation of a fighter wing with wingtip missiles. After a development history of flutter analysis and design methods, attention is given to analytical techniques, ground vibration testing, unsteady aerodynamics, the solution of the flutter equation, and the wind tunnel testing of dynamically similar models. O.C.

A86-44944

**NAVY DEPARTURE/SPIN AND AIR COMBAT MANEUVERING EVALUATION OF A NATIONAL AERONAUTICS AND SPACE ADMINISTRATION DEVELOPED FLIGHT CONTROL SYSTEM FOR THE F-14**

C. M. BAUCOM and C. CLARK (U.S. Navy, Naval Air Test Center, Patuxent River, MD) IN: Society of Experimental Test Pilots, Symposium, 29th, Beverly Hills, CA, September 25-28, 1985, Proceedings. Lancaster, CA, Society of Experimental Test Pilots, 1985, p. 162-177.

An account is given of work done under a program involving NASA, Grumman Aerospace Corp., and the Navy, intended to design a system that would prevent spins without compromising the tactical maneuvering capability of the F-14. (As currently flown by the operational Navy) the F-14 exhibits two extremely undesirable flying qualities characteristics in the high angle-of-attack flight regime. First, lateral control surface deflections at high AOA can induce departure which may progress into an unrecoverable flat spin if recovery control inputs are delayed. Second, basic flying qualities are significantly degraded (typically by wing rock and lateral control reversal) at high AOA, thus increasing pilot workload in the tactical environment. An automatic-rudder interconnect (ARI) system was developed and enhanced with a low speed/high AOA cross control capability. Topics covered include: test airplane description; external store configurations; test site; simulation support of the flight test effort; and flight tests. The ARI concepts provided significantly improved high AOA flying qualities characteristics for the F-14. No serious degradation to the departure/spin resistance characteristics resulted. The low speed/high AOA cross control modification was successfully integrated into the flight control system; this option permitted the pilot to override the differential stabilator limiting and the lateral-stick-to-rudder-interconnect features, thus retaining the gross lateral control capability that currently exists in the production F-14. Future plans for further development of the ARI are noted. D.H.

A86-44946

**A320 FLIGHT CONTROLS**

S. G. CORPS (Airbus Industrie, Toulouse, France) IN: Society of Experimental Test Pilots, Symposium, 29th, Beverly Hills, CA, September 25-28, 1985, Proceedings. Lancaster, CA, Society of Experimental Test Pilots, 1985, p. 196-210.

The A320 widebody twin aircraft is discussed with emphasis on the flight controls. The A320 is the successor to the A300 and A310, which employed a number of new technologies. The new aircraft will use the fly-by-wire technology proven on the A310 and on *Concorde*, with a type of controller permitting the aircraft to survive a short term total electrical failure by manually changing the flight path if necessary. (Probability of needing such a fly-by-wire failure mode is less than one in a billion per hour; *Concorde* has full mechanical reversion which has never had to be used). Side stick control will be used rather than center stick. The fly-by-wire architecture is to be developed by Aerospatiale (the French partner of Airbus Industrie). Control in pitch, envelope protection (overspeed), stall protection, windshear protection, maneuver protection, attitude protection, control in roll, and yaw control are discussed. In connection with side stick operation, side stick

coupling, the training situation, the take-over situation and system redundancy are covered. Counting options to buy, as of August 1985 (18 months before the first flight), the order book stood at about 200 aircraft. D.H.

A86-45058#

**PRELIMINARY DESIGN OF LOW AUTHORITY SAS. II**

T. HACKER (Institute of Aviation, Bucharest, Rumania) and B. TEODORESCU (Bucuresti, Institutul Politehnic, Bucharest, Rumania) *Revue Roumaine des Sciences Techniques, Serie de Mecanique Appliquee* (ISSN 0035-4074), vol. 31, Jan.-Feb. 1986, p. 3-12. refs

The region of admissible feedback gains is constructed for the Dutch roll mode. The time constant of the washout filter in the rudder loop is chosen as a tradeoff between response time and the interaction of the washout mode with fast lateral-directional air-frame modes. Perturbation methods are shown to provide the theoretical background to model simplification and to enable the assessment of the validity of simplified models. Author

A86-45144

**NUMERICAL MODELLING OF THE DYNAMICS OF AEROBATIC MANOEUVRES**

Z. DZYGADLO and R. BOLDAK *Journal of Technical Physics* (ISSN 0324-8313), vol. 26, no. 2, 1985, p. 225-245. refs

A method for calculating the plane and spatial aerobatic maneuvers of an aircraft assumed to be a rigid body, its control systems being displaceable but rigid, is discussed. The equations of motion constitute a complete, nonlinear set in a reference frame connected with the aircraft. The laws of control assume the aerodynamic characteristics and the data set for the TS-11 Iskra jet trainer. Numerical results are reported on the dynamics of an aircraft performing a loop or a roll; these results permit the influence of motion and control parameters on the behavior of the aircraft during these maneuvers to be determined. C.D.

A86-45748#

**THE DYNAMICS OF LIMITING HELICOPTER MANEUVERS AT A VERY LOW ALTITUDE [DYNAMIKA GRANICZNYCH MANEWROW SMIGLOWCA W LOTACH NISKICH]**

K. SZUMANSKI *Instytut Lotnictwa, Prace* (ISSN 0509-6669), no. 102, 1985, p. 3-38. In Polish. refs

The problems under consideration are those of a helicopter flying in the proximity of the ground including hovering, load lifting, and rescue operations, hedgehopping flights (during agricultural work, for instance) and the phases of flight near the ground (takeoff and landing). Helicopter maneuvers under normal conditions and in the case of a power system failure are analyzed. The limits of the possibility of performing such maneuvers are estimated assuming that full use is made of the functional and structural properties of the system composed of the aircraft and the pilot. Author

A86-46002\* National Aeronautics and Space Administration, Ames Research Center, Moffett Field, Calif.

**CONTROL OF V/STOL AIRCRAFT**

J. A. FRANKLIN (NASA, Ames Research Center, Moffett Field, CA) *Aeronautical Journal* (ISSN 0001-9240), vol. 90, May 1986, p. 157-173. refs

This paper deals with control of V/STOL aircraft in powered-lift flight. A review of representative operational mission tasks is presented for the take-off, transition, hover and landing flight phases. Characteristics inherent in the basic airframe and propulsion system and the behavior associated with control augmentation systems are considered. Demands for augmented stability and control response to meet certain mission operational requirements are discussed. Experience from ground-based simulation and flight experiments that illustrates the impact of augmented stability and control on aircraft design is related by example. Author

A86-46173#

**A SIMULATION OF AN INTEGRATED FLIGHT CONTROL/AIR-GROUND CANNON FIRING SYSTEM [SIMULATION D'UN SYSTEME INTEGRE DE COMMANDES DE VOL ET DE CONDUITE DE TIR CANON AIR-SOL]**

B. DANG VU and C. LA BURTHE (ONERA, Chatillon-sous-Bagneux, France) (NATO, AGARD, Symposium on Improvement of Combat Performance for Existing and Future Aircraft, Treviso, Italy, Apr. 14-18, 1986) ONERA, TP, no. 1986-31, 1986, 15 p. In French. refs

(ONERA, TP NO. 1986-31)

Results are reported on an ONERA study of an integrated flight and fire control system (IFFC) for modern attack aircraft. The IFFC was developed to furnish flight stability in the ground attack phase and to maximize the success of an air-ground strafing run. Maximizing the performance of the maneuver depended on integrating the pilot in the loop while minimizing the pilot workload. The pilot selected a target which the on-board computer maintained on a cockpit display while aiming the cannon, i.e., the aircraft. Target tracking therefore activated the control laws for guiding the aircraft toward the target. In the simulation, statistics were kept on the success of the firing and the success at maintaining a flight path to the target. The IFFC was effective at both guidance and workload alleviation tasks, and was compact enough for incorporation in current flight control and guidance computer systems. M.S.K.

A86-46367#

**AN ANALYSIS OF THE MOTION OF AN AIRCRAFT ON THE GROUND [ANALIZA RUCHU SAMOLOTU NA ZIEMI]**

A. WOJNAROWSKI and W. KOWALSKI Instytut Lotnictwa, Prace (ISSN 0509-6669), no. 103, 1985, p. 3-20. In Polish. refs

The method and the results of an analysis of the control problem of an aircraft in its motion on the ground are presented. It is assumed that the aircraft performs a translational motion along the runway and angular oscillation, forced by the control system, about the center of gravity. Two methods of analysis are suggested: a simplified operational method for a system with a single degree of freedom and a more universal numerical method, on the basis of which the characteristics of motion of the aircraft for a two-degree-of-freedom system have been determined. The computation methods make it possible to characterize in an accurate manner the motion of the aircraft and to select the optimum excitation range, which is a condition for correct design of the ground steering system. Author

A86-46368#

**VIBRATION ANALYSIS OF A HELICOPTER FUSELAGE BY MEANS OF MATHEMATICAL MODELS [ANALIZA DRGAN KADLUBA SMIGLOWCA PRZY UZYCIU MODELI MATEMATYCZNYCH]**

J. STANISLAWSKI Instytut Lotnictwa, Prace (ISSN 0509-6669), no. 103, 1985, p. 21-35. In Polish.

A simplified mathematical model of a helicopter in flight is described and used to determine the natural frequencies and modes of the fuselage. The problem of forced vibrations is studied by introducing into the model the external loads originating from the main rotor, the tail rotor, and the vibration damping element. Author

A86-46453#

**DISTURBANCE ATTENUATION BY A FREQUENCY-SHAPED LINEAR-QUADRATIC-REGULATOR METHOD**

H. IMAI (Setsunan University, Osaka, Japan), N. ABE (Mitsubishi Heavy Industry Co., Ltd., Nagoya, Japan), and M. KOBAYAKAWA (Kyoto University, Japan) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 9, July-Aug. 1986, p. 397-402. refs

The problem of designing a control system such that the effect of disturbances can be attenuated while the stability of the closed-loop system is assured are considered. It is shown that a linear-quadratic regulator method with frequency-dependent weighting matrices can be effectively applied to this problem. Some

inequalities that connect those weighting matrices to the return-difference matrix of a feedback control system are derived. Using these inequalities, the minimum singular value of the return-difference matrix of a feedback control system can be designed quite easily. C.D.

A86-46454#

**A DISCRETE-TIME MULTIVARIABLE MODEL-FOLLOWING METHOD APPLIED TO DECOUPLED FLIGHT CONTROL**

K. KANAI (Defense Academy, Yokosuka, Japan), P. N. NIKIFORUK (Saskatchewan, University, Saskatoon, Canada), and N. HORI Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 9, July-Aug. 1986, p. 403-407. refs (AIAA PAPER 85-1978)

The discrete-time version of the multivariable model-following control method, previously presented by the authors of this paper, is described. The modification of the control law that enables the control vector to be calculated at each instant using the past state vectors is also presented for synchronizing the change in the control input with the sampling instant. An alternative method of control is developed for a system whose high-frequency gain matrix is singular. This design requires a lower-order increase in the controller and makes the selection of the reference model easier than the method previously proposed by the authors. As an example, the design of the control system is given for flight control of an aircraft that has control-configured vehicle capabilities. The simulation study is carried out for a hypothetical T-2-CCV aircraft, with particular reference to a longitudinal mode. Author

A86-46456#

**UNFOLDING OF DEGENERATE HOPF BIFURCATION FOR SUPERSONIC FLOW PAST A PITCHING WEDGE**

N. SRI NAMACHCHIVAYA (Illinois, University, Urbana) and H. J. VAN ROESSEL (Western Ontario, University, London, Canada) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 9, July-Aug. 1986, p. 413-418. refs

This paper investigates the stability and bifurcation behavior of a double-wedge aerofoil performing a pitching motion at high angles of attack. When a pair of complex conjugate eigenvalues crosses the imaginary axis of the eigenvalue plane, the trivial solution loses stability giving rise to a periodic solution, known as Hopf bifurcation, provided certain transversality conditions are not violated. The existence of degenerate Hopf bifurcation due to the violation of Hopf's transversality condition at certain critical values of the system parameters is shown. The behavior of the pitching motion near these critical values is examined by unfolding the degeneracies. For the supersonic double-wedge aerofoil, various parameters defining the bifurcation paths were numerically evaluated. Author

A86-46459\*# California Univ., Davis.

**IDENTIFICATION OF PILOT-VEHICLE DYNAMICS FROM IN-FLIGHT TRACKING DATA**

R. A. HESS (California, University, Davis) and M. A. MNICH (Guidance, Navigation and Control Conference, Snowmass, CO, August 19-21, 1985, Technical Papers, p. 554-563) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 9, July-Aug. 1986, p. 433-440. NASA-supported research. Previously cited in issue 22, p. 3230, Accession no. A85-45935. refs

A86-46460\*# National Aeronautics and Space Administration, Flight Research Center, Edwards, Calif.

**DEVELOPMENT OF CONTROL LAWS FOR A FLIGHT TEST MANEUVER AUTOPILOT**

G. S. ALAG and E. L. DUKE (NASA, Flight Research Center, Edwards, CA) (Guidance, Navigation and Control Conference, Snowmass, CO, August 19-21, 1985, Technical Papers, p. 105-110) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 9, July-Aug. 1986, p. 441-445. Previously cited in issue 22, p. 3229, Accession no. A85-45888. refs

A86-46469#

**COMPARISON OF ANGULAR AND METRIC GUIDANCE LAWS FOR TACTICAL MISSILES**

J.-L. DURIEUX (Cabinet d'Etudes Techniques d'Automatisation, Angouleme, France) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 9, July-Aug. 1986, p. 505-507. refs

An angular guidance law for tactical missiles optimized by the adjoint technique is compared with a metric law for such missiles comprising an estimator connected to a terminal controller forcing the estimated miss distance to zero. The terms of comparison are miss distance and realizability. An analytic solution is given for one specific, significant case. It is concluded that linear-quadratic Gaussian optimization, without constraint on commanded acceleration and with stationary measurement and process noise, yields the same theoretical minimum miss distance irrespective of whether the control law is angular or metric. If an approximate angular law is used, the resulting performance degradation is inversely proportional to measurement noise. The metric law produces a performance advantage as a result of time-to-go measurement, which produces a better missile lateral acceleration history against a maneuvering target. C.D.

A86-46716

**PILOTING OF UNMANNED AIR VEHICLES**

R. E. CLAPP (Boeing Military Airplane Co., Wichita, KS) IN: Applications of artificial intelligence II; Proceedings of the Meeting, Arlington, VA, April 9-11, 1985. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1985, p. 227-232. refs

While computer-controlled and piloted preplanned missions can be accomplished by autonomous air vehicles, such systems lack the flexibility with which to respond to contemporary battlefield conditions. Attention is presently given to the results of incorporating remote piloting capabilities predicated on vehicle sensor telemetry to ground stations. The relationships of a displayed scene to vehicle altitude, sensor focal length and display scale (magnification) are illustrated. O.C.

**N86-29863\*# Stanford Univ., Calif. Guidance and Control Lab. THE DESIGN OF MULTIRATE DIGITAL CONTROL SYSTEMS Final Report**

M. C. BERG Mar. 1986 217 p (Contract NSG-4002) (NASA-CR-177126; NAS 1.26:177126; SU-SUDAAR-553) Avail: NTIS HC A10/MF A01 CSCL 01C

The successive loop closures synthesis method is the only method for multirate (MR) synthesis in common use. A new method for MR synthesis is introduced which requires a gradient-search solution to a constrained optimization problem. Some advantages of this method are that the control laws for all control loops are synthesized simultaneously, taking full advantage of all cross-coupling effects, and that simple, low-order compensator structures are easily accommodated. The algorithm and associated computer program for solving the constrained optimization problem are described. The successive loop closures, optimal control, and constrained optimization synthesis methods are applied to two example design problems. A series of compensator pairs are synthesized for each example problem. The successive loop closure, optimal control, and constrained optimization synthesis methods are compared, in the context of the two design problems.

Author

**N86-29864\*# Kansas Univ., Lawrence. Dept. of Aerospace Engineering. AN INVESTIGATION OF EMPENNAGE BUFFETING Status Report, 15 Sep. 1985 - 15 Jan. 1986**

C. E. LAN and I. G. LEE 28 Jan. 1986 50 p (Contract NAG2-371) (NASA-CR-176973; NAS 1.26:176973) Avail: NTIS HC A03/MF A01 CSCL 01C

Progress in the investigation of empennage buffeting in reviewed. In summary, the following tasks were accomplished: relevant literatures was reviewed; equations for calculating structural response were formulated; root-mean-square values of

root bending moment for a 65-degree rigid delta wing were calculated and compared with data; and a water-tunnel test program for an F-18 model was completed. Author

**N86-29865\*# California Polytechnic State Univ., San Luis Obispo. Dept. of Aeronautical Engineering.**

**FLIGHT DETERMINATION OF THE AERODYNAMIC STABILITY AND CONTROL CHARACTERISTICS OF THE NASA SGS 1-36 SAILPLANE IN THE CONVENTIONAL AND DEEP STALL ANGLES-OF-ATTACK OF BETWEEN -5 AND 75 DEGREES Final Report**

F. A. MAHDAVI and D. R. SANDLIN 1 Jun. 1984 110 p (Contract NCC4-1) (NASA-CR-176962; NAS 1.26:176962) Avail: NTIS HC A06/MF A01 CSCL 01C

The flight test procedure and the preliminary analysis of the results obtained from twenty manned flights of the SGS 1-36 in the high angles of attack Deep Stall region are discussed. A comparison of the flight determined stability and control derivatives, those of the wind tunnel, and the estimated aerodynamic data is also presented. Furthermore, deep stall dynamics response of the SGS 1-36 is discussed briefly to explain some of the unexpected flight observations. Author

**N86-29866\*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.**

**EXPERIENCE WITH SYNCHRONOUS AND ASYNCHRONOUS DIGITAL CONTROL SYSTEMS**

V. A. REGENIE, C. V. CHACON, and W. P. LOCK Aug. 1986 19 p To be Presented at the AIAA Guidance, Navigation and Control Conference, Williamsburg, Va., 18-20 Aug. 1986 (NASA-TM-88271; H-1372; NAS 1.15:88271; AIAA-86-2239-CP) Avail: NTIS HC A02/MF A01 CSCL 01C

Flight control systems have undergone a revolution since the days of simple mechanical linkages; presently the most advanced systems are full-authority, full-time digital systems controlling unstable aircraft. With the use of advanced control systems, the aerodynamic design can incorporate features that allow greater performance and fuel savings, as can be seen on the new Airbus design and advanced tactical fighter concepts. These advanced aircraft will be and are relying on the flight control system to provide the stability and handling qualities required for safe flight and to allow the pilot to control the aircraft. Various design philosophies have been proposed and followed to investigate system architectures for these advanced flight control systems. One major area of discussion is whether a multichannel digital control system should be synchronous or asynchronous. This paper addressed the flight experience at the Dryden Flight Research Facility of NASA's Ames Research Center with both synchronous and asynchronous digital flight control systems. Four different flight control systems are evaluated against criteria such as software reliability, cost increases, and schedule delays. Author

**N86-29867\*# National Aeronautics and Space Administration. Dryden (Hugh L.) Flight Research Center, Edwards, Calif.**

**MODEL-FOLLOWING CONTROL FOR AN OBLIQUE-WING AIRCRAFT**

G. S. ALAG, R. W. KEMPEL, J. W. PAHLE, J. J. BRESINA, and F. BARTOLI Aug. 1986 13 p Presented at the AIAA Conference on Guidance and Control, Williamsburg, Va., 18-20 Aug. 1986 (NASA-TM-88269; H-1362; NAS 1.15:88269; AIAA-86-2244CP) Avail: NTIS HC A02/MF A01 CSCL 01C

A variable-skew oblique wing offers a substantial aerodynamic performance advantage for aircraft missions that require both high efficiency in subsonic flight and supersonic dash or cruise. The most obvious characteristic of the oblique-wing concept is the asymmetry associated with wing-skew angle which results in significant aerodynamic and inertial cross-coupling between the aircraft longitudinal and lateral-directional axes. A technique for synthesizing a decoupling controller while providing the desired stability augmentation. The proposed synthesis procedure uses the concept of explicit model following. Linear quadratic optimization techniques are used to design the linear feedback system. The



effectiveness of the control laws developed in achieving the desired decoupling is illustrated for a given flight condition by application to linearized equations of motion, and also to the nonlinear equations of six degrees of freedom of motion with nonlinear aerodynamic data. Author

**N86-29868\*#** National Aeronautics and Space Administration. Dryden (Hugh L.) Flight Research Center, Edwards, Calif.  
**EIGENSYSTEM SYNTHESIS FOR ACTIVE FLUTTER SUPPRESSION ON AN OBLIQUE-WING AIRCRAFT**

G. S. ALAG (University of Western Michigan, Kalamazoo.), J. J. BURKEN, and G. B. GILYARD Aug. 1986 9 p Presented at the AIAA Guidance, Navigation and Control Conference, Williamsburg, Va., 18-20 Aug. 1986

(NASA-TM-88275; H-1359; NAS 1.15:88275; AIAA-86-2243-CP)

Avail: NTIS HC A02/MF A01 CSCL 01C

The application of the eigensystem synthesis technique to place the closed-loop eigenvalues and shape the closed-loop eigenvectors has not been practical for active flutter suppression, primarily because of the availability of only one control surface (aileron) for flutter suppression. The oblique-wing aircraft, because of its configuration, provides two independent surfaces (left and right ailerons), making the application of eigensystem synthesis practical. This paper presents the application of eigensystem synthesis using output feedback for the design of an active flutter suppression system for an oblique-wing aircraft. The results obtained are compared with those obtained by linear quadratic Gaussian techniques. Author

**N86-29869#** Air Force Wright Aeronautical Labs., Wright-Patterson AFB, Ohio.

**INTRODUCTION TO ROBUST MULTIVARIABLE CONTROL Final Report, Oct. 1983 - Sep. 1985**

D. B. RIDGELY and S. S. BANDA Feb. 1986 430 p (AD-A165891; AFWAL-TR-85-3102) Avail: NTIS HC A19/MF A01 CSCL 01C

Linear multiple-input multiple-output (multivariable) control systems are considered. The intent of this report is to familiarize the working engineers with some of the developments in the area of robust multivariable control theory that have occurred in the past 10 years. The concepts of singular values are used to systematically develop robust control systems analysis and design techniques. The advantages and limitations of these techniques are discussed. Examples are used to illustrate the methods.

Author (GRA)

**N86-29870#** Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Goettingen (West Germany). Abt. Elastomechanik und Aeroelastische Stabilitaet

**ACTIVE FLUTTER SUPPRESSION ON A DELTA WING MODEL STRUCTURE**

R. FREYMANN and K. CHENG Dec. 1985 72 p (DFVLR-FB-86-01; ISSN-0171-1342; ESA-86-97455) Avail: NTIS HC A04/MF A01; DFVLR, Cologne, West Germany DM 26

Active flutter suppression systems were designed for a flexible model delta wing structure based either on the concept of fictitious structural modifications or on frequency response methods. For validation of the results from the analytical investigations, extensive tests were performed on the model delta wing structure in a 3m x 3m low speed wind tunnel. During the tests the flutter speed of the actively controlled wing was increased by 25% compared to the basic, uncontrolled system. Good agreement between calculated and measured results is found. ESA

**N86-30630#** Messerschmitt-Boelkow-Blohm G.m.b.H., Bremen (West Germany).

**APPLICATION OF TRANSONIC UNSTEADY METHODS FOR CALCULATION OF FLUTTER AIRLOADS**

H. ZIMMERMANN and S. VOGEL /n DGLR The 2nd International Symposium on Aeroelasticity and Structural Dynamics p 47-61 1985

Avail: NTIS HC A99/MF E03

The supercritical MBB-A3 profile was used as an example for calculating steady and unsteady pressure distribution by unsteady transonic codes. Most of the calculations were performed using the nonlinear TSP-equation and its time linearized form solved by a time marching method and by an integral method. The influence of the coefficient of the nonlinear term, of the inclusion of the steady or quasi-steady boundary layer thickness, and of the fulfillment of the Rankine-Hugoniot condition on the resulting pressure distribution is shown. Flutter calculations were made for a two degree of freedom representative section. The resulting critical speeds show a considerable variation depending on which method was used. Results show that there are good arguments for using time-linearized TSP methods in flutter calculations in the transonic domain. ESA

**N86-30635#** Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Goettingen (West Germany). Inst. fuer Aeroelasticity.

**THEORETICAL FLUTTER INVESTIGATIONS ON A PLANE CASCADE IN INCOMPRESSIBLE FLOW**

V. CARSTENS /n DGLR The 2nd International Symposium on Aeroelasticity and Structural Dynamics p 169-179 1985

Avail: NTIS HC A99/MF E03

An analysis which predicts the aeroelastic behavior of a plane cascade in incompressible flow is presented. The unsteady aerodynamic forces and moments acting on the blades are calculated by the method of surface layers. In the general case of bending and/or torsional modes, this method is based on the simultaneous solution of two linear integral equations of the second kind which contain the interaction of steady and unsteady blade loading as well as the influence of all other specific cascade parameters. The solution of the flutter equations for a two degree of freedom model is discussed on the basis of a given cascade configuration. ESA

**N86-30637#** Northwestern Polytechnical Univ., Xian (China).

**A NUMERICAL ANALYSIS FOR VERTICAL GUST FIELD INDUCED BY GUST GENERATOR**

Y. YANG and J. WANG /n DGLR The 2nd International Symposium on Aeroelasticity and Structural Dynamics p 187-193 1985

Avail: NTIS HC A99/MF E03

A method for calculating vertical gust field induced by a gust generator, which consists of a group of oscillating vanes, based on subsonic unsteady lifting surface theory is presented. When the geometry of the gust generator, oscillating frequency and amplitude, and Mach number are given, the unsteady downwash field can be determined. In the calculation, the interference among the vanes is considered. Through numerical calculation, the characteristics of the vertical gust field induced by one, two, or three vanes with various reduced frequencies and Mach numbers are investigated. The influence of the gust generator on the characteristics of the vertical gust field are discussed, and conclusions for gust wind tunnel design are outlined. ESA

**N86-30642#** Air Force Wright Aeronautical Labs., Wright-Patterson AFB, Ohio. Flight Dynamics Lab.

**A REVIEW OF AEROELASTIC RESEARCH AT THE FLIGHT DYNAMICS LABORATORY**

T. M. HARRIS, T. E. NOLL, T. J. HERTZ, and W. A. SOTOMAYER /n DGLR The 2nd International Symposium on Aeroelasticity and Structural Dynamics p 233-243 1985

Avail: NTIS HC A99/MF E03

Research on aeroservoelasticity, adaptive flutter suppression, the effects of stores carriage on body freedom flutter, and three dimensional transonic unsteady aerodynamics is discussed.

## 08 AIRCRAFT STABILITY AND CONTROL

Aeroservoelasticity studies involve research to develop tools for aeroelastic analyses of aircraft when active feedback control systems are taken into account. Adaptive flutter suppression for aircraft carrying external stores is evaluated by wind tunnel tests. Subsonic wind tunnel tests were performed to evaluate the effect of store location, mass, and inertia on aeroelastic stability. ESA

**N86-30643#** Fairchild Republic Div., Farmingdale, N. Y.  
**AEROELASTIC WIND TUNNEL SIMILARITY THEORY FOR ANISOTROPIC AIRCRAFT WINGS**

G. A. OYIBO /in DGLR The 2nd International Symposium on Aeroelasticity and Structural Dynamics p 257-264 1985  
Avail: NTIS HC A99/MF E03

A theory outlining a simplified approach for aeroelastically simulating anisotropic aircraft wings is presented. An examination of the fundamental aeroelastic equations of motion for anisotropic aircraft wings, with the help of affine transformations, reveals that a unified simulation theory, which reduces to the existing theory in the isotropic limit can be formulated. It is discovered that the necessary condition for preserving the Strouhal number (reduced frequency) between the real aircraft wing and its wind tunnel model is by preserving the generalized forms of the similarity parameters suggested by Theodorsen and Garrick as well as new parameters. The additional similarity parameters reflect directional and coupling stiffness properties of anisotropic materials in a given aerospace structure. The results reduce to those for aircraft wings fabricated of isotropic materials if these new parameters are set equal to zero. ESA

**N86-30644#** British Aerospace Dynamics Group, Hatfield (England). Civil Div.  
**THE CHOICE OF TECHNIQUES USED FOR FLIGHT FLUTTER CLEARANCE WITH PARTICULAR REFERENCE TO THE BAE 146 AND BAE 125**

A. G. WOODS /in DGLR The 2nd International Symposium on Aeroelasticity and Structural Dynamics p 265-275 1985  
Avail: NTIS HC A99/MF E03

The considerations necessary to arrive at a safe and cost effective method of flutter clearance are discussed. Flight flutter tests of the BAe 146 and BAe 125, for both of which a fast sweep technique was chosen, are described. Methods of excitation, recording, and analysis are given. ESA

**N86-30645#** Saab-Scania, Linkoping (Sweden).  
**FLUTTER CALCULATION BY A NEW PROGRAM**

V. J. E. STARK /in DGLR The 2nd International Symposium on Aeroelasticity and Structural Dynamics p 276-285 1985  
Sponsored by Swedish Defence Administration and Saab Scania A.B.  
Avail: NTIS HC A99/MF E03

A flutter and response program based on general equations of motion is described. The equations are solved by Laplace transformation and by reducing the inversion integral to a sum of the residues at the poles at the zeros of the determinant. The resulting nonlinear eigenvalue problem, i.e., the problem of finding the zeros, is solved by the Newton-Raphson formula with numerical methods for calculation of the determinant and the principle of the argument for finding initial approximations. The program permits choice of different kinds of analytic functions in the linear approximation that is employed for approximating the aerodynamic transfer functions. Equations representing control laws of a flutter suppression system can be included. ESA

**N86-30647#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**DEVELOPMENT OF A FLUTTER SUPPRESSION CONTROL LAW BY USE OF LINEAR QUADRATIC GAUSSIAN AND CONSTRAINED OPTIMIZATION DESIGN TECHNIQUES**

W. M. ADAMS and S. H. TIFFANY /in DGLR The 2nd International Symposium on Aeroelasticity and Structural Dynamics p 297-308 1985

Avail: NTIS HCA99/MF E03 CSCL 01B

A control law to suppress symmetric flutter for a mathematical model of an aeroelastic research vehicle is developed. An implementable control law is attained by including modified linear quadratic Gaussian design techniques, controller order reduction, and gain scheduling. A complementary design approach for a flight condition wherein nongradient-based constrained optimization techniques are applied to maximize controller robustness is illustrated. ESA

**N86-30649#** National Aerospace Lab., Amsterdam (Netherlands). Dept. of Aeroelasticity.

**NLR EXPERIENCE IN THE APPLICATION OF ACTIVE FLUTTER SUPPRESSION AND GUST LOAD ALLEVIATION, APPLIED TO A WIND TUNNEL MODEL**

P. A. VANGELDER /in DGLR The 2nd International Symposium on Aeroelasticity and Structural Dynamics p 320-329 1985  
Sponsored by Netherlands Agency for Aerospace Programs and NLR

Avail: NTIS HC A99/MF E03

Control laws for flutter suppression and gust load alleviation systems were developed and tested using an aeroelastic model in a subsonic wind tunnel with the capability to simulate discrete or random gusts. Flutter suppression up to the maximum wind tunnel speed (1.4 m/sec) is achieved, while the gust load alleviation system reduces the wing root bending moment by 25% at 0.9 m/sec for simulated gusts with a Dryden spectrum. ESA

**N86-30650#** Royal Aircraft Establishment, Farnborough (England).

**THE DESIGN AND WIND TUNNEL DEMONSTRATION OF AN ACTIVE CONTROL SYSTEM FOR GUST LOAD ALLEVIATION AND FLUTTER SUPPRESSION**

I. W. KAYNES, C. W. SKINGLE, and J. C. COPLEY /in DGLR The 2nd International Symposium on Aeroelasticity and Structural Dynamics p 330-347 1985

Avail: NTIS HC A99/MF E03

Wind tunnel tests on a flexible model with an active control system are described. A flutter suppression control law was designed and tested. It is shown that flutter suppression is achieved in the presence of gusts. The mathematical model of the aircraft includes descriptions of the whole aircraft motion and the flexible aircraft deformations. Physically realistic modifications were made to the mathematical model to enhance the agreement between predictions and the measured loads and responses. Physical understanding of the active controls is facilitated by an interactive control system design package. The predicted and measured performance of the control laws are presented. ESA

**N86-30651#** Northwestern Polytechnical Univ., Xian (China).  
**CONTROL LAW SYNTHESIS FOR GUST LOAD ALLEVIATION USING LINEAR QUADRATIC GAUSSIAN THEORY**

J. CHANG /in DGLR The 2nd International Symposium on Aeroelasticity and Structural Dynamics p 362-367 1985  
Avail: NTIS HC A99/MF E03

A method of using linear quadratic Gaussian synthesis in the design of multiloop gust alleviation for a flexible aircraft is presented. To obtain an aeroelastic system with a finite-order state form matrix equation, the aerodynamic influence coefficients are approximated by a rational function of  $s$ . A technique to minimize the number of augmented states is presented. For all the coefficient matrices, a matrix least squares formula is established. The fitting accuracy of this methods is better than other methods. ESA



**N86-30657#** Purdue Univ., West Lafayette, Ind. School of Aeronautics and Astronautics.

**TAILORING METHODOLOGY FOR AEROELASTIC STABILITY AND LATERAL CONTROL ENHANCEMENT**

T. A. WEISSHAAR /n DGLR The 2nd International Symposium on Aeroelasticity and Structural Dynamics p 415-425 1985  
Avail: NTIS HC A99/MF E03

Uses of aeroelastic tailoring to enhance aircraft structural design for dynamic response are discussed. The incorporation of directional stiffness into a design may alter drastically the mode shapes and frequencies of lifting surface. This alteration affects dynamic aeroelastic interactions between modal forces as well as the modal forces themselves. Tailoring to increase flutter speed generally produces a degradation of the classical divergence speed. As a result, the freedom of the wing to move as a rigid body in concert with the fuselage may render the aircraft susceptible to an attitude instability called body-freedom flutter. Thus, aeroelastic tailoring may lead to aeroelastic behavior characteristics not unlike those of swept forward wings. Tailoring may improve controllability at reduced cost. It may provide increased effectiveness of active control by creating a harmonious control/structure environment.

ESA

**N86-30736\*#** California Polytechnic State Univ., San Luis Obispo. Dept. of Aeronautical Engineering.

**LONGITUDINAL STABILITY AND CONTROL DERIVATIVES OBTAINED FROM FLIGHT DATA OF A PA-30 AIRCRAFT Final Report**

D. R. TURLEY and D. R. SANDLIN Apr. 1981 60 p

(Contract NCC4-1)

(NASA-CR-176999; NAS 1.26:176999) Avail: NTIS HC A04/MF A01 CSCL 01C

In order to obtain reliable and accurate values of the stability and control derivatives, the Dryden Flight Research Center (DFRC) developed a technique for extracting the derivatives from flight data. This technique is implemented by a set of FORTRAN computer programs that is based on a modified maximum likelihood estimator that uses the Newton-Raphson algorithm to perform the required minimization of the derivatives. Data was obtained with a PA-30, light twin-engine general aviation aircraft in zero, half, and full flap configuration in level unaccelerated flight with the landing gear retracted. The derivatives were plotted as functions of angle of attack using various graphical arrangements to show variations of wind tunnel and flight determined values at zero flap settings. Also, data was displayed to show the effects of flap deflection and thrust variation on the longitudinal stability derivatives. The angle of attack and angle of sideslip were measured. The dynamic pressure, velocity, and altitude were calculated, using a FORTRAN computer program, from the static and dynamic pressures. The control deflections of the stabilator, ailerons, and rudder also were recorded along with left throttle position, engine rpm, and manifold pressure.

B.G.

**N86-30737\*#** Purdue Univ., West Lafayette, Ind. School of Aeronautics and Astronautics.

**THE INTEGRATED MANUAL AND AUTOMATIC CONTROL OF COMPLEX FLIGHT SYSTEMS Semiannual Status Report, Jul. 1984 - Mar. 1985**

D. K. SCHMIDT 12 Apr. 1985 68 p

(Contract NAG4-1)

(NASA-CR-176940; NAS 1.26:176940) Avail: NTIS HC A04/MF A01 CSCL 01C

The flight test results obtained recently (1984) by CALSPAN on pitch-rate flight control systems in the flared landing task, obtained with the Total In-Flight Simulator (TIPS), were analyzed. The analysis approach considered is based on the Optimal Control/Frequency Domain (OC/FD) techniques. These techniques originally stem from an optimal-control approach to perform a Neal-Smith-like analysis on aircraft attitude dynamics, but were extended and used successfully to analyze the flared landing task.

B.G.

**N86-30738\*#** California Polytechnic State Univ., San Luis Obispo. Dept. of Aeronautical Engineering.

**A SURVEY OF HANDLING QUALITIES CRITERIA AND THEIR APPLICATIONS TO HIGH PERFORMANCE AIRCRAFT Final Report**

D. L. PEAHL, F. KOLKAILAH, and D. R. SANDLIN Jan. 1986 68 p

(Contract NCC2-338)

(NASA-CR-179654; NAS 1.26:179654) Avail: NTIS HC A04/MF A01 CSCL 01C

Various handling qualities criteria and their application to high performance aircraft including state-of-the-art and highly augmented aircraft were surveyed. Neal-Smith, Bandwidth, Equivalent Systems, and Military Specification 8785 criteria are applied to flight test data from aircraft such as the F-8 Digital Fly-By-Wire, the YF-12, and an Advanced Fighter Aircraft. Backgrounds and example applications of each criteria are given. The results show that the handling qualities criteria investigated can be applied to highly augmented aircraft with fairly good results in most cases; however, since no one method excelled, more than one criteria should be used whenever possible. Equivalent time delays appear to be the most frequent critical factor in determining pilot rating levels of highly augmented aircraft.

Author

**N86-30739#** Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).

**AIRCRAFT RESPONSE TO TURBULENCE**

1985 32 p Presented at the 61st Meeting of the Structures and Materials Panel of AGARD, Oberammergau, West Germany, 8-13 Sep. 1985

(AGARD-R-738; ISBN92-835-0393-7) Avail: NTIS HC A03/MF A01

In 1985 the Structures and Materials Panel initiated an activity to consider the flight of flexible aircraft in turbulence. As a preliminary to the start of this activity, the Panel heard the two papers included in this report. One of the two papers discusses measurements of time histories of turbulence made by specially equipped aircraft and turbulence event statistics obtained from aircraft in commercial operation. The other paper considers aspects of collection and analysis of flight data, methods of calculating aircraft response and constraints in operation.

Author

**N86-30741#** Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).

**GUST LOAD PREDICTION AND ALLEVIATION ON A FIGHTER AIRCRAFT**

J. BECKER Jun. 1986 22 p Presented at the 61st Meeting of the Structures and Materials Panel of AGARD, Oberammergau, West Germany, 8-13 Sep. 1985

(AGARD-R-728; ISBN92-835-1532-3) Avail: NTIS HC A02/MF A01

In 1985 the AGARD Structures and Materials Panel initiated an activity on the flight of flexible aircraft in turbulence. As a preliminary the Panel heard this paper which discusses the influence of turbulence-induced dynamic loads on the structural design of fighter aircraft. Methods for calculating dynamic response are given, and the problems associated with improved ride are considered.

Author

## 09 RESEARCH AND SUPPORT FACILITIES (AIR)

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.

**A86-44458**

#### LANDING GEAR TEST FACILITIES EXAMINED

J. H. BRAHNEY Aerospace Engineering (ISSN 0736-2536), vol. 6, June 1986, p. 21-26.

The technology of landing-gear testing in the U.S. is reviewed. Consideration is given to roadwheel and table dynamometers for roll, dynamic-torque, and vibration tests; drop towers to test shock-absorption characteristics; and the full-scale takeoff and landing simulation apparatus at the NASA Langley Aircraft Landing Dynamics Facility (ALDF). The ALDF equipment, including a 100,000-lb test carriage with a 40 x 20-ft mounting bay, a propulsion system providing 2 x 10 to the 6th lb thrust, a 2800-ft test track with different road surfaces and water/ice/slush coverage, and facilities for a wide range of specific hardware tests, is described and illustrated with photographs. T.K.

**A86-44933**

#### COMPARISON OF MODAL ANALYSIS METHODS ON A LIGHT AIRCRAFT

W. J. STEVENSON (Council for Scientific and Industrial Research, National Institute for Aeronautics and Systems Technology, Pretoria, Republic of South Africa) Aeronautica Meridiana (ISSN 0257-8573), vol. 6, no. 1, 1985, p. 19-28. refs

In the present comparison between the classical multiple exciter sine well and transfer function ground vibration testing methods, attention is given to divergences of approach. While less testing time was required by the classical method, the transfer function method's present results are encouraging and subject to further improvement by means of software refinements. Only one exciter position was used in the present testing of the transfer function method. O.C.

**A86-45137**

#### FLIGHT SIMULATION

R. N. HABER (Illinois, University, Chicago) Scientific American (ISSN 0036-8733), vol. 255, July 1986, p. 96-103.

The technology of flight simulation has undergone great advances since the Link trainer of World War II vintage. The skills that crew members of today's advanced aircraft must have to accomplish their missions may be acquired and sharpened aboard actual aircraft, but this is often difficult, time-consuming, expensive and dangerous. The use of simulators overcomes all of these disadvantages. A flight simulator consists of a cockpit and a control room; the cockpit is enclosed by a projection surface (either a series of cathode ray tubes or a number of projection screens) to show the trainee the panorama that would be visible from the aircraft in flight. Motion is simulated, instrument readings change, and the displayed view changes all in accordance with actions taken by the pilot and with problem inputs initiated by an instructor pilot. Problems of achieving great realism (visual resolution, 3-D effect, scope of the display) are noted. A recent innovation, the heads-up helmet-mounted display, is getting considerable attention. Numerous emergencies, weather changes, and combat situations can be created in rapid sequence to challenge the trainee to respond correctly. It is noted that in combat, if a pilot successfully accomplishes five missions the odds are better than 95 percent that he will survive all his future missions; it appears that many lives could be saved if the equivalent of those first five missions could be 'flown' on simulators. D.H.

#### **A86-45425\* # Southwest Research Inst., San Antonio, Tex. PROPELLER-INDUCED STRUCTURE-BORNE NOISE LABORATORY-BASED TEST APPARATUS**

J. F. UNRUH (Southwest Research Institute, San Antonio, TX) AIAA, Aeroacoustics Conference, 10th, Seattle, WA, July 9-11, 1986. 9 p. refs  
(Contract NAS1-17921)  
(AIAA PAPER 86-1938)

A potentially important source of structure-borne interior noise transmission in advanced turboprop aircraft is the impingement of the propeller wake/vortex on downstream aerodynamic surfaces. The expected levels of propeller wake/vortex-induced structure-borne noise transmission are not known nor can they be determined with present-day technology. A test apparatus has been designed, built and calibrated for the purposes of studying propeller-induced, structure-borne noise transmission in prototypical aircraft structures. The principal approach to the test apparatus design was to provide a physical means of separating the airborne and structure-borne noise components so that the structure-borne noise transmission response could be studied directly without airborne noise contamination. This was accomplished by housing the receiving fuselage structure in an acoustic shield fitted with a wing-to-fuselage acoustic seal. Initial evaluation of the wing-to-fuselage acoustic seal indicates adequate airborne noise isolation to allow direct study of structure-borne noise transmission. Author

**A86-45673**

#### ARNOLD ENGINEERING DEVELOPMENT CENTER - SIMULATORS ENCOMPASS SPECTRUM OF AEROSPACE ENVIRONMENTS

Aviation Week and Space Technology (ISSN 0005-2175), vol. 125, July 7, 1986, p. 59, 64, 69, 73.

The types, capabilities and applications of the aerospace simulation facilities at Arnold Engineering Development Center (AEDC) are outlined. The hardware inventory covers 11 turbine and rocket test cells, four high speed wind tunnels, four ballistic and impact ranges, and one supersonic and three transonic wind tunnels. AEDC is operated by contractors working closely with Air Force R&D personnel. Efforts are continuously expended to project generic requirements and prepare for future developments in aeromechanics, propulsion, space and reentry vehicle technologies. Testing is underway to identify technologies which meet the needs of efficient engines for vectored thrust aircraft, high altitude liquid-fueled rocket engines, orbit transfer vehicles, simulation of the environment for the national aerospace plane, and the effects of collisions between birds and aircraft. Upgrades to the supersonic wind tunnel facility are described, along with recent flight dynamics accomplishments for military programs. M.S.K.

**A86-45674**

#### ARNOLD ENGINEERING DEVELOPMENT CENTER - NEW FACILITY TO ASSESS ENGINE-AIRFRAME COMPATIBILITY PRIOR TO FIRST FLIGHT

Aviation Week and Space Technology (ISSN 0005-2175), vol. 125, July 7, 1986, p. 74, 75, 77.

Design and projected performance features of the Aeropropulsion Systems Test Facility (ASTF) at the Arnold Engineering Development Center are summarized. Built to simulate flight speeds up to Mach 3.8 and altitudes to 100,000 ft, the Facility is to meet national test requirements for airflow, simulated airspeed, thrust, altitude, and air temperature in its performance envelope into the 21st century. The test cells are each 28 ft in diameter and 85 ft long, with a total of 2170 data channels. Vehicles in a test cell are operated with controls similar to those in aircraft and feedback data are provided in real time. The capability is also available for testing engines over all transient states in a flight trajectory, rather than varying the conditions from one steady state to another. A primary goal in the development of the \$600 million facility is to discover design flaws early in the development process and thus recoup the costs of the ASTF within a short number of years. M.S.K.

A86-46155#

**REQUIREMENTS AND RECOMMENDATIONS FOR THE DEVELOPMENT OF THEORETICAL CODES AND EXPERIMENTAL FACILITIES IN THE NEAR FUTURE**

B. COSTES (ONERA, Chatillon-sous-Bagneux, France) (Institut von Karman de Dynamique des Fluides, Cours, Brussels, Belgium, Athens, Greece, and Ankara, Turkey, Feb. 17-28, 1986) ONERA, TP, no. 1986-10, 1986, 16 p. refs  
(ONERA, TP NO. 1986-10)

The development of computational fluid mechanics (CFM) techniques and facilities and complementary wind-tunnel facilities is projected over the period 1985-2000, summarizing the findings of a number of published reviews and reports. The strength, limitations, and inconsistencies of current CFM programs are surveyed; the need for greater reliability and for more cooperation among research teams and between basic science and industry is stressed; the reasons for continuing and improved wind-tunnel verification of CFM results are outlined; the advantages of current advanced-design wind tunnels (such as ONERA F2, NASA National Transonic Facility, DFVLR cryogenic tunnel, and some adaptive-wall facilities) are considered; and the need for better flow-visualization techniques is indicated. Diagrams, drawings, and graphs of sample data are provided. T.K.

A86-46719

**PROBLEMS OF THE VISUAL DISPLAY IN FLIGHT SIMULATION**

R. E. CLAPP (Boeing Military Airplane Co., Wichita, KS) IN: Image quality: An overview; Proceedings of the Meeting, Arlington, VA, April 9, 10, 1985. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1985, p. 64-70. refs

The visual display presents a major source of critical information to the pilot in a flight training simulator. At the same time, due to underspecification or underdesign of the visual display system, the information presented to the pilot is grossly incomplete. These problems in the visual display are the result of misapplication or misunderstanding of the pilots visual perceptions and the limitations of resolution and scene detail of the visual display. This paper presents a summary of the principles of limiting resolution and the definition of scene detail, as well as a discussion of other visual parameters; and the importance of these factors in obtaining satisfactory standards in initial and continuation training in a flight simulator. Author

A86-47093

**DIGITAL DATA ACQUISITION SYSTEM FOR MODAL TESTING**

D. BANASZAK and R. D. TALMADGE (USAF, Flight Dynamics Laboratory, Wright-Patterson AFB, OH) IN: International Modal Analysis Conference, 3rd, Orlando, FL, January 28-31, 1985, Proceedings. Volume 1. Schenectady, NY, Union College, 1985, p. 108-116. refs

The instrumentation system for ground vibration testing (GVT) of a F-16 aircraft is examined. The GVT system provides the multiple accelerometer and force signal measurements for aircraft modal analyses. The instrumentation system is composed of 120 piezoelectric accelerometers with FET followers, 120 six pole low-pass-filters, 120 automatic gas-changing amplifiers, a digital multiplexer, and a programable data acquisition system (DAS). The configuration and functions of the equipment are described. The evaluation and calibration of the DAS are discussed. I.F.

A86-47127

**PROPELLER FOD QUALIFICATION USING MODAL ANALYSIS, ARTIFICIAL BIRDS, AND A STATIC IMPACT FACILITY**

M. L. DRAKE and R. S. BERTKE (Dayton, University, OH) IN: International Modal Analysis Conference, 3rd, Orlando, FL, January 28-31, 1985, Proceedings. Volume 2. Schenectady, NY, Union College, 1985, p. 1072-1081. refs

The results of a program to investigate the impact response of a composite propeller blade to bird impacts are discussed. The program consisted of four major tasks, each of which is described in detail. The first task consisted of establishing the blade station in the spanwise direction which would cause the most severe

structural response for the first three modes of the propeller. The second and third tasks consisted of impact tests of either 4 or 1.5 lb artificial birds to determine the structural and local response of the propeller blades. The fourth task consisted of determining the damage generated and documenting the damage. Rap testing indicated that the tip area would produce the maximum structural response. C.D.

N86-29871\*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**ADAPTIVE WALL WIND TUNNELS: A SELECTED, ANNOTATED BIBLIOGRAPHY**

M. H. TUTTLE (Vigyan Research Associates, Inc., Hampton, Va.) and R. E. MINECK Aug. 1986 55 p  
(NASA-TM-87639; L-16084; NAS 1.15:87639) Avail: NTIS HC A04/MF A01 CSCL 14B

This bibliography, with abstracts, consists of 257 citations arranged in chronological order. Selection of the citations was made for their value to researchers working to solve problems associated with reducing wall interference by the design, development, and operation of adaptive wall test sections. Author, source, and subject indexes are included. Author

N86-29872\*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**CRYOGENIC WIND TUNNELS FOR HIGH REYNOLDS NUMBER TESTING**

P. L. LAWING, R. A. KILGORE, and P. D. MCGUIRE May 1986 95 p  
(NASA-TM-87743; NAS 1.15:87743) Avail: NTIS HC A05/MF A01 CSCL 14B

A compilation of lectures presented at various Universities over a span of several years is discussed. A central theme of these lectures has been to present the research facility in terms of the service it provides to, and its potential effect on, the entire community, rather than just the research community. This theme is preserved in this paper which deals with the cryogenic transonic wind tunnels at Langley Research Center. Transonic aerodynamics is a focus both because of its crucial role in determining the success of aeronautical systems and because cryogenic wind tunnels are especially applicable to the transonic problem. The paper also provides historical perspective and technical background for cryogenic tunnels, culminating in a brief review of cryogenic wind tunnel projects around the world. An appendix is included to provide up to date information on testing techniques that have been developed for the cryogenic tunnels at Langley Research Center. In order to be as inclusive and as current as possible, the appendix is less formal than the main body of the paper. It is anticipated that this paper will be of particular value to the technical layman who is inquisitive as to the value of, and need for, cryogenic tunnels. Author

N86-30663# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Goettingen (West Germany). Inst. of Aeroelasticity.

**SIMULATION OF AIRCRAFT TAXI TESTING ON THE AGILE SHAKER TEST FACILITY**

R. FREYMANN and W. P. JOHNSON (Air Force Wright Aeronautical Labs., Wright-Patterson AFB, Ohio) In DGLR The 2nd International Symposium on Aeroelasticity and Structural Dynamics p 468-476 1985

Avail: NTIS HC A99/MF E03

Use of the Aircraft Ground Induced Loads Excitation test facility, an array of three independent shakers which allows laboratory simulation of an aircraft taxiing on rough surfaces, in the dynamic qualification process and for verification of the mathematical structural model of an aircraft is described. Experimental determination of the elastomechanical characteristics of aircraft landing gears and tires is outlined. ESA

## 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.

A86-46149

**DIGITAL CONTROL LOADING AND MOTION - THE FINAL WORD?**

J. COOPER, M. RUTHERFORD, and M. MCKINNON (CAE Electronics, Ltd., Montreal, Canada) ICAO Bulletin, vol. 41, May 1986, p. 30-33.

Attention is given to a novel flight simulator loading control and motion system which yields considerable logistics and performance benefits as well as dynamic flight simulations that are superior to those of modern analog systems. A 3-kHz iteration rate allows the modeling of nonlinear characteristics which are difficult to reproduce cost-effectively in the case of an analog model. Attention is given to the characteristics of the general control-loading model, the overall system's configuration, the sophisticated mechanical design employed, and safety considerations. O.C.

**N86-30684#** Technische Hochschule, Aachen (West Germany). Inst. fuer Leichtbau.

**RECONSTRUCTION OF FORCING FUNCTIONS BASED ON MEASURED STRUCTURAL RESPONSES**

H. OERY, H. GLASER, and D. HOLZDEPPE *In* DGLR The 2nd International Symposium on Aeroelasticity and Structural Dynamics p. 656-668 1985 Sponsored by Deutsche Forschungsgemeinschaft, ESA, and MBB/Erno G.m.b.H. Avail: NTIS HC A99/MF E03

A structural analysis procedure to reconstruct the significant parts of the forcing function time-histories based on a restricted number of test records is presented. Use of the inverse application of the phase-plane method and Williams' method is proposed. The procedure is based on the fact that very slowly varying loads induce deformations, which can be determined using the stiffness matrix only. It can be applied to aerospace structures and to earthquake engineering. ESA

## CHEMISTRY AND MATERIALS

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

A86-45185

**INVESTIGATION OF THE IGNITION CHARACTERISTICS OF HYDROGEN/AIR MIXTURES IN THE CASE OF COMBUSTION INDUCED BY OBLIQUE SHOCKS [UNTERSUCHUNG DES ZUENDVERHALTENS VON WASSERSTOFF/LUFT-GEMISCHEN BEI SCHRAEGSTOSSINDUZIERTER VERBRENNUNG]**

J. ALGERMISSEN (Stuttgart, Universitaet, West Germany) Zeitschrift fuer Flugwissenschaften und Weltraumforschung (ISSN 0342-068X), vol. 10, Mar.-Apr. 1986, p. 73-81. In German. refs (Contract DFG-SFB-85)

Questions regarding the combustion induced by oblique shocks are of interest in connection with the development of new types of propulsion systems for the hypersonic flight in the atmosphere. The idea of a utilization of atmospheric oxygen as oxidizer in the case of hypersonic flight vehicles, has led to the concept of a

'scramjet'. The propulsion system envisaged provides for the flight Mach number range above four to six the optimum specific impulse with respect to all chemical propulsion systems. This system represents the theoretically best solution also on the basis of other considerations. A promising approach in studies for the technological implementation of the theoretical concepts is related to the utilization of supersonic flows with adaptable oblique shock ignition systems. An experimental installation for the study of supersonic combustion processes is discussed. The installation provides a steady free-jet flame, which is uniformly ignited over the entire cross section. G.R.

A86-45395

**CARBON RESIDUE STUDIES WITH A MICROCARBON RESIDUE TESTER**

W. BOCHARTZ (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) ASLE, Annual Meeting, 41st, Toronto, Canada, May 12-15, 1986. 6 p. refs (ASLE PREPRINT 86-AM-7A-1)

A test procedure for coking propensity of gas turbine lubricants was developed using a commercial microcarbon residue tester (MCRT) used for the American Society of Testing and Materials Test Method D-4530, 'Standard Test Method for Micro Carbon Residue of Petroleum Products'. The MCRT, a microprocessor-controlled heating unit, was evaluated for its ability to determine carbon residue in weight percent of synthetic gas turbine lubricants under controlled static conditions. The purpose was to obtain information on the amount of deposit remaining in glass vials after a measured volume of lubricant had been exposed to different degrading environments, varying the parameters of temperature, gas (air or nitrogen), and exposure time. During a test, several processes occur simultaneously. The major effect is volatilization of the lubricant. Substantial oxidation and thermal degradation of the lubricant also occur, causing residue to form in the glass vials. A criterion for evaluating the test lubricants is the weight of the vial deposits. The basic studies were conducted with four lubricants meeting MIL-L-7808J specification and two lubricants meeting MIL-L-23699C specification. The evaluation shows that the MCRT has potential use as a cost-effective laboratory tester to differentiate lubricants regarding tendency to form coke deposits prior to engine tests. Comparison of test data from the MCRT and the static coker deposition tester indicates that the tests have a good correlation, which is most likely due to the similar test conditions. Author

A86-46827

**THE NEED FOR RAPIDLY SOLIDIFIED POWDER METALLURGY ALUMINUM ALLOYS FOR AEROSPACE APPLICATIONS**

W. E. QUIST (Boeing Commercial Airplane Co., Seattle, WA) and R. E. LEWIS (Lockheed Research Laboratories, Palo Alto, CA) *IN*: Rapidly solidified powder aluminum alloys; Proceedings of the Symposium, Philadelphia, PA, April 4, 5, 1984. Philadelphia, PA, American Society for Testing and Materials, 1986, p. 7-37; Discussion, p. 37, 38. refs

A need exists within the aerospace industry for the engineering properties promised by aluminum alloys produced by rapid solidification technology (RST). The extent to which these alloys will achieve technical and commercial success depends, however, upon: (1) achievement of the engineering property goals, (2) the degree of success in the development of competitive materials, including other aluminum products, and (3) the economics of using such alloys for any given application, including the total production, fabrication, and life cycle costs for the material. Useful applications of the new RST aluminum alloys are envisioned for each of the three primary groups of aerospace vehicles: aircraft, missiles, and space vehicles. Each of these groups has a different general set of material property and cost objectives. The current powder metallurgy (PM) aluminum alloy development efforts for aerospace applications can be divided conveniently into three categories or classes of alloys: (1) high-strength, corrosion-resistant alloys; (2) low-density, high-modulus alloys; and (3) elevated-temperature, creep-resistant alloys. The development objectives for each of these alloy categories depend on the specific needs of the

aerospace market for that category. The current status of progress in the development of the RST aluminum alloys indicates that some technical and economic success will be achieved in each category. The extent of this success is yet to be established. An assessment of various factors that affect the future course of development for these materials is presented. Author

**A86-46842****DEVELOPMENTS IN PREMIUM HIGH-STRENGTH POWDER METALLURGY ALLOYS BY KAISER ALUMINUM**

S. W. PING (Kaiser Aluminum and Chemical Corp., Pleasanton, CA) IN: Rapidly solidified powder aluminum alloys; Proceedings of the Symposium, Philadelphia, PA, April 4, 5, 1984. Philadelphia, PA, American Society for Testing and Materials, 1986, p. 369-380. refs

The development of PM alloys from 1953-1983 is discussed. The initial formation of high-modulus, high-temperature alloys, alloy supersaturation studies on binary, ternary, and more complex alloys, and the fabrication of PM processed extrusions with good room-temperature properties are considered. The use of the depurative/vacuum degassing technique to form the PM alloys is described. The development of 7XXX- and 2XXX-based PM alloys with increased minimum strength levels is studied. The properties of the Al-Zn-Cu-Mg-Zr-Cr-Co (PM 64) alloy applicable for aircraft development are examined. Studies were conducted from 1981-1983 to modify the PM 64 alloy in order to improve its fatigue crack growth resistance. I.F.

**N86-30007#** Federal Aviation Administration, Washington, D.C. Program Engineering and Maintenance Service.

**PROCEEDINGS OF FUEL SAFETY WORKSHOP**

31 Dec. 1985 382 p Workshop held in Alexandria, Va., 29 Oct. - 1 Nov. 1985 Prepared in cooperation with Analysis Group, Inc., Washington, D.C. (DOT/FAA/PM-86/13) Avail: NTIS HC A17/MF A01 CSCL 21D

The workshop served a four-fold purpose: (1) to discuss the results of the Federal Aviation Administration/NASA Controlled Impact Demonstration (CID) conducted December 1984 at Edwards Air Force Base, California; (2) to explore potential approaches to preventing post-crash aircraft fuel fires, including possible combinations of various approaches; (3) to re-evaluate past approaches in terms of current technology; and (4) to propose a course of action for future industry/government research, especially any future FAA research and development program. These proceedings contain the formal conference presentations followed by the recommendations of the attendees as agreed upon in the three informal working breakout sessions.

**N86-30008#** Federal Aviation Administration, Washington, D.C. **ANTIMISTING FUEL TECHNOLOGY FOR TRANSPORT CATEGORY AIRCRAFT**

E. P. KLUEG *In its* Proceedings of Fuel Safety Workshop p 11-60 31 Dec. 1985  
Avail: NTIS HC A17/MF A01 CSCL 21D

The antimisting kerosene (AMK) program is described. Details of the production and testing of AMK are given. Rheological studies on properties of antimisting, filtration, flammability, and viscoelasticity; heat transfer and frictional characteristics; and degradation levels are described. AMK flammability tests were performed in both the laboratory and in air crashes. Production details presented include in-line blending limitations and compatibility and degradation considerations. The organizational structure of the AMK development effort is described, and economic aspects of converting to AMK are discussed. J.P.B.

**N86-30009#** Federal Aviation Administration, Washington, D.C. **AMK FULL-SCALE TRANSPORT AIRCRAFT VALIDATION PHASE SUMMARY**

B. C. FENTON *In its* Proceedings of Fuel Safety Workshop p 61-114 31 Dec. 1985  
Avail: NTIS HC A17/MF A01 CSCL 21D

Fuel system modifications for CV-880 and B-720 aircraft were designed, built, and flight/crash tested in a controlled impact demonstration (CID), in order to assess the feasibility of antimisting kerosene (AMK) in fire retardation. Central to the fuel system modification was the degrader design. The inline blending of AMK at fueling point demonstrated consistently high fuel quality. The degrader demonstrated successful flight operation, and engine performance under degraded AMK was comparable to performance with jet A under nominal flight conditions. It is concluded that transport aircraft can operate on AMK with minor modifications, although there are accident scenarios where AMK may not prevent a fuel spill fireball attachment to the wing/fuselage. J.P.B.

**N86-30010#** Federal Aviation Administration, Washington, D.C. **POST CONTROLLED IMPACT DEMONSTRATION (CID) ANALYSIS**

W. T. WESTFIELD *In its* Proceedings of Fuel Safety Workshop p 115-135 31 Dec. 1985  
Avail: NTIS HC A17/MF A01 CSCL 21D

The unplanned deviations in a Controlled Impact Demonstration (CID) to test an antimisting kerosene (AMK) are reported. Post-impact tests were conducted to assess the performance of the fire-retardant fuel; some of these tests were modified because of the deviations from the planned impact. The history of the planning of the CID is given. Experiments to explain the (often unexpected) behavior of the fuel on impact were conducted. It is concluded that the CID was not typical of accident impacts and that the antimisting fuel was exposed to circumstances which it was not designed to withstand. Even so, the antimisting fuel presented a less hostile environment through its slower vaporization and heat release. J.P.B.

**N86-30011#** Federal Aviation Administration, Washington, D.C. **FAA FUEL CONTAINMENT R AND D**

L. M. NERI *In its* Proceedings of Fuel Safety Workshop p 137-148 31 Dec. 1985  
Avail: NTIS HC A17/MF A01 CSCL 21D

Fuel containment research by the Federal Aviation Administration (FAA) is summarized. The objective is to make post-crash fires less fatal and injurious. Three types of aircraft (transport airplanes, rotorcraft, and general aviation airplanes) are addressed independently. Data presented include: (1) compilation of accident data generated by airplane manufacturers; (2) accident percentage versus major failure modes; (3) accident percentage versus fire and fatalities; (4) impact events which possess the highest fuel spill potential; (5) generic technical approach addressing fuel containment; and (6) sequence of events leading to design criteria to satisfy program objectives. J.P.B.

**N86-30012#** Royal Aircraft Establishment, Farnborough (England). Materials and Structures Dept.

**UK WORK ON SAFETY FUELS**

S. P. WILFORD *In* FAA Proceedings of Fuel Safety Workshop p 163-179 31 Dec. 1985  
Avail: NTIS HC A17/MF A01 CSCL 21D

Work on safety fuels in the United Kingdom is described with respect to antimisting fuel development, fuel systems design, degradation, blending, and engine combustion. Current research focuses on cavitation studies, where preliminary results indicate that use of FM9 antimisting kerosene (AMK) may lead to increased cavitation damage; and quality control, where a Capillary Trajectory Rig (CTR) has advanced quality testing to the point where a margin of fire safety may be determined. Finally, investigation of the unexpected results of the Controlled Impact Demonstration (CID) is briefly reported. J.P.B.

## 11 CHEMISTRY AND MATERIALS

**N86-30013#** Jet Propulsion Lab., California Inst. of Tech., Pasadena.

### **HEAT TRANSFER, FRICTION, AND RHEOLOGICAL CHARACTERISTICS OF ANTIMISTING KEROSENE**

E. MATTHYS and V. SAROHIA *In* FAA Proceedings of Fuel Safety Workshop p 181-183 31 Dec. 1985  
(Contract NAS7-918; DTFA03-80-00215)

Avail: NTIS HC A17/MF A01 CSCL 21D

Experiments were performed to determine the skin friction and heat transfer behavior of antimisting kerosene (AMK) in pipe flows. The additive used was FM-9. Based on the results of the experiments, which identify high viscosity and viscoelasticity for AMK, it is recommended that AMK be degraded. Sufficient degradation produces behavior similar to that of jet A. J.P.B.

**N86-30015#** Jet Propulsion Lab., California Inst. of Tech., Pasadena.

### **CONTINUOUS INLINE BLENDING OF ANTIMISTING KEROSENE**

P. PARIKH, A. YAVROUIAN, and V. SAROHIA *In* FAA Proceedings of Fuel Safety Workshop p 203-217 31 Dec. 1985  
(Contract NAS7-917; DTFA03-80-A-00215)

Avail: NTIS HC A17/MF A01 CSCL 21D

A continuous inline blender was developed to blend polymer slurries with a stream of jet A fuel. The viscosity of the slurries ranged widely. The key element of the blender was a static mixer placed immediately downstream of the slurry injection point. A positive displacement gear pump for jet A was employed, and a progressive cavity rotary screw pump was used for slurry pumping. Turbine flow meters were employed for jet A metering while the slurry flow rate was calibrated against the pressure drop in the injection tube. While using one of the FM-9 variant slurries, a provision was made for a time delay between the addition of slurry and the addition of amine sequentially into the jet A stream. J.P.B.

**N86-30016#** Conoco, Inc., Ponca City, Okla.

### **OLEFIN POLYMERS AS JET FUEL ANTIMIST ADDITIVES**

S. L. BAXTER and J. M. IWASYK (Du Pont de Nemours (E. I.) and Co., Wilmington, Del.) *In* FAA Proceedings of Fuel Safety Workshop p 221-240 31 Dec. 1985

Avail: NTIS HC A17/MF A01 CSCL 21D

Ultra-high molecular weight, oil-soluble polymers (designated AM-2) have been developed which may have potential as antimist additives. Tests show that these polymers significantly reduce the concentration of fines in fuel spray and increase mean particle diameter. Impact of the additives on other fuel properties is briefly discussed. J.P.B.

**N86-30017#** ICI Americas, Inc., Wilmington, Del.

### **AMK: STILL VIABLE?**

C. G. RIVERS, JR. *In* FAA Proceedings of Fuel Safety Workshop p 241-249 31 Dec. 1985

Avail: NTIS HC A17/MF A01 CSCL 21D

The status of antimisting kerosene (AMK) as a fire-retardant fuel is discussed. Research to date indicates the likelihood that antimisting is effective; future research must be aimed at identifying the envelope of effectiveness. Existing technology appears adequate to provide for the onboard blending requirement for using AMK. Few problems in the area of aircraft operability using AMK have been encountered to date; however, a number of potential problems related to gelling remain. Extended engine testing may effectively address remaining concerns. J.P.B.

**N86-30018#** McDonnell-Douglas Corp., Long Beach, Calif.

### **SAFETY FUELS-SPECIFICATIONS AND PROGRESS**

A. T. PEACOCK *In* FAA Proceedings Fuel Safety Workshop p 255-260 31 Dec. 1985

Avail: NTIS HC A17/MF A01 CSCL 21D

This paper discusses fuel standardization and quality control and the mechanisms already in place to attain them. It reflects 20 years of development of safety fuels and considers where the Federal Aviation Administration (FAA) should go from here. The

need for a standard technical description of aviation turbine fuels that are developed to enhance fuel safety is discussed. Fuel property descriptions, test methods, and standardization procedures are also discussed, along with approvals for additives and fuel quality control. The role of the American Society for Testing and Materials (ASTM) in standardization is outlined, and a short history of safety fuels is given. It is suggested that fuel modification should not be abandoned as a method of improving safety. Author

**N86-30021#** General Technology Applications, Inc., Reston, Va. **GTA/BASF ANTIMISTING FUEL RESEARCH**

J. C. TRIPPE *In* FAA Proceedings of Fuel Safety Workshop p 301-311 31 Dec. 1985

Avail: NTIS HC A17/MF A01 CSCL 21D

The research resulting in a process for dissolving polyisobutylene (PIB) in antimisting fuel is described. Reasons for continued private industry research into antimisting fuel are outlined. The background of investigations of the relationship between high molecular weight polymer additives, droplet size, and mist-induced fires is reported. The promise of PIB in antimisting fuels is summarized on the basis of these characteristics: (1) satisfactory effectiveness at very low concentrations; (2) satisfactory effectiveness under high shear forces; (3) compatibility with current fuel specifications and unmodified fuel systems; (4) low cost under current high volume production; (5) ease of handling and application; and (6) elimination of catastrophic fuel explosions. J.P.B.

**N86-30024#** Jet Propulsion Lab., California Inst. of Tech., Pasadena.

### **ANTIMISTING KEROSENE: EVALUATION OF IMPROVED FM-9 ADDITIVE Final Report, Aug. 1983 - Nov. 1984**

A. YAVROUIAN, P. PARIKH, and V. SAROHIA Jun. 1986 51 p  
(Contract DTFA3-80-A-00215)

(DOT/FAA/CT-85-4; JPL-D-2581) Avail: NTIS HC A04/MF A01

During the past few years, studies by the Federal Aviation Administration (FAA) and other government agencies have shown that the hazards from aircraft crash fires might be significantly decreased if an antimisting kerosene (AMK) fuel could be utilized. The addition of polymeric additive at low concentrations to jet fuels is known to suppress mist formation and ignition of the fuels under circumstances often encountered in survivable aircraft crash landings. An antimisting additive, FM-9 (Trademark) has been developed by Imperial Chemical Industries (ICI) and is available under the trade name AVGARD. This material when dissolved in jet fuels imparts a strong time-dependent threshold type shear-thickening behavior. In case of fuel spillage from a ruptured fuel tank during an aircraft crash, the fuel misting is prevented. Simulated aircraft crash landing fuel spillage tests have indicated that fuel misting can be sufficiently suppressed, and the ignition and the subsequent fireball formation can be greatly reduced or eliminated. Optimization of FM-9 dissolution rate to attain acceptable mist suppression and degradation properties within 15 to 20 minutes of inline blending was carried out by ICI. This report discusses the evaluation of FM-9 variant which has better dissolution rate and consequently better degradability and compatibility with engine filters and fuel control system and was identified as a candidate additive to be used in a Control Impact Demonstration (CID) test. Author

**N86-30812\*#** Textron Bell Helicopter, Fort Worth, Tex.

### **FLIGHT SERVICE EVALUATION OF COMPOSITE COMPONENTS ON THE BELL HELICOPTER MODEL 206L Annual Flight Service Technical Summary Report**

H. E. WILSON, II Aug. 1986 53 p

(Contract NAS1-15279)

(NASA-CR-178148; NAS 1.26:178148; AFSR-2) Avail: NTIS HC A04/MF A01 CSCL 11D

This is the second annual report on the flight service components for the Bell Model 206L JetRanger helicopter. The components have been placed in service in the Continental United States, Canada, and Alaska. The report covers the period from 1 August 1983 to 1 January 1986. The status of 34 sets of

components is discussed in this report. Approximately 73,000 flight hours were accumulated on the components as of 1 January 1986. Three years of coupon tests on the components are presented with test results. A vertical fin had been struck by lightning and the results of its examination and tests are included. Author

**N86-30821#** Air Force Wright Aeronautical Labs., Wright-Patterson AFB, Ohio.

**THE USE OF A PYROCHEMILUMINESCENT NITROGEN ANALYZER AS A CAPILLARY GC (GAS CHROMATOGRAPH) DETECTOR Final Report, Mar. - May 1985**

E. W. PITZER Feb. 1986 21 p  
(AD-A166597; AFWAL-TR-85-2077) Avail: NTIS HC A02/MF A01 CSCL 07D

A study was conducted to determine the feasibility of interfacing a pyrochemiluminescent nitrogen analyzer to a high resolution glass capillary gas chromatograph. The instruments used were a Varian Model 3700 gas chromatograph and an Antek Model 703C pyrochemiluminescent nitrogen analyzer. Known standards of nitrogen containing compounds were prepared in shale derived jet propulsion fuel that had been previously determined to have no nitrogen containing species. These solutions were then chromatographed on the GC/CLD system. The resulting data were reduced using relative response factors with an internal standard. The nitrogen content of the standard solutions were validated by analyses on a separate Antek nitrogen analyzer used to determine total nitrogen content. The method of GC/CLD was deemed feasible. However, it is recommended that appropriate design changes be made to the Antek Model 703C nitrogen analyzer to accommodate the type of flows common with capillary gas chromatographs. GRA

**N86-30838#** Dayton Univ., Ohio. Research Inst.

**ADVANCES IN THE STUDY OF THE MECHANICAL BEHAVIOR OF MATERIALS Final Report, 15 Jun. 1981 - 30 Sep. 1984**

N. E. ASHBAUGH, M. KHOBAIB, T. WEERASOORIYA, G. A. HARTMAN, A. M. RAJENDRAN, D. C. MAXWELL, and R. C. GOODMAN Dec. 1985 138 p  
(Contract F33615-81-C-5015; AF PROJ. 2307)  
(AD-A164656; AFWAL-TR-85-4124) Avail: NTIS HC A07/MF A01 CSCL 11F

The design of high performance aircraft engines requires the development of reliable life-prediction methodology to aid in the evaluation and safety of the critical gas-turbine engine components. A comprehensive multi-task research and development program was conducted to establish a sound life-prediction methodology. The program consisted mainly of: (1) Experimental investigations and analytical modeling of crack growth behavior; (2) Experimental investigation of mechanical properties and performance characteristics of structural materials; (3) Environmental effect on elevated temperature mechanical behavior; and (4) Development of test techniques, upgrading, and maintenance of the AFWAL/MLLN Mechanical Test Facility. GRA

**N86-30883#** Federal Aviation Agency, Atlantic City, N.J. Technical Center.

**ANTIMISTING FUEL RESEARCH AND DEVELOPMENT FOR COMMERCIAL AIRCRAFT Final Report**

M. YAFFEE Apr. 1986 78 p  
(FAA/CT-86/7) Avail: NTIS HC A05/MF A01

This report covers the research, development, testing, and evaluation conducted by the Federal Aviation Administration (FAA) in pursuit of an effective, feasible antimisting agent for kerosene jet fuels that would prevent or reduce the dangers of postcrash, fuel mist fires. For the past eight years, most of this effort was focused on a high molecular weight polymer, FM-9 (Trademark), as a representative agent to prove the antimisting fuel concept. The results of this work indicate that the goal is achievable. Jet fuel can be modified to provide a significant degree of protection against postcrash fires in impact-survivable accidents. Additional development and testing would be required before the fuel is operationally acceptable. It would be necessary to make some modifications in fuel handling procedures and hardware in aircraft

and at airports. But there appear to be no technically insurmountable problems. Author

## 12

## 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.

**A86-43489#**

**A SURVEY OF MULTIPLE TARGETS TRACKING TECHNIQUE**

H. ZHOU (Chinese Aeronautical Establishment, Beijing, People's Republic of China) Acta Aeronautica et Astronautica Sinica, vol. 7, Feb. 1986, p. 1-10. In Chinese, with abstract in English. refs

This paper discusses the development of multiple targets tracking techniques over the past twenty years. Attention is paid to data correlation since this is the most important and difficult aspect of multiple targets tracking. The methods of tracking a target in a repeat echoes environment are introduced, and the methods of tracking multiple targets in a repeat echoes environment are presented. Other related aspects are briefly included in the paper. Author

**A86-43495#**

**STABILITY ANALYSIS OF COMPOSITE STIFFENED LAYER PLATES UNDER COMPRESSION**

X. TONG (Aircraft Structural Strength Research Institute, People's Republic of China) Acta Aeronautica et Astronautica Sinica, vol. 7, Feb. 1986, p. 54-62. In Chinese, with abstract in English. refs

The stability of composite stiffened layer plates under axial compression is studied by analytical and finite strip element methods. Rational selection of the displacement functions is stressed and solutions are given for five different combinations of plate stiffness with load cases. By using the displacement expression chosen, the prediction of the critical stress could be performed with a computer program instead of the previous complex calculation. Therefore, it is clear in physical concept and easy to control the convergence process. A general-purpose computer program is developed for a stability analysis based on this method. Some typical cross-section configurations and composite stiffened layer plates with stiffeners have been calculated. The numerical results are in good agreement with the experimental data and the analytical solutions. Author

**A86-43496#**

**BUCKLING AND INITIAL POST BUCKLING ANALYSIS OF COMPOSITE PANELS UNDER AXIAL COMPRESSION**

J. ZHOU, T. FENG, and S. LI (Nanjing Aeronautical Institute, People's Republic of China) Acta Aeronautica et Astronautica Sinica, vol. 7, Feb. 1986, p. 63-70. In Chinese, with abstract in English.

The buckling and the initial post-buckling behavior of laminated composite shallow panels with orthotropic modular properties under axial compression are analyzed. The expressions for critical load and initial post-buckling parameters and the asymptotic solutions of the post-buckling state are given by solving the first two perturbation equations. As one application, the buckling and initial post-buckling behavior of long shallow panels of two different laminations cross-ply and angle-ply, are considered. Author



A86-43502#

**SENSITIVITY ANALYSIS OF PARAMETERS IN SOLVING INVERSE PROBLEM OF STRUCTURAL DYNAMICS**

F. GAO (Aeronautical Computation Technique Institute, People's Republic of China) Acta Aeronautica et Astronautica Sinica, vol. 7, Feb. 1986, p. 108-113. In Chinese, with abstract in English. refs

A sensitivity analysis of parameters in solving the inverse problem of structural dynamics is presented using the perturbation theory. By introducing a set of variable parameters in the structure, the derivatives of structural natural frequencies and/or modes with respect to these parameters are obtained so as to determine the sensitive elements or locations of the structure. In the degenerated case with multiple eigenvalues, the sensitivities of the natural frequencies are obtained by means of Puiseux series and considered as the eigenvalues of the matrix. The method is easy to implement obtaining thus the automatization of the dynamic design for the structure. It has been applied to the vibration design of several beam frame structures in aeronautical engineering and has been verified by experimental data. Author

A86-43534#

**AN ANALYSIS OF BENDING WAVE PROPAGATION ON IMPACT IN A ROTATING FAN BLADE**

T. SHIOYA (Tokyo, University, Japan) Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 34, April 1986, p. 195-198. In Japanese, with abstract in English. refs

This paper presents an theoretical analysis of the electric bending wave propagation in a rotating fan blade by the use of a simplified model. An impact of constant lateral force or constant moment is subject to a semi-infinite elastic beam at the end. Constant body force which represents the centrifugal force due to the rotation is acting parallel to the initial beam direction. The result of the analysis shows that a similar solution for the bending wave exists in case of no centrifugal force. The wave velocity and the moment are obtained in a simple form. The centrifugal force effects the decrease of the wave velocity and the amplitude of the bending moment. Author

A86-43566\* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

**MODE II FATIGUE CRACK GROWTH SPECIMEN DEVELOPMENT**

R. J. BUZZARD, B. GROSS, and J. E. SRAWLEY (NASA, Lewis Research Center, Cleveland, OH) IN: Fracture mechanics; Proceedings of the Seventeenth National Symposium, Albany, NY, August 7-9, 1984. Philadelphia, PA, American Society for Testing and Materials, 1986, p. 329-345; Discussion, p. 345, 346. Previously announced in STAR as N84-29248. refs

A Mode II test specimen was developed which has potential application in understanding phenomena associated with mixed mode fatigue failures in high performance aircraft engine bearing races. The attributes of the specimen are: it contains one single ended notch, which simplifies data gathering and reduction; the fatigue crack grows in-line with the direction of load application; a single axis test machine is sufficient to perform testing; and the Mode I component is vanishingly small. Author

A86-43759

**COMPUTER AIDED ENGINEERING IN STRUCTURAL DESIGN AND OPTIMIZATION**

B. FREDERIKSSON, J. BRANDT, and T. BRANA (SAAB-Scania AB, Linkoping, Sweden) IN: International FEM-Congress, 14th, Baden-Baden, West Germany, November 18, 19, 1985, Proceedings. Stuttgart, West Germany, IKOSS GmbH, 1985, p. 251, 253-266. refs

A systematic approach to the structural engineering design work is discussed. The use of the finite element internal loads models as a basis for the stress analysis and sizing work is presented. Software has been developed for automatic load and spectra generation. Local load sequences and spectra are generated based upon the result from the FE-analysis. This is then used for fatigue

and fracture analysis of the structure components. In the design process it is important to find optimal solutions. Examples are minimization of structural weight or minimization of moment of inertia. Software has been developed for structural optimization. Examples on wing weight minimization and fin rudder moment of inertia minimization are discussed. Author

A86-43784

**DAMAGE TOLERANCE - USAF EXPERIENCE**

J. W. LINCOLN (USAF, Aeronautical Systems Div., Wright-Patterson AFB, OH) IN: Durability and damage tolerance in aircraft design; Proceedings of the Thirteenth Symposium, Pisa, Italy, May 22-24, 1985. Warley, England, Engineering Materials Advisory Services, Ltd., 1985, p. 265-295. refs

The damage tolerance experience on U.S. Air Force aircraft is traced from the F-111 in the early seventies to the present. The phases of the damage tolerance assessment are discussed by means of examples to highlight important aspects of the process. The experience derived from the individual assessment is used to describe the lessons learned and to illustrate the evolution of structural criteria to be used for future USAF procurements. Author

A86-43789

**CONTINUING STRUCTURAL INTEGRITY PROGRAM FOR TRANSPORT AIRCRAFT**

P. R. ABELKIS, M. B. HARMON, and D. S. WARREN (Douglas Aircraft Co., Long Beach, CA) IN: Durability and damage tolerance in aircraft design; Proceedings of the Thirteenth Symposium, Pisa, Italy, May 22-24, 1985. Warley, England, Engineering Materials Advisory Services, Ltd., 1985, p. 395-422. refs

Continuing structural integrity of commercial transport aircraft is provided by inspection programs established through the combined efforts of aircraft manufacturers, regulatory agencies, and aircraft operators. Criteria and guidelines have been established for the evaluation and supplementation, if necessary, of these inspection programs for older commercial transport aircraft. The evaluation is based on aircraft current usage, durability, and damage tolerance assessment of the structure using current analysis and testing technology and state-of-the-art inspection methods. A supplemental inspection program, when necessary, is based on statistical-probabilistic concepts of having and detecting damage-cracks and is implemented through a sampling program of the high-time aircraft. Author

A86-43791

**MAINTENANCE SYSTEM BY MEANS OF DAMAGE TOLERANCE PRINCIPLE**

K. H. GALDA (Deutsche Lufthansa AG, Hamburg, West Germany) IN: Durability and damage tolerance in aircraft design; Proceedings of the Thirteenth Symposium, Pisa, Italy, May 22-24, 1985. Warley, England, Engineering Materials Advisory Services, Ltd., 1985, p. 473-494.

The maintenance of the structure of a civil jet transport aircraft is based on the damage tolerance principle. The inspection intervals and methods have to be determined such that a possible failure will most probably be detected before becoming critical. For new and old airplanes, the inspection system is based on the acceptable damage of the aircraft structure without a risk of a catastrophic failure. The application of the damage tolerance system includes all existing inspections geared toward more flexibility in planning and maintenance. Author



A86-43792

**A RATIONALE FOR THE SAFE OPERATION OF AN AIRCRAFT FLEET HAVING KNOWN CRACKS IN PRIMARY STRUCTURE**

J. M. GRANDAGE (Department of Defence, Aeronautical Research Laboratories, Melbourne, Australia) IN: Durability and damage tolerance in aircraft design; Proceedings of the Thirteenth Symposium, Pisa, Italy, May 22-24, 1985. Warley, England, Engineering Materials Advisory Services, Ltd., 1985, p. 495-510. refs

This paper presents a rationale and procedure aimed at operating known-to-be-cracked structures at acceptable risk levels. Existing airworthiness requirements for design are referred to, and problems of applying these requirements to a fleet of cracked structures are discussed. This leads to an appropriate adaptation of the requirements. Author

A86-43793

**THE INFLUENCE OF SLOW GROWTH AND NET SECTION YIELDING ON THE RESIDUAL STRENGTH OF STIFFENED STRUCTURE**

T. SWIFT (FAA, Long Beach, CA) IN: Durability and damage tolerance in aircraft design; Proceedings of the Thirteenth Symposium, Pisa, Italy, May 22-24, 1985. Warley, England, Engineering Materials Advisory Services, Ltd., 1985, p. 511-550. refs

In order to limit detectable crack sizes used in the damage tolerance evaluation of commercial aircraft in compliance with FAR 25.571, the regulatory authorities have been considering a further requirement that the structure be capable of 95 percent ultimate load with cracking up to detectable length. From a fracture mechanics viewpoint this is not achievable with the current materials, design concepts and working stress levels. This paper discusses the authorities' concerns together with the difficulties encountered with such a requirement. Author

A86-43794

**FRACTURE DIAGRAMS FOR STIFFENED AIRCRAFT STRUCTURES - EFFECTS OF MATERIAL NON-LINEARITY**

M. C. LOW (British Aerospace, PLC, Aircraft Group, Bristol, England) and D. J. CARTWRIGHT (Bucknell University, Lewisburg, PA) IN: Durability and damage tolerance in aircraft design; Proceedings of the Thirteenth Symposium, Pisa, Italy, May 22-24, 1985. Warley, England, Engineering Materials Advisory Services, Ltd., 1985, p. 551-583. Research supported by British Aerospace, PLC. refs

The complex variable formulation of two-dimensional elasticity is used to analyze a crack with unequal strip yield zones in an asymmetrically stiffened sheet. The simultaneous effects of yielding in the fasteners and stiffeners are included in the analysis. The strip yield zone lengths, the crack tip opening displacements, the maximum load concentration in the stiffener and the maximum fastener force are determined for a typical aircraft stiffened panel. Fracture diagrams are constructed for the panel and are used to show the effects of panel geometry and fastener flexibility. Author

A86-43796

**A SIMPLE CRACK CLOSURE MODEL FOR PREDICTING FATIGUE CRACK GROWTH UNDER FLIGHT SIMULATION LOADING**

D. ALIAGA, A. DAVY (Aerospatiale, Suresnes, France), and H. SCHAFF (Aerospatiale, Toulouse, France) IN: Durability and damage tolerance in aircraft design; Proceedings of the Thirteenth Symposium, Pisa, Italy, May 22-24, 1985. Warley, England, Engineering Materials Advisory Services, Ltd., 1985, p. 605-630. refs

The model described is based on the crack closure concept. A rule which fixes changes in the opening point is used to take into account the effects of the stress ratio and the retardation effect. A conservative counting method, similar to the 'rain flow' technique, is applied to each cycle. The model therefore combines a cycle-by-cycle analysis with a conservative counting method. Other advantages of the approach are the facility with which the

parameters used to represent the material can be determined, its reliability and its applicability to all metal alloys. Examples of its application to aluminum alloys and a steel are included. Author

A86-43798

**THE CERTIFICATION OF AIRFRAMES AND COMPONENTS IN METALS AND COMPOSITES**

A. W. CARDRICK (Royal Aircraft Establishment, Airworthiness Div., Farnborough, England) IN: Durability and damage tolerance in aircraft design; Proceedings of the Thirteenth Symposium, Pisa, Italy, May 22-24, 1985. Warley, England, Engineering Materials Advisory Services, Ltd., 1985, p. 651-672. refs

The UK Military airworthiness authorities believe that aircraft should have a good fatigue life and tolerance to variations from the conditions used in design. The most serious variations are those which affect the entire fleet as is the case with increases in all up weight, new maneuvers, changes in stores carriage policies and wear in mechanical components. If the structure is unduly sensitive to any consequential elevated loads operational effectiveness will be impaired. A brief description is given of draft requirements for Defence Standard 00-970. It is intended that these requirements should be applied to aeroplanes and helicopters and to all structural materials including fiber composites. Author

A86-43896

**EXPERT SYSTEMS FOR MECHANICAL FAULT DIAGNOSIS**

R. M. STEWART (Stewart Hughes, Ltd., Southampton, England) IN: AUTOTESTCON '85; Proceedings of the International Automatic Testing Conference, Uniondale, NY, October 22-24, 1985. New York, Institute of Electrical and Electronics Engineers, 1985, p. 295-300.

The interfacing of numerically intensive, imperative programs in expert systems for mechanical fault diagnosis is examined. The design of a Machinery Management Computer for helicopters is discussed as an example of such interfacing. The fundamentals of the interfacing problem are addressed, discussing an expert system for bearing diagnostics, the interface between imperative and declarative elements, and the problem of evidence accumulation. The potential benefits and problems of artificial intelligence and expert systems in the machinery management field are considered. C.D.

A86-43994

**HYPERSONIC VISCOUS SHOCK LAYER ON A SURFACE WITH AN ABRUPT VARIATION OF CATALYTIC ACTIVITY**

E. A. GERSHBEIN, V. I. U. KAZAKOV, and V. S. SHCHELIN (Moskovskii Gosudarstvennyi Universitet, Moscow, USSR) (Teplofizika Vysokikh Temperatur, vol. 23, Sept.-Oct. 1985, p. 916-921) High Temperature (ISSN 0018-151X), vol. 23, no. 5, March 1986, p. 727-732. Translation. refs

The flow of a multicomponent mixture of nonequilibrium-reacting gases over catalytic surfaces having an inset zone of materials with different catalytic properties is investigated within the framework of the theory of a hypersonic viscous shock layer on infinite-span wings with a blunt leading edge. Author

A86-44801

**FLOW OF REAL FLUIDS**

G. E. A. MEIER, ED. and F. OBERMEIER, ED. (Max-Planck-Institut fuer Stroemungsforschung, Goettingen, West Germany) Berlin and New York, Springer-Verlag (Lecture Notes in Physics. Volume 235), 1985, 353 p. In English and German. For individual items see A86-44802 to A86-44813.

A survey is presented of recent advances in fundamental research into numerically modelling and experimentally observing and controlling various processes of interest in fluid mechanics. Studies on the effects of the compressibility of a flow on sound propagation are reported, including work with the reverse flow theorem for transonic flow and sound generation by airfoil-vortex interaction. Sound radiation from planes and cylinders into fluids and from turbomachinery and propellers is examined. Wave momentum and power balance in a boundary layer are investigated, along with the gas dynamics, heat, adiabatic phase transitions

and wavesplitting in fluids with high specific heat. Consideration is also given to acoustic turbulence, models for slender vortex breakdown, and the vortical structure of bounded turbulent shear flow. M.S.K.

**A86-44934****STRUCTURAL MODIFICATION BY MODAL CORRECTION**

D. M. WILSON (Council for Scientific and Industrial Research, National Institute for Aeronautics and Systems Technology, Pretoria, Republic of South Africa) *Aeronautica Meridiana* (ISSN 0257-8573), vol. 6, no. 1, 1985, p. 37-42.

In the interest of achieving cost reductions in the ground testing of vibration characteristics in such large structures as those of aircraft, attention is given to alternative methods of airframe structural modification. The method of modal correction involves the addition or subtraction of pylons, fuel tanks, etc., by theoretical means, thereby reducing vibration testing requirements. Theoretically predicted results compare well with experimental data, and show that the inclusion of stiffness modification improves predictions. O.C.

**A86-45059#****AN ITERATIVE METHOD FOR STATICALLY INDETERMINATE STRUCTURES OF FLIGHT VEHICLE**

O. MARTIN (Institutul National pentru Creatie Stiintifica si Tehnica, Bucharest, Rumania) *Revue Roumaine des Sciences Techniques, Serie de Mecanique Appliquee* (ISSN 0035-4074), vol. 31, Jan.-Feb. 1986, p. 41-46.

Using the principles of the slope deflection method and matrix calculus, an iterative method is presented which allows the reactions in the attachment points of aircraft movable surfaces, the elevator, rudder and aileron, to be determined as a function of their displacement. A deflecting supporting structure loaded with air loads is also considered, and the individual effects of the load are summed using the superposition principle. R.R.

**A86-45208****A SYSTEM FOR INTRODUCING MUTUAL CORRECTIONS INTO THE AIRBORNE TEMPERATURE AND AIR-SPEED METERS [SISTEMA VVEDENIIA VZAIMNYKH POPRAVOK DLIA SAMOLETNYKH IZMERITELEI TEMPERATURY I SKOROSTI VOZDUSHNYKH POTOKOV]**

V. K. DMITRIEV and M. A. STRUNIN IN: *Methods and technology for experimental studies of the atmosphere*. Moscow, Gidrometeoizdat, 1985, p. 104-112. In Russian.

A scheme for introducing mutual corrections into the airborne thermometer and pneumoanemometer data indicating the atmospheric temperature and airspeed, as well as fluctuations in the temperature and the horizontal airspeed component, is discussed. Error estimates for several temperature and altitude values have been calculated, and the restitution coefficient for the temperature detector has been determined. The results of flight tests are presented, along with a block diagram of the system. I.S.

**A86-45231****A QUASI-ONE-DIMENSIONAL MODEL FOR THE EVOLUTION OF THE TURBULENT WAKE OF A BODY IN A STRATIFIED MEDIUM [KVAZIODNOMERNAIA MODEL' EVOLIUTSII V STRATIFITSIROVANNOMI SREDE TURBULENTNOI OBLASTI SLEDA ZA TELOM]**

L. I. SKURIN (Leningradskii Gosudarstvennyi Universitet, Leningrad, USSR) *Akademiia Nauk SSSR, Izvestiia, Fizika Atmosfery i Okeana* (ISSN 0002-3515), vol. 22, April 1986, p. 373-379. In Russian. refs

The time dependence of the sizes of plane turbulent spots in a stratified medium is described. The plane turbulent spots are studied under conditions where the pulsation Froude number values are large and the volume increases in the region considered due to turbulent diffusion is substantial. A system of equations for the evolution of such spots in a quasi-one-dimensional approximation is derived, and conditions under which the viscous stage of

evolution occurs are established. The evolution of the turbulent wake of a hypersonic vehicle is considered. I.F.

**A86-45256\*#** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

**FATIGUE LIFE ANALYSIS OF A TURBOPROP REDUCTION GEARBOX**

D. G. LEWICKI, J. J. COY (NASA, Lewis Research Center; U.S. Army, Propulsion Laboratory, Cleveland, OH), J. D. BLACK (General Motors Corp., Allison Gas Turbine Div., Indianapolis, IN), and M. SAVAGE (Akron, University, OH) *ASME, Transactions, Journal of Mechanisms, Transmission, and Automation in Design*, vol. 108, June 1986, p. 255-262. Previously announced in STAR as N85-27228. refs (ASME PAPER 85-DET-10)

A fatigue life analysis of the Allison T56/501 turboprop reduction gearbox was developed. The life and reliability of the gearbox was based on the lives and reliabilities of the main power train bearings and gears. The bearing and gear lives were determined using the Lundberg-Palmgren theory and a mission profile. The five planet bearing set had the shortest calculated life among the various gearbox components, which agreed with field experience where the planet bearing had the greatest incidences of failure. The analytical predictions of relative lives among the various bearings were in reasonable agreement with field experience. The predicted gearbox life was in excellent agreement with field data when the material life adjustment factors alone were used. The gearbox had a lower predicted life in comparison with field data when no life adjustment factors were used or when lubrication life adjustment factors were used either alone or in combination with the material factors. Author

**A86-45344****CALCULATION OF THE EXPLOSION OF A RAPIDLY FLYING BODY [K RASCHETU VZRYVA BYSTRO LETIASHCHEGO TELA]**

L. V. SHURSHALOV *Zhurnal Vychislitel'noi Matematiki i Matematicheskoi Fiziki* (ISSN 0044-4669), vol. 26, June 1986, p. 924-933. In Russian. refs

The paper formulates the problem of the explosion of a rapidly flying body, considered as a spherical gas volume characterized by high explosion energy and a high translational velocity. An algorithm for solving the problem is proposed which, together with the conventional divergent system of gasdynamic equations, uses nondivergent equations for the kinetic and internal energy of the gas, and a difference grid moving with the exploding body. Attention is given to cases of the explosion of gas volumes moving at velocities corresponding to  $M = 3$  and  $M = 30$ . B.J.

**A86-45422\*#** Old Dominion Univ., Norfolk, Va.

**RESPONSE OF SYMMETRIC RECTANGULAR COMPOSITE LAMINATES WITH NONLINEAR DAMPING SUBJECTED TO ACOUSTIC LOADING**

C. MEI (Old Dominion University, Norfolk, VA) and C. B. PRASAD *AIAA, Aeroacoustics Conference*, 10th, Seattle, WA, July 9-11, 1986. 16 p. refs (Contract NAS1-17993) (AIAA PAPER 86-1933)

Effects of both nonlinear damping and large-deflection are included in the analysis in an attempt to explain the experimental phenomena of aircraft panels excited at high sound pressure levels; that is the broadening and flattening out of the strain response peaks and the increasing of the response frequency. A nonlinear damping model is considered in the analysis using a single-mode approach. Root-mean-square (RMS) maximum deflection, RMS strains, spectral density functions of strain, and equivalent linear frequency are obtained for clamped and simply supported rectangular symmetric laminated composite plates. It is demonstrated that nonlinear damping is the one which causes the broadening of the response peaks, and it has great influence on RMS panel deflection, RMS strains, and frequency. Author

A86-45437#

**THE PRESSURE FIELD GENERATED BY JET-JET IMPINGEMENT**

N. S. NOSSEIR and U. PELED (San Diego State University, CA) AIAA, Aeroacoustics Conference, 10th, Seattle, WA, July 9-11, 1986. 7 p. refs  
(Contract N00014-84-K-0373)  
(AIAA PAPER 86-1951)

The impingement of two, axisymmetric turbulent jets on each other is investigated experimentally. The angle of impingement is equal to 180 deg, and the jets issue from large flat plates. Characteristics of the flowfield and pressure disturbances generated in the impinging region and amplified by feedback mechanisms are discussed. Author

A86-45490\*# Virginia Polytechnic Inst. and State Univ., Blacksburg.

**EXPERIMENTAL INVESTIGATION OF UNSTEADY FAN FLOW INTERACTION WITH DOWNSTREAM STRUTS**

W. F. NG, W. F. OBRIEN, and T. L. OLSEN (Virginia Polytechnic Institute and State University, Blacksburg) AIAA, Aeroacoustics Conference, 10th, Seattle, WA, July 9-11, 1986. 11 p. NASA-supported research. refs  
(AIAA PAPER 86-1870)

In the present study of the unsteady pressure field produced on fan rotor blades by interaction with downstream struts, a single stage, low speed axial-flow fan was instrumented with blade-mounted high frequency pressure transducers. In addition, stationary pressure problems were used to map out the flowfield. Fluctuating pressure measurements are presented for blade midspan and 85-percent span on both the suction and pressure surfaces of the rotor blades at several positions of the downstream struts, and for two different flow coefficients. The strut is found to produce an effect on the unsteady pressure field on the rotor blades; this effect exceeds that due to the stator at design rotor-stator-strut spacing, but it rapidly declines as the struts are moved downstream. O.C.

A86-45694

**THE VIBRATION AND STABILITY OF SYMMETRICALLY-LAMINATED COMPOSITE RECTANGULAR PLATES SUBJECTED TO IN-PLANE STRESSES**

D. J. DAWE (Birmingham, University, England) and T. J. CRAIG (VSEL Consortium, PLC, Dept. of Naval Architecture, Barrow-in-Furness, England) Composite Structures (ISSN 0263-8223), vol. 5, no. 4, 1986, p. 281-307. Research supported by the Royal Aircraft Establishment and SERC. refs

Consideration is given to the twin problems of the elastic buckling of rectangular, symmetrically-laminated composite plates and of the vibration in the presence of applied in-plane stress of such laminates. First-order shear deformation plate theory provides the mathematical model of plate behavior and the Rayleigh-Ritz and finite strip methods are used to generate numerical results for laminates of thin and moderately thick geometry, with various combinations of standard plate edge conditions. The applied stresses include uniform shear stress as well as direct stresses, and anisotropic material properties can be included. The presented results demonstrate the accuracy of the numerical methods and highlight the very significant influence that transverse shear and related thickness effects can have in the subject problems. Author

A86-45762

**OPTIMIZATION OF STIFFENED PANELS UNDER COMPRESSION**

W. LI (Northwestern Polytechnical University, Xian, People's Republic of China) Journal of Strain Analysis for Engineering Design (ISSN 0309-3247), vol. 21, July 1986, p. 153-158. refs

The optimization of the angle-stiffened panel under compression using the feasible direction method is studied. Only the most critical constraint could be taken into account for each iteration when using the feasible direction method, with the result that the process of calculation is greatly simplified. It is beneficial for stability and

convergence of the design process that the design variables in each iteration are modified once by some experience formulae, if necessary. The illustrative examples and the comparison of the numerical results of this paper with those of another paper indicate the effectiveness and efficiency of the method presented here.

A86-45816

**PRECISION CASTING OF AERO GAS TURBINE COMPONENTS**

G. A. WHITTAKER (G. A. Whittaker and Associates, Crewe, England) (Institute of Metals, Conference on Casting of Superalloys, London, England, Feb. 27, 1985) Materials Science and Technology (ISSN 0267-0836), vol. 2, May 1986, p. 436-441.

The development of techniques for the production of aircraft gas turbine components by precision casting is described. Various steps in the casting process are discussed, including conditions of the wax and core assembly and molding practices, dewaxing, mold firing, melting practice, core removal, and the cut-off and finishing. Attention is paid to quality failures and their remedies, with special consideration given to dimensional and grain size controls; the problems of shrinkage porosity, misruns, hot tears, and surface oxidation pitting; and the causes of mechanical failures. I.S.

A86-46135

**FIBER OPTIC SENSORS FOR FLEXURE MEASUREMENT OF AIRCRAFT STRUCTURES**

R. C. MURPHY (Canadian Marconi Co., Montreal, Canada) Unmanned Systems, vol. 4, Spring 1986, p. 31-35. refs

An evaluation is made of the possible roles that fiber-optics technologies can play in constituting an EMI-immune, low-weight structural monitoring system for very long endurance aircraft (VLEA). The key to such systems is the obviation of the fiber-optic cabling's protective material, and the direct realization of sensor devices in glass fiber structures or integrated optics devices. Attention is given to passive multiplexing techniques, lens and modulator designs, the structure of fiber-optical EM field, structural strain and deflection sensors, and the instrumentation of a VLEA's wing structure. O.C.

A86-46148

**NEW LEVELS OF REALISM ACHIEVED IN VISUALS FOR FLIGHT SIMULATION**

M. LONG (Rediffusion Simulation, Ltd., Crawley, England) ICAO Bulletin, vol. 41, May 1986, p. 28, 29.

Novoview SP1/T and SupraWIDE are visual simulation systems for aircrew training which respectively improve image texture and furnish wrap-around imagery. Both fixed wing and rotary wing flight simulations can be implemented with these systems. SupraWIDE employs a specially designed Schmidt projection system for its CRTs which incorporates reflective rather than refractive optics. Novoview SP1/T can realistically represent actual world airports under full lighting conditions, with surrounding environmental lights and such terrain features as mountains and three-dimensional buildings. O.C.

A86-46562

**SUPERALLOY COMPONENT DURABILITY ENHANCEMENTS**

R. A. SPRAGUE (GE Engineering Materials Technology Laboratory, Evendale, OH and Lynn, MA) and S. J. FRIESEN (General Electric Co., Evendale, OH) Journal of Metals (ISSN 0148-6608), vol. 38, July 1986, p. 24-30. refs

This overview summarizes process improvements in wrought and cast superalloy components for turbine engine applications. Techniques such as VIM, VAR, ESR and electron beam melting are discussed with respect to product cleanliness. Property enhancement is now an important consideration of forging technology. Scientists are quantifying the dependence of crack growth on microstructure and alloy design. Directional solidification casting practices that promote integrity and property enhancement are achievable through careful process control. State-of-the-art developments and future directions for the industry are also reviewed. Author

A86-46701

**SENSITIVITY, NOISE AND OPTICAL CROSSTALK IN HETERODYNE ACOUSTO-OPTICAL SIGNAL PROCESSORS**

T. S. CHEN (TRW Electro-Optics Research Center, Redondo Beach, CA) and S. K. YAO (TRE Semiconductor Equipment Corp., Woodland Hills, CA) IN: Optical technology for microwave applications II; Proceedings of the Meeting, Arlington, VA, April 9, 10, 1985. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1985, p. 88-94.

The suggestion that optical scattering in a heterodyne acoustooptical system can be ignored, in view of a beat frequency with the reference beam that lies outside the IF bandpass of the heterodyne detection, is contradicted by the present analysis. Instead, a finite point-spread function convolving with the reference beam of a heterodyne spectrum analyzer causes a mixing of photons with different frequency shifts, thereby generating IF noise. The additional contribution of a signal beam with finite scattering level to optical cross-talk, through mixing with the scattered reference beam, is presently clarified by both analytical derivation and experimental data. O.C.

A86-46788

**IMPACT OF SUPERCOMPUTERS ON THE NEXT DECADE OF COMPUTATIONAL FLUID DYNAMICS**

E. M. MURMAN (MIT, Cambridge, MA) and S. S. ABARBANEL (Tel Aviv University, Israel) IN: Progress and supercomputing in computational fluid dynamics; Proceedings of U.S.-Israel Workshop, Jerusalem, Israel, December 1984. Boston, MA, Birkhaeuser, 1985, p. 1-10.

The current status of computational fluid dynamics is surveyed, and future trends are projected, with an emphasis on the application of supercomputers. It is predicted that supercomputer directly addressable high-speed memory capacity will increase from 2-16 to 256 Mwords and that processor speed will increase from 100 to 1000 MFLOPS over the next 10 yrs. The implications of these improvements for the exploratory design of aircraft, for treatment of unclean aerodynamic flows, for theoretical understanding of complex flow problems, for algorithms and languages, and for subsystem development are discussed. T.K.

A86-47011

**INCREMENTAL AND ITERATIVE METHODS FOR SOLVING FLUID/STRUCTURE INTERACTION PROBLEMS**

Y. GONG (Beijing Institute of Aeronautics and Astronautics, People's Republic of China) IN: Numerical methods in laminar and turbulent flow; Proceedings of the Fourth International Conference, Swansea, Wales, July 9-12, 1985. Part 2. Swansea, Wales, Pineridge Press, 1985, p. 1292-1300. refs

Fluid/solid coupling effects were analyzed using the finite element method as an integrated means and applying both incremental and iterative methods to solve the fluid/structure coupled equations. The incremental procedure with iteration in final steps is proposed. The proposed method was applied to solve an airflow/wing structure coupling problem, and the results were compared with those obtained by using the iterative method alone, with similar findings obtained in both procedures. I.S.

A86-47107

**MULTI SHAKER MODAL TESTING USING A MODIFIED TRANSIENT RANDOM EXCITATION**

M. CLARK (Northrop Corp., Aircraft Div., Hawthorne, CA) IN: International Modal Analysis Conference, 3rd, Orlando, FL, January 28-31, 1985, Proceedings. Volume 1. Schenectady, NY, Union College, 1985, p. 553-557. Research supported by the Northrop Independent Research and Development Program. refs

A modal testing method which includes multishaker and transient random modal testing procedures is described. The force and response functions of the testing method are improved with digital-to-analog-converter-driver software and a modified excitation function. The method is applied to a model of a fighter aircraft being tested under transient random single and dual point excitations, true random dual point excitation, and modified transient random dual point excitation conditions. The frequency response

and coherence functions are evaluated. It is noted that this method provides improvements in the transfer function and coherence. I.F.

A86-47122

**DETERMINING COMPONENT LOADS AND STRESSES WITH IMPROVED SYSTEM MODELING TECHNIQUES**

J. W. KLAHS and G. E. TOWNLEY (Structural Dynamics Research Corp., Milford, OH) IN: International Modal Analysis Conference, 3rd, Orlando, FL, January 28-31, 1985, Proceedings. Volume 2. Schenectady, NY, Union College, 1985, p. 941-948. refs

The use of static correction terms to improve the modal representation of components by accounting for the effect of truncated higher frequency modes is analytically discussed. The determination of the dynamic load field experienced by a component in a system and the resulting strains and stresses are examined. The use of modal analysis, system dynamic analysis, and finite element analysis into a very automated procedure for determining complex dynamic loads and stress/strain distributions with a high degree of confidence prior to building and testing a prototype is demonstrated. Modeling considerations and limitations are discussed, and examples are presented. C.D.

A86-47124

**IDENTIFICATION OF AEROELASTIC PHENOMENON EMPLOYING BISPECTRAL ANALYSIS TECHNIQUES**

J.-H. CHANG, R. O. STEARMAN, D. CHOI, and E. J. POWERS (Texas, University, Austin) IN: International Modal Analysis Conference, 3rd, Orlando, FL, January 28-31, 1985, Proceedings. Volume 2. Schenectady, NY, Union College, 1985, p. 956-964. refs

The analytical determination of the stability features of a classical bending-torsion degree of freedom aeroelastic system is presented based on the generalized Bolotin's or harmonic balance method. It is found that the system can experience combination and/or parametric resonance phenomena when periodic time-dependent loads are induced along the chordwise dimension of the wing. These phenomena may or may not promote the occurrence of classical flutter or divergence. The advantages of this result for developing techniques in subcritical flutter testing are discussed. C.D.

A86-47133#

**ULTRASONIC DIRECT BACKSCATTERING TECHNIQUE FOR MATERIAL SURFACE INSPECTION**

E. J. CHERN and G. P. EGAN (General Electric Co., Aircraft Engine Business Group, Cincinnati, OH) IN: Symposium on Nondestructive Evaluation, 15th, San Antonio, TX, April 23-25, 1985, Proceedings. San Antonio, TX, Nondestructive Testing Information Analysis Center, 1986, p. 82-88. refs

The experimental results obtained from low cycle fatigue (LCF) surface cracks using the ultrasonic direct backscattering satellite pulse measurements and frequency domain analysis are reported. The specimens examined were an Inconel 718 flat plate with three surface-connected LCE cracks and a DA 718 plate with six cracks of various sizes. The ultrasonic transducer used in the experiment was a 5 MHz broadband longitudinal transducer with a 6-in. focal length. The angle of incidence was varied from 0 to 40 deg incrementally in steps of 10 deg. The experimental results showed improved detectability of fatigue cracks at 20 deg oblique angle of incidence. The defect sizes were estimated based on the satellite pulse delay time and frequency resonance pattern. The ultrasonic results were compared with the metallographic measurements and are in good agreement. The technique can be used to eliminate the inspection dead zone of normal longitudinal inspections. Author

**N86-29827#** Pratt and Whitney Aircraft of Canada Ltd., Longueuil (Quebec).

**PRESSURE DROP AND HEAT TRANSFER CHARACTERISTICS OF CIRCULAR AND OBLONG LOW ASPECT RATIO PIN FINS**

S. C. ARORA and W. A. MESSEH *In* AGARD Heat Transfer and Cooling in Gas Turbines 15 p Sep. 1985

Avail: NTIS HC A23/MF A01

The pressure drop and heat transfer characteristics of circular and oblong pin fins of height-to-diameter ratio of unity used to augment internal cooling of gas turbine airfoils are presented. Data were obtained for an array of 10 rows of staggered pin fins in a 25:1 aspect ratio channel, with both pins and channel endwalls forming the heat transfer surface. Results show that the array average friction factor increases with increasing blockage caused by different arrangement of pin fin geometries in the channel. The local heat transfer coefficient increases up to the 3rd row of pin fins and decreases thereafter. Oblong pin fins with  $\gamma=90$  deg (major axis parallel to the direction of flow) result in higher heat transfer rates and lower friction factor than the circular pin fins. For other orientations, oblong pin fins do not offer any advantage over circular pin fins for  $Re$  or  $= 20,000$  (typical of small gas turbine engines). M.G.

**N86-29847#** Societe Nationale d'Etudes et de Construction de Moteurs d'Aviation, Moissy-Cramayel (France). Centre de Villaroche

**COOLING TECHNIQUES FOR TURBOJET PRE-HEATER CHANNELS [TECHNIQUES DE FROIDISSEMENT DES CANAUX DE RECHAUFFE DES TURBOREACTEURS]**

M. DESAULTY, P. TROULLOT, and S. COUTOR *In* AGARD Heat Transfer and Cooling in Gas Turbines 11 p Sep. 1985  
*In* FRENCH

Avail: NTIS HC A23/MF A01

Increases in the performance of turbojets with pre-heating are dependent upon technological research in the area of protection of the wall in pre-heater channels. The procedures used to cool the thermal protection jackets have undergone important improvements which have optimized performance, reduced weight and improved cooling efficiency. This report presents a comparison of the thermal protection jackets for several SNECMA engines, as well as the principal stages of development for the jacket from the design stages through static engine tests. M.G.

**N86-29856#** Motoren- und Turbinen-Union Muenchen G.m.b.H. (West Germany).

**TRANSIENT THERMAL BEHAVIOUR OF A COMPRESSOR ROTOR WITH VENTILATION: TEST RESULTS UNDER SIMULATED ENGINE CONDITIONS**

E. REILE, U. RADONS, and D. K. HENNECKE *In* AGARD Heat Transfer and Cooling in Gas Turbines 9 p Sep. 1985

Avail: NTIS HC A23/MF A01

The development of advanced compressors for modern aero-engines requires detailed knowledge of the transient thermal behavior of the rotor disks to enable accurate prediction of rotor life and, additionally, of the thermal growth of the rotor for the evaluation of tip clearances. In the quest for longer life and higher reliability of the parts as well as reduced clearances even at transient conditions, the designer has to be able to influence the thermal behavior of the rotor. A very effective way is to vent small amounts of air through the rotor cavities. The design of such a vented rotor is presented. The main emphasis is placed on a detailed description of a test rig specially built for this purpose. The testing was carried out under simulated engine conditions for a wide range of parameters. The results are compared with those obtained with a theoretical model derived from fundamental tests at the University of Sussex, where heat transfer in rotating cavities is investigated. Good agreement is observed. Some final tests were done in an engine. The results also exhibit good agreement with the rig results under simulated conditions, when the proper dimensionless parameters are considered, providing the validity of the simulation. Author

**N86-29830#** Oxford Univ. (England). Dept. of Engineering Science.

**WAKE-PASSING IN A TURBINE ROTOR CASCADE**

D. J. DOORLY, M. L. G. OLDFIELD, and C. T. J. SCRIVENER (Rolls-Royce Ltd., Derby, England) *In* AGARD Heat Transfer and Cooling in Gas Turbines 18 p Sep. 1985

Avail: NTIS HC A23/MF A01

A technique for generating realistic wakes upstream of a stationary turbine blade cascade at full scale Mach numbers and Reynolds numbers is described. High speed Schlieren photographs showing the development of the wake flow through the cascade are presented, together with unique high speed measurements of the fluctuations of the surface heat transfer rate as the nozzle guide vane (NGV) wakes pass over the rotor blade surface. Combining the flow visualization results with the unsteady heat transfer measurements reveals the radically different nature of the boundary layer transition caused by wake passing; an understanding of which will be essential for the development of improved prediction techniques. M.G.

**N86-29840#** Purdue Univ., West Lafayette, Ind. School of Mechanical Engineering.

**A MODEL FOR CORRELATING FLAT PLATE FILM COOLING EFFECTIVENESS FOR ROWS OF ROUND HOLES**

M. R. LECUYER and F. O. SOECHTING (Pratt and Whitney Aircraft, West Palm Beach, Fla.) *In* AGARD Heat Transfer and Cooling in Gas Turbines 12 p Sep. 1985

Avail: NTIS HC A23/MF A01

An effective method of cooling, that has found widespread application in aircraft gas turbines, is the injection of a film of cooling air through holes into the hot mainstream gas to provide a buffer layer between the hot gas and the airfoil surface. Film cooling has been extensively investigated and the results have been reported in the literature. However, there is no generalized method reported in the literature to predict the film cooling performance as influenced by the major variables. A generalized film cooling correlation has been developed, utilizing data reported in the literature, for constant velocity and flat plate boundary layer development. This work provides a basic understanding of the complex interaction of the major variables effecting film cooling performance. Author

**N86-29857#** Instituto Superior Tecnico, Lisbon (Portugal). Dept. of Mechanical Engineering.

**HEAT EXCHANGERS IN REGENERATIVE GAS TURBINE CYCLES**

M. N. R. NINA and M. P. N. AGUAS *In* AGARD Heat Transfer and Cooling in Gas Turbines 8 p Sep. 1985

Avail: NTIS HC A23/MF A01

Advances in compact heat exchanger design and fabrication together with fuel cost rises continuously improve the attractability of regenerative gas turbine helicopter engines. In this study cycle parameters aiming at reduced specific fuel consumption and increased payload or mission range, have been optimized together with heat exchanger type and size. The discussion is based on a typical mission for an attack helicopter in the 900 kw power class. A range of heat exchangers is studied to define the most favorable geometry in terms of lower fuel consumption and minimum engine plus fuel weight. Heat exchanger volume, frontal area ratio and pressure drop effect on cycle efficiency are considered. Author

**N86-29858#** Office National d'Etudes et de Recherches Aeronautiques, Paris (France).

**CERAMIC HEAT EXCHANGERS FOR GAS TURBINES OR TURBOJET ENGINES**

S. BOUDIGUES and J. FABRI *In* AGARD Heat Transfer and Cooling in Gas Turbines 14 p Sep. 1985 *In* FRENCH; ENGLISH summary

Avail: NTIS HC A23/MF A01

Heat exchangers made of steel and placed downstream of the last turbine of a turbojet engine or any gas turbine are too heavy and too cumbersome. With a heat exchanger made of silicon carbide mass, performance, volume and cost balances which greatly benefit civilian or military use can be obtained. Silicon carbide has good thermal performance and makes it possible to situate the heat exchanger between turbine stages. Both the pressure of cold and hot gases are thus increased, the heat exchange processes are amplified, the length and the diameter of the exchanger are reduced. With the density of this material being only 3.2, the overall mass of the exchanger is considerably reduced. It is also possible to shortcut part of the cold air, and thus obtain a controlling parameter. A kind of after burner effect is obtained, although a single combustor is used, and the corresponding thermodynamic process has a higher efficiency than the after burning process. Author

**N86-29859#** Technische Univ., Aachen (West Germany). Inst. for Jet Propulsion and Turbomachinery.

**EFFECT OF FILM COOLING ON THE AERODYNAMIC PERFORMANCE OF A TURBINE CASCADE**

O. KOELLEN and W. KOSCHEL *In* AGARD Heat Transfer and Cooling in Gas Turbines 16 p Sep. 1985

Avail: NTIS HCA23/MF A01

The aerodynamic performance of a film cooled turbine cascade for a typical design with multiple rows of cooling holes was investigated in an annular cascade rig with air at room temperature. The work was concentrated on the individual effect of the injection row position on the aerodynamic cascade losses and on the downstream flow field. For six different single row configurations the tests were conducted in a wide range of varying coolant mass flow rates and main stream Mach numbers. Typical results of these measurements are presented and discussed. Three models for the aerodynamic loss prediction based on different theoretical approaches, which are known from literature, were examined and improved. The presented two mixing layer models take into account the penetration of the injected cooling air into the main stream, whereas the third model predicts flow losses by a boundary layer calculation with film cooling air injection. Some tests with flow visualization by Schlieren photography were carried out showing the mixing effects of the injected coolant flow. Finally results of the predicted performance are compared with the experimental data. M.G.

**N86-29861#** Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Goettingen (West Germany). Inst. fuer Experimentelle Stroemungsmechanik.

**AERODYNAMIC EFFECT OF COOLANT EJECTION IN THE REAR PART OF TRANSONIC ROTOR BLADES**

F. H. KOST and A. T. HOLMES (Rolls-Royce Ltd., Bristol, England) *In* AGARD Heat transfer and Cooling in Gas Turbines 12 p Sep. 1985

Avail: NTIS HC A23/MF A01

An investigation of transonic turbine blades designed by Rolls-Royce/Bristol concerning the aerodynamic penalties of coolant flow for two alternative cooling configurations is discussed. Rolls-Royce designed a blade with a thick trailing edge where the coolant is ejected through slots in the trailing edge and a second blade with a thin trailing edge where coolant is ejected through a row of holes on the pressure side and a row of holes on the suction side. Tests were performed in a plane cascade wind tunnel. The results indicate the sensitivity of the blade performance to cooling configuration and coolant flow rate. By combining measured data from blade surface and wake traverses it was possible to separate the various loss mechanisms. Therefore, the separate

losses due to the momentum of the coolant, change of base pressure, and change of blade friction could be determined quantitatively as a function of coolant flow rate. M.G.

**N86-30090\*#** Nevada Univ., Reno. Engineering Research and Development Center.

**COMPUTATIONS AND TURBULENT FLOW MODELING IN SUPPORT OF HELICOPTER ROTOR TECHNOLOGY Final Report, 1 Jun. 1984 - 30 Nov. 1985**

W. C. ROSE Nov. 1985 53 p

(Contract NSG-2291)

(NASA-CR-177095; NAS 1.26:177095) Avail: NTIS HC A04/MF A01 CSCL 20D

The angle of attack (AOA) tandem cavity wind tunnel experiment was prepared. Actual wind tunnel testing started shortly after the beginning of 1985. A multi-probe aerodynamic rake was designed and installed for use in surveying the shear layers present over the open cavity on the Kuiper Airborne Observatory (KAO). The nature of the behavior of the thermal environment within the KAO cavity at operational altitudes was determined. Assistance was given in the design of the cavity for the University of Denver radiometer. Attempts to distinguish between the optical terms of blur circle size (or image size) and the term due to jitter were discussed. B.G.

**N86-30094\*#** Stanford Univ., Calif. Dept. of Aeronautics and Astronautics.

**EXPERIMENTAL RESULTS OF THE CONTROL OF A VORTICAL FLOW BY TANGENTIAL BLOWING**

N. J. WOOD and L. ROBERTS May 1986 73 p Sponsored by NASA

(NASA-CR-176932; NAS 1.26:176932; JIAA-TR-71) Avail: NTIS HC A04/MF A01 CSCL 20D

The results of a wind tunnel test to investigate the controlling effects of tangential, leading edge blowing on the vortical flow over a delta wing are given. Blowing is used to directly control the crossflow separation points at the rounded leading edge and hence, the trajectory of the feeding sheet and the location of the vortex. Experiments were conducted for both co-flowing and counter-flowing configurations over a range of angles of attack from 0 to 90 degrees. Results in the form of pressure distributions, overall force coefficients and flow mappings were obtained. The emphasis is on data presentation rather than detailed analysis. The initial results indicate that the co-flowing configuration was capable of extending the regime of stable, controlled vortical flow over the upper surface by approximately 30 degrees angle of attack for modest blowing requirements. Increases in maximum normal force coefficient of approximately 30% were achieved and significant rolling moments produced at angles of attack from 30 to 60 degrees. The counter-flowing configuration indicated only minor lift augmentation with the exception of an isolated occurrence at 20 degrees angle of attack. At that condition, with very weak blowing, a lift augmentation of approximately 20 was measured.

**N86-30128#** Air Force Academy, Colo. Research Lab.

**ADVANCED LASER BASED INERTIAL INSTRUMENT DEVELOPMENT Final Report, Jan. 1984 - Mar. 1986**

J. R. ROTGE 1986 18 p

(AD-A166307; FJSRL-TR-86-0001) Avail: NTIS HC A02/MF A01 CSCL 17G

Active laser gyroscopes suffer from a lock-in phenomenon, a result of backscatter from the cavity optical elements, which limit their performance in the regime of near-zero rotation. The flip-flop gyro proposed and initially investigated under this effort shows potential for minimizing or avoiding this lock-in effect. The need for a high accuracy, inexpensive and reliable clock, suitable for avionics applications was the motivation for the laser clock proposed and studied during the course of this effort. Both devices require and deserve further investigation to properly demonstrate their utility. GRA



**N86-30219#** Office National d'Etudes et de Recherches Aérospatiales, Paris (France). Direction Scientifique de la Résistance des Struct

**PRELIMINARY INSTRUMENTATION FOR AEROELASTIC TESTS AT THE COMPRESSOR LEVEL Final Report [INSTRUMENTATION PRELIMINAIRE AUX ESSAIS AEROELASTIQUES AU BANC COMPRESSEUR]**

I. CAFARELLI Dec. 1985 15 p In FRENCH (Contract SNECMA-265.806-VY) (ONERA-RT-95/7108-RY-054-R; ESA-86-97274) Avail: NTIS HC A02/MF A01

Unsteady pressure characterization methods are presented. The instrumentation of the blades before being assembled is described, including the unsteady sensors and an interface printed circuit. The assembling procedures and supplementary precautions such as protective painting are also discussed. ESA

**N86-30233\*#** National Aeronautics and Space Administration, Langley Research Center, Hampton, Va.

**TECHNIQUE FOR MEASURING SIDE FORCES ON A BANKED AIRCRAFT WITH A FREE-SWIVELING NOSE GEAR**

S. M. STUBBS and J. A. TANNER Aug. 1986 23 p (NASA-TM-87719; L-16137; NAS 1.15:87719) Avail: NTIS HC A02/MF A01 CSCL 20K

An experimental investigation was conducted at the Langley Research Center to determine a method for towing an aircraft to measure the side forces of a free-swiveling nose gear due to variations in bank angle. A F-106 aircraft and the Space Shuttle orbiter OV-101 were towed to measure side forces on full-size aircraft for bank angles up to 3 deg. These tests indicate that substantial side forces will occur if an aircraft is rolling on a runway in a banked attitude even when the nose gear is free to swivel. Corotation of a twin-tire nose gear appears to cause a substantial increase in side force due to bank angle compared with a nose gear with independently rotating wheels. Author

**N86-30641#** Israel Aircraft Industries Ltd., Ben-Gurion Airport. **STATIC AEROELASTIC ANALYSIS USING AIRCRAFT VIBRATION MODES**

Z. SHEENA and M. KARPEL In DGLR The 2nd International Symposium on Aeroelasticity and Structural Dynamics p 229-232 1985

Avail: NTIS HC A99/MF E03

A method for the calculation of the airload distribution and aeroelastic effectiveness parameters of a flexible aircraft from the distribution of a rigid one, using its vibration modes, is presented. The method uses modal data of the model in the form of a limited number of low frequency mode shapes and their associated generalized stiffnesses. The mathematical operations are done on the generalized matrices of the model which have a small number of degrees of freedom. The method can calculate the static aeroelastic properties of a free-free aircraft using its elastic, inertial, and aerodynamic properties. The method is suitable for making parametric analyses involving changes in the stiffness of the structure and the aerodynamics of the model. Numerical examples are given and the convergence with the number of modes taken into account is discussed. ESA

**N86-30646#** Pilatus Aircraft Ltd., Stans (Switzerland).

**EXPERIENCE WITH AEROELASTIC ANALYSIS OF A SINGLE ENGINE TURBO TRAINER USING FINITE ELEMENT METHODS**

M. J. REINICKE, A. S. TURI (Omega G.m.b.H., Immenstaad West Germany), and A. VOLLAN In DGLR The 2nd International Symposium on Aeroelasticity and Structural Dynamics p 286-296 1985

Avail: NTIS HC A99/MF E03

The PC-9 trainer aircraft dynamic analysis concept, based on a theoretical approach relying upon results of extensive ground vibration tests conducted on the similar structure of the PC-7, is outlined. The mathematical model shows good agreement with test results. Flight flutter tests verify the calculated aeroelastic stability. The program dealing with modal variation of mass, stiffness and damping allows changes on superelement level. Hence, the

size of the residual structure can be further reduced and the CPU time cut down accordingly. ESA

**N86-30669#** Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Stuttgart (West Germany). Inst. of Aeroelasticity.

**ADVANCES IN GROUND VIBRATION TESTING USING A COMBINATION OF PHASE RESONANCE AND PHASE SEPARATION METHODS**

N. NIEDBAL In DGLR The 2nd International Symposium on Aeroelasticity and Structural Dynamics p 523-528 1985  
Avail: NTIS HC A99/MF E03

A ground vibration test (GVT) method that uses the complex response modes obtained directly from harmonic excitation near resonance with the arbitrary force distribution to set up the generalized dynamic equation of motion without knowledge of normal modes and normal mode parameter was derived. The dominating quantities of the method are the response mode matrices and the characteristic matrices which may be compared with the generalized mass and stiffness matrices of the phase resonance method. It is demonstrated how to derive normal mode shapes and associated normal mode parameters from the information contained in the characteristic matrices and in the response mode matrices. The method was validated by applying it to the solution of a flutter problem and the evaluation of normal mode parameters. Data were obtained from a GVT performed on a full-scale aircraft. ESA

**N86-30781#** Strathclyde Univ., Glasgow (Scotland). Dept. of Mechanics of Materials.

**ASSESSING THE EFFECTS OF DELAMINATIONS ON THE POSTBUCKLING STRENGTH OF CRFP PANELS**

W. M. BANKS, J. RHODES, and G. B. CHAI In ESA Proceedings of a Workshop on Composites Design for Space Applications p 197-202 Feb. 1986 Sponsored by UK Ministry of Defense and ESA

Avail: NTIS HC A16/MF A01

The effect of deliberately inbuilt delaminations on the postbuckling strength of carbon fiber composite panels with a b/t ratio of 70 and 50 was tested. The panels are fabricated from 14 layers of unidirectional carbon fiber using an autoclave process. The delamination positions were chosen to coincide with the position of highest interlaminar shear stress, the position of highest direct strain, the central buckle peak, and the inflection points on the panel. The control panel for a b/t ratio of 68.57 failed prematurely due to unforeseen edge effects. However it is clear that the worst position for delamination is when it coincides with the highest interlaminar shear stress at the edge of the panel. There appears to be little effect with the delamination at the buckle peak. ESA

**N86-30890#** New Mexico Univ., Albuquerque. Engineering Research Inst.

**FIRE EXTINGUISHING AGENTS FOR OXYGEN-ENRICHED ATMOSPHERES Final Report, 1 Apr. 1982 - 30 Nov. 1985**

M. A. PLUGGE, C. W. WILSON, D. M. ZALLEN, and J. L. WALKER Dec. 1985 98 p (Contract F29601-81-C-0013) (AD-A166967; NMERI-TA3-19; ESL-TR-85-26) Avail: NTIS HC A05/MF A01 CSCL 13L

Fire-suppression agent requirements for extinguishing fires in oxygen-enriched atmospheres were determined employing small-, medium-, large-, and full-scale test apparatuses. The small- and medium-scale tests showed that a doubling of the oxygen concentration required five times more HALON for extinguishment. For fires of similar size and intensity, the effect of oxygen enrichment of the diluent volume in the HC-131A was not as grate as in the smaller compartments of the B-52 which presented a higher damage scenario. The full-scale tests showed that damage to the airframe was as important a factor in extinguishment as oxygen enrichment. GRA

**N86-30898#** Selenia Industrie Associate S.p.A., Rome (Italy).  
Engineering Support Dept.

**AN EXAMPLE OF INTEGRATED LOGISTIC SUPPORT APPLIED ALSO TO PRODUCTION TESTING**

V. BUONTEMPO *In its Rivista Tecnica Selenia*, v. 9, no. 4, p 26-45 1985

Avail: NTIS HC A03/MF A01

The basic concepts of an aerospace industry integrated logistic support plan are presented. An example shows that as well as achieving overall economy on system life cycle support cost, it reduces production costs by designing support means and production test in harmony with the logistic support means. A life cycle computation model related to the logistic support is provided. The model is also applicable to on board avionic systems such as Tornado and AMX aircraft and EH 101 helicopter. ESA

**N86-30907#** Aerospace Medical Research Labs.,  
Wright-Patterson AFB, Ohio.

**A MODIFICATION OF THE H-133 GROUND COMMUNICATIONS HEADSET FOR USE IN INTENSE NOISE ENVIRONMENTS**

C. W. NIXON and H. C. SOMMER 7 Mar. 1986 31 p  
(AD-A166981; AAMRL-TR-86-009) Avail: NTIS HC A03/MF A01  
CSCL 17B

Detailed technical information and instructions are provided for a simple modification of the Air Force standard H-133 ground communications headset for use in intense noise environments at levels of 135 db (SPL) and higher. This modification involves the replacement of the conventional H-136 earphone with a miniaturized receiver mounted on a custom molded insert earplug. An adaptor box-line potentiometer is fabricated to provide manual control of the level of the speech signal at the ear of the wearer. The modified H-133 communications headset has been utilized at selected Air Force bases by ground maintenance personnel who rate the hearing protection and voice communications performance as excellent. GRA

**N86-30908#** Mitre Corp., Bedford, Mass.

**MONOPOLE ELEMENT AT THE CENTER OF A CIRCULAR GROUNDPLANE OF ARBITRARY RADIUS. VOLUME 1: THEORY AND RESULTS Final Report**

M. M. WEINER, S. P. CRUZE, C. C. LI, and W. J. WILSON Mar. 1986 136 p

(Contract F19628-84-C-0001)

(AD-A166991; MTR-9622-VOL-1) Avail: NTIS HC A07/MF A01  
CSCL 20N

The Air Force SINGARS VHF-FM radio is a frequency-hopping anti-jam device utilizing electrically short antenna to minimize aerodynamic drag on airborne platforms. The development of optimally efficient, electronically tuneable antennas for this radio is of interest. Although the antenna groundplane is platform-dependent, it is usually small compared to an rf wavelength. A circular groundplane provides a standardized geometry with which to model and evaluate candidate antennas. Accordingly, a VHF antenna range with an 8 ft. diameter circular groundplane has been constructed to evaluate candidate antennas. The electrical properties of a monopole element at the center of a circular groundplane of finite radius are of interest to this program for (1) qualifying the antenna range; (2) establishing antenna standards with which to measure test antennas; and (3) modeling candidate antennas. A survey of the literature revealed that although this antenna has the simplest geometry of any monopole antenna, its properties are neither well understood nor standardized, particularly for groundplane radii which are small or comparable to a wavelength. This paper attempts to address this deficiency. Author (GRA)

**N86-30931#** Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).

**DETERMINATION OF ANTENNAE PATTERNS AND RADAR REFLECTION CHARACTERISTICS OF AIRCRAFT**

H. BOTHE, D. MACDONALD, and A. POOL, ed. May 1986 138 p

(AGARD-AG-300-VOL-4; ISBN92-835-1530-7) Avail: NTIS HC A07/MF A01

The different types of aircraft antennas, their radiation characteristics and their preferred siting on the airframe are described. Emphasis is placed on the various methods for determining aircraft antenna radiation patterns (ARP) and advantages, disadvantages and limitations of each method are indicated. Mathematical modelling, model measurements and in-flight measurements in conjunction with the applied flight test techniques are included. Examples of practical results are given. Methods of determining aircraft radar characteristics are also described, indicating advantages, disadvantages and limitations of each method. Relevant fundamentals of radar theory are included only as necessary to appreciation of the real meaning of radar cross section (RCS) and angular glint. The measuring methods included are dynamic full-scale, static full-scale, sub-scale optical, ultrasonic and radio modelling. References are made to RCS measuring facilities in the USA and Europe and the UK Radio Modelling Facility is used extensively to exemplify the sub scale technique. Author

**N86-30988#** Von Karman Inst. for Fluid Dynamics,  
Rhode-Saint-Genese (Belgium).

**NUMERICAL TECHNIQUES FOR VISCOUS FLOW CALCULATIONS IN TURBOMACHINERY BLADINGS**

1986 516 p Lecture Series held in Rhode-Saint-Genese, Belgium, 20-24 Jan. 1986

(VKI-LS-1986-02; ESA-86-97482) Avail: NTIS HC A22/MF A01

Governing equations and solution methods of Navier-Stokes equations; numerical modeling of Navier-Stokes equations; turbulence models; grid generation systems in turbomachinery; Navier-Stokes computations for circulation controlled airfoils and exotic airfoils; multigrid convergence acceleration techniques for explicit Euler solvers and applications to Navier-Stokes calculations; and application of full Navier-Stokes solvers to turbomachinery flow problems were discussed. ESA

**N86-30995#** National Aeronautics and Space Administration.  
Ames Research Center, Moffett Field, Calif.

**NAVIER-STOKES COMPUTATIONS FOR CIRCULATION CONTROLLED AIRFOILS**

T. H. PULLIAM, D. C. JESPEREN, and T. J. BARTH *In Von Karman Inst. for Fluid Dynamics Numerical Techniques for Viscous Flow Calculations in Turbomachinery Bladings* 18 p 1986

Presented at 18th AIAA Fluid Dynamics and Plasmadynamics and Lasers Conference, Cincinnati, Ohio, 16-18 Jul. 1985 (AIAA-85-1587) Avail: NTIS HC A22/MF A01

Navier-Stokes computations of subsonic to transonic flow past airfoils with augmented lift due to rearward jet blowing over a curved trailing edge are presented. The approach uses a spiral grid topology. Solutions are obtained using a Navier-Stokes code which employs an implicit finite difference method, an algebraic turbulence model, and developments which improve stability, convergence, and accuracy. Results are compared against experiments for no jet blowing and moderate jet pressures and demonstrate the capability to compute these complicated flows. ESA



**N86-30996#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

**NAVIER-STOKES COMPUTATIONS FOR EXOTIC AIRFOILS**

T. J. BARTH (Informatics General Corp., Palo Alto, Calif.), T. H. PULLIAM, and P. G. BUNING *In* Von Karman Inst. for Fluid Dynamics Numerical Techniques for Viscous Flow Calculations in Turbomachinery Bladings 17 p 1986 Presented at 23rd AIAA Aerospace Science Meeting, Reno, Nev., 14-17 Jan. 1985 (AIAA-85-0109) Avail: NTIS HC A22/MF A01

A hyperbolic grid generator with improvements for handling sharp corners and concave surfaces combined with a Navier-Stokes flow solver is applied to complex two dimensional airfoil configurations. Steady separated flow about an iced leading edge of an airfoil is presented. Unsteady viscous separated flows past an airfoil at two angles of attack with a spoiler deployed at 60 deg are compared with experiment. The spoiler computations are performed with two different topological maps of the physical domain to the computational domain. Graphical techniques for the static and unsteady display of the flow fields are discussed.

ESA

**N86-30999\*#** Aeronautical Research Associates of Princeton, Inc., N. J.

**A FUNDAMENTAL STUDY OF DRAG AND AN ASSESSMENT OF CONVENTIONAL DRAG-DUE-TO-LIFT REDUCTION DEVICES**

J. E. YATES and C. D. DONALD Washington NASA Sep. 1986 34 p

(Contract NAS1-18065)

(NASA-CR-4004; NAS 1.26:4004; ARAP-577) Avail: NTIS HC A03/MF A01 CSCL 20D

The integral conservation laws of fluid mechanics are used to assess the drag efficiency of lifting wings, both CTOL and various out-of-plane configurations. The drag-due-to-lift is separated into two major components: (1) the induced drag-due-to-lift that depends on aspect ratio but is relatively independent of Reynolds number; (2) the form drag-due-to-lift that is independent of aspect ratio but dependent on the details of the wing section design, planform and Reynolds number. For each lifting configuration there is an optimal load distribution that yields the minimum value of drag-due-to-lift. For well designed high aspect ratio CTOL wings the two drag components are independent. With modern design technology CTOL wings can be (and usually are) designed with a drag-due-to-lift efficiency close to unity. Wing tip-devices (winglets, feathers, sails, etc.) can improve drag-due-to-lift efficiency by 10 to 15% if they are designed as an integral part of the wing. As add-on devices they can be detrimental. It is estimated that 25% improvements of wing drag-due-to-lift efficiency can be obtained with joined tip configurations and vertically separated lifting elements without considering additional benefits that might be realized by improved structural efficiency. It is strongly recommended that an integrated aerodynamic/structural approach be taken in the design of (or research on) future out-of-plane configurations. Author

**N86-31010#** Princeton Univ., N. J. Dept. of Mechanical and Aerospace Engineering.

**THREE-DIMENSIONAL SHOCK WAVE AND TURBULENT BOUNDARY LAYER INTERACTIONS Final Report, 1 Aug. 1981 - 31 Jul. 1984**

S. M. BOGDONOFF Sep. 1985 75 p

(Contract F49620-81-K-0018)

(AD-A167086; REPT-1723-MAE; AFOSR-85-1242TR) Avail: NTIS HC A04/MF A01 CSCL 20D

An extensive experimental study of three-dimensional shock wave turbulent boundary layer interactions caused by shock generators defined solely by angles has been carried out at Mach 3. Sharp fins, sharp swept fins, swept wedges, and semi-cones have been used to generate a wide range of shock waves. The interaction of these waves with turbulent boundary layers has been investigated by surface flow visualization, mean surface static pressure distributions, flowfield surveys of total pressure and yaw, and several flowfield visualization techniques. Some exploratory

high frequency surface pressure measurements have been carried out to evaluate the steadiness of these interactions. Scaling laws for both surface and flowfield features have been derived. Some limited studies were carried out at a Mach number of 2. A flowfield study has shown that the initial part of interactions caused by the same strength and geometrical shock wave generated by different shock generators are all similar. The footprints of the interactions, as shown by surface flow visualization, can be categorized as approximately conical or cylindrical, and the boundaries between these two regions have been defined for both Mach 3 and Mach 2. There are still questions with regards to the detailed flowfield structures and physical mechanisms, but the three-dimensional interactions appeared to be less unsteady than that of two-dimensional separated flows. GRA

**N86-31030\*#** General Electric Co., Wilmington, Mass. Aircraft Instruments Dept.

**HIGH ACCURACY FUEL FLOWMETER Final Report**

1986 346 p

(Contract NAS3-22139)

(NASA-CR-174869; NAS 1.26:174869) Avail: NTIS HC A15/MF A01 CSCL 14B

All three flowmeter concepts (vortex, dual turbine, and angular momentum) were subjected to experimental and analytical investigation to determine the potential portotype performance. The three concepts were subjected to a comprehensive rating. Eight parameters of performance were evaluated on a zero-to-ten scale, weighted, and summed. The relative ratings of the vortex, dual turbine, and angular momentum flowmeters are 0.71, 1.00, and 0.95, respectively. The dual turbine flowmeter concept was selected as the primary candidate and the angular momentum flowmeter as the secondary candidate for prototype development and evaluation. B.G.

**N86-31070\*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**AEROELASTIC CONSIDERATIONS FOR TORSIONALLY SOFT ROTORS**

W. R. MANTAY and W. T. YEAGER, JR. Aug. 1986 20 p Presented at the AHS 2nd Decennial Specialists' Meeting on Rotorcraft Dynamics, Moffett Field, Calif., 7-9 Nov. 1984

(NASA-TM-87687; NAS 1.15:87687; USAVSCOM-TR-86-B-1)

Avail: NTIS HC A02/MF A01 CSCL 20K

A research study was initiated to systematically determine the impact of selected blade tip geometric parameters on conformable rotor performance and loads characteristics. The model articulated rotors included baseline and torsionally soft blades with interchangeable tips. Seven blade tip designs were evaluated on the baseline rotor and six tip designs were tested on the torsionally soft blades. The designs incorporated a systematic variation in geometric parameters including sweep, taper, and anhedral. The rotors were evaluated in the NASA Langley Transonic Dynamics Tunnel at several advance ratios, lift and propulsive force values, and tip Mach numbers. A track sensitivity study was also conducted at several advance ratios for both rotors. Based on the test results, tip parameter variations generated significant rotor performance and loads differences for both baseline and torsionally soft blades. Azimuthal variation of elastic twist generated by variations in the tip parameters strongly correlated with rotor performance and loads, but the magnitude of advancing blade elastic twist did not. In addition, fixed system vibratory loads and rotor track for potential conformable rotor candidates appears very sensitive to parametric rotor changes. Author

## GEOSCIENCES

Includes geosciences (general); earth resources; energy production and conversion; environment pollution; geophysics; meteorology and climatology; and oceanography.

**A86-44150#****DYNAMIC STALL - THE CASE OF THE VERTICAL AXIS WIND TURBINE**

A. LANEVILLE and P. VITTECOQ (Sherbrooke, Univesite, Canada) ASME, Transactions, Journal of Solar Energy Engineering (ISSN 0199-6231), vol. 108, May 1986, p. 140-145. IREG-NSERC-supported research. refs

This paper presents the results of an experimental investigation on a driven Darrieus turbine rotating at different tip speed ratios. For a Reynolds number of  $3.8 \times 10^4$  to the 4th, the results indicate the presence of dynamic stall at tip speed ratio less than 4, and that helicopter blade aerodynamics can be used in order to explain some aspects of the phenomenon. It was observed that in deep stall conditions, a vortex is formed at the leading edge; this vortex moves over the airfoil surface with 1/3 of the airfoil speed and then is shed at the trailing edge. After its shedding, the vortex can interact with the airfoil surface as the blade passes downstream. Author

**A86-44380****FORECASTING FOR CIVIL AVIATION. II**

L. DENT (Meteorological Office, Bracknell, England) Weather (ISSN 0043-1656), vol. 41, March 1986, p. 82-89.

The distinguishing features of long-haul intercontinental flights, short-haul continental flights and general aviation (transporting of business executives, etc.) are outlined and examples of flight documentation are provided. It is noted that the two primary concerns for both pilot and forecaster are air safety and economics. While the former requires constant vigilance on the part of aircrews, ground crews, meteorological observers and forecasters, the latter requires careful calculation of just how much fuel is needed for a flight. In effect, route winds and temperatures must be determined with great accuracy. K.K.

**A86-46138****LLWAS - AN INTEGRAL PART OF THE U.S. WIND-SHEAR SAFETY PROGRAMME**

C. B. BAKER, D. W. GILMORE, and R. MCCALL (Climatronics Corp., Bohemia, NY) ICAO Bulletin, vol. 41, March 1986, p. 11-13.

The use of the low level wind shear alert system (LLWAS) to detect wind shear and provide warnings for aircraft is examined. Wind shear alters lift forces and causes abrupt changes in wind direction and velocity within a very small area and for a short period of time. Wind shear is either vertical or horizontal and is classified into micro, meso, and synoptic scale groups. The effects of micro- and macro-mesoscale wind shear on aircraft are described. The LLWAS consists of an array of wind sensors composed of a center-field unit and five outlying remote stations; the system provides continuous display of wind data to the air traffic control tower. Modifications to the system, such as improving the gust direction algorithm, the display, and the speed and accuracy of the ground/pilot communications, are studied. The need to train pilots and ground personnel for recognition avoidance and reaction to wind-shear events is discussed. The development of a wind shear detection system that combines the capabilities of the LLWAS and Doppler detection systems is proposed. I.F.

**N86-30285\*#** Dayton Univ., Ohio.

**THE PHYSICAL AND EMPIRICAL BASIS FOR A SPECIFIC CLEAR-AIR TURBULENCE RISK INDEX Final Report, 2 Jul. 1982 - 30 Aug. 1985**

J. L. KELLER Washington NASA Apr. 1986 48 p

(Contract NAS8-34687)

(NASA-CR-3971; NAS 1.26:3971) Avail: NTIS HC A03/MF A01 CSCL 04B

The fundamental emphasis of this research was to develop a technique which would be a significant improvement over those currently used for flight planning to avoid clear air turbulence (CAT). The technique should, ideally, be both quantitative in determining potential intensity and specific in locating regions of relatively high risk. Furthermore, it should not rely on specialized data but be functional using the currently available rawinsonde observation (raob) system. Encouraging results documented in an earlier investigation were considered compelling enough to warrant a closer look into the possibilities of a Specific Clear Air Turbulence Risk (SCATR) index approach to the clear air turbulence problem. Unlike that research, which considered sustained periods of flight in light to moderate clear air turbulence, this study focuses on several cases of documented severe CAT. Results of these case studies suggest that a SCATR index is not an unrealizable goal and that uses of such an index, even in its current prototype level of development, are also apparent. Author

## 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.

**A86-43476#****APPLICATION OF ADAPTIVE CONTROL TO AIRCRAFT SYSTEMS**

Z. CHEN and H. ZHANG (Beijing Institute of Aeronautics and Astronautics, People's Republic of China) Acta Aeronautica et Astronautica Sinica, vol. 6, Dec. 1985, p. 513-520. In Chinese, with abstract in English. refs

The competition of the adaptive technique with other techniques is reviewed. The inherent drawback of the adaptive technique in application to aircraft systems is considered in the light of the analysis of the features of flight control systems. The potentials and perspectives of the adaptive technique are also suggested. The development of advanced aircraft demands performance beyond the capacity of the airdata scheduling technique. Therefore, the adaptive control schemes are expected to be applied to these flight control problems. In order to make full use of the advantages, such as saving sensor hardware, requiring less prior knowledge of aircraft and providing higher flexibility, it is necessary to carry out robustness research of existing adaptive control schemes and to develop new more robust adaptive control schemes. Author

**A86-43482#****AN OPTIMAL PARAMETER ESTIMATION METHOD COMPATIBLE WITH STABLE PARAMETER PREDICTION IN TIME DOMAIN**

H. GAN and Y. WU (Harbin Institute of Technology, People's Republic of China) Acta Aeronautica et Astronautica Sinica, vol. 6, Dec. 1985, p. 565-571. In Chinese, with abstract in English. refs

A compatible identification algorithm is presented, in which the Lainiotis (1976) general partitioning identification algorithm (GPIA) is combined with the model reference identification algorithm (MRIA) based on the stability theory of Liapunov. By means of this algorithm, the residuals of the system can approach to zero asymptotically and variance of the residuals can be minimized. In

the GPIA-MRIA algorithm, GPIA gives a linear optimal estimation of state and parameters according to a finite measurement set, and MIRA offers an asymptotical approach of the models. This means that GPIA contributes the state estimator of MIRA on the one hand, and on the other hand MIRA predicts the parameters and adjusts the model of GPIA to an optimal estimation of the parameters. This method has been applied to identification of aerodynamic coefficients and control derivatives of an aircraft, by means of digital simulation. It is shown that this method is superior to the single GPIA in accuracy of identification and speed of convergence, and requires almost no increase in the capacity of computation. Author

A86-43511#

**ON A METHOD FOR PILOT DYNAMICS IDENTIFICATION REFLECTING FEEDBACK STRUCTURES**

N. GOTO (Kyushu University, Fukuoka, Japan) Kyushu University, Technology Reports (ISSN 0023-2718), vol. 58, Dec. 1985, p. 985-991. In Japanese, with abstract in English. refs

A statistical method that has been used to study pilot control behavior in multiloop situations is extended to the identification of pilot dynamics in a class of feedback systems with an inner loop. The method utilizes the autoregressive scheme and determines the unknown dynamics by reducing the system to a feedback structure suited to the scheme. Distinguishing the system structure with an inner loop from other candidate system structures is possible by examining the correlation characteristics of the innovation processes as well as the identified dynamics. To test the method, a digital simulation study is conducted, treating the longitudinal flight-path control of an aircraft as an example in which the pilot is considered to tightly close the pitch-attitude-control inner loop. The results show that the method checks the feedback structure of the concerned system and yields good estimates of the unknown dynamics as well. The method seems to be feasible enough to be applied to the analysis of real flight and simulator test data. Author

A86-43889

**SMART BUILT-IN-TEST (BIT)**

K. A. HALLER, J. D. ZBYTNIIEWSKI (Grumman Aerospace Corp., Bethpage, NY), and K. ANDERSON (Bolt Beranek and Newman, Inc., Cambridge, MA) IN: AUTOTESTCON '85; Proceedings of the International Automatic Testing Conference, Uniondale, NY, October 22-24, 1985. New York, Institute of Electrical and Electronics Engineers, 1985, p. 140-147.

This paper summarizes the Smart BIT study performed under contract to Rome Air Development Center, Griffiss Air Force Base, NY. Current and state-of-the-art design techniques for Built-In-Test (BIT) were surveyed along with Artificial Intelligence (AI) techniques applicable to the identification and reduction of BIT false alarms and intermittents. Analysis of each potentially useful concept ascertained which techniques would be feasible for system application. Techniques were selected from those deemed feasible and several were incorporated as part of the demonstration system. An AI diagnostic program on a remote LISP machine performed the levels of reasoning required to identify false alarms inserted under the control of a local computer connected to the test unit. Author

A86-44505

**SINUSOIDAL DISTURBANCE REJECTION WITH APPLICATION TO HELICOPTER FLIGHT DATA ESTIMATION**

G. C. GOODWIN, R. J. EVANS (Newcastle, University, Australia), R. L. LEAL (Centro de Investigaciones y Estudios Avanzados, Mexico City), and R. A. FEIK (Department of Defence, Aeronautical Research Laboratories, Melbourne, Australia) IEEE Transactions on Acoustics, Speech, and Signal Processing (ISSN 0096-3518), vol. ASSP-34, June 1986, p. 479-484. refs

This paper is concerned with the problem of eliminating sinusoidal disturbances from data while producing minimal distortion to the underlying data. A particular example of this problem arises in the filtering of helicopter data which are corrupted by sinusoidal disturbances due to rotor motion. It is shown that an optimal

solution to the problem can be found using Kalman filtering theory. The properties of the optimal filter are analyzed using recent results on filtering for nonstabilizable systems. These results are then used to motivate a particular near-optimal filter which has enhanced robustness properties relative to the optimal filter. It will be shown that an identical filter can be derived using recent results on the evaluation of recursive discrete Fourier transforms. This link between time and frequency domain methods leads to a rather complete understanding of the characteristics of the filter. Specific results are presented showing the application of the filter to real helicopter data. Author

A86-45473

**RECTANGULAR PARALLELEPIPED CODING - A VOLUMETRIC REPRESENTATION OF THREE-DIMENSIONAL OBJECTS**

Y. C. KIM and J. K. AGGARWAL (Texas, University, Austin) IEEE Journal of Robotics and Automation (ISSN 0882-4967), vol. RA-2, Sept. 1986, p. 127-134. refs  
(Contract F49620-85-K-0007)

A new three-dimensional object representation scheme called rectangular parallelepiped coding is presented. Rectangular parallelepiped coding is an extension to three-dimensional space of the two-dimensional rectangular coding scheme. It is a volume-based representation of three-dimensional objects constructed from three orthogonal views (silhouettes) of the object using volume intersection method and is coded as a list of rectangular parallelepipeds. The representation is versatile and easily edited. For the objects coded in this representation, the operations of translation, rotation, and scaling are easily performed and the properties of volume, surface, and moments are easily computed. Examples are given for which processing time and storage requirements are examined. Author

A86-45728

**USE OF BLOCK-PULSE FUNCTIONS IN THE OPTIMAL CONTROL OF DETERMINISTIC SYSTEMS**

C. HWANG, D.-H. SHIH, and F.-C. KUNG (National Cheng Kung University, Tainan, Republic of China) International Journal of Control (ISSN 0020-7179), vol. 44, Aug. 1986, p. 343-349. refs

The synthesis of an optimal control function for deterministic systems described by integrodifferential equations is investigated. By using the elegant operational properties of block-pulse functions, a directly computable algorithm for evaluating the optimal control and trajectory of deterministic systems is developed. An example is given to illustrate the utility of this method. Author

A86-45736

**THE SINGULAR-G METHOD FOR UNSTABLE NON-MINIMUM-PHASE PLANTS**

I. HOROWITZ (California, University, Davis; Weizmann Institute of Science, Rehovot, Israel) International Journal of Control (ISSN 0020-7179), vol. 44, Aug. 1986, p. 533-541. refs  
(Contract NSF ECS-83-03333; F33615-83-C-3000)

In linear time-invariant feedback systems with plants which have both poles and zeros in the right half-plane, it is always possible to stabilize the system for a fixed plant. But in the previous optimum techniques, the stability margins might be so small as to render the design wholly impractical. This problem was overcome in the X-29 aircraft in a multiple-input-multiple-output (MIMO) setting, by use of a singular-G (compensation) matrix inside the loop. Excellent stability margins were then achievable over a wide plant parameter range, by means of a fixed-G compensation matrix. This paper extends the singular-G technique to the single-input-single-output plant. The latter is converted into an equivalent  $N \times N$  MIMO plant by means of  $N$  parallel independent time-varying modulators acting on the plant output, a technique previously used for nonlinear network synthesis. The singular-G method is then applicable to the equivalent  $N \times N$  MIMO plant. The detailed design procedure is presented by means of an example with  $N = 2$ . Author

A86-46369#

**SIMULATION OF THE ALGORITHMS OF A NAVIGATION COMPUTER [SYMULACJA ALGORYTMOW KOMPUTERA NAWIGACYJNEGO]**

M. LIJOWSKI Instytut Lotnictwa, Prace (ISSN 0509-6669), no. 103, 1985, p. 37-52. In Polish. refs

Methods for determining the position of an aircraft on the basis of the signals obtained from the air data unit, an induction gyrocompass, two VOR receivers, an automatic direction finder and a Doppler radar set are discussed. Problems connected with the search for radio stations of optimum location are explained as algorithms for the joint operation of the navigation computer with the map indicator. The programs were tested, showing the correctness of the proposed algorithms and the possibility of their realization in real time. Author

A86-46377

**A FAST SHAPE DESCRIPTOR**

J. MA, C.-K. WU, and X.-R. LU (Northwest Telecommunication Engineering Institute, Xian, People's Republic of China) Computer Vision, Graphics, and Image Processing (ISSN 0734-189X), vol. 34, June 1986, p. 282-291. refs

A fast normalized shape descriptor for digital pattern-recognition and classification applications is developed and demonstrated. The descriptor employs the rapid transformation of Reitboeck and Brody (1968), preceded by a distance transform to assure invariance to rotation. The performance of the descriptor is compared experimentally with that of a normalized Fourier descriptor (Wallace and Wintz, 1980) in problems involving two-dimensional aircraft images. The new descriptor is found to be faster than and just as accurate as the Fourier descriptor, and to require significantly less memory storage capacity. T.K.

A86-46401

**CONTROLLABILITY THEORY OF DISCRETE DYNAMIC SYSTEMS**

R. G. FARADZHEV, MR. PHAT VU NGOC, and A. V. SHAPIRO Automation and Remote Control (ISSN 0005-1179), vol. 47, no. 1, June 10, 1986, pt. 1, p. 1-20. Translation. refs

The current status of discrete dynamics systems controllability theory is reviewed as well as applications and prospects for further development. Consideration is given to systems that are linear, bilinear, nonlinear, finite, ordinary modified and multiparameter in nature. It is noted that the theory of controllability in time systems is applied in such areas as biology, mechanics, and aircraft/spacecraft control; in multiparameter systems, this theory plays a major role in designing the means for digital display processing and multidimensional data arrays. In the case where space-time multidimensional discrete systems are combined with finite control methods, the theory of controllability potentially plays a significant role in synthesizing optimal high-speed antenna arrays and plasma processes. Problems related to these applications are discussed. K.K.

A86-46706

**APPLICATIONS OF ARTIFICIAL INTELLIGENCE II; PROCEEDINGS OF THE MEETING, ARLINGTON, VA, APRIL 9-11, 1985**

J. F. GILMORE, ED. (Georgia Institute of Technology, Atlanta) Meeting sponsored by SPIE. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers (SPIE Proceedings. Volume 548), 1985, 275 p. For individual items see A86-46707 to A86-46717. (SPIE-548)

The present conference considers topics in image segmentation and texture analysis, robotic vision, image understanding, expert system design, motion planing, and heuristic systems. Attention is given to the use of texture operators in segmentation, knowledge-based terrain analysis, a computer vision system for the identification of overlapping workpieces, stereopsis and scene partitioning for terrain interpretation, and the shape recognition of complex objects by syntactical primitives. Also discussed are the application of expert system techniques to a visual tracker,

knowledge-based route planning through natural terrain, decision-aiding for tactical aircraft, a model-based system for force structure analysis, search processes for artificial intelligence applications, a hierarchical planner for intelligent systems, an analysis of motion patterns generated by moving shapes, the role of understanding in automated program synthesis, and the detection of objects in high resolution multispectral aerial images. O.C.

A86-46791

**REMARKS ON THE DEVELOPMENT OF A MULTIBLOCK THREE-DIMENSIONAL EULER CODE FOR OUT OF CORE AND MULTIPROCESSOR CALCULATIONS**

A. JAMESON (Princeton University, NJ), S. LEICHER (Dornier GmbH, Friedrichshafen, West Germany), and J. DAWSON (Cray Research, Inc., Minneapolis, MN) IN: Progress and supercomputing in computational fluid dynamics; Proceedings of U.S.-Israel Workshop, Jerusalem, Israel, December 1984. Boston, MA, Birkhaeuser, 1985, p. 53-66. refs

A multiblock modification of the FLO57 code for three-dimensional wing calculations is described and demonstrated. The theoretical basis of the multistage time-stepping algorithm is reviewed; the multiblock grid structure is explained; and results from a computation of vortical flow past a delta wing, using 2.5 x 10 to the 6th grid points and performed on a Cray X/MP computer with a 128-Mword solid-state storage device, are presented graphically. T.K.

N86-30349\*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**DEVELOPMENT OF AN ALGORITHM TO MODEL AN AIRCRAFT EQUIPPED WITH A GENERIC CDTI DISPLAY**

W. C. DRISCOLL (Youngstown State Univ., Ohio.) and J. A. HOUCK Jul. 1986 58 p (NASA-TM-87732; NAS 1.15:87732) Avail: NTIS HC A04/MF A01 CSCL 12A

A model of human pilot performance of a tracking task using a generic Cockpit Display of Traffic Information (CDTI) display is developed from experimental data. The tracking task is to use CDTI in tracking a leading aircraft at a nominal separation of three nautical miles over a prescribed trajectory in space. The analysis of the data resulting from a factorial design of experiments reveals that the tracking task performance depends on the pilot and his experience at performing the task. Performance was not strongly affected by the type of control system used (velocity vector control wheel steering versus 3D automatic flight path guidance and control). The model that is developed and verified results in state trajectories whose difference from the experimental state trajectories is small compared to the variation due to the pilot and experience factors. Author

N86-30371\*# Texas Technological Coll., Lubbock. Dept. of Electrical Engineering/Computer Science.

**A CANONICAL FORM FOR NONLINEAR SYSTEMS**

R. SU and L. R. HUNT (Texas Univ., Dallas.) 1986 21 p (Contract NAG2-203; NAG2-189; N0014-76-C-1136; N00014-84-C-0104) (NASA-CR-176974; NAS 1.26:176974) Avail: NTIS HC A02/MF A01 CSCL 09B

The concepts of transformation and canonical form have been used in analyzing linear systems. These ideas are extended to nonlinear systems. A coordinate system and a corresponding canonical form are developed for general nonlinear control systems. Their usefulness is demonstrated by showing that every feedback linearizable system becomes a system with only feedback paths in the canonical form. For control design involving a nonlinear system, one approach is to put the system in its canonical form and approximate by that part having only feedback paths. Author

**N86-30648#** London Univ. (England). Dept. of Aeronautical Engineering.

**FINITE STATE MODELLING OF AEROELASTIC SYSTEMS FOR ACTIVE CONTROL APPLICATIONS: A GENERAL THEORY**

R. VEPA /in DGLR The 2nd International Symposium on Aeroelasticity and Structural Dynamics p 309-319 1985  
 Avail: NTIS HC A99/MF E03

The theory of modeling aeroelastic systems by finite state models is discussed. The models are classified as autonomous finite state models, time varying system models, and differential delay system models. It is shown that control law synthesis for active control can be performed using the differential delay model, which does not contribute to any additional states and is valid for the closed and open loop cases. However, control law implementation requires that the states used for feedback be measured directly or estimated from measurements which are linear combinations of system states. Direct measurements of all feedback states is probably not practical so that sensor output data processing is required. Two alternatives are the statistical Kalman-Bucy filter with error dynamics governed by the statistics of the measurements noise, and a state estimator with error dynamics selected arbitrarily. ESA

**N86-31237\*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**GEOMETRIAL DESCRIPTION FOR A PROPOSED AEROASSIST FLIGHT EXPERIMENT VEHICLE**

F. M. CHEATWOOD, F. J. DEJARNETTE (North Carolina State Univ., Raleigh.), and H. H. HAMILTON, II Jul. 1986 38 p  
 (NASA-TM-87714; NAS 1.15:87714) Avail: NTIS HC A03/MF A01 CSCL 09B

One geometry currently under consideration for the Aeroassist Flight Experiment (AFE) vehicle is composed of several segments of simple general conics: an ellipsoidal nose tangent to an elliptical cone and a base skirt with the base plane raked relative to the body axis. An analytic representation for the body coordinates and first and second partial derivatives of this configuration has been developed. Equations are given which define the body radius and partial derivatives for a prescribed axial and circumferential position on the vehicle. The results for a sample case are tabulated and presented graphically. Author

**N86-31265\*#** Toledo Univ., Ohio. Dept. of Electrical Engineering.

**CONTROL DESIGN FOR ROBUST STABILITY IN LINEAR REGULATORS: APPLICATION TO AEROSPACE FLIGHT CONTROL Final Report, 1 Jun 1985 - 17 Jul. 1986**

R. K. YEDAVALLI 1986 63 p  
 (Contract NAG1-578)  
 (NASA-CR-176858; NAS 1.26:176858) Avail: NTIS HC A04/MF A01 CSCL 09B

Time domain stability robustness analysis and design for linear multivariable uncertain systems with bounded uncertainties is the central theme of the research. After reviewing the recently developed upper bounds on the linear elemental (structured), time varying perturbation of an asymptotically stable linear time invariant regulator, it is shown that it is possible to further improve these bounds by employing state transformations. Then introducing a quantitative measure called the stability robustness index, a state feedback control design algorithm is presented for a general linear regulator problem and then specialized to the case of modal systems as well as matched systems. The extension of the algorithm to stochastic systems with Kalman filter as the state estimator is presented. Finally an algorithm for robust dynamic compensator design is presented using Parameter Optimization (PO) procedure. Applications in a aircraft control and flexible structure control are presented along with a comparison with other existing methods. Author

**N86-31420\*#** Prairie View Agricultural and Mechanical Coll., Tex. Dept. of Mechanical Engineering.

**DEVELOPMENT OF A NUMERICAL PROCEDURE TO MAP A GENERAL 3-D BODY ONTO A NEAR-CIRCLE**

M. J. HOMMEL /in NASA. Johnson Space Center NASA/American Society for Engineering Education (ASEE) Summer Faculty Fellowship Program, 1985 5 p Jul. 1986  
 Avail: NTIS HC A99/MF E03 CSCL 12A

Conformal mapping is a classical technique utilized for solving problems in aerodynamics and hydrodynamics. Conformal mapping is utilized in the construction of grids around airfoils, engine inlets and other aircraft configurations. These shapes are transformed onto a near-circle image for which the equations of fluid motion are discretized on the mapped plane and solved numerically by utilizing the appropriate techniques. In comparison to other grid-generation techniques such as algebraic or differential type, conformal mapping offers an analytical and accurate form even if the grid deformation is large. One of the most appealing features is that the grid can be constrained to remain orthogonal to the body after the transformation. Hence, the grid is suitable for analyzing the supersonic flow past a blunt object. The associated shock as a coordinate surface adjusts its position in the course of computation until convergence is reached. The present work applied conformal mapping to 3-D bodies with no axis of symmetry such as the Aerobraking Flight Experiment (AFE) vehicle, transforming the AFE shape onto a near-circle image. A numerical procedure and code are used to generate grids around the AFE body. Author

## 16

### 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.

**A86-44805**

**MODELLING OF ACOUSTIC RADIATION PROBLEMS ASSOCIATED WITH TURBOMACHINERY AND ROTATING BLADES**

W. EVERSMAN (Missouri-Rolla, University, Rolla) IN: Flow of real fluids. Berlin and New York, Springer-Verlag, 1985, p. 63-72. refs

Finite element methods developed for computational predictions of turbofan and propeller acoustic radiation are presented. Account is taken of the disparate acoustic and geometric scales, the complex geometry, sound propagation in a nonuniformly flowing medium, the presence of a lining, and definition of bounds for calculations which are carried out in an unbounded domain. Density and pressure perturbations in the turbofan inlet are modeled with a linearized momentum equation. The sound radiation is represented by the Fourier components, i.e., angular modes. The same nacelle geometry is used for propeller noise, which requires inclusion of acoustic volume sources and forces. A forced convected wave equation for harmonic driving is obtained by combining continuity, momentum and state equations linearized for acoustic perturbations. The weak formulations for the two types of noise generation are solved by the Galerkin method modified with a frontal solver to reduce the required computer time. Model predictions show good agreement with experimental data for the directivity and amplitude of sound from the bellmouth inlet of the NASA-Langley Spinning Mode Synthesizer. M.S.K.

**A86-45401\*#** Cornell Univ., Ithaca, N.Y.

**HELICOPTER TAIL ROTOR NOISE**

S.-T. CHOU and A. R. GEORGE (Cornell University, Ithaca, NY) AIAA, Aeroacoustics Conference, 10th, Seattle, WA, July 9-11, 1986. 16 p. NASA-supported research. Previously announced in STAR as N86-26163. refs (AIAA PAPER 86-1900)

A study was made of helicopter tail rotor noise, particularly that due to interactions with the main rotor tip vortices, and with the fuselage separation mean wake. The tail rotor blade-main rotor tip vortex interaction is modelled as an airfoil of infinite span cutting through a moving vortex. The vortex and the geometry information required by the analyses are obtained through a free wake geometry analysis of the main rotor. The acoustic pressure-time histories for the tail rotor blade-vortex interactions are then calculated. These acoustic results are compared to tail rotor loading and thickness noise, and are found to be significant to the overall tail rotor noise generation. Under most helicopter operating conditions, large acoustic pressure fluctuations can be generated due to a series of skewed main rotor tip vortices passing through the tail rotor disk. The noise generation depends strongly upon the helicopter operating conditions and the location of the tail rotor relative to the main rotor. Author

**A86-45402#**

**CALCULATION OF TRANSONIC ROTOR NOISE USING A FREQUENCY DOMAIN FORMULATION**

J. PRIEUR (ONERA, Chatillon-sous-Bagneux, France) AIAA, Aeroacoustics Conference, 10th, Seattle, WA, July 9-11, 1986. 10 p. Research supported by the Ministere de la Defense. refs (AIAA PAPER 86-1901)

This paper presents a formulation of the prediction of transonic quadrupolar rotor noise in hover by means of a frequency domain method. An application is made to a model rotor. Tests on the computational stability of the method are presented and theoretical results are compared with published experimental data. Noise predictions on rotors with swept-tip blades are made and discussed. Author

**A86-45403#**

**HIGH SPEED ROTOR NOISE DUE TO BLADE LOADING**

R. DASH (Douglas Aircraft Co., Long Beach, CA) AIAA, Aeroacoustics Conference, 10th, Seattle, WA, July 9-11, 1986. 10 p. refs (AIAA PAPER 86-1902)

An equation for the far field radiated sound due to dipole sources, which results from blade loading, is derived using the theories of Lawson (1965) and Ffowcs et. al. (1969). The power spectral density (PSD) of the pressure field in a far field is analyzed. The effects caused by the Doppler shift in the amplitude and in the PSD of load fluctuations are considered. The equation relates the PSD of a time-dependent dipole strength to the PSD of the pressure fluctuation in the distant radiation field. The theory is employed to study fan noise, and a modified form of the Gutin theory of propeller noise is developed. The application of the data to the prediction of helicopter rotor noise and broadband noise is discussed. I.F.

**A86-45404\*#** United Technologies Research Center, East Hartford, Conn.

**ROTOR NOISE DUE TO ATMOSPHERIC TURBULENCE INGESTION. II AEROACOUSTIC RESULTS**

R. K. AMIET, J. C. SIMONICH, and R. H. SCHLINKER (United Technologies Research Center, East Hartford, CT) AIAA, Aeroacoustics Conference, 10th, Seattle, WA, July 9-11, 1986. 10 p. refs (Contract NAS1-17096) (AIAA PAPER 86-1903)

A computer program for the prediction of noise due to the turbulence of inflow to a propeller or helicopter rotor is extended to the case of nonisotropic turbulence, on the basis of a combined mean flow contraction model and rapid distortion theory. The mean flow distortion is noted to stretch the turbulence, decreasing the

velocities along the principal axis of the stretching. In the case of a principal stretching axis lying close to the rotor axis, the distortion acts to decrease the upwash velocities of the rotor: thereby decreasing the noise from levels associated with isotropic turbulence. Acoustic energies are calculated at observer location for several cases, and compared to the turbulence energy as affected by the contraction. O.C.

**A86-45405\*#** National Aeronautics and Space Administration, Langley Research Center, Hampton, Va.

**APPLICATION OF THE BASELINE ROTONET SYSTEM TO THE PREDICTION OF HELICOPTER TONE NOISE**

R. A. GOLUB (NASA, Langley Research Center, Hampton, VA), D. S. WEIR, and M. B. TRACY (Kentron International, Inc., Hampton, VA) AIAA, Aeroacoustics Conference, 10th, Seattle, WA, July 9-11, 1986. 8 p. refs (AIAA PAPER 86-1904)

The capabilities of the baseline Rotonet system designed to predict helicopter noise are analyzed. The modules of the system utilized for main and tail rotor geometry and blade section aerodynamic characteristics, for analyses, and for source-to-observer geometry, and atmospheric and ground effects calculations are described; a diagram of the system is provided. The Rotonet system produces axial force, tone noise, and sound pressure level information and a one third octave spectrum related to rotor tone noise and broadband noise sources. Main rotor noise predictions are compared with flight data. It is observed that both sets of data reveal increase loading on the advancing side and decrease loading on the retreating side. The tone noise and sound pressure levels for the first and second harmonics correlate well with the flight data; however, there is only fair agreement for the third harmonics of the sound pressure level. Analysis of the spectra display lower noise levels for higher altitudes and lower speeds. It is noted that the baseline Rotonet system is applicable for predicting performance and noise signatures for the lower harmonics. A phase II Rotonet system for evaluating higher harmonics is being developed. I.F.

**A86-45408#**

**SOUND TRANSMISSION THROUGH DOUBLE PANEL CONSTRUCTIONS LINED WITH ELASTIC POROUS MATERIALS**

J. S. BOLTON and E. R. GREEN (Purdue University, West Lafayette, IN) AIAA, Aeroacoustics Conference, 10th, Seattle, WA, July 9-11, 1986. 13 p. refs (AIAA PAPER 86-1907)

Attention is given to a theory governing one-dimensional wave motion in elastic porous materials which is capable of reproducing experimental transmission measurements for unfaced polyurethane foam layers. Calculations of the transmission loss of fuselage-like foam-lined double panels are presented and it is shown that the foam/panel boundary conditions have a large effect on the panel performance; a hybrid arrangement whereby the foam is bonded directly to one panel and separated from the other by a thin air gap appears to be the most advantageous under practical circumstances. With this configuration, the mass-air-mass resonance is minimized and increased low-frequency performance is offered. K.K.

**A86-45417#**

**THE EFFECT ON RADIATED NOISE OF NON-ZERO PROPELLER ROTATIONAL PLANE ATTITUDE**

W. M. DOBRZYNSKI (DFVLR, Institut fuer Entwurfs-Aerodynamik, Brunswick, West Germany) AIAA, Aeroacoustics Conference, 10th, Seattle, WA, July 9-11, 1986. 15 p. Research supported by the Bundesministerium fuer Verkehr, FAA and BMFT. refs (AIAA PAPER 86-1926)

Subsequent to CAEP's decision to introduce a new noise certification procedure, a joint attempt was made by the FAA and DFVLR to quantitatively determine the influence of a nonzero propeller-disk attitude on the resulting noise; tests were conducted with the German Dutch Wind Tunnel (DNW) in its aeroacoustic mode. It was found that the effect of propeller disk-plane attitude

on maximum overall A-weighted noise levels can be related to a steady-state Mach number effect for the propeller operating at subsonic helical blade-tip (HBT) Mach-numbers exceeding a value of 0.7. For HBT Mach-numbers significantly below 0.7, additional noise radiation due to the unsteady flow properties within one propeller revolution dominate the overall A-weighted noise levels.

K.K.

**A86-45418\*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**COUNTER-ROTATING PROPELLER NOISE DIRECTIVITY AND TRENDS**

P. J. W. BLOCK (NASA, Langley Research Center, Hampton, VA), R. J. KLATTE (United Technologies Corp., Hamilton Standard Div., Windsor Locks, CT), and P. M. DRUEZ (Douglas Aircraft Co., Long Beach, CA) AIAA, Aeroacoustics Conference, 10th, Seattle, WA, July 9-11, 1986. 12 p. refs (AIAA PAPER 86-1927)

The effects of power loading on the far field noise spectra and directivity of counter-rotating propellers (CRP) were studied using a model scale SR-2 propeller in a low-speed anechoic wind tunnel. Approximately 264 far field noise measurements were obtained for each CRP configuration (pusher and tractor) and operating conditions covering from 30 to 140 deg to the flight direction and up to 340 deg circumferentially. Data indicated that the CRP tractor produced higher levels in the second and third harmonics which propagated axially; in effect, the noise exposure time increased over that of a single single-rotation propeller. The effects of pylon-to-propeller spacing, type of pylon attachment and reduced rear-blade row radius are considered and it is found that the 0.3 chord radial pylon produces less additional noise than the 0.1 chord radial pylon and that the 0.2 chord tangential pylon is the quietest pusher configuration.

K.K.

**A86-45419#**

**EXPERIMENTAL RESULTS OF THE NOISE RADIATION OF PROPELLERS IN NON-UNIFORM FLOWS**

I. U. BORCHERS, R. SCHOLTEN (Dornier GmbH, Friedrichshafen, West Germany), and B. W. GEHLHAR (DFVLR, Brunswick, West Germany) AIAA, Aeroacoustics Conference, 10th, Seattle, WA, July 9-11, 1986. 13 p. refs (Contract BMFT-LKV-8330) (AIAA PAPER 86-1928)

The noise radiation of propellers operating in airfoil or fuselage wakes is studied via 1:7 model-scale wind-tunnel testing. The effect of the wake is assessed for a variety of propeller parameters and flow data and the influence of reflecting surfaces in the propeller near-field (given by aircraft T-type tail units) is investigated. The wake results in an increase in noise generation occurring primarily at the higher harmonics and in the upstream direction. Tests with the reflecting surfaces reveal that T-type horizontal tails may effect both the far-field noise levels for rear-mounted propellers and the upstream near-field noise close to the rear fuselage section.

K.K.

**A86-45420\*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**PUSHER PROPELLER NOISE DIRECTIVITY AND TRENDS**

P. J. W. BLOCK (NASA, Langley Research Center, Hampton, VA) AIAA, Aeroacoustics Conference, 10th, Seattle, WA, July 9-11, 1986. 12 p. refs (AIAA PAPER 86-1929)

The effects of pylon wake interaction on far-field propeller noise are studied using a model scale SR-2 propeller in a low-speed anechoic wind tunnel. The variation in the pusher noise penalty with axial angle theta and circumferential angle phi is compared to that of the tractor noise penalty; and the former exhibits minima occurring in the propeller plane and maxima occurring toward the propeller axis. The magnitude of the pusher installation noise penalty decreased with increase in shaft horsepower and tip Mach number. Directivity comparisons revealed that both a noise reduction and a directivity pattern change resulted when the pylon was moved farther from the propeller. Noise emerging from the

wake interaction was distinguished from that of the propeller by means of a modal decomposition.

K.K.

**A86-45421\*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**PREDICTED AND MEASURED STRAIN RESPONSE OF RECTANGULAR PANELS DUE TO ACOUSTIC LOADING**

L. A. ROUSSOS, K. E. HEITMAN, and C. E. RUCKER (NASA, Langley Research Center, Hampton, VA) AIAA, Aeroacoustics Conference, 10th, Seattle, WA, July 9-11, 1986. 11 p. refs (AIAA PAPER 86-1931)

The objective of the research described in this paper is to assess the accuracy of classical linear acceleration/strain prediction theory for flat, rectangular panels excited by low level, acoustic plane waves. Predictions for both aluminum and laminated composite panels were based on the Ritz method using an orthotropic, multi-mode analysis with rotational springs on the boundaries. The measured natural frequencies and critical damping ratio of the panels were empirical inputs to the model. The comparison between measured and predicted acceleration was very good. Although a factor of three bias error was found between measured and predicted strains, the model was good for predicting the trends in the spatial variation in strain across the panel.

Author

**A86-45430\*#** Florida State Univ., Tallahassee.

**THE NEAR AND FAR ACOUSTIC FIELDS OF BROADBAND SHOCK ASSOCIATED NOISE**

C. K. W. TAM (Florida State University, Tallahassee) AIAA, Aeroacoustics Conference, 10th, Seattle, WA, July 9-11, 1986. 15 p. refs

(Contract NAG1-421)

(AIAA PAPER 86-1943)

A stochastic model theory is presented which suggests that the broadband shock associated noise of supersonic jets is generated by the weak interaction between downstream propagating large turbulence structures and the quasiperiodic shock cells in the jet plume. The large turbulence structures are modelled by a superposition of the intrinsic instability waves of the mean flow of the jet, and the quasiperiodic shock cells are broken down into time-independent waveguide modes of the jet flow using multiple scales expansion. The observed broadband shock associated noise consists of a superposition of the spectra generated by the different waveguide modes. Starting from the equations of motion of a compressible fluid, formulas for calculating the far field and near field noise are developed. Good general agreement is found with previous results.

R.R.

**A86-45431#**

**HIGH SPEED FLIGHT EFFECTS ON SHOCK ASSOCIATED NOISE**

W. H. BROWN, K. K. AHUJA, and C. K. W. TAM (Lockheed-Georgia Co., Marietta) AIAA, Aeroacoustics Conference, 10th, Seattle, WA, July 9-11, 1986. 8 p. Research sponsored by the Lockheed-Georgia Co. (AIAA PAPER 86-1944)

An experimental study was conducted to evaluate the effects of high speed flight on shock associated noise. This study was conducted in the Lockheed anechoic wind tunnel using flow from a 4-inch diameter pipe for flight simulation and a 0.4-inch diameter flow to simulate the supersonic jet. Acoustic measurements were made in the farfield and within the flight simulation flow for simulated flight Mach numbers up to 0.8 for unheated jet Mach numbers of 1.42 and 1.49. It is shown that the peak frequency of the shock-associated noise decreases with increasing flight speed. Similarly, shock-associated broadband noise magnitude was observed to increase with flight velocity.

Author



**A86-45432\*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**SHOCK NOISE FROM SUPERSONIC JETS IN SIMULATED FLIGHT TO MACH 0.4**

T. D. NORUM and J. G. SHEARIN (NASA, Langley Research Center, Hampton, VA) AIAA, Aeroacoustics Conference, 10th, Seattle, WA, July 9-11, 1986. 10 p. refs (AIAA PAPER 86-1945)

Simulated flight experiments to Mach 0.4 on underexpanded jets show that flight has only minor effects on both the shock structure and shock associated noise. Although screech modes that do not exist statically become dominant at the higher flight speeds, the screech amplitudes and directivity as well as the broadband shock noise amplitudes remain relatively constant as the forward speed is increased. The change in wavelength due to flight on both shock noise components are predicted well from existing theories of shock noise. Author

**A86-45433\*#** Syracuse Univ., N. Y.

**AEROACOUSTICS OF CONTOURED PLUG-NOZZLE SUPERSONIC JET FLOWS**

D. S. DOSANJH (Syracuse University, NY) and I. S. DAS (Pennsylvania State University, Sharon) AIAA, Aeroacoustics Conference, 10th, Seattle, WA, July 9-11, 1986. 17 p. refs (Contract NAG1-129) (AIAA PAPER 86-1946)

Experimental investigations of the acoustic far-field, the shock associated noise, and the characteristics of the repetitive shock structure of supersonic jet flows issuing from a plug-nozzle having an externally expanded contoured plug with a pointed termination, operated at a range of supercritical pressure ratios of 2.0 to 4.5 are reported. The supersonic jet flow from the contoured plug is shown to be shock-free and virtually wakeless at a pressure ratio of 3.60 (flow Mach number, 1.49). By comparison with the noise characteristics of underexpanded jet flows from an equivalent convergent nozzle, substantial reductions in the total (mixing and the shock associated) noise levels are obtained when the contoured plug nozzle is operated either in the fully-expanded (shock-free) mode or in the over- and the underexpanded modes. Author

**A86-45434#**

**TONE-LIKE NOISE FROM AN ISOLATED TWO DIMENSIONAL AIRFOIL**

S. AKISHITA (Mitsubishi Electric Corp., Amagasaki, Japan) AIAA, Aeroacoustics Conference, 10th, Seattle, WA, July 9-11, 1986. 9 p. refs (AIAA PAPER 86-1947)

The frequencies of a tone-like noise consisting of a series of tones radiating from isolated two-dimensional NACA 0015 airfoils are investigated, in addition to the effect of a trip wire in the boundary layer. It is found that the index in the power law of the tone-like noise is far less than that of the broadband noise, and that the tone frequencies increase with flow velocity and decrease with chord length. The results show that the tone-like noise relates to linear instability of the boundary layer on the pressure surface. Based on flow turbulence measurements in the boundary layer, and flow visualization by an oil film technique, a new model is proposed of a self-excited feedback loop consisting of the turbulent boundary layer downstream of a laminar separation bubble, and the wake flow near the trailing edge. R.R.

**A86-45435#**

**BROAD BAND NOISE FROM AN ISOLATED TWO DIMENSIONAL AIRFOIL**

S. AKISHITA and K. OHTSUTA (Mitsubishi Electric Corp., Amagasaki, Japan) AIAA, Aeroacoustics Conference, 10th, Seattle, WA, July 9-11, 1986. 10 p. refs (AIAA PAPER 86-1948)

The turbulence noise characteristics from an isolated two-dimensional airfoil immersed in low turbulence uniform flow are investigated for axial-flow fans at Reynolds numbers applicable to full scale rotors. The far-field noise is characterized as broadband noise (BBN) and tone-like high-frequency noise. The BBN is found

to predominate over the tone-like noise in flow and wing geometry conditions of low camber, small thickness ratio, and low incidence flow angle. The BBN overall intensity is proportional to the 5th or 6th power of the flow velocity, and is related to the characteristics of the boundary layer near the trailing edge. The BBN spectrum level and peak frequency are found to depend on the wing geometry parameters and the flow characteristics. The BBN directivity resembles a point dipole, and the surface dipole strength distribution of the BBN along the chordwise direction is shown to increase from the leading edge towards the trailing edge. R.R.

**A86-45443#**

**ACTIVE MINIMISATION OF ACOUSTIC POTENTIAL ENERGY IN HARMONICALLY EXCITED CYLINDRICAL ENCLOSED SOUND FIELDS**

A. J. BULLMORE, P. A. NELSON, and S. J. ELLIOTT (Southampton, University, England) AIAA, Aeroacoustics Conference, 10th, Seattle, WA, July 9-11, 1986. 11 p. refs (AIAA PAPER 86-1958)

Quadratic optimization theory is used to apply active noise control methods to the control of cylindrical enclosed sound fields which are harmonically excited due to the structural response of a surrounding thin cylindrical shell excited by two harmonic point forces. Using ten secondary control sources, it is shown that reductions of up to 5.7 dB in the total time averaged acoustic potential energy in the enclosure can be realized in a cylinder with dimensions typical of a 50-seat propeller driven aircraft, and being driven at a frequency typical of propfan blade passage frequency. It is noted, however, that the model may not give reliable predictions of reductions possible in real aircraft due to the highly selective nature of the coupling between structural and acoustic modes in the model used. R.R.

**A86-45444\*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**ADVANCED TURBOPROP AIRCRAFT NOISE ANNOYANCE - A REVIEW OF RECENT NASA RESEARCH**

D. A. MCCURDY, J. D. LEATHERWOOD (NASA, Langley Research Center, Hampton, VA), and K. P. SHEPHERD (Bionetics Corp., Hampton, VA) AIAA, Aeroacoustics Conference, 10th, Seattle, WA, July 9-11, 1986. 14 p. refs (AIAA PAPER 86-1959)

Passenger and community response to advanced turboprop aircraft noise are studied. Four experiments were conducted utilizing an aircraft noise synthesis system, an exterior effects room, an anechoic listening room, and a Space Station/aircraft acoustic apparatus; the experimental conditions and procedures for the psychoacoustic studies are described. The community noise studies involved evaluating the effects of various tonal characteristics on annoyance. It was observed that the frequency envelope shape did not effect annoyance; however, the interaction of the fundamental frequency with tone-to-broadband noise ratio did have a large effect on annoyance. The effects of low frequency tones, turbulent boundary layer noise, and tonal beats on passenger annoyance are investigated. The data reveal that passenger annoyance is greater for a given level of boundary layer noise when tones are at levels sufficient to increase the overall sound pressure level within the cabin. The annoyance response of an advanced turboprop and a conventional aircraft are compared. It is determined that the flyover noise level for the turboprop aircraft is not more annoying than that of a conventional aircraft. I.F.

**A86-45445#**

**AIRCRAFT NOISE MEASUREMENT - ALTERNATIVES TO THE STANDARD 1-2 METRES MICROPHONE HEIGHT**

M. J. T. SMITH (Rolls-Royce, Ltd., Derby, England) AIAA, Aeroacoustics Conference, 10th, Seattle, WA, July 9-11, 1986. 12 p. refs (AIAA PAPER 86-1960)

The results of tests carried out on alternative microphone configurations are presented and related to previous work. Consideration is given to (1) a 'reference' microphone flush in the hard test bed surface, (2) the international standard 1.2-m height

grazing incident system over grass, (3) an inverted microphone with its diaphragm 15 mm above and at 3/4 radius on a 40-cm diameter heavy metal plate, and (4) a 10-m height grazing incidence microphone over grass. It is concluded that the alternative ground-based microphone presently being considered by ICAO for propeller-powered light aircraft noise certification is technically advantageous. It is recommended that comparative measurements be made between the 1.2 m standard and alternative ground-based systems to provide data as close to pressure-doubled as possible and to define the corrections that will be necessary for adjustment of ground-based data to average 1.2-m levels. K.K.

**A86-45447#**  
**BROADBAND NOISE - ITS PREDICTION AND LIKELY IMPORTANCE FOR ADVANCED PROPFANS**

K. KNOWLES (Royal Military College of Science, Shrivenham, England) AIAA, Aeroacoustics Conference, 10th, Seattle, WA, July 9-11, 1986. 9 p. refs  
 (AIAA PAPER 86-1963)

A comparison of published experimental results and analytical results on broadband noise evaluations for rotating many-bladed propellers has been conducted to assess the importance of broadband noise in the perceived noise (PN) level of propfans. It is concluded that, in cruise conditions, the tone noise dominates the broadband noise of typical propfans by 8 dB. As the speed is reduced, and the values of forward Mach number and helical tip Mach number are reduced, the tones fall more rapidly than the broadband component until, at approach conditions, the broadband noise is dominant by 8 to 16 PNdB. A survey of the state-of-the-art of broadband noise prediction suggests that the broadband noise can be predicted to within 5 dB. I.S.

**A86-45448#**  
**BROADBAND PROPELLER NOISE PREDICTION IN THE PLANE OF THE ROTOR**

S. A. L. GLEGG (Florida Atlantic University, Boca Raton, FL) AIAA, Aeroacoustics Conference, 10th, Seattle, WA, July 9-11, 1986. 8 p. refs  
 (AIAA PAPER 86-1964)

The unsteady thickness noise of Hawkins (1978) is shown to account for the discrepancy between the predicted broadband rotor noise, thought to consist of trailing edge and unsteady lift noise, and the observed plane rotor noise. A generalized formulation for the sound radiation of blades of finite span in linear motion is presented, and comparison of the theoretical results with noise measurements from a model scale rotor operating in a high level of turbulence demonstrates the importance of the present phenomenon. The power spectral density of the radiated acoustic pressure is also formulated in terms of the wavenumber spectrum of the inflow turbulence and blade response functions. R.R.

**A86-45451#**  
**AN EXPERIMENTAL AND THEORETICAL INVESTIGATION OF THE PROPAGATION OF SOUND WAVES THROUGH A TURBULENT BOUNDARY LAYER**

M. SALIKUDDIN, C. K. W. TAM, R. H. BURRIN, and J. A. GALLAGHER (Lockheed-Georgia Co., Marietta) AIAA, Aeroacoustics Conference, 10th, Seattle, WA, July 9-11, 1986. 17 p. Research supported by Lockheed Independent Research and Development Program. refs  
 (AIAA PAPER 86-1968)

An experiment was carried out to determine the attenuation of sound crossing a turbulent boundary layer over a flat plane attached on one side of a high-speed square jet at Mach numbers approaching 0.8. Substantial transmission losses were measured and were found to increase with Mach number, frequency, and forward direction. To estimate the acoustic transmission loss as turbopropeller sound waves are transmitted through a turbulent boundary layer (TBL) on the surface of the fuselage, a theoretical model was developed in which the effect of refraction due to TBL velocity and density gradients are taken into account. It is shown that the effect of viscosity on the acoustic transmission loss depends strongly on the frequency of the sound wave and on the

location relative to the propfan. Good agreement was found between the theoretical model and experimental results. K.K.

**A86-45476#**  
**MID-FIELD AND FAR-FIELD CALCULATIONS OF BLADE-VORTEX INTERACTIONS**

A. R. GEORGE and A. S. LYRINTZIS (Cornell University, Ithaca, NY) AIAA, Aeroacoustics Conference, 10th, Seattle, WA, July 9-11, 1986. 16 p. Research supported by the McDonnell Douglas Helicopter Co. refs  
 (AIAA PAPER 86-1854)

A study is made of mid-field and far-field noise generated by transonic Blade-Vortex Interactions (BVI) typical of helicopter main rotor noise. The VTRAN2 small disturbance, two-dimensional, transonic flow code which includes convected vorticity was used to compute near and mid-field flow field information. Because of mesh size limitations this information is restricted to the mid-field and does not give the desired far field and three-dimensional information. A method of extending the solutions to the far field in three dimensions is developed based on Kirchhoff's solution to the linear flow outside a surface S inclosing the nonlinear near field. A number of the directionality aspects of BVI noise are explained in terms of the propagation characteristics of the waves. The relation of unsteady 'Type C' shock motion on the airfoil to far field sound is shown. The farfield radiation was affected only weakly by Mach number in the transonic range but airfoil thickness, shape, and miss distance were found to be important. Author

**A86-45477\*#** National Aeronautics and Space Administration, Langley Research Center, Hampton, Va.  
**CONCEPTS FOR REDUCTION OF BLADE-VORTEX INTERACTION NOISE**

J. C. HARDIN (NASA, Langley Research Center, Hampton, VA) and S. L. LAMKIN (Kentrion International, Inc., Hampton, VA) AIAA, Aeroacoustics Conference, 10th, Seattle, WA, July 9-11, 1986. 7 p. refs  
 (AIAA PAPER 86-1855)

A model is developed to determine the critical parameters that control noise generation by blade-vortex interaction (BVI). The equations for evaluation BVI are derived. The analysis of BVI using the model reveals that the interaction is dependent on incoming vortex strength, blade lift, the interaction length, and the miss distance of the interaction. Several methods for reduction of the noise source are proposed. I.F.

**A86-45478\*#** National Aeronautics and Space Administration, Langley Research Center, Hampton, Va.

**SURFACE PRESSURE MEASUREMENT DURING LOW SPEED TWO-DIMENSIONAL BLADE-VORTEX INTERACTION**

E. R. BOOTH, JR. (NASA, Langley Research Center, Hampton, VA) AIAA, Aeroacoustics Conference, 10th, Seattle, WA, July 9-11, 1986. 7 p. refs  
 (AIAA PAPER 86-1856)

Unsteady blade surface pressures were measured during two-dimensional blade-vortex interaction. A periodically generated vortex filament interacted with a blade model instrumented over the first 20 percent of the blade surface. Analysis of data confirm the leading edge nature of BVI and show the amplitude of the interaction to be a strong function of blade-to-vortex spacing. Lift perturbation time histories were computed and are used to examine details of the encounter process. Author

**A86-45479\*#** United Technologies Research Center, East Hartford, Conn.

**ROTOR NOISE DUE TO ATMOSPHERIC TURBULENCE INGESTION. I - FLUID MECHANICS**

J. C. SIMONICH, R. K. AMIET, R. H. SCHLINKER (United Technologies Research Center, East Hartford, CT), and E. M. GREITZER (MIT, Cambridge, MA) AIAA, Aeroacoustics Conference, 10th, Seattle, WA, July 9-11, 1986. 15 p. refs (Contract NAS1-17096) (AIAA PAPER 86-1857)

In the present analytical procedure for the prediction of helicopter rotor noise generation due to the ingestion of atmospheric turbulence, different models for turbulence fluid mechanics and the ingestion process are combined. The mean flow and turbulence statistics associated with the atmospheric boundary layer are modeled with attention to the effects of atmospheric stability length, windspeed, and altitude. The turbulence field can be modeled as isotropic, locally stationary, and homogeneous. For large mean flow contraction ratios, accurate predictions of turbulence vorticity components at the rotor face requires the incorporation of the differential drift of fluid particles on adjacent streamlines. O.C.

**A86-45481#**

**PREDICTION OF STRUCTURE-BORNE NOISE, BASED ON THE FINITE ELEMENT METHOD**

G. SENGUPTA, A. E. LANDMANN, A. MERA, and T. F. YANTIS (Boeing Co., Seattle, WA) AIAA, Aeroacoustics Conference, 10th, Seattle, WA, July 9-11, 1986. 11 p. refs (AIAA PAPER 86-1861)

A coupled structural-acoustic finite-element method was selected as a means of predicting and controlling structure-borne noise in propeller-powered aircraft. An existing finite-element program was adapted for structural-acoustic analysis by redefining certain input parameters and by imposing certain restrictions on two of the three orthogonal components of the structural displacement variable. In order to verify the predictions of this modified finite-element program, closed-form solutions were developed for predicting the structural-acoustic responses of two- and three-dimensional cylinders enclosing an acoustic medium. When the coupled structural-acoustic finite-element equations were solved in terms of the physical coordinates, good agreement was found between the two methods. A more cost-effective approach, based on modal analysis was developed as well as an uncoupled approach. K.K.

**A86-45482\*#** Comtek, Grafton, Va.

**A FEASIBILITY STUDY ON THE NUMERICAL MODELING OF INTERIOR NOISE FIELDS**

A. L. ABRAHAMSON (COMTEK, Grafton, VA) and C. A. POWELL (NASA, Langley Research Center, Hampton, VA) AIAA, Aeroacoustics Conference, 10th, Seattle, WA, July 9-11, 1986. 11 p. (AIAA PAPER 86-1862)

New developments in electronics and computer control have made active methods of noise suppression feasible. To date, however, active methods of noise control have been applied principally in geometrically uniform spaces with localized sound sources. The purpose of this paper is to demonstrate how finite element techniques may be used to model sound fields and active control inside geometrically complex spaces with non-uniform acoustic boundaries and multiple spatially separated sources. A closed-form solution is derived for the case of a one-dimensional tube with a vibrating piston at each end. Results are compared with finite element solutions and the problem is then generalized to two-dimensions with non-uniform geometry and non-uniform acoustic boundaries. Author

**A86-45484\*#** Purdue Univ., West Lafayette, Ind.

**PREDICTION OF SOUND FIELDS IN CAVITIES USING BOUNDARY ELEMENT METHODS**

R. J. BERNHARD, B. K. GARDNER, C. G. MOLLO (Purdue University, West Lafayette, IN), and C. R. KIPP (AT&T Bell Laboratories, Whippany, NJ) AIAA, Aeroacoustics Conference, 10th, Seattle, WA, July 9-11, 1986. 10 p. refs (Contract NAG1-58) (AIAA PAPER 86-1864)

Two boundary element formulations of acoustical behavior exist; the Direct Boundary Element Methods (DBEM) based on the Helmholtz Integral Equations and the Indirect Boundary Element Methods (IBEM) based on Huygen's Principle. In this investigation, both methods are implemented utilizing a simple linear superparametric element. In addition the IBEM is studied using a quadratic isoparametric element. The accuracy and relative efficiency of the various techniques are examined. In order to properly model aircraft interior cavities the additional capability to model wall treatments and internal point sources is added to the methods. The procedures are verified for several well-understood cavity problems. The relative merits of each boundary element method and the finite element method are examined. Author

**A86-45486\*#** Florida State Univ., Tallahassee.

**ON THE SCREECH TONES OF SUPERSONIC RECTANGULAR JETS**

C. K. W. TAM (Florida State University, Tallahassee) AIAA, Aeroacoustics Conference, 10th, Seattle, WA, July 9-11, 1986. 9 p. refs (Contract NAG1-421) (AIAA PAPER 86-1866)

The shock cell structure and screech tone frequencies of nonaxisymmetric supersonic jets are examined. A linear shock cell model that utilizes a vortex sheet as the mixing layer of the jet is developed in order to estimate the characteristics of the shock structures and tone frequencies. Eigenvalue problems for rectangular and elliptical jets are solved, and shock cell structure solutions for the jets are derived. The shock cell spacings calculated with the model are compared to the data of Powell (1953) and Hammit (1961); good correlation is obtained over a wide range of Mach numbers. The shock cell spacing formula is applied to the computation of screech tone frequencies of rectangular jets. It is observed that the calculated frequencies agree with the measurements of Powell and Krothapalli et. al. (1986) for the Mach number range 1.15-1.80. I.F.

**A86-45487\*#** National Aeronautics and Space Administration, Langley Research Center, Hampton, Va.

**ACOUSTIC PROPERTIES ASSOCIATED WITH RECTANGULAR GEOMETRY SUPERSONIC NOZZLES**

J. M. SEINER, J. C. MANNING (NASA, Langley Research Center, Hampton, VA), and M. K. PONTON (Kentron International, Inc., Hampton, VA) AIAA, Aeroacoustics Conference, 10th, Seattle, WA, July 9-11, 1986. 13 p. refs (AIAA PAPER 86-1867)

Acoustic property experiments have been conducted to ascertain the behavior of rectangular geometry supersonic nozzles whose throat aspect ratios vary over a 2.0-7.6 range, and whose three partial sidewall geometries range from full to 75-percent cutback. The tests employed unheated air at static conditions for nozzle Mach numbers of 1.35-1.66. It is found that sonic fatigue failures are possible at certain partial sidewall geometries and high nozzle aspect ratios. Unlike axisymmetric supersonic nozzles, shock noise dominates both the rear and forward arc for throat aspect ratio cases greater than 5.6. Jet screech frequency was adequately predicted with a simple vortex sheel model. O.C.

A86-45489#

**THE NOISE EMITTED BY TURBULENT JETS IN CLOSE PROXIMITY TO SOLID SURFACES**

P. W. CARPENTER (Exeter, University, England) and C. PARSONS AIAA, Aeroacoustics Conference, 10th, Seattle, WA, July 9-11, 1986. 10 p. Research supported by the British Petroleum Co., PLC and SERC. refs  
(AIAA PAPER 86-1869)

The present calculations of basic directivity patterns for randomly oriented longitudinal and lateral quadrupole types near a rigid plane indicate substantial differences between the two types. By applying Lighthill's (1954) acoustic analogy and extending the Ribner (1969) modeling method for acoustic sources, the basic directivity pattern of the sound generated by a unit volume of jet-type shear layer turbulence near an infinite grid plane is calculated and found to be very different from the corresponding elliptical one obtained by unit volume of free-field shear layer turbulence. The theory is presently applied to an actual turbulent shear flow, in the form of a plane, two-dimensional wall jet, basic aeroacoustic predictions are thereby obtained. O.C.

A86-45491#

**ROTOR-STRUT INTERACTION NOISE OF A MODEL FAN**

Y. NAKAMURA, K. ISOMURA, and H. KODAMA (Ishikawajima-Harima Heavy Industries Co., Ltd., Tokyo, Japan) AIAA, Aeroacoustics Conference, 10th, Seattle, WA, July 9-11, 1986. 8 p. refs  
(AIAA PAPER 86-1871)

Rotor-strut interaction noise was studied by using modern turbofans with different strut configuration. It was shown that the potential perturbation field induced by fat strut has important effect on the generation of blade passing frequency tone which is usually designed to be cut off by selecting appropriate stator vane number. This fact was further confirmed by the induct acoustic mode measurement. Semi-actuator disk approach for rotor blade row combined with singularity method well predicted the static pressure perturbation field. Quasi-steady calculation of rotor unsteady aerodynamic force due to down stream perturbation was also obtained as an interim step for the interaction noise estimation.

Author

A86-45492\*# Arizona Univ., Tucson.

**NOISE GENERATED BY CONVECTED GUSTS INTERACTING WITH SWEEP AIRFOIL CASCADES**

E. ENVIA and E. J. KERSCHEN (Arizona, University, Tucson) AIAA, Aeroacoustics Conference, 10th, Seattle, WA, July 9-11, 1986. 10 p. refs  
(Contract NAG3-357)  
(AIAA PAPER 86-1872)

An analysis is developed for the noise generated by the interaction of a rotor viscous wake with a cascade of swept stator vanes. The stator vanes span a channel formed by infinite parallel walls and containing a subsonic mean flow. High frequency interactions, for which the noise generation is concentrated at the vane leading edge, are considered. The analysis utilizes a superposition of the solution to the isolated stator vane problem, presented in an earlier paper, to develop an approximate solution to the cascade problem. The rotor wake model includes the features of wake circumferential lean and a linear spanwise variation of the magnitude of the wake deficit velocity. Calculations are presented which show that, for rotor wakes with moderate circumferential lean, stator sweep produces substantial reductions in noise level. The vane sweep must be oriented to enhance the phase lags along the vane leading edge produced by wake lean. The noise levels are found to be fairly insensitive to spanwise variations in the wake deficit. Author

A86-45493\*# Arizona Univ., Tucson.

**INFLUENCE OF AIRFOIL CAMBER ON CONVECTED GUST INTERACTION NOISE**

M. R. MYERS and E. J. KERSCHEN (Arizona, University, Tucson) AIAA, Aeroacoustics Conference, 10th, Seattle, WA, July 9-11, 1986. 11 p. refs  
(Contract NAG3-357)  
(AIAA PAPER 86-1873)

This paper investigates the effect of airfoil steady loading on the sound generated by the interaction of an airfoil with a convected disturbance. A previous theory, which included only the incidence angle contribution to the mean loading, is extended to include camber. The theory is based on a linearization of the Euler equations about a nonuniform,  $O(1)$  Mach number subsonic mean flow. The discussion concentrates on the case of a slightly cambered airfoil at small incidence angle, interacting with a gust whose wavelength is short compared to the airfoil chord. The small parameter representing the amount of camber and incidence, and the large parameter representing the ratio of airfoil chord to disturbance wavelength, are utilized in a singular perturbation solution to the governing equations. Acoustic power calculations reveal that the amount of sound generated increases significantly with increased loading. More importantly, it is shown that the radiated acoustic power correlates very well with the strength of the mean flow around the leading edge. Author

A86-45500\*# Lockheed-Georgia Co., Marietta.

**DEVELOPMENT OF AN IMPULSIVE NOISE SOURCE TO STUDY THE ACOUSTIC REFLECTION CHARACTERISTICS OF HARD-WALLED WIND TUNNELS**

M. SALIKUDDIN, R. H. BURRIN, K. K. AHUJA, and H. W. BARTEL (Lockheed-Georgia Co., Marietta) AIAA, Aeroacoustics Conference, 10th, Seattle, WA, July 9-11, 1986. 12 p.  
(Contract NAS3-24339)  
(AIAA PAPER 86-1887)

Two impulsive sound sources, one using multiple acoustic drivers and the other using a spark discharge were developed to study the acoustic reflection characteristics of hard-walled wind tunnels, and the results of laboratory tests are presented. The analysis indicates that though the intensity of the pulse generated by the spark source was higher than that obtained from the acoustic source, the number of averages needed for a particular test may require an unacceptably long tunnel-run time due to the low spark generation repeat rate because of capacitor charging time. The additional hardware problems associated with the longevity of electrodes and electrode holders in sustaining the impact of repetitive spark discharges, show the multidriver acoustic source to be more suitable for this application. R.R.

A86-45501\*# Lockheed-Georgia Co., Marietta.

**ACOUSTIC REFLECTION CONTAMINATION MEASUREMENTS IN THE 16-FOOT NASA LANGLEY TRANSONIC WIND TUNNEL**

R. H. BURRIN, M. SALIKUDDIN, K. K. AHUJA, and H. W. BARTEL (Lockheed-Georgia Co., Marietta) AIAA, Aeroacoustics Conference, 10th, Seattle, WA, July 9-11, 1986. 12 p. refs  
(Contract NAS3-24339)  
(AIAA PAPER 86-1888)

The Propfan Test Assessment (PTA) contract, awarded recently to Lockheed by the NASA-Lewis Research Center, required a comprehensive series of near field acoustic measurements. These were to use transducers mounted on the surfaces on a one-ninth scale model of the Gulfstream G-II aircraft, modified to the PTA single propfan testbed configuration. The 16-foot Transonic Wind Tunnel at the NASA Langley Research Center was chosen as the facility to be used for these model acoustic tests. Since the tunnel was hard-walled, it is not clear to what extent the propfan noise signals, reaching the various transducers, might be contaminated by reflections from the walls. A Multidriver Acoustic Source was built, and using an impulse and time domain averaging technique, the reflection contaminations in the wind tunnel were measured at selected microphone locations. Results of the investigations of near field measurements exists, due to reflections from the hard walls of the wind tunnel. Author

A86-45503#

**THEORETICAL PREDICTION OF SINGLE ROTATION PROPELLER NOISE**

A. B. PARRY (Rolls-Royce, Ltd., Derby, England) and D. G. CRIGHTON (Cambridge University, England) AIAA, Aeroacoustics Conference, 10th, Seattle, WA, July 9-11, 1986. 13 p. refs (AIAA PAPER 86-1891)

Expressions for the harmonic components of propeller noise are derived in a novel way and shown to provide excellent agreement with measured data. Using asymptotic techniques the complex expressions for the radiated sound are reduced to provide simple results which do not involve numerical integration of Bessel functions but retain the main parameteric dependences. Comparison with the detailed predictions shows that the asymptotic expressions are extremely accurate, in terms of both absolute level and parametric trends. The asymptotics are used to explain clearly and simply many published results on the noise characteristics of propellers. In addition it is shown how the acoustic benefits of blade sweep and chordwise noncompactness can be predicted using asymptotic techniques. Author

A86-45505#

**A STUDY OF THE ROTOR/ROTOR INTERACTION TONES FROM A CONTRA-ROTATING PROPELLER DRIVEN AIRCRAFT**

A. J. BRADLEY (Rolls-Royce, Ltd., Derby, England) AIAA, Aeroacoustics Conference, 10th, Seattle, WA, July 9-11, 1986. 8 p. (AIAA PAPER 86-1894)

A series of noise measurements have been performed on a contra-rotating propeller driven aircraft. Both near and far-field data have been obtained from which it is possible to extract the tonal noise resulting from the aerodynamic interaction between the two propeller rows by a tone splitting technique. Data from these tests are presented and an existing contra-rotating propeller theory is used in a novel way to identify the dominant source component and its radial location on the blades. Author

A86-45507\*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

**EFFECT OF A WIND TUNNEL ON THE ACOUSTIC FIELD FROM VARIOUS AEROACOUSTIC SOURCES**

M. MOSHER (NASA Ames Research Center, Moffett Field, CA) AIAA, Aeroacoustics Conference, 10th, Seattle, WA, July 9-11, 1986. 16 p. (AIAA PAPER 86-1897)

The effects of the walls of an enclosed test section wind tunnel on measurements of sound fields from various sources has been studied. The acoustic field from a known source in a wind tunnel has been modeled as an infinitely long duct with constant cross section. The model was solved with a numerical panel technique in a control volume near the source, and matched to an outer analytic solution. Several sample problems were studied in a rectangular duct with and without flow. The results indicate that the presence of the duct affects the acoustic field, and that small changes in the product of duct cross dimensions and the source wave number can change the acoustic field significantly. It is also shown that, for low-frequency helicopter rotor harmonic noise, measured in typical wind tunnel rotor tests, the sound levels beyond one rotor diameter from the hub are unreliable indications of the free-field sound levels. I.S.

N86-30468# Royal Aircraft Establishment, Farnborough (England).

**INVESTIGATION OF THE AERODYNAMIC PERFORMANCE AND NOISE CHARACTERISTICS OF A 1/5TH SCALE MODEL OF THE DOWTY ROTOL R212 PROPELLER**

W. J. G. TREBBLE 15 Nov. 1983 35 p (RAE-TM-AERO-1983; BR90678; ESA-86-97104) Avail: NTIS HC A03/MF A01

The four-bladed Dowty Rotol R212 propeller (NACA 16 sections) was studied at 1/5th scale (0.7 m diameter) in 1.5 m acoustic tunnel. Propeller power absorption and thrust were measured over

a range of rotational speeds up to 8000 rev/min at mainstream speeds from 15 to 60 m/sec for a range of blade settings. Slipstream wake surveys show outward movement of the position of the peak pressure as propeller loading is increased. Noise analysis demonstrates the predominance of multiple tones whose number and intensity increase with helical-tip Mach number. An empirical formula shows that the fundamental tone sound pressure level varies with tip speed and power loading in an identical manner to that observed on an ARA-D section propeller. ESA

N86-30469\*# PRC Kentron, Inc., Hampton, Va. Aerospace Technologies Div.

**NOISE PREDICTIONS OF A HIGH BYPASS TURBOFAN ENGINE USING THE LOCKHEED NEAR-FIELD NOISE PREDICTION PROGRAM**

J. W. RAWLS, JR. Jul. 1986 71 p (Contract NAS1-18000) (NASA-CR-178146; NAS 1.26:178146) Avail: NTIS HC A04/MF A01 CSCL 20A

The prediction of engine noise during cruise using the Near-Field Noise Prediction Program developed by Lockheed is examined. Test conditions were established which simulate the operation of a high bypass turbofan engine under a wide range of operating conditions. These test conditions include variations in altitude, flight Mach number and thrust setting. Based on the results of noise prediction made using the Lockheed program, an evaluation of the impact of these test conditions on the overall sound pressure level (OASPL) and the one-third octave band spectra is made. An evaluation of the sensitivity of flight condition parameters is also made. The primary noise source from a high bypass turbofan was determined to be fan broadband shock noise. This noise source can be expected to be present during normal cruising conditions. When present, fan broadband shock noise usually dominates at all frequencies and all directivity angles. Other noise sources of importance are broadband shock noise from the primary jet, fan noise, fan mixing noise and turbine noise. Author

N86-30470\*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**SONIC-BOOM RESEARCH: SELECTED BIBLIOGRAPHY WITH ANNOTATION**

H. H. HUBBARD (Bionetics Corp., Hampton, Va.), D. J. MAGLIERI, and D. G. STEPHENS Sep. 1986 44 p (NASA-TM-87685; L-16127; NAS 1.15:87685) Avail: NTIS HC A03/MF A01 CSCL 20A

Citations of selected documents are included which represent the state of the art of technology in each of the following subject areas: prediction, measurement, and minimization of steady-flight sonic booms; prediction and measurement of accelerating-flight sonic booms; sonic-boom propagation; the effects of sonic booms on people, communities, structures, animals, birds, and terrain; and sonic-boom simulator technology. Documents are listed in chronological order in each section of the paper, with key documents and associated annotation listed first. The sources are given along with acquisition numbers, when available, to expedite the acquisition of copies of the documents. Author

N86-30471\*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**A NEW VERSION OF THE HELICOPTER AURAL DETECTION PROGRAM, ICHIN**

A. W. MUELLER, C. D. SMITH (PRC Kentron, Inc., Hampton, Va.), K. P. SHEPHERD (Bionetics Corp., Hampton, Va.), and B. M. SULLIVAN Jul. 1986 8 p (NASA-TM-87745; NAS 1.15:87745) Avail: NTIS HC A02/MF A01 CSCL 20A

NASA Langley Research Center personnel have conducted an evaluation of the helicopter aural detection program I Can Hear It Now (ICHIN version-5). This was accomplished using flight noise data of five helicopters, obtained from a joint NASA and U.S. Army acoustics measurement program. The evaluation consisted of presenting the noise data to a jury of 20 subjects and to the ICHIN-5 program. A comparative study was then made of the

detection distances determined by the jury and predicted by ICHIN-5. This report presents the changes made in the ICHIN-5 program as a result of this comparative study. The changes represent current psychoacoustics and propagation knowledge.

Author

**N86-30474#** Foersvarets Forskingsansalt, Stockholm (Sweden).  
**AUDITORY HELICOPTER DETECTION AND LOCALIZATION; A LITERATURE REVIEW FOCUSING ON SEARCH FOR HELICOPTERS**

C. WEIKERT Jan. 1986 19 p In SWEDISH; ENGLISH summary  
(FOA-C-50033-H2; ISSN-0347-7665; ESA-86-97241) Avail: NTIS HC A02/MF A01

About 300 references on auditory localization were reviewed. Detection of low frequency sound is discussed. Literature shows that man's ability to localize sounds by auditory detection is good. Vision may also assist the auditory localization. A helicopter approaching at a great height (1500 feet) is easier to localize than a low flying one (200 feet), and a helicopter heading into the wind is significantly more difficult to localize than one having the wind astern, even when the wind speed is low. When background conditions are quiet, one may expect to detect a noisy helicopter at a distance over 13 km.

ESA

**N86-31335\*#** Purdue Univ., West Lafayette, Ind. School of Mechanical Engineering.

**A STUDY OF METHODS TO PREDICT AND MEASURE THE TRANSMISSION OF SOUND THROUGH THE WALLS OF LIGHT AIRCRAFT Semiannual Status Report, 1 Oct. 1985 - 15 May 1986**

R. J. BERNHARD, J. S. BOLTON, B. GARDNER, J. MICKOL, C. MOLLO, and C. BRUER May 1986 35 p  
(Contract NAG1-58)  
(NASA-CR-177147; NAS 1.26:177147; PRF-520-1288-0353; REPT-0353-3; HL86-19) Avail: NTIS HC A03/MF A01 CSCL 20A

Progress was made in the following areas: development of a numerical/empirical noise source identification procedure using boundary element techniques; identification of structure-borne noise paths using structural intensity and finite element methods; development of a design optimization numerical procedure to be used to study active noise control in three-dimensional geometries; measurement of dynamic properties of acoustical foams and incorporation of these properties in models governing three-dimensional wave propagation in foams; and structure-borne sound path identification by use of the Wigner distribution.

Author

**N86-31337\*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**ACOUSTIC TREATMENT OF THE NASA LANGLEY 4- BY 7-METER TUNNEL: A FEASIBILITY STUDY**

J. C. YU and A. L. ABRAHAMSON (Comtek, Grafton, Va.) Aug. 1986 38 p  
(NASA-TP-2563; L-16037; NAS 1.60:2563) Avail: NTIS HC A03/MF A01 CSCL 20A

A feasibility study for upgrading the NASA Langley 4- by 7-Meter Tunnel so that it may be used for aeroacoustic research related to helicopters is described. The requirements for noise research leading to the design of the next generation of helicopters impose a set of acoustic test criteria that no existing wind tunnel in the United States can presently meet. Included in this feasibility study are the following considerations: (1) an evaluation of general wind-tunnel requirements and desired tunnel background noise levels for helicopter aeroacoustic research; (2) an assessment of the present acoustic environment for testing model rotors; (3) a diagnostic investigation of tunnel background noise sources and paths; (4) acoustic treatment options for tunnel background noise reduction and a trade-off study between these options; (5) an engineering feasibility assessment of the selected option; and (6) an integrated analysis of study components and recommendations of treatment for an approach to meet the tunnel background noise

reduction goal. It is concluded that the Langley 4- by 7-Meter Tunnel is a fundamentally suitable facility for helicopter aeroacoustic research. It is also concluded that acoustic treatment of this facility for meeting the required tunnel background noise goal can be accomplished technically at reasonable risk and cost.

M.G.

**N86-31338\*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**ADVANCED TURBOPROP NOISE PREDICTION: DEVELOPMENT OF A CODE AT NASA LANGLEY BASED ON RECENT THEORETICAL RESULTS**

F. FARASSAT, M. H. DUNN (PRC Kentron, Inc., Hampton, Va.), and S. L. PADULA Jul. 1986 58 p Presented at the 9th AIAA Aeroacoustics Conference, Williamsburg, Va., Oct. 1984  
(NASA-TM-88993; NAS 1.15:88993; AIAA-84-2303) Avail: NTIS HC A04/MF A01 CSCL 20A

The development of a high speed propeller noise prediction code at Langley Research Center is described. The code utilizes two recent acoustic formulations in the time domain for subsonic and supersonic sources. The structure and capabilities of the code are discussed. Grid size study for accuracy and speed of execution on a computer is also presented. The code is tested against an earlier Langley code. Considerable increase in accuracy and speed of execution are observed. Some examples of noise prediction of a high speed propeller for which acoustic test data are available are given. A brisk derivation of formulations used is given in an appendix.

Author

**N86-31339\*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**STRUCTUREBORNE NOISE IN AIRCRAFT: MODAL TESTS**

S. A. CLEVENSON and V. L. METCALF Jul. 1986 36 p  
(Contract DA PROJ. 1L1-61102-AH-45)  
(NASA-TM-87739; NAS 1.15:87739; USAAVSCOM-TM-86-B-3) Avail: NTIS HC A03/MF A01 CSCL 20A

As part of an investigation to develop measurement techniques for structureborne noise, three modal surveys have been conducted on an OV-10A aircraft and the results have been presented. The purpose of the modal surveys was to identify suitable locations for mounting accelerometer and strain gages in subsequent tests in which transfer functions relating wing vibration to interior noise were to be determined. These surveys are as follows:(1) wing/fuselage modal survey utilizing one shaker under the right wing; (2) complete wing modal survey utilizing two shakers, one under each wing; and (3) fuselage side panel modal survey utilizing a small instrumented hammer. The predominant frequencies and damping ratios for each analysis were listed in tables. The primary mode shapes at the lower frequencies and at frequencies near the expected engine driving frequencies have been shown for each survey.

Author

**N86-31341\*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**DIRECTIVITY AND TRENDS OF NOISE GENERATED BY A PROPELLER IN A WAKE**

P. J. W. BLOCK and C. L. GENTRY, JR. Sep. 1986 63 p  
(NASA-TP-2609; L-16131; NAS 1.60:2609) Avail: NTIS HC A04/MF A01 CSCL 20A

An experimental study of the effects on far-field propeller noise of a pylon wake interaction was conducted with a scale model of a single-rotation propeller in a low-speed anechoic wind tunnel. A detailed mapping of the noise directivity was obtained at 10 test conditions covering a wide range of propeller power landings at several subsonic tip speeds. Two types of noise penalties were investigated-pulsor and spacing. The pusher noise penalty is the difference in the average overall sound pressure level, OASPL, for pusher and tractor installations. (In a pusher installation, the propeller disk is downstream of a pylon or another aerodynamic surface.) The spacing noise penalty is the difference in the average OASPL for different distances between the pylon trailing edge and the propeller. The variations of these noise penalties with axial, or flyover, angle theta and circumferential angle phi are

presented, and the trends in these noise penalties with tip Mach number and power loading are given for selected values of theta and phi. The circumferential directivity of the noise from a pusher installation showed that the addition noise due to the interaction of the pylon wake with the propeller had a broad peak over a wide range of circumferential angles approximately perpendicular to the pylon with a sharp minimum 90 deg. to the pylon for the majority of cases tested. The variation of the pusher noise penalty with theta had a minimum occurring near the propeller plane and maximum values of as much as 20 dB occurring toward the propeller axes. The magnitude of the pusher noise penalty generally decreased as propeller tip Mach number or power loading was increased. Author

**N86-31357\*** # Nevada Univ., Reno. Engineering Research and Development Center.

**AERODYNAMICS OF SEEING ON LARGE TRANSPORT AIRCRAFT Progress Report, 1 Dec. 1985 - 31 May 1986**

W. C. ROSE 31 May 1986 102 p

(Contract NCC2-382)

(NASA-CR-177035; NAS 1.26:177033) Avail: NTIS HC A06/MF A01 CSCL 20F

Data were obtained in the full scale flight environment of the Kuiper Airborne Observatory (KAO) on the nature of turbulent shear layer over the open cavity. These data were used to verify proposed aerodynamic scaling relationships to describe the behavior of the turbulent layers and to estimate the optical performance of systems of various wavelengths operating within the KAO environment. These data and wind tunnel data are used to scale the expected optical effects for a potential stratospheric observatory for infrared astronomy (SOFIA) in which a telescope approximately 3.5 times larger than that on the KAO is envisioned. It appears that the use of combinations of active and passive aeromechanical flow control techniques can improve the optical behavior of systems in the SOFIA environment. Experiments to verify these potential improvements can be performed on the KAO with sufficient modifications to the cavity and aero-mechanical technique installations. Author

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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.

**A86-45703#**

**DOD OVERHAULS MAINTENANCE**

R. E. BERG (DOD Offices of the Assistant Secretary of Defense, Washington, DC) Aerospace America (ISSN 0740-722X), vol. 24, July 1986, p. 20-22.

Actions taken by the Department of Defense in a new maintenance approach promise substantial gains in aircraft availability and big cost savings. First, DOD has adopted two industry-inspired approaches to maintenance management: reliability-centered maintenance and serial number tracking. Decisions are made whether to repair just what requires repair or to replace prior to failure. Second, DOD has stepped up depot maintenance interservicing - one service using its own or contracted facilities to maintain another service's equipment. Third, DOD has established a program to improve test equipment; managers are being asked to review the 80,000 different models of test equipment owned by the department and reduce the list to fewer, standardized items and where possible use commercial off-the-shelf gear. Important aspects of the program will include increased use of robotics, better nondestructive inspection techniques, and lasers. Better trained personnel and equipment designed from the beginning to be easily maintained will also be significant. D.H.

**N86-31454#** Air Force Wright Aeronautical Labs., Wright-Patterson AFB, Ohio.

**FISCAL YEAR 1987 TECHNICAL OBJECTIVE DOCUMENT**

**Annual Report, Jan. 1985 - Jan. 1986**

Mar. 1986 115 p Supersedes AFWAL-TR-85-2000

(AD-A166659; AFWAL-TR-86-2000; AFWAL-TR-85-2000) Avail: NTIS HC A06/MF A01 CSCL 21E

This Technical Objective Document was prepared to provide science and industry with specific technical objectives which the Air Force feels are critical to maintain aerospace superiority in the future. The TOD contains three functional areas (Aircraft, Missile and Space) which provide planning objectives covering the technical disciplines of airbreathing propulsion, aerospace vehicle power, fire protection, and aircraft and missile fuels and lubrication. GRA

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## SPACE SCIENCES

Includes space sciences (general); astronomy; astrophysics; lunar and planetary exploration; solar physics; and space radiation.

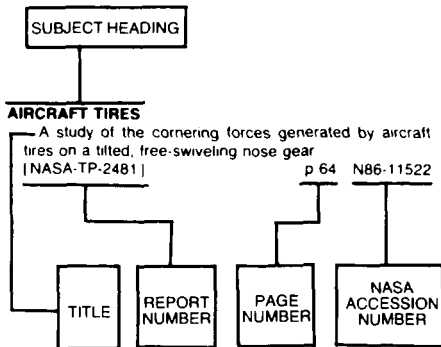
**A86-43672**

**COSMIC-RAY DOSE CHARACTERISTICS ON THE FLIGHT PATHS OF HIGH-ALTITUDE AIRCRAFT [DOZOVYE KHARAKTERISTIKI KOSMICHESKIKH LUCHEI NA TRASSAKH POLETOV VYSOTNYKH SAMOLETOV]**

IU. I. BARANNIKOV, O. A. BARSUKOV, and P. F. GAVRILOV Kosmicheskie Issledovaniia (ISSN 0023-4206), vol. 24, Mar.-Apr. 1986, p. 314-319. In Russian. refs



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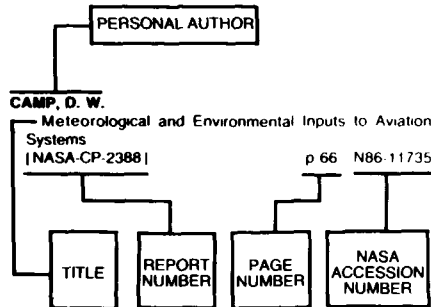
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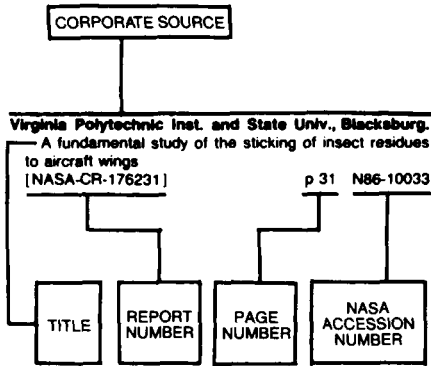
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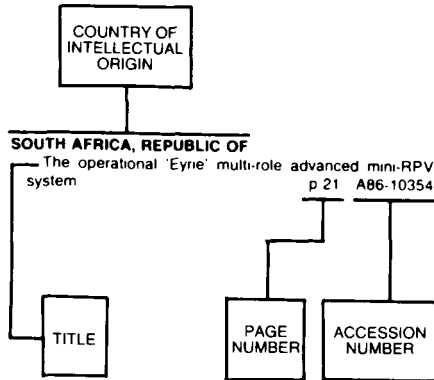
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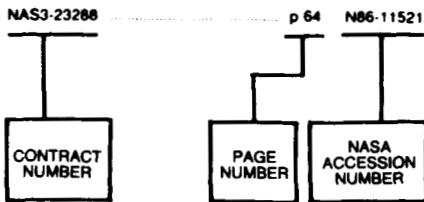
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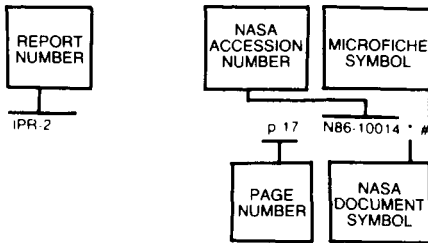


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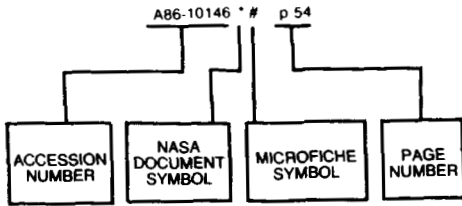


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