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A Continuing Bibliography with Indexes

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NASA SP-7037(214)

AERONAUTICAL ENGINEERING

A CONTINUING BIBLIOGRAPHY WITH INDEXES

(Supplement 214)

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 May 1987 in

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

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INTRODUCTION

This issue of *Aeronautical Engineering -- A Continuing Bibliography* (NASA SP-7037) lists 422 reports, journal articles and other documents originally announced in May 1987 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 cummulative index will be published.

Information on the availability of cited publications including addresses of organizations and NTIS price schedules is located at the back of this bibliography.

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TYPICAL REPORT CITATION AND ABSTRACT

NASA SPONSORED

ON MICROFICHE

ACCESSION NUMBER → **N87-10039*#** National Aeronautics and Space Administration. ← CORPORATE SOURCE
Langley Research Center, Hampton, Va.
TITLE → **WIND-TUNNEL INVESTIGATION OF THE FLIGHT CHARACTERISTICS OF A CANARD GENERAL-AVIATION AIRPLANE CONFIGURATION**
PUBLICATION DATE
AVAILABILITY SOURCE
AUTHOR → D. R. SATRAN Oct. 1986 60 p
REPORT NUMBERS → (NASA-TP-2623; L-15929; NAS 1.60:2623) Avail: NTIS HC
PRICE CODE → A04/MF A01 CSCL 01A ← COSATI CODE

A 0.36-scale model of a canard general-aviation airplane with a single pusher propeller and winglets was tested in the Langley 30- by 60-Foot Wind Tunnel to determine the static and dynamic stability and control and free-flight behavior of the configuration. Model variables made testing of the model possible with the canard in high and low positions, with increased winglet area, with outboard wing leading-edge droop, with fuselage-mounted vertical fin and rudder, with enlarged rudders, with dual deflecting rudders, and with ailerons mounted closer to the wing tips. The basic model exhibited generally good longitudinal and lateral stability and control characteristics. The removal of an outboard leading-edge droop degraded roll damping and produced lightly damped roll (wing rock) oscillations. In general, the model exhibited very stable dihedral effect but weak directional stability. Rudder and aileron control power were sufficiently adequate for control of most flight conditions, but appeared to be relatively weak for maneuvering compared with those of more conventionally configured models.

Author

TYPICAL JOURNAL ARTICLE CITATION AND ABSTRACT

NASA SPONSORED

ACCESSION NUMBER → **A87-11487*** National Aeronautics and Space Administration.
Ames Research Center, Moffett Field, Calif.
COMPUTATION OF TURBULENT SUPERSONIC FLOWS AROUND POINTED BODIES HAVING CROSSFLOW SEPARATION ← TITLE
AUTHORS → D. DEGANI and L. B. SCHIFF (NASA, Ames Research Center, Moffett Field, CA) ← AUTHOR'S AFFILIATION
JOURNAL TITLE → Journal of Computational Physics (ISSN 0021-9991), vol. 66, Sept. 1986, p. 173-196. refs

The numerical method developed by Schiff and Sturek (1980) on the basis of the thin-layer parabolized Navier-Stokes equations of Schiff and Steger (1980) is extended to the case of turbulent supersonic flows on pointed bodies at high angles of attack. The governing equations, the numerical scheme, and modifications to the algebraic eddy-viscosity turbulence model are described; and results for three cones and one ogive-cylinder body (obtained using grids of 50 nonuniformly spaced points in the radial direction between the body and the outer boundary) are presented graphically and compared with published experimental data. The grids employed are found to provide sufficient spatial resolution of the leeward-side vortices; when combined with the modified turbulence model, they are shown to permit accurate treatment of flows with large regions of crossflow separation.

T.K.

01

AERONAUTICS (GENERAL)

A87-23744

THE LIGHT STUFF - BURT RUTAN TRANSFORMS AIRCRAFT DESIGN

T. A. HEPPENHEIMER High Technology (ISSN 0277-2981), vol. 6, Dec. 1986, p. 29-35.

The leading edge of aeronautical design is considered, with reference to novel structural arrangements and the use of extremely lightweight foam and fiber construction to develop what can be called 'designer aircraft'. The most noteworthy aircraft of this class is Voyager, designed to fly around the world without refueling. Voyager has a 111-foot wingspan, but empty of fuel, weighs just 1858 pounds. The two-person crew will take turns piloting and sleeping. Aircraft designer Burt Rutan bases his designs on solid intuition, confirmed by microcomputer simulation and uses styrofoam or urethane foam (at a density of four pounds per cubic foot), fiberglass, and epoxy as basic materials. Cutting and shaping are done with an electrically heated wire. The method has allowed individuals to construct flying aircraft at home for as little as a few thousand dollars. Aircraft discussed include: the Grizzly (with short takeoff and landing capability) the Vari-Eze and Long-Eze (available as kits); and demonstrators for the T-64A military trainer, the AD-1 oblique-wing aircraft, and the Starship business turboprop. Achievements of another aeronautical entrepreneur and lightweight-aircraft designer, Paul MacCready, who developed the Gossamer Condor, Gossamer Albatross, Solar Challenger, and Bionic Bat, are noted. D.H.

A87-24922#

THREE-DIMENSIONAL FLOW PRODUCED BY A PITCHING-PLUNGING MODEL DRAGONFLY WING

D. SAHARON and M. LUTTGES (Colorado, University, Boulder) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 18 p. refs

(Contract F49620-84-C-0065; N00014-85-K-0053)

(AIAA PAPER 87-0121)

Three-dimensional unsteady separated flow generated by a dragonfly forewing model was visualized during various wing motions. Simplified kinematics were tested first. To get a better understanding of dragonfly-produced unsteady flows as well as those produced by simulated dragonfly kinematics, the kinematics were broken down into simple elements. Sinusoidal pitching (small and large amplitudes), then large amplitude sinusoidal plunging and finally combined motions were tested. The results revealed the similarity between visualized unsteady separated flow fields elicited by the dragonfly and those produced by simplified kinematics using models of the forewing. In addition, the results showed the similarity of three-dimensional separated flows generated by oscillating airfoils and wings as compared to those produced by the model dragonfly wings. The observed flow fields generated by the models were evaluated in terms of the large lift peaks dragonfly are known to produce. Author

A87-25268

TECHNOLOGY AND THE SERVICE LIFE OF AIRCRAFT [TEKHNOLOGIIA I OBESPECHENIE RESURSA SAMOLETOV]

LEON DAVIDOVICH BRONDZ Moscow, Izdatel'stvo Mashinostroenie, 1986, 184 p. In Russian. refs

The book is concerned with the problem of ensuring the required service life of aircraft components and structures through careful selection of materials-processing technology. Topics discussed include the physical aspect of the service life of aircraft, principal mechanisms of fatigue damage, and selection of materials for critical structures. The discussion also covers stress concentration, interaction of stress raisers, and localized stressed state; the effect of processing technology on materials and structures; and structural means and processing techniques for ensuring the required service life. V.L.

N87-17658*# Lockheed-Georgia Co., Marietta.

LFC LEADING EDGE GLOVE FLIGHT: AIRCRAFT MODIFICATION DESIGN, TEST ARTICLE DEVELOPMENT AND SYSTEMS INTEGRATION

F. R. ETCHBERGER et al. Nov. 1983 319 p

(Contract NAS1-16219)

(NASA-CR-172136; NAS 1.26:172136; LG83ER0080) Avail: NTIS HC A14/MF A01 CSCL 01B

Reduction of skin friction drag by suction of boundary layer air to maintain laminar flow has been known since Prandtl's published work in 1904. The dramatic increases in fuel costs and the potential for periods of limited fuel availability provided the impetus to explore technologies to reduce transport aircraft fuel consumption. NASA sponsored the Aircraft Energy Efficiency (ACEE) program in 1976 to develop technologies to improve fuel efficiency. This report documents the Lockheed-Georgia Company accomplishments in designing and fabricating a leading-edge flight test article incorporating boundary layer suction slots to be flown by NASA on their modified JetStar aircraft. Lockheed-Georgia Company performed as the integration contractor to design the JetStar aircraft modification to accept both a Lockheed and a McDonnell Douglas flight test article. McDonnell Douglas uses a porous skin concept. The report describes aerodynamic analyses, fabrication techniques. JetStar modifications, instrumentation requirements, and structural analyses and testing for the Lockheed test article. NASA will flight test the two LFC leading-edge test articles in a simulated commercial environment over a 6 to 8 month period in 1984. The objective of the flight test program is to evaluate the effectiveness of LFC leading-edge systems in reducing skin friction drag and consequently improving fuel efficiency. Author

N87-17659*# McDonnell-Douglas Corp., Long Beach, Calif.

DEVELOPMENT OF SELECTED ADVANCED AERODYNAMICS AND ACTIVE CONTROL CONCEPTS FOR COMMERCIAL TRANSPORT AIRCRAFT Program Summary Report, Feb. 1979 - Dec. 1983

A. B. TAYLOR Washington NASA Feb. 1984 89 p

(Contract NAS1-15327)

(NASA-CR-3781; NAS 1.26:3781; ACEE-17-FR-3206) Avail: NTIS HC A05/MF A01 CSCL 01B

Work done under the Energy Efficient Transport project in the field of advanced aerodynamics and active controls is summarized. The project task selections focused on the following: the investigation of long-duct nacelle shape variation on interference drag; the investigation of the adequacy of a simple control law for the elastic modes of a wing; the development of the aerodynamic technology at cruise and low speed of high-aspect-ratio supercritical wings of high performance; and the development of winglets for a second-generation jet transport. All the tasks involved analysis and substantial wind tunnel testing. The winglet program also included flight evaluation. It is considered that the technology base has been built for the application of high-aspect-ratio supercritical wings and for the use of winglets on second-generation transports. Author

N87-17661# Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.
ACTA AERONAUTICA ET ASTRONAUTICA SINICA (SELECTED ARTICLES)
QIN ZHENHAN, CHEN TIEMIN, PAN HUACHEN, and ZHANG SHIYING 2 Oct. 1986 36 p Transl. into ENGLISH from Hong Kong Xuebao (China), v. 7, no. 1, Feb. 1986 p 11-18; 104-107; 114-118
(AD-A173364; FTD-ID(RS)T-0777-86) Avail: NTIS HC A03/MF A01 CSCL 20D

Translation of a Chinese journal is presented. Some representative titles of the articles are: Application of harmonic analysis method to research on rotor airloads, Problems in the finite-difference computation of three-dimensional transonic flows, and Numerical computation of the three-dimensional viscous interference flow field of a vertical jet in a crossflow. GRA

02

AERODYNAMICS

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

A87-23626
COMPUTATIONAL METHODS IN POTENTIAL AERODYNAMICS
LUIGI MORINO, ED. (Boston University, MA) Billerica, MA/Berlin, Computational Mechanics Publications/Springer-Verlag, 1985, 741 p. For individual items see A87-23627 to A87-23645.

Computational approaches to the aerodynamics of potential flows are discussed in reviews and reports based on contributions presented at an ITCS course held in Amalfi, Italy, in 1983. Consideration is given to steady and unsteady subsonic and supersonic flows, steady and unsteady transonic flows, wake analysis, and advanced integral-equation formulations. Topics examined include surface source methods, panel methods, double-lattice applications, Green's-function methods, and design applications. T.K.

A87-23629
PANEL METHODS - PAN AIR
E. N. TINOCO and P. E. RUBBERT (Boeing Commercial Airplane Co., Seattle, WA) IN: Computational methods in potential aerodynamics. Billerica, MA/Berlin, Computational Mechanics Publications/Springer-Verlag, 1985, p. 39-92. refs.

PAN AIR (Magnus and Epton, 1980; Carmichael and Erickson, 1981), a higher-order panel method for predicting subsonic and supersonic linear potential flows about arbitrary configurations, is described and demonstrated. PAN AIR is a three-dimensional boundary-value-problem solver for the Prandtl-Glauert equation and features higher-order numerics, continuity of doublet strength and geometry, a very general user-specified boundary-condition equation, and logically independent networks. The capabilities of PAN AIR in computational modeling, supersonic configuration analysis, and analysis of complex configurations are illustrated in drawings, diagrams, and graphs and discussed. T.K.

A87-23630* National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
UNSTEADY SUBSONIC AND SUPERSONIC FLOWS - HISTORICAL REVIEW; STATE OF THE ART
E. C. YATES, JR. (NASA, Langley Research Center, Hampton, VA) IN: Computational methods in potential aerodynamics. Billerica, MA/Berlin, Computational Mechanics Publications/Springer-Verlag, 1985, p. 95-153. refs

This lecture is introductory to the subject of unsteady subsonic and supersonic flows. The primary objective is to present fundamental concepts in order to promote an understanding of the relations between the basic physical problems and their mathematical formulation as well as to establish a common foundation for the more detailed presentations of subsequent lectures in this session. Linearized (small-perturbation) potential flow is emphasized, although needs beyond that limit are indicated. The basic equations, concepts, and procedures common to all the methods are reviewed first, followed by the development, discussion, and status of methods for creating two-dimensional incompressible flow, strip theory, subsonic lifting-surface theory, subsonic/supersonic surface-panel methods, and supersonic lifting-surface theory. Author

A87-23631
BASIC PRINCIPLES AND DOUBLE LATTICE APPLICATIONS IN POTENTIAL AERODYNAMICS
J. P. GIESING (McDonnell Douglas Corp., Aircraft Div., Long Beach, CA) IN: Computational methods in potential aerodynamics. Billerica, MA/Berlin, Computational Mechanics Publications/Springer-Verlag, 1985, p. 155-196. refs.

The fundamental role of the acoustic pulse in potential aerodynamics is explored, and its use in constructing source and doublet solutions to the differential equations governing both uniform and nonuniform (static, subsonic, supersonic, accelerating, decelerating, and transonic) flow fields is demonstrated. The velocity and pressure doublet solution obtained is applied to basic vortex-lattice and doublet-lattice methods, and applications of these techniques to a number of specific problems are shown in diagrams and graphs. Also included is a discussion of the Kutta condition for the general case of unsteady multienergy three-dimensional flows. T.K.

A87-23632
COMPARISON OF ANALYSIS METHODS USED IN LIFTING SURFACE THEORY
W. S. ROWE (Boeing Commercial Airplane Co., Seattle, WA) IN: Computational methods in potential aerodynamics. Billerica, MA/Berlin, Computational Mechanics Publications/Springer-Verlag, 1985, p. 197-240. refs.

Various problems involved in predicting accurate unsteady subsonic loadings using lifting surface theory are reviewed. Components of the integral equation solution are examined to evaluate their effects on prediction accuracy and are highlighted in the discussions involving hidden singularities, integration procedures, solution procedures applied to discontinuous downwash distributions, solution convergence, and transient motions. Comparisons of experimental and theoretical results are presented to indicate the degree of prediction accuracy that may be attained in application of linearized subsonic lifting surface theory. Author

A87-23633
INTRODUCTION TO THE GREEN'S FUNCTION METHOD IN AERODYNAMICS
M. I. FREEDMAN (Boston University, MA) IN: Computational methods in potential aerodynamics. Billerica, MA/Berlin, Computational Mechanics Publications/Springer-Verlag, 1985, p. 241-267. refs.

The Green's-function method for solving flow problems of potential aerodynamics is introduced. The method allows for direct formulation of problems involving arbitrary wing-body configurations. The numerical techniques developed using a finite-element approach (i.e., a panel method) have been incorporated into a computer program called SOUSSA. This program has been developed with a modular structure in such a manner as to make it applicable in the widest variety of settings. In particular, all of the following aerodynamic flow situations may be treated: steady, unsteady (oscillatory or nonoscillatory), subsonic, supersonic, and combinations of the foregoing. Author

A87-23634
MATHEMATICAL FOUNDATIONS OF INTEGRAL-EQUATION METHODS
L. MORINO (Boston University, MA) IN: Computational methods in potential aerodynamics. Billerica, MA/Berlin, Computational Mechanics Publications/Springer-Verlag, 1985, p. 269-291. refs.

Green's function and Green's theorem for unsteady subsonic and supersonic potential aerodynamics are presented. Green's theorem is the basis for the mathematical foundations of the integral equation methods (such as lifting-surface and panel methods) examined in this paper. These include several lifting-surface formulations (for subsonic and supersonic flows) as well as panel methods and Green's function method. Steady-state formulations are covered first, followed by oscillatory formulations. Author

A87-23636
TRANSONIC COMPUTATIONAL DESIGN AND ANALYSIS APPLICATIONS
C. W. BOPPE (Grumman Aerospace Corp., Engineering Dept., Bethpage, NY) IN: Computational methods in potential aerodynamics. Billerica, MA/Berlin, Computational Mechanics Publications/Springer-Verlag, 1985, p. 369-412. refs.

Computational aerodynamic methods have had a dramatic effect on the way air vehicles are designed. Although computer flow simulations have, to a large extent, replaced the wind tunnel as the aerodynamicist's primary design tool, many challenges still remain for both the computational method developer and the engineering designer. A number of two and three-dimensional case studies are presented, along with brief descriptions of the methods which were implemented. Both design problems and analysis applications are included. Author

A87-23637
COMPUTATIONAL PROCEDURES IN AERODYNAMIC DESIGN
J. W. SLOOFF (Nationaal Lucht- en Ruimtevaartlaboratorium, Amsterdam, Netherlands) IN: Computational methods in potential aerodynamics. Billerica, MA/Berlin, Computational Mechanics Publications/Springer-Verlag, 1985, p. 413-461. refs.

A survey is given of computational aerodynamic methods that can be used in transonic airfoil and wing design. The characteristics are described of the hodograph, fictitious gas, inverse and numerical optimization approaches. Finally a discussion is presented on the relative merits of the various approaches. Author

A87-23638
EXPERIENCE, ISSUES, AND OPPORTUNITIES IN STEADY TRANSONICS
E. N. TINOCO and P. E. RUBBERT (Boeing Commercial Airplane Co., Seattle, WA) IN: Computational methods in potential aerodynamics. Billerica, MA/Berlin, Computational Mechanics Publications/Springer-Verlag, 1985, p. 463-498. refs.

The evolutionary refinement of steady transonic computational methods at the Boeing Company is discussed. A steady development program to improve geometric capability, to refine transonic algorithms, to improve computational efficiency, and to couple in boundary layer effects, has resulted in an excellent capability to analyze realistic wing-body configurations with or without wing mounted engine nacelles. However, problems still exist with the strong case in which deficiencies with the potential formulation, or inadequate treatment of the shock/boundary layer interaction may prevent better correlation with experimental data. A brief discussion of these problems and those associated with the developing a more general geometry capability conclude this paper. Included are descriptions of the computational modeling and comparison with experimental data. Author

A87-23639* National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
UNSTEADY TRANSONIC FLOWS - INTRODUCTION, CURRENT TRENDS, APPLICATIONS
E. C. YATES, JR. (NASA, Langley Research Center, Hampton, VA) IN: Computational methods in potential aerodynamics. Billerica, MA/Berlin, Computational Mechanics Publications/Springer-Verlag, 1985, p. 501-568. refs.

The computational treatment of unsteady transonic flows is discussed, reviewing the historical development and current techniques. The fundamental physical principles are outlined; the governing equations are introduced; three-dimensional linearized and two-dimensional linear-perturbation theories in frequency domain are described in detail; and consideration is given to frequency-domain FEMs and time-domain finite-difference and integral-equation methods. Extensive graphs and diagrams are included. T.K.

A87-23640* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
FINITE DIFFERENCE METHODS FOR THE SOLUTION OF UNSTEADY POTENTIAL FLOWS
F. X. CARADONNA (NASA, Ames Research Center; U.S. Army, Aerodynamics Laboratory, Moffett Field, CA) IN: Computational methods in potential aerodynamics. Billerica, MA/Berlin, Computational Mechanics Publications/Springer-Verlag, 1985, p. 569-602. refs.

A brief review is presented of various problems which are confronted in the development of an unsteady finite difference potential code. This review is conducted mainly in the context of what is done for a typical small disturbance and full potential methods. The issues discussed include choice of equation, linearization and conservation, differencing schemes, and algorithm development. A number of applications including unsteady three-dimensional rotor calculation, are demonstrated. Author

A87-23641
AN INTEGRAL EQUATION METHOD FOR POTENTIAL AERODYNAMICS
K. TSENG (Icarus, Inc., Boston, MA) IN: Computational methods in potential aerodynamics. Billerica, MA/Berlin, Computational Mechanics Publications/Springer-Verlag, 1986, p. 603-626. refs.

A brief review of progress with a Green's function method for unsteady subsonic and supersonic potential flows is presented. Numerical results obtained in the past decade using the method are included to typify the various stages of development of Green's function method. The extension of the method to transonic flow is presented in detail. Author

A87-23642* Old Dominion Univ., Norfolk, Va.
STEADY AND UNSTEADY INCOMPRESSIBLE FREE-WAKE ANALYSIS
O. A. KANDIL (Old Dominion University, Norfolk, VA) IN: Computational methods in potential aerodynamics. Billerica, MA/Berlin, Computational Mechanics Publications/Springer-Verlag, 1985, p.629-678. NASA-Army-Navy-supported research. refs.

The flows around highly sweptback wings and bodies of revolution at high angle of attack are described, and inviscid model approximations and mathematical formulation of the problem are given to steady and unsteady incompressible flows. A general presentation of the methods of solution is given, with emphasis on current computational techniques. Detailed descriptions of the nonlinear vortex-lattice and vortex-panel techniques are presented to show how the boundary conditions are enforced using iteration. Typical numerical results are compared with the available experimental data. Author

A87-23643
WAKE DYNAMICS FOR INCOMPRESSIBLE AND COMPRESSIBLE FLOWS
S. R. SIPCIC (Sarajevu, Univerzitet, Sarajevo, Yugoslavia) and L. MORINO (Boston University, MA) IN: Computational methods in potential aerodynamics. Billerica, MA/Berlin, Computational Mechanics Publications/Springer-Verlag, 1985, p. 679-699. refs.

The doublet-layer method developed by Morino et al. (1983) for the aerodynamic analysis of the free wakes of helicopter rotors is described and demonstrated. Both the formulation for incompressible potential flows and its extension to compressible flows are outlined; the numerical algorithm and its computer implementation are characterized; and results for the single-blade problem studied by Rao and Schatzle (1977) are presented graphically. The applicability of the method to rotors in forward flight and to isentropic potential flows is indicated. T.K.

A87-23644
SOME NEW DEVELOPMENTS IN EXACT INTEGRAL EQUATION FORMULATIONS FOR SUB- OR TRANSONIC COMPRESSIBLE POTENTIAL FLOW
J. W. SLOOFF (Nationaal Lucht- en Ruimtevaartlaboratorium, Amsterdam, Netherlands) IN: Computational methods in potential aerodynamics. Billerica, MA/Berlin, Computational Mechanics Publications/Springer-Verlag, 1985, p. 703-725. refs.

A review is given of some current new developments at NLR in integral equation ('panel') methods for the computation of potential flows. One of these developments concerns the exact modeling of (nonlinear) compressibility effects through field source distributions, in combination with the artificial viscosity, retarded density and flux-splitting concepts. The other is the development of 'fast solvers' for panel methods in the form of multigrid type algorithms. Author

A87-23645
AN INTEGRAL EQUATION FOR COMPRESSIBLE POTENTIAL FLOWS IN AN ARBITRARY FRAME OF REFERENCE
L. MORINO, M. I. FREEDMAN (Boston University, MA), D. J. DEUTSCH (Singer Link, Silverspring, MA), and S. R. SIPCIC (Sarajevu, Univerzitet, Sarajevo, Yugoslavia) IN: Computational methods in potential aerodynamics. Billerica, MA/Berlin, Computational Mechanics Publications/Springer-Verlag, 1985, p. 727-733. refs.

A general integral equation for nonlinear unsteady potential aerodynamics is presented. The integral equation is written in a frame of reference having arbitrary motion; the boundary surface itself is assumed to move in arbitrary motion with respect to the frame of reference. Application to helicopter rotors are emphasized. Author

A87-23651*# California Univ., Los Angeles.
NEW APPROACH TO FINITE-STATE MODELING OF UNSTEADY AERODYNAMICS
C. VENKATESAN and P. P. FRIEDMANN (California, University, Los Angeles) (Structures, Structural Dynamics and Materials Conference, 27th, San Antonio, TX, May 19-21, 1986, Technical Papers, Part 2, p. 178-191) AIAA Journal (ISSN 0001-1452), vol. 24, Dec. 1986, p. 1889-1897. Previously cited in issue 18, p. 2604, Accession no. A86-38900. refs
(Contract NAG2-209)

A87-23652*# Stanford Univ., Calif.
UNSTEADY WAKE MEASUREMENTS OF AN OSCILLATING FLAP AT TRANSONIC SPEEDS
SATYANARAYANA BODAPATI and CHYANG SHENG LEE (Stanford University, CA) AIAA Journal (ISSN 0001-1452), vol. 24, Dec. 1986, p. 1898, 1899. Previously cited in issue 22, p. 3179, Accession no. A84-46112.
(Contract NSG-2233)

A87-23654#
INTERACTION BETWEEN TWO COMPRESSIBLE, TURBULENT FREE SHEAR LAYERS
M. SAMIMY (Ohio State University, Columbus) and A. L. ADDY (Illinois, University, Urbana) AIAA Journal (ISSN 0001-1452), vol. 24, Dec. 1986, p. 1918-1923. Army-supported research. Previously cited in issue 07, p. 835, Accession no. A86-19882. refs

A87-23656*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
ARTIFICIAL DISSIPATION MODELS FOR THE EULER EQUATIONS
THOMAS H. PULLIAM (NASA, Ames Research Center, Moffett Field, CA) AIAA Journal (ISSN 0001-1452), vol. 24, Dec. 1986, p. 1931-1940. Previously cited in issue 07, p. 850, Accession no. A85-20870. refs

A87-23658*# Cincinnati Univ., Ohio.
CALCULATION OF SUPERSONIC FLOWS WITH STRONG VISCOUS-INVISCID INTERACTION
MARK BARNETT and R. THOMAS DAVIS (Cincinnati, University, OH) AIAA Journal (ISSN 0001-1452), vol. 24, Dec. 1986, p. 1949-1955. Previously cited in issue 07, p. 839, Accession no. A85-19562. refs
(Contract NCA2-OR-130-101; NGT-36-004-800; N00014-76-C-0364)

A87-23672#
WAVY WALL SOLUTIONS OF THE EULER EQUATIONS
PHILIP BEAUCHAMP (General Electric Co., Lynn, MA) and EARLL M. MURMAN (MIT, Cambridge, MA) AIAA Journal (ISSN 0001-1452), vol. 24, Dec. 1986, p. 2042-2045. refs

In the present solutions for subsonic and transonic flows past a wavy wall, results for the numerical evaluation of the former case indicate the Euler flow to be periodic, comparing well with the classic small perturbation solution. The transonic results show that the solution consists of a series of shocks which progressively weaken with flow over successive wave crests, until stagnation pressure loss is sufficient to yield waves with a single sonic point; from this point, the solution appears to be periodic in space. O.C.

A87-23728#
CALCULATION OF TRANSONIC POTENTIAL FLOW THROUGH A TWO-DIMENSIONAL CASCADE USING AF 1 SCHEME
KENJI INOUE Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 34, no. 392, 1986, p. 491-498. In Japanese, with abstract in English. refs

A method is presented for calculating the flowfield about a cascade of arbitrary two-dimensional blades. A conformal transformation is used to generate a finite-difference grid. Implicit approximate factorization (AF) scheme is used for the solution of matrix equations resulting from finite-difference approximation to the full potential equation in conservation form. For transonic flows, an artificial viscosity, required to maintain stability in supersonic regions, is introduced by an upwind bias of the density. This allows the simple matrix form of the scheme to be retained over the entire flowfield. Supercritical test cases are considered. Blade Mach number or pressure distributions have been computed and are in good agreement with independent results. Author

A87-23755#
A TIME MARCHING METHOD OF EXPLICIT SCHEME FOR SOLVING TRANSONIC VISCOUS FLOW WITHIN CASCADES
ZIKANG JIANG and XIN YUAN (Qinghua University, Beijing, People's Republic of China) Journal of Engineering Thermophysics, vol. 7, Aug. 1986, p. 217-222. In Chinese, with abstract in English. refs

The major objective of this paper is to study the transonic viscous flow (only laminar flow) within the plane cascades and the losses of cascades. A time marching method in which the explicit difference scheme is composed of the basic scheme and the corrected link is used to obtain the steady-state solutions of the complete, unsteady Navier-Stokes equations within the transonic cascades. Approximately second order accuracy is obtained. The choice of difference scheme and the representation of boundary conditions given in this paper are successful. It provides a means of numerical simulation for researching the transonic viscous flow of cascade within turbomachine. This scheme can be extended to the computation of turbulent flow conveniently. Author

A87-23757#

ANALYSIS OF FLOWFIELD ON LEADING EDGE OF TRANSONIC BLADE PROFILE

XINHAI ZHOU and FANGYUAN ZHU (Northwestern Polytechnical University, Xian, People's Republic of China) Journal of Engineering Thermophysics, vol. 7, Aug. 1986, p. 229-231. In Chinese, with abstract in English. refs

The aim of this paper is to develop a numerical approach to analyze the flowfield in the leading edge region of a blade profile. The Euler equations written in strong conservation form in arbitrary curvilinear coordinates are solved using a time-dependent finite difference scheme. A numerical result for a transonic turbine cascade is presented and compared with experimental data. Treatment of the boundary conditions is discussed in some detail. Author

A87-23759#

A DISCUSSION ABOUT THE MEAN S2 STREAM SURFACES APPLIED TO CALCULATION OF QUASI-3-D FLOW IN TURBOMACHINERY

ZHONGQI WANG and XUJIN ZHU (Harbin Institute of Technology, People's Republic of China) Journal of Engineering Thermophysics, vol. 7, Aug. 1986, p. 235-237. In Chinese, with abstract in English.

The mean S2 stream surfaces applied to the calculation of the quasi-three-dimensional flow in turbomachinery are given three different kinds of meaning by different authors. The calculation results using these three different mean S2 stream surfaces for turbomachinery in nonorthogonal curvilinear coordinates are given in this paper. Author

A87-24009#

THREE-DIMENSIONAL FLOW EFFECTS IN A TWO-DIMENSIONAL SUPERSONIC AIR INTAKE

S. A. FISHER (Department of Defence, Aeronautical Research Laboratories, Melbourne, Australia) (International Symposium on Air Breathing Engines, 7th, Beijing, People's Republic of China, September 2-6, 1985, Proceedings, p. 118-124) Journal of Propulsion and Power (ISSN 0748-4658), vol. 2, Nov.-Dec. 1986, p. 546-551. Previously cited in issue 02, p. 108, Accession no. A86-11612. refs

A87-24010*# Cornell Univ., Ithaca, N.Y.

STALL TRANSIENTS OF AXIAL COMPRESSION SYSTEMS WITH INLET DISTORTION

F. K. MOORE (Cornell University, Ithaca, NY) Journal of Propulsion and Power (ISSN 0748-4658), vol. 2, Nov.-Dec. 1986, p. 552-561. Previously cited in issue 18, p. 2611, Accession no. A85-39740. refs
(Contract NAG3-349)

A87-24026#

PERFORMANCE AUGMENTATION OF A 60-DEGREE DELTA AIRCRAFT CONFIGURATION BY SPANWISE BLOWING

A. SEGINER and M. SALOMON (Technion - Israel Institute of Technology, Haifa) Journal of Aircraft (ISSN 0021-8669), vol. 23, Nov. 1986, p. 801-807. refs

Spanwise blowing (SWB) over the wing and canard of a close-coupled-canard, 60-deg delta fighter-aircraft configuration was investigated experimentally in low-speed flow at angles of attack up to 60 deg and yaw angles of up to 36 deg. Significant improvement in lift-curve slope, maximum lift, drag polar, and lateral/directional stability was found, enlarging the usable flight envelope beyond its previous low-speed/maximum-lift limit. It was shown that SWB can achieve the same lift augmentation produced by a canard, without the drag penalty. Contrary to previous experience with 60-deg swept wings, the efficiency of the lift augmentation by SWB was relatively high and was found to increase with increasing jet-momentum coefficient on the close-coupled-canard configuration. Interesting and promising possibilities of obtaining much higher efficiencies with swirling or multiple nonaligned jets were indicated. Author

A87-24029*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

DENSITY STRATIFICATION EFFECTS ON WAKE VORTEX DECAY

DAN H. NEUHART, GEORGE C. GREENE, DALE R. SATRAN, and G. THOMAS HOLBROOK (NASA, Langley Research Center, Hampton, VA) Journal of Aircraft (ISSN 0021-8669), vol. 23, Nov. 1986, p. 820-824. Previously cited in issue 07, p. 836, Accession no. A85-19482. refs

A87-24032*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

TRANSONIC SEPARATED SOLUTIONS FOR AN AUGMENTOR WING

JOLEN FLORES and WILLIAM R. VAN DALSEM (NASA, Ames Research Center, Moffett Field, CA) Journal of Aircraft (ISSN 0021-8669), vol. 23, Nov. 1986, p. 837-842. Previously cited in issue 01, p. 6, Accession no. A86-11057. refs

A87-24246

NUMERICAL SOLUTION OF SINGULAR INTEGRAL EQUATIONS IN A CLASS OF SINGULAR FUNCTIONS AND THE PROBLEM OF FLOW SUCTION IN AERODYNAMICS [CHISLENNOE RESHENIE SINGULIARNYKH INTEGRAL'NYKH URAVNENII V KLASSE SINGULIARNYKH FUNKTSII I ZADACHA OTSOSA POTOKA V AERODINAMIKE]

V. I. BUSHUEV and I. K. LIFANOV Zhurnal Vychislitel'noi Matematiki i Matematicheskoi Fiziki (ISSN 0044-4669), vol. 26, Oct. 1986, p. 1572-1577. In Russian. refs

A numerical method for solving singular integral equations in a class of singular functions is proposed which makes it possible to determine the aerodynamic characteristics of a wing with suction of flow of an ideal fluid under conditions of circulation, noncirculation, and nonshock flow. The method proposed here is a modified version of the discrete vortex method commonly used in aerodynamics. The method is demonstrated by using it to investigate some characteristics of an airfoil augmented by flow suction. V.L.

A87-24468

UNSTEADY MOTION OF A WING DUE TO A VERTICAL GUST [NEUSTANOVIVSHEESIA DVIZHENIE KRYLA PRI DEISTVII VERTIKAL'NOGO PORYVA]

B. A. ERSHOV Leningradskii Universitet, Vestnik, Matematika, Mekhanika, Astronomiia (ISSN 0024-0850), July 1986, p. 100-102. In Russian.

The paper is concerned with the vibration of an elastic wing of infinite span moving in an ideal compressible fluid. In particular, an analysis is made of the coupled vibrations of the wing induced by a vertical gust. A perturbation velocity potential is obtained for unsteady vibrations of the wing. V.L.

A87-24647

CALCULATING THE AERODYNAMIC LOADS AND MOMENTS ON AIRPLANE WINGS: CANTILEVER MONOPLANES

HARMEN KOFFEMAN Hamilton, Canada, Hek Aero Engineering, 1986, 203 p.

A comprehensive guide to the determination of wing aerodynamic loads and moments is presented for the use of amateur aircraft designers. Six basic planforms are considered: rectangular, straight tapered, rectangular tapered, double-tapered, elliptical, and rectangular-tapered with strakes. Attention is given to the determination of dimensions and areas, shear loading, bending moment, and torsion moment for each of the planforms. Extensive tabulations and step-by-step calculations are provided, together with illustrations of wing parameters. O.C.

A87-24713#
INFLUENCE OF THE REGULAR WATER WAVE UPON THE AERODYNAMIC CHARACTERISTICS OF A WING DURING THE LOW ALTITUDE FLYING
CHUANJING LU and YOUSHENG HE (Jiaotong University, Shanghai, People's Republic of China) Acta Aeronautica et Astronautica Sinica, vol. 7, Oct. 1986, p. 423-427. In Chinese, with abstract in English.

It is well known that the sneak attack with the near-sea flight is one of the best ways in military attack in a limited war. However, it is remarkable that the aerodynamic behavior of a wing is influenced by the interaction of the water wave with the air when the vehicle flies over the rough sea. A proper procedure based on previous theoretical works for solving this problem is presented in this paper. Some examples of calculating the influence of the regular wave upon the aerodynamic characteristics of a wing during the low altitude flying are also given. Author

A87-24714#
THE RESEARCH OF SHOCK AND VORTEX INTERACTION ON AN OGIVE CYLINDER BODY AT HIGH ANGLES OF ATTACK
XING TU (Northwestern Polytechnical University, Xian, People's Republic of China) Acta Aeronautica et Astronautica Sinica, vol. 7, Oct. 1986, p. 428-432. In Chinese, with abstract in English. refs

A shock is formed on an ogive cylinder body in transonic flow. There are also vortices formed on the leeside surface of an ogive cylinder body at high angles of attack. This provides a condition for shock and vortex interaction on an ogive cylinder body. Tests and analyses have shown that the shock on the leeside surface has a large influence on the asymmetric vortex pattern. When a pair of asymmetric vortices passes through a shock, the asymmetricity is decreased, and the vortex path will be deflected to leave the body. Therefore, the action of a vortex passing through a shock is the main reason for causing the lateral force decrease with increasing Mach number. Author

A87-24901*# Purdue Univ., West Lafayette, Ind.
MEASUREMENT OF A COUNTER ROTATION PROPELLER FLOWFIELD USING A LASER DOPPLER VELOCIMETER
G. L. HARRISON (Embry-Riddle Aeronautical University, Prescott, AZ) and J. P. SULLIVAN (Purdue University, West Lafayette, IN) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 8 p. refs
(Contract NSG-3135)
(AIAA PAPER 87-0008)

This paper is a summary of the results of the experimental investigation of the flow field about a counter-rotating propeller (CRP) system using a Laser Doppler Velocimeter (LDV). The number of configurations available for the CRP system is limitless, thus only a small portion of the number of possible cases were examined. Measurements were made upstream, in between and downstream of the propeller system. The abundance of data readily available from the LDV system clearly identifies the tip vortices and wake regions. The recovery by the downstream propeller of the swirl velocity imparted to the flow by the upstream propeller is very evident. The coefficients of thrust and power were determined using momentum and energy analysis of the data and compared to theory. Author

A87-24906*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
TRANSONIC NAVIER-STOKES SOLUTIONS FOR A FIGHTER-LIKE CONFIGURATION
JOLEN FLORES, STEVEN G. REZNICK, TERRY L. HOLST (NASA, Ames Research Center, Moffett Field, CA), and KAREN GUNDY AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 22 p. refs
(AIAA PAPER 87-0032)

The Transonic Navier-Stokes wing code is extended to a 16-zone TNS wing-fuselage code and used to solve the transonic viscous flow over a modified F-16A. The computer code, called Transonic Navier-Stokes Wing/Fuselage uses a zonal approach to solve the three-dimensional Euler and Navier-Stokes equations. With the zonal implementation, clustering suitable for viscous calculations is achieved on all solid surfaces. The transonic case has flow conditions of free-stream M = 0.9, alpha = 4.12 deg, and a Reynolds number based on root chord of 4.5 million. This case required about 3,000 iterations to reduce the L2-norm of the residual by three orders, which takes about 15 hr of cpu time on the Cray X-MP/48 processor. Pressure distributions, as well as separaton patterns, compare favorably with experiment for this transonic case. Author

A87-24907#
A COMPARISON OF INVISCID AND VISCOUS TRANSONIC SEPARATED FLOWS
JAMES A. RHODES and ERNST VON LAVANTE (Old Dominion University, Norfolk, VA) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 20 p. refs
(AIAA PAPER 87-0036)

A comparison of results obtained using various computer codes which solve the Euler and Navier-Stokes equations is presented. The codes were used to solve for transonic flow past two configurations which produce flow separation under certain conditions. The results show that while inviscid flow separation is most strongly related to vorticity produced by flow through curved shock waves, viscous flow is much more sensitive to adverse pressure gradients and the presence of a boundary layer leads to flow separation when under the same conditions the inviscid flow remains attached. Author

A87-24908#
FLAT PLATE DELTA WING SEPARATED FLOWS WITH ZERO TOTAL PRESSURE LOSSES
FRANK MARCONI (Grumman Corporate Research Center, Bethpage, NY) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 9 p. refs
(Contract F49620-85-C-01115)
(AIAA PAPER 87-0038)

Computational results for the inviscid, supersonic flow about flat delta wings are presented. The Euler equations are solved and leading edge separation and vortices are predicted. The numerical formulation is such that total pressure losses are allowed only across shock waves. Separated Euler solutions akin to the classical irrotational, fit sheet solutions are obtained simply by capturing the associated vortex sheet. This method is compared with Euler formulations where vortices exhibit significant total pressure losses. A Kutta type condition is introduced for the leading edge flow which clearly defines the local singularity. In addition to leading edge primary separation, secondary separation is introduced by shedding vorticity from the surface of the wing. Computational results are compared with those of other investigators and with experimental results. Author

A87-24910*# Virginia Polytechnic Inst. and State Univ., Blacksburg.
EFFECT OF A BULGE ON THE SECONDARY INSTABILITY OF BOUNDARY LAYERS
ALI H. NAYFEH and SAAD A. RAGAB (Virginia Polytechnic Institute and State University, Blacksburg) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 12 p. refs
(Contract N00014-85-K-0011; NR PROJECT 432-5201; NAG1-714)
(AIAA PAPER 87-0045)

The influence of a two-dimensional hump on the three-dimensional (3-D) subharmonic secondary instability on a flat plate is investigated. The mean flow is calculated using interacting boundary layers, thereby accounting for the inviscid/viscous interaction. The primary wave is taken in the form of a two-dimensional (2-D) Tollmien-Schlichting (T-S) wave. The secondary wave is taken in the form of a 3-D subharmonic T-S wave. Author

A87-24916*# Virginia Univ., Charlottesville.
QUANTITATIVE MEASUREMENT OF TRANSVERSE INJECTOR AND FREE STREAM INTERACTION IN A NONREACTING SCRAMJET COMBUSTOR USING LASER-INDUCED IODINE FLUORESCENCE
D. G. FLETCHER and J. C. MCDANIEL (Virginia, University, Charlottesville) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 25 p. refs
(Contract NAG1-373)
(AIAA PAPER 87-0087)

A preliminary quantitative study of the compressible flowfield in a steady, nonreacting model SCRAMJET combustor using laser-induced iodine fluorescence (LIIF) is reported. Measurements of density, temperature, and velocity were conducted with the calibrated, nonintrusive, optical technique for two different combustor operating conditions. First, measurements were made in the supersonic flow over a rearward-facing step without transverse injection for comparison with calculated pressure profiles. The second configuration was staged injection behind the rearward-facing step at an injection dynamic pressure ratio of 1.06. These experimental results will be used to validate computational fluid dynamic (CFD) codes being developed to model supersonic combustor flowfields. Author

A87-24920#
UNSTEADY FULL POTENTIAL COMPUTATIONS FOR COMPLEX CONFIGURATIONS
VIJAYA SHANKAR, HIROSHI IDE, and THOMAS GOEBEL (Rockwell International Science Center, Thousand Oaks, CA) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 11 p. refs
(AIAA PAPER 87-0110)

A unified formulation is presented based on the full potential framework coupled with an appropriate structural model to compute steady/unsteady flows over rigid/flexible configurations for across the Mach number range (subsonic to supersonic). The unsteady form of the full potential equation in conservation form is solved using an implicit scheme maintaining time accuracy through internal Newton iterations. A flux biasing procedure based on the unsteady sonic reference conditions is implemented to compute hyperbolic regions with moving sonic and shock surfaces. The wake behind a trailing edge is modeled using a mathematical cut across which the pressure is satisified to be continuous by solving an appropriate vorticity convection equation. An aeroelastic model based on the generalized model deflection approach interacts with the nonlinear aerodynamics and includes both static as well as dynamic structural analyses capability. Results are presented for rigid and flexible configurations at different Mach numbers ranging from subsonic to supersonic conditions. The dynamic response of a flexible wing below and above its flutter point is demonstrated. Author

A87-24921#
CALCULATION OF THREE-DIMENSIONAL CAVITY FLOWFIELDS
JOSEPH J. GORSKI, DALE K. OTA, and SUKUMAR R. CHAKRAVARTHY (Rockwell International Science Center, Thousand Oaks, CA) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 8 p. refs
(AIAA PAPER 87-0117)

Numerical calculations of laminar and turbulent flow in a three-dimensional cavity configuration, relative to a weapons bay flowfield, is presented. Solutions are presented for a simplified version of the F-111 weapons bay which has a L/D ratio of 6.2. These results were obtained by solving the Navier-Stokes equations with the Baldwin-Lomax turbulence model modified for multiple wall effects. The solution procedure makes use of high accuracy TVD schemes, which guarantee oscillation free solutions for the convective terms of the Navier-Stokes equations. The results, presented here, have demonstrated the ability of the code to predict the complex flowfields associated with these cavity configurations. Further comparison with experimental data is necessary to finalize the validation of this application. Author

A87-24929*# Texas A&M Univ., College Station.
EXPERIMENTAL AND THEORETICAL STUDY OF PROPELLER SPINNER/SHANK INTERFERENCE
C. C. CORNELL (Texas A & M University, College Station) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 23 p. refs
(Contract NAG3-272)
(AIAA PAPER 87-0145)

A fundamental investigation into the aerodynamic interference associated with propeller spinner and shank regions has been 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 has been established for prediction of interference effects in terms of either interference drag or propeller thrust and torque coefficients. These quantities have been examined with attention to engineering parameters such as spinner finess ratio, blade shank form, and number of blades. Also, cascade effects and spinner/shank juncture interference have been semi-empirically modeled using existing theories and placed into a compatible form with an existing propeller performance code. Author

A87-24931*# New York Univ., New York.
ANALYTICAL AND EXPERIMENTAL EVALUATION OF A 3-D HYPERSONIC FIXED-GEOMETRY, SWEPT, MIXED COMPRESSION INLET
ANTHONY M. AGNONE (New York University, Westbury, NY) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 30 p. refs
(Contract NGR-33-016-131)
(AIAA PAPER 87-0159)

The performance of a fixed-geometry, swept, mixed compression hypersonic inlet is presented. The experimental evaluation was conducted for a Mach number of 6.0 and for several angles of attack. The measured surface pressures and pitot pressure surveys at the inlet throat are compared to computations using a three-dimensional Euler code and an integral boundary layer theory. Unique features of the intake design, including the boundary layer control, insure a high inlet performance. The experimental data show the inlet has a high mass averaged total pressure recovery, a high mass capture and nearly uniform flow diffusion. The swept inlet exhibits excellent starting characteristics, and high flow stability at angle of attack. Author

A87-24932*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
NUMERICAL SIMULATION OF THREE-DIMENSIONAL SUPERSONIC INLET FLOW FIELDS
T. KAWAMURA, W. J. CHYU, and D. P. BENCZE (NASA, Ames Research Center, Moffett Field, CA) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 13 p. refs
(AIAA PAPER 87-0160)

Supersonic inlet flows with mixed external-internal compressions of an axisymmetric inlet model were computed using a combined implicit-explicit (Beam-Warming-Steger/MacCormack) method for solving the three-dimensional unsteady, compressible Navier-Stokes equations in conservation form. Numerical calculations were made of various flows typically found in supersonic inlets such as shock-wave intersections, flow spillage around the cowl lip, shock-wave/boundary-layer interactions, control of shock-induced flow separation by means of boundary layer bleed, internal normal (terminal) shocks, and the effects of flow incidence. Computed results were compared with available wind tunnel data. Author

A87-24934#
ON THE NUMERICAL SIMULATION OF THE UNSTEADY WAKE BEHIND AN AIRFOIL
D. T. MOOK (Virginia Polytechnic Institute and State University, Blacksburg), S. ROY, G. CHOKSI, and D. M. ALEXANDER AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 11 p. Research supported by the United Technologies Corp. refs
(Contract AF-AFOSR-85-0158)
(AIAA PAPER 87-0190)

The unsteady wake behind an airfoil is simulated numerically by a system of discrete vortex cores, also called point vortices. In common with previously developed procedures, at each time step a core is added to the wake at the trailing edge, and the cores already in the wake are convected at the local particle velocity. The innovation of the present method is that, as the cores begin to separate, more cores are added to the system and the circulations around the individual cores are reduced according to a linear interpolation routine. The spacing between cores is maintained approximately while the total circulation around the wake and airfoil is maintained exactly. Several examples show good agreement between computed wake shapes and flow visualization. The method shows promise as a means of simulating unsteady, close-coupled aerodynamic interference. Author

A87-24942#
DYNAMIC STALL WAKE INTERACTION WITH A TRAILING AIRFOIL
JOHN WALKER, M. (U.S. Air Force Academy, Colorado Springs, CO) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 11 p. refs
(AIAA PAPER 87-0239)

Experiments were conducted with tandem NACA 0015 airfoils placed in a wind tunnel 0.5c apart. The leading airfoil was pitched about its quarter-chord axis at high constant rates from zero to sixty degrees incidence at chord Reynolds numbers from 50,000 to 200,000. These motions produced energetic dynamic stall vortex flows which impinged on the trailing airfoil fixed at zero degrees geometric angle of attack. Smoke-wire flow visualization and dynamic surface pressure measurement experiments were performed to study the effects of the unsteady vortical wakes on the trailing airfoil. The dynamic stall vortices produced by the pitching airfoil elicited complex, time-dependent secondary flow structures around the trailing airfoil which in turn produced large dynamic loads. These large transient loads may pose significant problems to the designers of control systems of aircraft generating or encountering such unsteady vortical flow structures. Author

A87-24953*# California Univ., Berkeley.
NUMERICAL SIMULATION BY TVD SCHEMES OF COMPLEX SHOCK REFLECTIONS FROM AIRFOILS AT HIGH ANGLE OF ATTACK
YOUNG J. MOON (California, University, Berkeley) and H. C. YEE (NASA, Ames Research Center, Moffett Field, CA) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 18 p. refs
(AIAA PAPER 87-0350)

The shock-capturing capability of total variation diminishing (TVD) schemes is demonstrated for a more realistic complex shock-diffraction problem for which the experimental data are available. Second-order explicit upwind and symmetric TVD schemes are used to solve the time-dependent Euler equations of gas dynamics for the interaction of a blast wave with an airfoil at high angle-of-attack. The test cases considered are a time-dependent moving curved-shock wave and a contant moving planar-shock wave impinging at an angle-of-attack 30 deg on a NACA 0018 airfoil. Good agreement is obtained between isopycnic contours computed by the TVD schemes and those from experimental interferograms. No drastic difference in flow-field structure is found between the curved- and planar-shock wave cases, except for a difference in density level near the lower surface of the airfoil. Computation for cases with higher shock Mach numbers is also possible. Numerical experiments show that the symmetric TVD scheme is less sensitive to the boundary conditions treatment than the upwind scheme. Author

A87-24954*# Boeing Commercial Airplane Co., Seattle, Wash.
AN EXPERIMENTAL INVESTIGATION OF COMPRESSIBLE THREE-DIMENSIONAL BOUNDARY LAYER FLOW IN ANNULAR DIFFUSERS
DEEPAK OM (Boeing Commercial Airplane Co., Seattle, WA) and MORRIS E. CHILDS (Washington, University, Seattle) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 11 p. refs
(Contract NAG3-376)
(AIAA PAPER 87-0366)

An experimental study is described in which detailed wall pressure measurements have been obtained for compressible three-dimensional unseparated boundary layer flow in annular diffusers with and without normal shock waves. Detailed mean flow-field data were also obtained for the diffuser flow without a shock wave. Two diffuser flows with shock waves were investigated. In one case, the normal shock existed over the complete annulus whereas in the second case, the shock existed over a part of the annulus. The data obtained can be used to validate computational codes for predicting such flow fields. The details of the flow field without the shock wave show flow reversal in the circumferential direction on both inner and outer surfaces. However, there is a lag in the flow reversal between the inner nad the outer surfaces. This is an interesting feature of this flow and should be a good test for the computational codes. Author

A87-24959#
GRUMFOIL - A COMPUTER CODE FOR THE COMPUTATION OF VISCOUS TRANSONIC FLOW OVER AIRFOILS
R. E. MELNIK, J. W. BROOK, and H. R. MEAD (Grumman Corporate Research Center, Bethpage, NY) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 15 p. refs
(AIAA PAPER 87-0414)

The paper presents computed results obtained with the GRUMFOIL code which were carried out for three airfoils as part of a viscous transonic airfoil workshop held at the AIAA 25th Aerospace Sciences Meeting. The GRUMFOIL code is based on an interacting boundary layer formulation that uses a multigrid method for the conservative full potential equations and integral methods for the boundary layer. The results presented in the paper include comparisons with wind tunnel data for two of the cases: the NACA 0012 and the RAE 2822 airfoils. The third set of the calculations for the Jones airfoil was carried out as a 'blind' test as part of the workshop. The results presented in this paper include cases of transonic shock induced separation near maximum lift. A

full evaluation of the results collected at the workshop is to be presented in June 1987 by the organizers of the workshop.
Author

A87-24960*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
VISCOUS TRANSONIC AIRFOIL WORKSHOP RESULTS USING ARC2D
CATHERINE M. MAKSYMIUK and THOMAS H. PULLIAM (NASA, Ames Research Center, Moffett Field, CA) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 55 p. refs
(AIAA PAPER 87-0415)

Computations have been performed in response to the Viscous Transonic Airfoil Workshop associated with the AIAA 25th Aerospace Sciences Meeting (January 1987). The purpose of the workshop is to establish the capabilities of various methods for computing viscous flowfields for a range of conditions and geometries. The results of the test cases will demonstrate the capabilities of the methods in predicting both aerodynamic trends and flowfield details. ARC2D, a well-established Navier-Stokes code, was used to compute the flowfields for the designated airfoils, Mach numbers, angles of attack and other specifications of the Workshop committee.
Author

A87-24961*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
NUMERICAL SIMULATION OF VISCOUS TRANSONIC AIRFOIL FLOWS
THOMAS J. COAKLEY (NASA, Ames Research Center, Moffett Field, CA) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 15 p. refs
(AIAA PAPER 87-0416)

Numerical simulations of transonic airfoil flows using the Reynolds-averaged Navier-Stokes equations and various turbulence models are presented and compared with experimental data. Three different airfoils were investigated under varying flow conditions ranging from subcritical unseparated flows to supercritical separated flows. The turbulence models investigated consisted of three zero-equation models and one two-equation model. For unseparated flows involving weak viscous-inviscid interactions, the four models were comparable in their agreement with experiment. For separated flows involving strong viscous-inviscid interactions, the nonequilibrium zero-equation model of Johnson and King gave the best overall agreement with experiment.
Author

A87-24962#
USING AN UNFACTORED PREDICTOR-CORRECTOR METHOD
W. KORDULLA (DFVLR, Institut fuer theoretische Stroemungsmechanik, Goettingen, West Germany) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 11 p. refs
(AIAA PAPER 87-0423)

A new version of an unfactored predictor-corrector method for simulating transonic airfoil flows with relatively coarse C-type meshes has been developed, and results using the method are presented. The method dramatically reduces the time used on a supercomputer by imposing zero-change boundary conditions for the implicit increments at the wake cut. The method uses matrix-split fluxes of first-order accuracy in the implicit terms and second-order accurate upwind and central approximations for the explicit terms in the wall-tangential and wall-normal directions. For higher-order flux splitting limiter functions improve the solution for Euler equations, particularly if they result in total variation diminishing schemes.
C.D.

A87-24963#
A NUMERICAL STUDY OF VISCOUS TRANSONIC FLOWS USING RRK SCHEME
KOJI MORINISHI and NOBUYUKI SATOFUKA (Kyoto Institute of Technology, Japan) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 10 p. refs
(AIAA PAPER 87-0426)

An efficient numerical solution has been developed for viscous transonic flows. The thin-layer Navier-Stokes equations are solved by using the rational Runge-Kutta time-stepping procedure combined with the usual central finite difference approximations. The residual averaging and multigrid techniques are incorporated into the method, so that the rate of convergence to a steady state solution is improved. The algebraic two-layer eddy viscosity model proposed by Baldwin and Lomax (1978) is used to simulate turbulent flows. Numerical results for all mandatory cases of the NACA 0012, RAE 2822, and Jones airfoil are included. The results for the RAE 2822 airfoil cases are compared with experiments of Cook et al. (1979). The present numerical method is confirmed to be stable and efficient over a wide range of viscous transonic flow conditions.
Author

A87-24964#
A SEMIEMPIRICAL INTERPOLATION TECHNIQUE FOR PREDICTING FULL-SCALE FLIGHT CHARACTERISTICS
S. H. REICHENBACH and J. H. MCMASTERS (Boeing Commercial Airplane Co., Seattle, WA) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 6 p. refs
(AIAA PAPER 87-0427)

A new method for predicting full-scale flight characteristics using both wind tunnel data and inviscid computational fluid dynamics (CFD) results has been developed. This method, termed 'semiempirical interpolation', has been validated for prediction of empennage control effectiveness. Results are presented for two modern transport aircraft over a wide range of Mach number. Alternate applications and the range of validity of the method are briefly addressed.
Author

A87-24966*# Florida State Univ., Tallahassee.
UNSTEADY SEPARATED FLOWS - NOVEL EXPERIMENTAL APPROACH
A. KROTHAPALLI (Florida State University, Tallahassee) and L. LOURENCO AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 14 p. refs
(Contract NAG2-314; AF-AFOSR-86-0243)
(AIAA PAPER 87-0459)

A novel experimental technique, commonly referred to as laser speckle velocimetry or particle image displacement velocimetry (PIDV), is developed for the measurement of instantaneous velocity fields in unsteady and steady flows. The main advantage of this technique is the fact that the velocity field is measured with sufficient accuracy so that the distribution of vorticity can be calculated with accuracy. The PIDV technique, which is ideally suited for the study of unsteady separated flows, has been utilized to measure the development of the separated flow field generated by a high angle-of-attack (alpha = 30 deg) NACA 0012 airfoil, started impulsively from rest.
Author

A87-24970#
THE INFLUENCE OF AN ADDITIONAL DEGREE OF FREEDOM ON SUBSONIC WING ROCK OF SLENDER DELTA WINGS
J. M. ELZEBDA, D. T. MOOK, and A. H. NAYFEH (Virginia Polytechnic Institute and State University, Blacksburg) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 15 p. refs
(Contract AF-AFOSR-85-0158)
(AIAA PAPER 87-0496)

A numerical simulation of the subsonic wing-rock phenomenon for slender delta wings is described for a wing free to rotate simultaneously in roll and pitch. The equations of motion for the two-degree-of-freedom (DOF) case are integrated numerically by a predictor-corrector technique, and the unsteady vortex-lattice method is used to provide the aerodynamic loads. The results show that, below the first critical angle of attack (CAOA), all disturbances decay for both one and two DOFs. The first CA appears to be the same for one and two DOFs. For one DOF in roll, the motion develops a limit cycle when the AOA is above the first CA. For two DOFs in roll and pitch, the motion is almost entirely in roll when the AOA is above the first CA and below the second CA. For one DOF in pitch, the motion always decays to the static equilibrium position. C.D.

A87-24971*# Boeing Vertol Co., Philadelphia, Pa.
BLADE-VORTEX INTERACTION
DAVID R. POLING, LEO DADONE (Boeing Vertol Co., Philadelphia, PA), and DEMETRI P. TELIONIS (Virginia Polytechnic Institute and State University, Blacksburg) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 8 p. NASA-sponsored research. refs
(AIAA PAPER 87-0497)

A conformal transformation and discrete vortex dynamics are used to calculate the interaction of a blade with vortices drifting with the free stream. An unsteady Kutta condition is employed to dictate the strength of vortices shed at the trailing edge. Instantaneous pressure distributions are calculated and compared with earlier experimental and analytical data. Author

A87-24976#
NUMERICAL METHOD FOR NON-EQUILIBRIUM HYPERSONIC BOUNDARY LAYERS
M. L. FINSON and P. G. AMEER (Physical Sciences, Inc., Andover, MA) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 22 p. refs
(Contract F04704-84-C-0069; F04704-86-C-0030)
(AIAA PAPER 87-0516)

A new method is developed for the computation of nonequilibrium boundary layer chemical properties around a hypersonic vehicle. The method is based on a fully-implicit numerical algorithm, with complete coupling between chemical species. It provides reliable solutions for all conditions ranging from nonreacting cases to situations arbitrarily close to chemical equilibrium. A general coordinate system is used which applies to both laminar and turbulent flow conditions and automatically allows the computational mesh to expand with boundary layer growth. Available models for multicomponent species diffusion and turbulent eddy viscosity are employed. Sample results are presented for a hypersonic vehicle over the altitude range 45 to 15 km, illustrating the nonequilibrium nature of air electron chemistry at higher altitudes and the approach to equilibrium at low altitudes. Author

A87-24977#
TRANSONIC WING OPTIMIZATION USING EVOLUTION THEORY
R. D. GREGG (Douglas Aircraft Co., Long Beach, CA) and K. P. MISEGADES (Cray Research, Inc., Mendota Heights, MN) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 7 p. refs
(AIAA PAPER 87-0520)

The development of a transonic wing optimization procedure using evolution theory is discussed. Measure-of-merit functions used to evaluate the aerodynamic efficiency of a wing are reviewed. FLO-22 is utilized to analyze the transonic aerodynamic characteristics in the current optimization process, and multitasking is applied to reduce turnaround time. Two optimization test cases are presented, which investigate the impact of the number of design variables on convergence rate. Results indicate that the evolution theory is a simple optimization technique that is easy to implement, exhibits fast convergence rates, and is insensitive to the number of design variables. Author

A87-24981*# Arizona Univ., Tucson.
A TRUNCATION ERROR INJECTION APPROACH TO VISCOUS-INVISCID INTERACTION
B. D. GOBLE and K.-Y. FUNG (Arizona, University, Tucson) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 9 p. refs
(Contract NCA2-107; AF-AFOSR-83-0071)
(AIAA PAPER 87-540)

An approach to viscous-inviscid interaction which is based on truncation error injection is presented in the context of solving flow over an airfoil. A two-dimensional interpolation scheme is used to restrict the fine grid solutions to the global coarse grid. Details on the current implementation of the approach are given, and the boundary conditions being used are discussed. Inviscid results from a NACA0012 airfoil test case and the viscous results are presented. C.D.

A87-24982#
FREE WAKE ANALYSIS OF COMPRESSIBLE ROTOR FLOWS
JOHN STEINHOFF and K. RAMACHANDRAN (Tennessee, University, Tullahoma) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 14 p. refs
(Contract DAAG29-K-0019)
(AIAA PAPER 87-0542)

A method for computing the three-dimensional flow over a helicopter rotor in hover is described which includes compressibility and wake effects. The method requires only the blade geometry and rotational speed as inputs, and no external data or parameter adjustments to define the wake position or other features of the flow. Results are presented which indicate good agreement with experimental results of wake descent and contraction as well as surface pressure distributions and thrust coefficients. These results include both high and low aspect ratio blades with two and four blades and subsonic and transonic flows, including shocks. C.D.

A87-24989*# Texas A&M Univ., College Station.
AN EXPERIMENTAL STUDY OF THE AERODYNAMIC CHARACTERISTICS OF PLANAR AND NON-PLANAR OUTBOARD WING PLANFORMS
D. A. NAIK and C. OSTOWARI (Texas A & M University, College Station) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 14 p. refs
(Contract NAG1-344)
(AIAA PAPER 87-0588)

A series of wind tunnel experiments have been conducted to investigate the aerodynamic characteristics of several planar and nonplanar wingtip planforms. Seven different configurations: base-line rectangular, elliptical, swept and tapered, swept and tapered with dihedral, swept and tapered with anhedral, rising arc, and drooping arc, were investigated for two different spans. The data are available in terms of coefficient plots of force data, flow visualization photographs, and velocity and pressure flowfield surveys. All planforms, particularly the nonplanar, have some advantages over the baseline rectangular planform. Span efficiencies up to 20-percent greater than baseline are a possibility. However, it is suggested that the span efficiency concept might need refinement for nonplanar wings. Flow survey data show the change in effective span with vortex roll-up. The flow visualization shows the occurrence of mushroom-cell-separation flow patterns at angles of attack corresponding to stall. These grow with an increase in post-stall angle of attack. For the larger aspect ratios, the cells are observed to split into sub-cells at the higher angles of attack. For all angles of attack, some amount of secondary vortex flow is observed for the planar and nonplanar out-board planforms with sweep and taper. Author

A87-24990#
MULTIZONE EULER MARCHING TECHNIQUE FOR FLOW OVER SINGLE AND MULTIBODY CONFIGURATIONS
K. Y. SZEMA, S. R. CHAKRAVARTHY (Rockwell International Science Center, Thousand Oaks, CA), W. T. RIBA, J. BYERLY, and H. S. DRESSER (Rockwell International Corp., Space Div., Downey, CA) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 11 p. refs
(AIAA PAPER 87-0592)

A new unified approach to efficiently solve the unsteady Euler equations across the entire Mach-number range is developed and applied to a variety of very complex three-dimensional configurations. A finite volume, multizone implementation of high accuracy, total variation-diminishing (TVD) formulation (based on Roe's scheme) is used in the Euler solver. In the supersonic regions of the flow, an 'infinitely large' time step and a space-marching scheme are employed. A finite time step and a relaxation method are used in subsonic flow regions. The multizone technique allows very complicated configurations to be modeled without geometry modifications. Numerical results are obtained for several realistic fighter configurations and mated Shuttle Orbiter with external tank and solid rocket boosters. Solutions are in very good agreement with available experimental data. Author

A87-24991*# Cincinnati Univ., Ohio.
SOLUTION OF THE TWO-DIMENSIONAL NAVIER-STOKES EQUATIONS USING SPARSE MATRIX SOLVERS
ERICH E. BENDER and PREM K. KHOSLA (Cincinnati, University, OH) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 10 p. refs
(Contract F49620-85-C-0027; NGT-36-004-800)
(AIAA PAPER 87-0603)

The use of direct sparse matrix solvers in the solution of the Navier-Stokes equations is investigated. The Yale Sparse Matrix Package and its implementation in the solution algorithm is described. The streamfunction-vorticity form of the Navier-Stokes equations are discretized and linearized and the resulting system of equations are solved using this package. Several viscous flow problems are investigated, including flow in a cavity and flow around a NACA0012 airfoil. Massively separated flow around a sine wave airfoil is investigated and high Reynolds number solutions are obtained. A solution of the unsteady flow around a Joukowski airfoil at high angle of attack is presented. Author

A87-24992*# Cornell Univ., Ithaca, N.Y.
MULTIGRID SOLUTION OF INVISCID TRANSONIC FLOW THROUGH ROTATING BLADE PASSAGES
WAYNE A. SMITH and DAVID A. CAUGHEY (Cornell University, Ithaca, NY) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 10 p. refs
(Contract NAG3-645)
(AIAA PAPER 87-0608)

A fast Euler solver for three dimensional inviscid transonic flow in rotating domains is described. The time dependent Euler equations are discretized spatially with finite volumes, and are advanced temporally with a multiple stage time stepping scheme. A dramatic increase in the rate of convergence for steady solutions is achieved with a multigrid algorithm that employs the multistage scheme as its smoothing procedure. The effectiveness of the multistage scheme as a multigrid driver is enhanced by the utilization of analytically determined combinations of the governing parameters. Author

A87-25002
A NUMERICAL METHOD FOR THE CALCULATION OF INCOMPRESSIBLE, STEADY, SEPARATED FLOWS AROUND AEROFOILS
G. TZABIRAS, T. LOUKAKIS (Athens, National Technical University, Greece), and A. DIMAS International Journal for Numerical Methods in Fluids (ISSN 0271-2091), vol. 6, Nov. 1986, p. 789-809. refs

The present work deals with the numerical calculation of the incompressible turbulent flow around airfoils. An orthogonal curvilinear grid of 'C' type is used for the solution of the time-averaged equations, and Reynolds stresses are modeled according to the k-epsilon turbulence model. PISO and SIMPLE algorithms are used to solve the strongly coupled system of the derived finite volume equations, and convergence is improved by applying the method of variable local underrelaxation factors. Comparisons between the calculated and measured pressure distributions are presented for NACA 0012 and NACA 4412 wing sections. The formation of separation bubbles according to calculations is also shown. Author

A87-25028
UNSTEADY SWEEP - A KEY TO SIMULATION OF THREE-DIMENSIONAL ROTOR BLADE AIRLOADS
ULRICH LEISS (Muenchen, Universitaet der Bundeswehr, Munich, West Germany) (European Rotorcraft Forum, 11th, London, England, Sept. 10-13, 1985) Vertica (ISSN 0360-5450), vol. 10, no. 3-4, 1986, p. 341-351. refs
(Contract BMFT-LFF-83408)

A two-dimensional semiempirical model exists for simulation of aerodynamic coefficients at arbitrary angles of attack and Mach numbers. The developed structure was modular to include three-dimensional effects. First of all the steady influence of the radial flow component is considered in a manner consistent with the fundamental two-dimensional formulation. Next tip losses are accounted for by a continuous reduction function due to the aspect ratio. Finally parameters are introduced as low order functions of the radial blade coordinate. Consequently fixed blade elements are no longer necessary. Analytical radial integration of aerodynamic coefficients is presented. The unsteady sweep is derived on this steady physical basis. Recent experiments on swept oscillating airfoils are used to simulate the dominating viscous effects. Dynamic sweep plays an important role interacting with the two-dimensional unsteady phenomenas. It is shown how the developed formulation can be a general aerodynamic module for the next generation real time simulation analyses. Author

A87-25226
A THREE-DIMENSIONAL TURBULENT BOUNDARY LAYER ON A BODY OF COMPLEX SHAPE [PROSTRANSTVENNYI TURBULENTNYI POGRANICHNYI SLOI NA TELE SLOZHNOI FORMY]
V. A. ALEKSIN and IU. D. SHEVELEV Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza (ISSN 0568-5281), Sept.-Oct. 1986, p. 25-35. In Russian. refs

Three-dimensional flow of a compressible gas past bodies of complex shape at small angles of attack is calculated by the finite difference method. Equations of a three-dimensional turbulent boundary layer are solved numerically, and an analysis is made of the effect of the principal parameters on the evolution of three-dimensional flows and heat transfer. Characteristic flow regions in the boundary layer are determined, as are the positions of maximum heat flow and surface friction. The intensity of secondary flows in the boundary layer is estimated. V.L.

A87-25227
THE EFFECT OF THE SURFACE NONISOTHERMALITY OF A THIN PROFILE ON THE STABILITY OF A LAMINAR BOUNDARY LAYER [VLIIANIE NEIZOTERMICHNOSTI POVERKHNOSTI TONKOGO PROFILIA NA USTOICHIVOST' LAMINARNOGO POGRANICHNOGO SLOIA]
A. V. KAZAKOV and A. P. KURIACHII Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza (ISSN 0568-5281), Sept.-Oct. 1986, p. 36-42. In Russian. refs

A study is made of the possibility of delaying the turbulent transition by creating a nonuniform temperature distribution over the surface of thin profiles in the case where the presence of an unfavorable pressure gradient in external flow has a destabilizing effect on the boundary layer. Calculations are presented to show that, even in the presence of an unfavorable pressure gradient in external flow, the heating of a part of the profile surface near the leading edge and the generation of a certain temperature distribution over the body surface make it possible to increase the rise time of unstable perturbations and to delay the laminar-turbulent transition. V.L.

A87-25228

THE EFFECT OF A FINELY DISPERSED ADMIXTURE ON THE BOUNDARY LAYER STRUCTURE IN HYPERSONIC FLOW PAST A BLUNT BODY [VLIIANIE MELKODISPERSNOI PRIMESI NA STRUKTURU POGRANICHNOGO SLOIA PRI GIPERZVUKOVOM OBTEKANII ZATUPLENNOGO TELA]

A. N. OSIPTSOV and E. G. SHAPIRO Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza (ISSN 0568-5281), Sept.-Oct. 1986, p. 55-62. In Russian. refs

Heat flow toward the critical point of a blunt body in hypersonic flow of a dusted gas is investigated analytically, with allowance for the effect of particles on the motion of the carrier phase made only in the boundary layer due to a sharp increase in particle concentration near the wall. The motion of the gas in the shock layer is described by using the constant-density solution. The equations of the boundary layer in the vicinity of the critical point are solved over a wide range of parameters. It is shown that, even in the case of low mass concentrations of particles in the incoming flow (2-5 percent), a significant increase (up to 100 percent) of heat flow toward the critical point of the body is possible. V.L.

A87-25229

FLOW OF AN IDEAL INCOMPRESSIBLE FLUID PAST A FINITE-SPAN THIN WING VIBRATING WITH A LARGE AMPLITUDE [OBTEKANIE IDEAL'NOI NESZHIMAEMOI ZHIDKOST'IU TONKOGO KRYLA KONECHNOGO RAZMAKHA KOLEBLIUSHCHEGOSIA S BOL'SHOI AMPLITUDOI]

A. A. ZAITSEV and A. A. FEDOTOV Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza (ISSN 0568-5281), Sept.-Oct. 1986, p. 75-82. In Russian. refs

Nonstationary flow of an ideal incompressible fluid past an infinitely thin finite-span wing vibrating with a large amplitude is investigated with allowance for nonlinear effects. The problem is solved numerically using the vortex surface method whereby the wing and the tangential fluid velocity discontinuity surface are represented by continuous vortex surfaces. The accuracy of the vortex surface method is verified experimentally for the case of a square plate accelerating at constant angle of attack and constant velocity from the state of rest. A hydrodynamic model is developed for the tail fin of a dolphin. V.L.

A87-25231

A STUDY OF THE SHAPE OF THE CROSS-SECTION PROFILE OF A MINIMUM-DRAG THREE-DIMENSIONAL CONICAL BODY MOVING IN A RAREFIED GAS [ISSLEDOVANIE FORMY POPERECHNOGO KONTURA KONICHESKOGO PROSTRANSTVENNOGO TELA MINIMAL'NOGO SOPROTIVLENIAA, DVIZHUSHCHEGOSIA V RAZREZHENNOM GAZE]

A. I. BUNIMOVICH and G. E. IAKUNINA Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza (ISSN 0568-5281), Sept.-Oct. 1986, p. 112-117. In Russian. refs

The objective of the study is to determine the optimal shape of three-dimensional bodies characterized by minimum drag during flight in a rarefied gas at intermediate altitudes. The optimal shape of the cross-section profile of minimum-drag bodies is determined by solving a variational problem for a functional in a class of piecewise smooth functions with isoperimetric and closed-profile conditions. The limiting cases of Newtonian hypersonic and free-molecular flows of a rarefied gas are examined. It is shown that star-shaped bodies are more efficient in terms of drag than bodies of revolution at all altitudes. However, the efficiency of using star-shaped bodies in comparison with equivalent bodies of revolution decreases with increasing flight altitude (gas rarefaction). V.L.

A87-25232

A STUDY OF SUPERSONIC THREE-DIMENSIONAL FLOW PAST POINTED AXISYMMETRIC BODIES [ISSLEDOVANIIE SVERKHZVUKOVOGO PROSTRANSTVENNOGO OBTEKANIIA ZAOSTRENNYKH OSESIMMETRICHNYKH TEL]

V. I. LAPYGIN Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza (ISSN 0568-5281), Sept.-Oct. 1986, p. 127-133. In Russian. refs

Flow past bodies of revolution with a long pointed cylindrical nose section is analyzed in the context of an ideal gas model using a numerical model based on McCormak's finite difference scheme. The existence in the shock layer of internal shocks of both longitudinal and transverse orientations is demonstrated. Changes in the aerodynamic coefficients of the configuration are investigated as a function of its length, angles of attack, and the Mach number of the incoming flow. The results obtained are compared with experimental data, and a relationship is established between flow parameters on the body surface and the position of the boundary layer separation line on the lateral surface of the body. A method is proposed for taking account of the effect of the boundary layer on the aerodynamic coefficients of bodies of revolution of large aspect ratios at small angles of attack. V.L.

A87-25233

NUMERICAL MODELING OF SHOCK WAVE INTERSECTIONS [O CHISLENNOM MODELIROVANII PERESECHENII UDARNYKH VOLN]

IU. M. LIPNITSKII and A. V. PANASENKO Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza (ISSN 0568-5281), Sept.-Oct. 1986, p. 134-140. In Russian. refs

The nonstationary intersection of shock waves is investigated by solving numerically the axisymmetric boundary value problem associated with the diffraction of a plane shock wave by a cone in supersonic gas flow. In the context of linear theory, an analysis of stationary flow parameters leads to the existence of five qualitatively different flow regimes. It is shown, that, even in the case of low-intensity shock waves, the five flow regimes result in different formulations of the corresponding boundary value problems. V.L.

A87-25280

COLLISION OF MULTIPLE SUPERSONIC JETS RELATED TO PIP NOISE GENERATION IN CAGE VALVE

R. OKUTSU (Yamatake-Honeywell Co., Ltd., Samukawa, Japan), W. OOMOTO, T. MACHIYAMA (Nippon Institute of Technology, Miyashiro, Japan), and E. OUTA (Waseda University, Tokyo, Japan) IN: Fluid control and measurement; Proceedings of the International Symposium, Tokyo, Japan, Sept. 2-5, 1985. Volume 1 . Oxford, England and New York, Pergamon Press, 1986, p. 533-538.

The generation of pip-type noise during the throttling of a compressible fluid in a cage valve is investigated experimentally, using Xe-microflash shadow photography to visualize the collision of two supersonic jets. Phenomena observed include formation of a large eddy in a low-supercritical center-collision case (with a sustained wave mode relative to a dipole source) and multistage-stable center or off-center collisions (with intermittent wave modes and a quadrupole-source mode when the collision is on center) at pressure ratio 3-6. T.K.

A87-25293

VISUALIZATION AND REGISTRATION OF UNSTEADY PHENOMENA IN TRANSONIC FLOWS

W. FRANK (Karlsruhe, Universitaet, West Germany) IN: Fluid control and measurement; Proceedings of the International Symposium, Tokyo, Japan, Sept. 2-5, 1985. Volume 2 . Oxford, England and New York, Pergamon Press, 1986, p. 775-780.

The flow around a wedge profile which periodically changes its angle of attack is investigated experimentally in a supersonic wind tunnel for freestream Mach numbers which are only slightly greater than one. For low angle of attack, an attached shock wave detaches and moves upstream; if the angle decreases it approaches the tip again. The moving bow shock is visualized by optical methods such as schlieren, color schlieren, and interference techniques. The path-time diagrams for the shock motion are registered by high-speed cameras and by schlieren-streak pictures. The investigations show that there exists a phase shift between the running shock wave and the varying angle of attack of the profile. The experimental results for the time-dependent stand-off distance are compared with theoretical considerations. Author

A87-25395*# Sverdrup Technology, Inc., Cleveland, Ohio.
A NUMERICAL SIMULATION OF THE INVISCID FLOW THROUGH A COUNTERROTATING PROPELLER
M. L. CELESTINA, R. A. MULAC (Sverdrup Technology, Inc., Middleburg Heights, OH), and J. J. ADAMCZYK (NASA, Lewis Research Center, Cleveland, OH) ASME, Transactions, Journal of Turbomachinery (ISSN 0889-504X), vol. 108, Oct. 1986, p. 187-193. Previously announced in STAR as N86-16195. refs
(ASME PAPER 86-GT-138)
The results of a numerical simulation of the time-averaged inviscid flow field through the blade rows of a multiblade row turboprop configuration are presented. The governing equations are outlined along with a discussion of the solution procedure and coding strategy. Numerical results obtained from a simulation of the flow field through a modern high-speed turboprop will be shown. Author

A87-25416#
EXPERIMENTAL INVESTIGATION ON COMPRESSOR STATOR TANDEM CASCADES AT HIGH SUBSONIC SPEED
BIAONAN ZHUANG and BINGHENG GUO (Nanjing Aeronautical Institute, People's Republic of China) Journal of Aerospace Power, vol. 1, July 1986, p. 37-40. In Chinese, with abstract in English.
The results of wind-tunnel tests on two compressor stator cascades (one with an approximately C-4 profile and one with a double-circular-arc profile) at freestream Mach numbers 0.55-0.75 and angles of incidence I = -5 to +7.5 deg are reported. The results are presented in tables and graphs and characterized. The optimum values for the C-4 cascade at Mach 0.7 are found to be I = 0 deg, Delta beta = 57.7 deg, omega-bar = 0.106, and c(p) = 0.31; the corresponding values for the double-arc cascade are 0 deg, 54 deg, 0.136, and 0.35. T.K.

A87-25595
ON THE APPLICATION OF LINEARISED THEORY TO MULTI-ELEMENT AEROFOILS. II - EFFECTS OF THICKNESS, CAMBER AND STAGGER
G. D. WATT (Defence Research Establishment Atlantic, Dartmouth, Canada) and G. V. PARKINSON (British Columbia, University, Vancouver, Canada) Aeronautical Journal (ISSN 0001-9240), vol. 90, Nov. 1986, p. 339-356. refs
A linearized two-dimensional incompressible potential flow theory for two-element aerofoil sections is developed. It is capable of predicting the effects of angle of attack, flap deflection, camber, thickness, stagger and overlap of aerofoil elements on the forces. These effects are summarized in integrals which are analogous to the one-element thin aerofoil theory Munk integrals. Analytical expressions for the forces on tandem NACA 23012 aerofoils have been derived and results are presented. Comparisons are also made with a realistic slotted flap configuration with overlap for which experimental data is available. The linearized theory is seen to correlate with these real flow results as well as and better than it does in the one-element regime. Author

A87-25716*# Stanford Univ., Calif.
CIRCULATION CONTROL AIRFOILS AS APPLIED TO ROTARY-WING AIRCRAFT
N. J. WOOD (Stanford University, CA) and JACK N. NIELSEN (NASA, Ames Research Center, Moffett Field, CA) Journal of Aircraft (ISSN 0021-8669), vol. 23, Dec. 1986, p. 865-875. Previously cited in issue 07, p. 840, Accession no. A85-19588. refs

A87-25718#
NAVIER-STOKES SOLUTION FOR A COMPLETE RE-ENTRY CONFIGURATION
J. S. SHANG and S. J. SCHERR (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) (Computational Fluid Dynamics Conference, 7th, Cincinnati, OH, July 15-17, 1985, Technical Papers, p. 182-191) Journal of Aircraft (ISSN 0021-8669), vol. 23, Dec. 1986, p. 881-888. Previously cited in issue 19, p. 2743, Accession no. A85-40944. refs

A87-25720*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
UNSTEADY TRANSONIC FLOW CALCULATIONS FOR WING/FUSELAGE CONFIGURATIONS
JOHN T. BATINA (NASA, Langley Research Center, Hampton, VA) (Structures, Structural Dynamics and Materials Conference, 27th, San Antonio, TX, May 19-21, 1986, Technical Papers. Part 2, p. 142-155) Journal of Aircraft (ISSN 0021-8669), vol. 23, Dec. 1986, p. 897-903. Previously cited in issue 18, p. 2603, Accession no. A86-38897. refs

A87-25723*# Helicopter Aeronautics and Noise Associates, Mountain View, Calif.
FULL-POTENTIAL CIRCULAR WAKE SOLUTION OF A TWISTED ROTOR BLADE IN HOVER
HANS R. AGGARWAL (Helicopter Aerodynamics and Noise Associates, Mountain View, CA) Journal of Aircraft (ISSN 0021-8669), vol. 23, Dec. 1986, p. 914, 915. refs
(Contract NAS2-12072)
A solution for transonic flow past a twisted rotor blade in hover is obtained using a modified version of the full-potential code ROT22 and a circular wake. The flow is also evaluated for a fixed-wing-type straight wake. The solutions for the straight wake and circular wake, and the circular wake and a two-dimensional wake are compared. The data reveal that the circular wake and the general two-dimensional wake solutions have similar characteristics. I.F.

A87-25907#
ANALYSIS OF VELOCITY POTENTIAL AROUND INTERSECTING BODIES
Y. MORCHOISNE (ONERA, Chatillon-sous-Bagneux, France) and J. RYAN La Recherche Aerospatiale (English Edition) (ISSN 0379-380X), no. 2, 1986, p. 1-7.
Up till now, when the panel method was used in computing inviscid, incompressible and stationary flows around arbitrary bodies, only the outer surfaces were meshed. With the method developed here, totally independent, disconnected meshes can be used for connected elements of disparate geometry such as wing + fuselage + pylon + nacelle. The fictitious inner surfaces are then analyzed in the same way as the outer surfaces. Applications to simple cases are offered to validate this technique, which will greatly simplify aerodynamic studies of complex configurations. Author

A87-25912#
REDUCTION OF TURBULENT SKIN FRICTION - TURBULENCE MODERATORS
E. COUSTOLS and J. COUSTEIX (ONERA, Centre d'Etudes et de Recherches de Toulouse, France) La Recherche Aerospatiale (English Edition) (ISSN 0379-380X), no. 2, 1986, p. 63-78. Previously cited in issue 23, p. 3394, Accession no. A86-48455. refs

A87-25972#

ANALYSIS OF THE INFLUENCE OF THE HEIGHT ABOVE THE GROUND OF A JET-ENGINE AIR-INTAKE ON THE STRUCTURE OF FREE INLET AIR FLOW [ANALIZA WPLYWU ODLEGLOSCI OD ZIEMI WLOTU SILNIKA ODRZUTOWEGO NA STRUKTURE SWOBODNEGO PRZEPLYWU WLOTOWEGO]

TADEUSZ GAJEWSKI (Wyzsza Oficerska Szkola Lotnicza, Deblin, Poland) Technika Lotnicza i Astronautyczna (ISSN 0040-1145), vol. 41, July 1986, p. 6-9. In Polish. refs

A method for free inlet air flow modelling and analysis is presented. This method makes it possible to determine the minimum height above the ground of a jet-engine air intake for the ground effect on the inlet air flow to be negligible. K.K.

A87-26079

A NUMERICAL STUDY OF INCOMPRESSIBLE NAVIER-STOKES FLOW THROUGH RECTILINEAR AND RADIAL CASCADE OF TURBINE BLADES

W. SHYY (General Electric Co., Schenectady, NY) and T. C. VU (Dominion Engineering Works, Montreal, Canada) Computational Mechanics (ISSN 0178-7675), vol. 1, no. 4, 1986, p. 269-279. refs

A numerical study is conducted to analyze the two-dimensional incompressible Navier-Stokes flows through the rectilinear and radial cascade of turbine blades. The flows are turbulent and their characteristics are relevant to those of the hydraulic turbines. For the rectilinear cascade, calculations have been made for a NACA 80 series turbine blade with various angles of attack. The outflow turning angle, force coefficients and static pressure distribution have been compared between the prediction and measurement with satisfactory agreements being obtained. The implications of flow turning angles on the total pressure loss are also discussed. The effects of grid distribution on the numerical predictions are also observed. Author

A87-27168#

UNSTEADY AERODYNAMIC CHARACTERISTICS OF ANNULAR CASCADE OSCILLATING IN TRANSONIC FLOW. I - MEASUREMENT OF AERODYNAMIC DAMPING WITH FREON GAS CONTROLLED-OSCILLATED ANNULAR CASCADE TEST FACILITY

HIROSHI KOBAYASHI (National Aerospace Laboratory, Chofu, Japan) JSME, Bulletin (ISSN 0021-3764), vol. 29, Oct. 1986, p. 3303-3312. refs

This paper describes a developed annular cascade wind tunnel and newly developed experimental techniques for investigating aerodynamic damping acting on an annular cascade in a transonic flow and at a high reduced frequency. For the study, a high speed mechanical drive system has been developed and Freon gas has been chosen as working fluid in the wind tunnel. The drive system can oscillate in controlled fashion all 16 blades composing an annular cascade in torsional mode at a constant amplitude and at a constant interblade phase angle up to a frequency of 500 Hz. This frequency corresponds to a reduced frequency of 1.2 (at M = 1.4 and C = 72 mm). Three auxiliary apparatus also have been developed for aerodynamic damping measurement and flow visualization. Author

A87-27469#

PRESSURE MEASUREMENT ON TWO SPANWISE REFLEX CAMBERED DELTA WINGS WITH LEADING EDGE SEPARATION

V. S. HOLLA (Indian Institute of Technology, Bangalore, India) and P. K. RAMAMURTHY Aeronautical Society of India, Journal (ISSN 0001-9267), vol. 38, Feb. 1986, p. 21-26. refs

An experimental investigation on two spanwise-cambered reflex slender delta wings with conical camber is reported. Static pressure measurements were made on both wings, in subsonic flow, at incidence ranging from 10 to 25 deg, under leading edge-separated flow conditions. The theoretical results calculated by Fernandez and Holla (1979) for the cambered wings are compared with experimental data in respect of the location and magnitude of the upper surface suction peak pressure coefficient near the leading edges. It is concluded that the theoretical method predicts the suction peak values and their location fairly accurately at some chordwise station in the middle portion of the wing (between 20 to 60 percent chordwise stations) at fairly large incidence. The reasons for these limitations of the theory are pointed out. Author

A87-27474#

ANALYSIS OF THE AIR FLOW INTO RAMJET COMBUSTION CHAMBERS

K. S. PADIYAR, V. RAMANUJACHARI, V. SRIRAMULU, and R. NATARAJAN (Indian Institute of Technology, Madras, India) Aeronautical Society of India, Journal (ISSN 0001-9267), vol. 38, Feb. 1986, p. 49-54.

In the present analysis of the flow of ram air through an axisymmetric annulus and into a cylindrical combustion chamber, the flow is subsonic and undergoes a sudden enlargement in cross-sectional area as it proceeds to the combustion chamber. Continuity, energy, momentum, and state-of-entropy equations have been solved iteratively to obtain flow properties at a cross sectional point where reattachment to the combustion chamber wall occurs, on the basis of four area enlargement ratios and three angles of air injection. Attention is given to exit Mach number, exit static pressure, exit temperature, and stagnation pressure loss. O.C.

A87-27475#

TRANSONIC POTENTIAL FLOW COMPUTATIONS AROUND FINITE WINGS

N. R. SUBRAMANIAN and S. K. CHAKRABARTTY (National Aeronautical Laboratory, Bangalore, India) Aeronautical Society of India, Journal (ISSN 0001-9267), vol. 38, Feb. 1986, p. 55-57. refs

Two computer programs STWING and SFL022 (adapted versions of NASA and Jameson's codes respectively) have been made operational on the UNIVAC 1160/H1 computer at NAL. The STWING solves the conservative 3D transonic full potential equation for a wing using the approximate factorization scheme. The SFL022 solves the nonconservative form of the transonic full potential equation using a relaxation scheme. These programs have been applied to a typical ONERA M6 wing. Comparisons between the results obtained by these codes have been made with calibrated experimental results. It is observed that both the codes predict the pressure distribution and the shock wave satisfactorily. Author

A87-27476#

WORKING PRINCIPLES OF INTAKE FENCES

SHIYING ZHANG and GAOMING YANG (Nanjing Aeronautical Institute, People's Republic of China) Journal of Aerospace Power, vol. 1, Oct. 1986, p. 97-102, 181. In Chinese, with abstract in English. refs

Air intake with fences installed at the entrance is investigated at low speed. With fences at high angles of attack, the steady and dynamic distortions are effectively reduced and the total pressure recovery is increased at the exit. These improvements are shown to be closely related to the reduced extent of separation along the leeward wall of the intake by the fences at the angle of attack. The mechanisms of the fences can be explained with this model, and the performance of the slanted inlet with fences can be predicted. The effects of the position, lengths, and the number of the fences on the inlet performance are studied. The difference between a slanted and a pitot inlet with fences is examined, and an intake with an S-duct and fences is evaluated. A multichannel inlet with less radar reflection is shown to be attractive. C.D.

A87-27479#
A METHOD FOR CALCULATION OF FLOW PROCESS IN AN AXISYMMETRIC STRAIGHT-WALL ANNULAR DIFFUSER
GUANGSHI HUA (Northwestern Polytechnical University, Xian, People's Republic of China) Journal of Aerospace Power, vol. 1, Oct. 1986, p. 111-116, 183. In Chinese, with abstract in English. refs

A complete method for calculation of the steady compressible flow in an axisymmetric straight-wall annular diffuser with boundary layer correction based on the stream-tube method has been developed. One of the main features is that, for determination of the static pressure (p/i + 1) at any downstream section from the inlet, two correlated formulas for direct and accurate calculation of the values of lambda(i + 1) and p(i + 1) respectively are derived. CPU time is then greatly reduced if the new solution procedure of the present study is employed. Calculations have been carried out for a short annular diffuser. The results are all in very good agreement with experimental data. This method is also applicable to the calculation of flow fields in a pre-diffuser of a short annular combustor-dump diffuser or in a two-dimensional straight-wall diffuser. Author

A87-27483#
A METHOD FOR COMPUTATION OF VISCID/INVISCID INTERACTION ON TRANSONIC COMPRESSOR CASCADES
HAOXIN JIANG, MAOZHANG CHEN, and JIYA CUI (Beijing Institute of Aeronautics and Astronautics, People's Republic of China) Journal of Aerospace Power, vol. 1, Oct. 1986, p. 131-136, 185, 186. In Chinese, with abstract in English. refs

An inviscid/viscous interaction method has been developed to predict the blade-to-blade flow in transonic compressor cascades. The method is to be used primarily for relatively high camber blades where the suction surface boundary layer may be slightly separated near the trailing edge. The inviscid flow was calculated by means of AF2 finite-difference scheme on a newly constructed H-type grid system, and the viscous flow by the aid of an integral method for laminar and turbulent boundary layers. An integration calculation was then carried out to determine the blade deviation angle and the total pressure loss coefficient. The numerical predictions obtained have been compared with test data on four different transonic cascades with reasonably good agreement. Author

A87-27484#
OPTIMUM COMPUTATION FOR EXIT CONE CONTOUR OF NOZZLE WITH TWO-PHASE FLOW
DINGYOU FANG (National University of Defense Technology, People's Republic of China) Journal of Aerospace Power, vol. 1, Oct. 1986, p. 137-140, 186. In Chinese, with abstract in English. refs

Optimum calculations of the exit cone contour of a nozzle with both transonic and supersonic two-phase flow are performed. The characteristics method is utilized, applying the direct marching method to the interior points and axis points and the inverse marching method to the wall points. The influences of inertia, compression, and rarefaction are considered. The two-dimensional two-phase specific impulse losses are computed, and the results indicate that the optimum initial expansion angles are about 28.5, 29.5, and 27.0 deg for parabolic, circular, and cubic contours respectively. The specific impulse losses for these nozzle configurations are almost the same when the exit angles are equal and the initial angles are close. C.D.

A87-27486#
RANDOM VERTEX METHOD AND SIMULATION OF VORTEX STRUCTURE BEHIND A TRIANGULAR PRISM
CHENGGANG XU, CHUANJUN YAN, HONGJI WANG, HUILING ZHU, and MING TANG (Northwestern Polytechnical University, Xian, People's Republic of China) Journal of Aerospace Power, vol. 1, Oct. 1986, p. 151-153, 188. In Chinese, with abstract in English.

In this paper, the flow passing a triangular prism has been calculated by random vertex method. In order to eliminate the oscillation of the tangential velocity at the prism surface, a coefficient Kw is introduced which is used to consider the interaction of newly generated vortex blobs at the surface. The idea of so called 'gravity blob' is proposed to save the CPU time in running the program for simulation of vortex structure behind the triangular prism. The essential features of the large-scale vortex structure in the recirculation region and Karman vortex street downstream are clearly shown in the figures of vortex blob distribution obtained from calculations. Author

A87-27487#
A FLIGHT-TEST STUDY ON THE TOTAL PRESSURE RECOVERY AND EXIT FLOW FIELD IN AN INLET
LIANG MIAO (Flight-Test Research Centre, People's Republic of China) Journal of Aerospace Power, vol. 1, Oct. 1986, p. 154-156, 188, 189. In Chinese, with abstract in English.

A flight-test study on the total pressure recovery and the exit flow field in an inlet of a supersonic jet aircraft is presented. The total pressure recovery characteristics and the exit total pressure distortion patterns in the transonic flight are given. The variation of the total pressure recovery coefficient and the distortion factor with Mach number during inlet-engine matching is illustrated. The flight test study provides valuable data for research on inlet-engine compatibility. Author

A87-27488#
EFFECT OF WAKE-TYPE INLET VELOCITY PROFILES ON PERFORMANCE OF SUBSONIC DIFFUSER
XIAO CHEN (Nanjing Aeronautical Institute, People's Republic of China) Journal of Aerospace Power, vol. 1, Oct. 1986, p. 157, 158, 189. In Chinese, with abstract in English.

The paper discusses an experimental investigation on a subsonic diffuser. When in the front of the subsonic two-dimensional diffuser an elliptic bar is placed perpendicular to the flow stream and parallel to the diverging wall of the diffuser, the wake-type inlet velocity profile is created and the core-stream turbulence level at the entrance of the diffuser is increased, which results in flatter velocity profile implying an increase in momentum transport across the boundary layer. The value of the boundary layer shape factor is therefore decreased. Consequently, the flow separation is delayed and the separation range is reduced. As a result, the static and the total pressure recovery coefficients of the diffuser rise by 30 percent and by 3 percent respectively when the maximum Mach number of the diffuser inlet reaches 0.7. Author

N87-16786 Stanford Univ., Calif.
THE AERODYNAMICS AND AEROACOUSTICS OF ROTATING TRANSONIC DISTURBANCES Ph.D. Thesis
JOHN W. RUTHERFORD 1986 122 p
Avail: Univ. Microfilms Order No. DA8619812

The aerodynamic flow field about a two-dimensional, transonically rotating disturbance is obtained using computational results from the transonic, small-disturbance, potential equation. A two-dimensional model, consisted of a circular-arc attached to the surface of a transonically, rotating cylinder, provides the same mechanism for the propagation of shocks into the far field as that found for a helicopter rotor blade in high tip speed hover. Current efforts to predict the high speed impulsive noise signature of a rotor blade have met with limited success above a limiting tip Mach number known as the delocalization Mach number. This is due to a radiating shock which forms even though the tip speed is subsonic. The two-dimensional model provides a simpler means of studying the flow field and predicting the pressure pulse without significantly altering the physics. A technique known as shock fitting is used to maintain the strong pressure discontinuity across the shock well into the flow field. Results are obtained out to nine cylinder radii, and a comparison of the pulse shape for shock fitting and shock capturing is also made. The method presented should be adaptable to the helicopter rotor problem due to experimental evidence showing the two-dimensionality of the radiating shock. Dissert. Abstr.

N87-16788 Purdue Univ., West Lafayette, Ind.
MEASUREMENT OF THE THREE-DIMENSIONAL AERODYNAMICS OF AN ANNULAR CASCADE AIRFOIL ROW Ph.D. Thesis
RICHIE CHARLES STAUTER 1986 247 p
Avail: Univ. Microfilms Order No. DA8622225

Aerodynamic design systems for turbomachine blade rows, which are evolving from simplified 2-D flow models to fundamentally 3-D models, necessarily use many assumptions. Such flow models must be validated by correlating their predictions with experimental data. The Purdue Annular Cascade Facility has been used to produce experimental data necessary to more fully understand the fundamentally 3-D nature of a turbomachine blade row flow field, and thus provide a database for flow model validation. The 3-D velocity field in the Purdue Annular Cascade Facility has been measured using a Laser Doppler Anemometer (LDA). A five degree-of-motion traversing system has been designed and fabricated to provide the various LDA probe volume orientations necessary to fully determine the velocity vector at any point in the flow field. Data produced by these experiments indicate significant three-dimensionality of the cascade passage flow field. Strong interaction is indicated between the vortices generated within the passage and the boundary layers on the passage surfaces. These interactions include transport of freestream fluid into the endwall regions and transport of fluid from the endwall regions onto the airfoil suction surface. These effects become more pronounced as the incidence angle increases.
Dissert. Abstr.

N87-16789*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
MEASUREMENTS OF THE UNSTEADY FLOW FIELD WITHIN THE STATOR ROW OF A TRANSONIC AXIAL-FLOW FAN. 1: MEASUREMENT AND ANALYSIS TECHNIQUE
K. L. SUDER, M. D. HATHAWAY (Army Research and Technology Labs., Cleveland, Ohio), T. H. OKIISHI (Iowa State Univ. of Science and Technology, Ames.), A. J. STRAZISAR, and J. J. ADAMCZYK 1987 17 p Proposed for presentation at the 32nd International Gas Turbine Conference and Exhibition, Anaheim, Calif., 31 May - 4 Jun. 1987; sponsored by ASME
(NASA-TM-88945; E-3393; NAS 1.15:88945; USAAVSCOM-TR-86-C-30) Avail: NTIS HC A02/MF A01 CSCL 01A

This two-part paper presents laser anemometer measurements of the unsteady velocity field within the stator row of a transonic axial-flow fan. The objective is to provide additional insight into unsteady blade-row interactions within high speed compressors which affect stage efficiency, energy transfer, and other design considerations. Part 1 describes the measurement and analysis techniques used for resolving the unsteady flow field features. The ensemble-average and variance of the measured velocities are used to identify the rotor wake generated and unresolved unsteadiness, respectively. (Rotor wake generated unsteadiness refers to the unsteadiness generated by the rotor wake velocity deficit and the term unresolved unsteadiness refers to all remaining contributions to unsteadiness such as vortex shedding, turbulence, mass flow fluctuations, etc.). A procedure for calculating auto and cross correlations of the rotor wake generated and unresolved unsteady velocity fluctuations is described. These unsteady-velocity correlations have significance since they also result from a decomposition of the Navier-Stokes equations. This decomposition of the Navier-Stokes equations resulting in the velocity correlations used to describe the unsteady velocity field will also be outlined in this paper.
Author

N87-16790*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
MEASUREMENTS OF THE UNSTEADY FLOW FIELD WITHIN THE STATOR ROW OF A TRANSONIC AXIAL-FLOW FAN. PART 2: RESULTS AND DISCUSSION
M. D. HATHAWAY, K. L. SUDER, T. H. OKIISHI (Iowa State Univ. of Science and Technology, Ames), A. J. STRAZISAR, and J. J. ADAMCZYK 1987 16 p Prepared for presentation at the 32nd International Gas Turbine Conference and Exhibition, Anaheim, Calif., 31 May - 4 Jun. 1987; sponsored by ASME
(NASA-TM-88946; E-3394; NAS 1.15:88946; USAAVSCOM-TR-86-C-31) Avail: NTIS HC A02/MF A01 CSCL 01A

Unsteady velocity field measurements made within the stator row of a transonic axial-flow fan are presented. Measurements were obtained at midspan for two different stator blade rows using a laser anemometer. The first stator row consists of double circular-arc airfoils with a solidity of 1.68. The second features controlled-diffusion airfoils with a solidity of 0.85. Both were tested at design-speed peak efficiency conditions. In addition, the controlled-diffusion stator was also tested at near stall conditions. The procedures developed here are used to identify the rotor wake generated and unresolved unsteadiness from the velocity measurements (rotor wake generated unsteadiness refers to the unsteadiness generated by the rotor wake velocity deficit and unresolved unsteadiness refers to all remaining unsteadiness which contributes to the spread in the distribution of velocities such as vortex shedding, turbulence, etc.). Auto and cross correlations of these unsteady velocity fluctuations are presented to show their relative magnitude and spatial distributions. Amplification and attenuation of both rotor wake generated and unresolved unsteadiness are shown to occur within the stator blade passage.
Author

N87-16791*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
COMPUTATION OF SEPARATION AHEAD OF BLUNT FIN IN SUPERSONIC TURBULENT FLOW
CHING-MAO HUNG Dec. 1986 9 p
(NASA-TM-89416; A-87047; NAS 1.15:89416) Avail: NTIS HC A02/MF A01 CSCL 01A

Separation ahead of a flat-face blunt fin in a supersonic turbulent boundary layer was studied numerically. The following observations and conclusions were made: (1) the length of separation increases to about 5.2 D, compared with about 2.0 to 2.5 D for the typical hemi-cylindrical results, and this numerical result confirms experimental observation; (2) even though there is a kink in pressure in the present case, there is no secondary separation under the main horseshoe vortices and there are three vortices, leading to the conclusion that the number of vortices is not always an even number; and (3) for the case investigated the separation point is connected to the inner (first) horseshoe vortex, rather than the outer (second) one. The four layers of fluid entrain in the three vortices, respectively.
Author

N87-16792*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
EULER SOLUTIONS USING AN IMPLICIT MULTIGRID TECHNIQUE
CHIEN-PENG LI Nov. 1986 19 p Presented at the 2nd Copper Mountain Multigrid Conference, 31 Mar. - 3 Apr. 1985
(NASA-TM-58276; NAS 1.15:58276) Avail: NTIS HC A02/MF A01 CSCL 01A

A coarse-grid correction algorithm has been implemented into an implicit upwind Euler solver and tested for transonic airfoil problems. The Euler solver uses split-flux formulation and penta-diagonal scalar equations, respectively, for the explicit and implicit operators. The multigrid sequence starts at the fine grid level, then steps down to each coarse grid level to smooth error components using implicit operators. Estimate of residuals can be obtained by two approaches, which differ in the level where the residuals are collected. Both approaches will lead to a work reduction factor of 12 for a Mach 0.75 flow at 2 degrees incidence on a 65x26 grid. The work reduction factor is found to increase proportional to the number of grid levels. Author

N87-16793*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

GEOMETRIES FOR ROUGHNESS SHAPES IN LAMINAR FLOW Patent

BRUCE J. HOLMES, inventor (to NASA), GLENN L. MARTIN, inventor (to NASA) (Kentron International, Inc., Hampton, Va.), CHRISTOPHER S. DOMACK, inventor (to NASA), CLIFFORD J. OBARA, inventor (to NASA), and AHMED A. HASSAN, inventor (to NASA) (Arizona State Univ., Tempe) 28 Oct. 1986 9 p Filed 10 Nov. 1983 Supersedes N84-12092 (22 - 03, p 320)
(NASA-CASE-LAR-13255-1; US-PATENT-4,619,423; US-PATENT-APPL-SN-550681; US-PATENT-CLASS-244-130; US-PATENT-CLASS-244-35R; US-PATENT-CLASS-244-200; US-PATENT-CLASS-244-204) Avail: US Patent and Trademark Office CSCL 01A

A passive interface mechanism between upper and lower skin structures, and a leading edge structure of a laminar flow airfoil is described. The interface mechanism takes many shapes. All are designed to be different than the sharp orthogonal arrangement prevalent in the prior art. The shapes of the interface structures are generally of two types: steps away from the centerline of the airfoil with a sloping surface directed toward the trailing edge and, the other design has a gap before the sloping surface. By properly shaping the step, the critical step height is increased by more than 50% over the orthogonal edged step.
Official Gazette of the US Patent and Trademark Office

N87-16794# Aeronautical Research Inst. of Sweden, Stockholm.

NAVIER-STOKES SOLUTION FOR LAMINAR TRANSONIC FLOW OVER A NACA0012 AIRFOIL

BERNHARD MUELLER 1986 101 p
(FAA-140) Avail: NTIS HC A06/MF A01

Laminar transonic flow at medium Reynolds numbers over a NACA0012 airfoil is numerically simulated by solving the two-dimensional compressible Navier-Stokes equations by means of the implicit central difference scheme of Beam and Warming. Recent improvements in efficiency, accuracy and convergence for the approximate factorization algorithm are employed, including local time stepping for steady-state calculations, combined 2nd and 4th order numerical damping, refined body and farfield boundary conditions, and linearization of the mixed derivatives. C-type meshes are generated by the transfinite interpolation method. The results cover the test cases for external flow of the GAMM Workshop on Numerical Simulation of Compressible Navier-Stokes Flows (1985) for Mach number M sub infinity=0.8, 0.85, 2, angles of attack alpha=0 deg and Reynolds numbers Re sub infinity=73 to 10 to the 4th power. Author

N87-16796*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

LOADS AND AEROELASTICITY DIVISION RESEARCH AND TECHNOLOGY ACCOMPLISHMENTS FOR FY 1986 AND PLANS FOR FY 1987

JAMES E. GARDNER and S. C. DIXON Jan. 1987 123 p
(NASA-TM-89084; NAS 1.15:89084) Avail: NTIS HC A06/MF A01 CSCL 01A

The Loads and Aeroelasticity Division's research accomplishments for FY 86 and research plans for FY 87 are presented. The work under each Branch (technical area) is described in terms of highlights of accomplishments during the past year and highlights of plans for the current year as they relate to five year plans for each technical area. This information will be useful in program coordination with other government organizations and industry in areas of mutual interest. Author

N87-16798*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

EULER ANALYSIS OF THE THREE DIMENSIONAL FLOW FIELD OF A HIGH-SPEED PROPELLER: BOUNDARY CONDITION EFFECTS

M. NALLASAMY (Sverdrup Technology, Inc., Cleveland, Ohio), B. J. CLARK, and J. F. GROENEWEG 1987 18 p Proposed for presentation at the 32nd International Gas Turbine Conference and Exhibition, Anaheim, Calif., 31 May - 4 Jun. 1987; sponsored by ASME
(NASA-TM-88955; E-3399; NAS 1.15:88955) Avail: NTIS HC A02/MF A01 CSCL 01A

The results of an investigation of the effects of far field boundary conditions on the solution of the three dimensional Euler equations governing the flow field of a high speed single rotation propeller are presented. The results show that the solutions obtained with the nonreflecting boundary conditions are in good agreement with experimental data. The specification of nonreflecting boundary conditions is effective in reducing the dependence of the solution on the location of the far field boundary. Details of the flow field within the blade passage and the tip vortex are presented. The dependence of the computed power coefficient on the blade passage and the tip vortex are presented. The dependence of the computed power coefficient on the blade setting angle is examined. Author

N87-16801*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

COMPUTATIONAL, UNSTEADY TRANSONIC AERODYNAMICS AND AEROELASTICITY ABOUT AIRFOILS AND WINGS

PETER M. GOORJIAN and GURU P. GURUSWAMY Jan. 1987 9 p Prepared for presentation at the International Conference on Fluid Mechanics, Beijing, China, 16-19 Jun. 1987
(NASA-TM-89414; A-87042; NAS 1.15:89414) Avail: NTIS HC A02/MF A01 CSCL 01A

Research in the area of computational, unsteady transonic flows about airfoils and wings, including aeroelastic effects is reviewed. In the last decade, there have been extensive developments in computational methods in response to the need for computer codes with which to study fundamental aerodynamic and aeroelastic problems in the critical transonic regime. For example, large commercial aircraft cruise most effectively in the transonic flight regime and computational fluid dynamics (CDF) provides a new tool, which can be used in combination with test facilities to reduce the costs, time, and risks of aircraft development. Author

N87-16802*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

COMPENDIUM OF NASA LANGLEY REPORTS ON HYPERSONIC AERODYNAMICS

FRANCES E. SABO, AUBREY M. CARY, and SHIRLEY W. LAWSON Jan. 1987 177 p
(NASA-TM-87760; NAS 1.15:87760) Avail: NTIS HC A09/MF A01 CSCL 01A

Reference is made to papers published by the Langley Research Center in various areas of hypersonic aerodynamics for the period 1950 to 1986. The research work was performed either in-house by the Center staff or by other personnel supported entirely or in part by grants or contracts. Abstracts have been included with the references when available. The references are listed chronologically and are grouped under the following general headings: (1) Aerodynamic Measurements - Single Shapes; (2) Aerodynamic Measurements - Configurations; (3) Aero-Heating; (4) Configuration Studies; (5) Propulsion Integration Experiment; (6) Propulsion Integration - Study; (7) Analysis Methods; (8) Test Techniques; and (9) Airframe Active Cooling Systems. Author

N87-16805*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
UNSTEADY FLOWS IN A SINGLE-STAGE TRANSONIC AXIAL-FLOW FAN STATOR ROW Ph.D. Thesis - Iowa State Univ.
MICHAEL D. HATHAWAY Dec. 1986 210 p
(NASA-TM-88929; E-3190; NAS 1.15:88929; USAAVSCOM-TR-86-C-29) Avail: NTIS HC A10/MF A01 CSCL 01A

Measurements of the unsteady velocity field within the stator row of a transonic axial-flow fan were acquired using a laser anemometer. Measurements were obtained on axisymmetric surfaces located at 10 and 50 percent span from the shroud, with the fan operating at maximum efficiency at design speed. The ensemble-average and variance of the measured velocities are used to identify rotor-wake-generated (deterministic) unsteadiness and turbulence, respectively. Correlations of both deterministic and turbulent velocity fluctuations provide information on the characteristics of unsteady interactions within the stator row. These correlations are derived from the Navier-Stokes equation in a manner similar to deriving the Reynolds stress terms, whereby various averaging operators are used to average the aperiodic, deterministic, and turbulent velocity fluctuations which are known to be present in multistage turbomachines. The correlations of deterministic and turbulent velocity fluctuations throughout the axial fan stator row are presented. In particular, amplification and attenuation of both types of unsteadiness are shown to occur within the stator blade passage. Author

N87-16807*# Vigyan Research Associates, Inc., Hampton, Va.
CALCULATION OF SIDEWALL BOUNDARY-LAYER PARAMETERS FROM RAKE MEASUREMENTS FOR THE LANGLEY 0.3-METER TRANSONIC CRYOGENIC TUNNEL
A. V. MURTHY Feb. 1987 36 p
(Contract NAS1-17919)
(NASA-CR-178241; NAS 1.26:178241) Avail: NTIS HC A03/MF A01 CSCL 01A

Correction of airfoil data for sidewall boundary-layer effects requires a knowledge of the boundary-layer displacement thickness and the shape factor with the tunnel empty. To facilitate calculation of these quantities under various test conditions for the Langley 0.3 m Transonic Cryogenic Tunnel, a computer program was written. This program reads the various tunnel parameters and the boundary-layer rake total head pressure measurements directly from the Engineering Unit tapes to calculate the required sidewall boundary-layer parameters. Details of the method along with the results for a sample case are presented. Author

N87-16809# Instituto Nacional de Tecnica Aeroespacial, Madrid (Spain). Lab. de Ensayos Aerodinamicos.
THE EFFECTS OF HEAVY RAIN ON PROFILE AERODYNAMICS [EFECTOS DE LA LLUVIA INTENSA SOBRE LA AERODINAMICA DE UN PERFIL]
ALEJANDRO FEO PALACIOS 1986 7 p In SPANISH; ENGLISH summary
(ETN-87-98848) Avail: NTIS HC A02/MF A01

The joint effects of rain and other meteorological phenomena on the aerodynamic characteristics of wing profiles is discussed. They may play a role in aircraft accidents taking place in take-off and landing conditions. Simulated trajectories were studied including heavy rain effects calculated under simplified conditions. It is shown that the simulations reproduce the paths of two accidents that happened approaching the runways. The relevant rain characteristics and the physical mechanisms under which degradations of the aerodynamic coefficients are produced are described. ESA

N87-16810# Instituto Nacional de Tecnica Aeroespacial, Madrid (Spain). Dept. de Aerodinamica y Navegabilidad.
PROFILE DESIGN IN TRANSONIC REGIME [DISENO DE PERFILES EN REGIMEN TRANSONICO]
FERNANDO MONGE GOMEZ 1986 12 p In SPANISH; ENGLISH summary
(ETN-87-98849) Avail: NTIS HC A02/MF A01

Inverse design problem numerical methods are studied in order to solve difficulties encountered in their application to airfoils in transonic regime, due to the high pressure gradients across the shock wave. The MacFadden computer program is shown to behave poorly when supersonic points data are included. Modifications to alleviate computation problems are described. Suggestions to improve the usefulness of the MacFadden method are made. ESA

N87-16811# Aeronautical Research Inst. of Sweden, Stockholm. Aerodynamics Dept.
A COMPARISON OF SINGLE-BLOCK AND MULTI-BLOCK GRIDS AROUND WING-FUSELAGE CONFIGURATIONS
TORSTEN BERGLIND 20 Aug. 1986 34 p
(Contract FMV-F-K-82260-84-254-73-001)
(FFA-TN-1986-42; ETN-87-98906) Avail: NTIS HC A03/MF A01

Computational procedures for the generation of single and multiblock grids by transfinite interpolation around wing-fuselage configurations are presented. The single-block grid is generated from an initial grid around the wing alone, adapted to conform to the fuselage by transfinite interpolation. One of the grid lines also conforms to the cut between the fuselage and the symmetry plane. The single-block grid contains highly skewed grid cells outside the fuselage, especially if the fuselage is exposed far from the wing. It is better to divide the flow region into several subregions, each a geometrically simple figure. The flow region around the wing-fuselage configuration is divided into three subregions. The multiblock grid is better than a single-block grid to generate nearly orthogonal grids and to condense grid points in regions where the dependent variables change rapidly. ESA

N87-17663*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
MODELING AERODYNAMIC DISCONTINUITIES AND THE ONSET OF CHAOS IN FLIGHT DYNAMICAL SYSTEMS
M. TOBAK, G. T. CHAPMAN, and A. UENAL Dec. 1986 50 p
Presented at the meeting, Journee dEtudes sur les Phenomenes non Lineares Chaotiques, Paris, France, 3-5 Dec. 1986
(NASA-TM-89420; A-87064; NAS 1.15:89420) Avail: NTIS HC A03/MF A01 CSCL 01A

Various representations of the aerodynamic contribution to the aircraft's equation of motion are shown to be compatible within the common assumption of their Frechet differentiability. Three forms of invalidating Frechet differentiality are identified, and the mathematical model is amended to accommodate their occurrence. Some of the ways in which chaotic behavior may emerge are discussed, first at the level of the aerodynamic contribution to the equation of motion, and then at the level of the equations of motion themselves. Author

N87-17664*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
DESCRIPTION OF THE US ARMY SMALL-SCALE 2-METER ROTOR TEST SYSTEM
ARTHUR E. PHELPS, III and JOHN D. BERRY Feb. 1987 61 p
(Contract DA PROJ. 1L1-61102-AH-45)
(NASA-TM-87762; L-16165; NAS 1.15:87762; AVSCOM-TM-86-B-4) Avail: NTIS HC A04/MF A01 CSCL 01A

A small-scale powered rotor model was designed for use as a research tool in the exploratory testing of rotors and helicopter models. The model, which consists of a 29 hp rotor drive system, a four-blade fully articulated rotor, and a fuselage, was designed to be simple to operate and maintain in wind tunnels of moderate size and complexity. Two six-component strain-gauge balances are used to provide independent measurement of the rotor and fuselage aerodynamic loads. Commercially available standardized hardware and equipment were used to the maximum extent possible, and specialized parts were designed so that they could be fabricated by normal methods without using highly specialized tooling. The model was used in a hover test of three rotors having different planforms and in a forward flight investigation of a 21-percent-scale model of a U.S. Army scout helicopter equipped with a mast-mounted sight. Author

N87-17666*# Vigyan Research Associates, Inc., Hampton, Va.
LOW-SPEED WIND TUNNEL STUDY OF LONGITUDINAL STABILITY AND USABLE-LIFT IMPROVEMENT OF A CRANKED WING Contractor Report, 25 Sep. 1984 - 30 Nov. 1986
DHANVADA M. RAO Jan. 1987 22 p
(Contract NAS1-17835)
(NASA-CR-178204; NAS 1.26:178204) Avail: NTIS HC A02/MF A01 CSCL 01A

An exploratory low-speed investigation of a 70 deg/46 deg cranked-wing planform was undertaken to evaluate two vortex-control concepts aimed at alleviating a severe pitch up which limits the usable lift well below the C(sub L,max) of the basic wing. One concept was a strake-like extension introduced across the wing crank, whose vortex helps to stabilize the outer-wing flow and alleviate tip stall. The other was a lower-surface cavity flap employed to trap a vortex just beneath the inboard leading edge, resulting in reduced vortex lift over the inner-wing panel. Each of these concepts was shown to eliminate the high-alpha pitch up, potentially raising the maximum usable lift of the cranked wing practically to its C(sub L,max) value. Author

N87-17667*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
HIGHLIGHTS OF UNSTEADY PRESSURE TESTS ON A 14 PERCENT SUPERCRITICAL AIRFOIL AT HIGH REYNOLDS NUMBER, TRANSONIC CONDITION
ROBERT W. HESS, DAVID A. SEIDEL, WILLIAM B. IGOE, and PIERCE L. LAWING Jan. 1987 19 p Presented at the AIAA 25th Aerospace Sciences Meeting, Reno, Nev., 12-15 Jan. 1987
(NASA-TM-89080; NAS 1.15:89080; AIAA-87-0035) Avail: NTIS HC A02/MF A01 CSCL 01A

Steady and unsteady pressures were measured on a 2-D supercritical airfoil in the Langley Research Center 0.3-m Transonic Cryogenic Tunnel at Reynolds numbers from 6 x 1,000,000 to 35 x 1,000,000. The airfoil was oscillated in pitch at amplitudes from plus or minus .25 degrees to plus or minus 1.0 degrees at frequencies from 5 Hz to 60 Hz. The special requirements of testing an unsteady pressure model in a pressurized cryogenic tunnel are discussed. Selected steady measured data are presented and are compared with GRUMFOIL calculations at Reynolds number of 6 x 1,000,000 and 30 x 1,000,000. Experimental unsteady results at Reynolds numbers of 6 x 1,000,000 and 30 x 1,000,000 are examined for Reynolds number effects. Measured unsteady results at two mean angles of attack at a Reynolds number of 30 x 1,000,000 are also examined. Author

N87-17670*# Rockwell International Science Center, Thousand Oaks, Calif.
NONLINEAR POTENTIAL ANALYSIS TECHNIQUES FOR SUPERSONIC AERODYNAMIC DESIGN
V. SHANKAR and K. Y. SZEMA 1 Mar. 1985 149 p
(Contract NAS1-15820)
(NASA-CR-172507; NAS 1.26:172507) Avail: NTIS HC A07/MF A01 CSCL 01A

A numerical method based on the conservation form of the full potential equation has been applied to the problem of three-dimensional supersonic flows with embedded subsonic regions. The governing equation is cast in a nonorthogonal coordinate system, and the theory of characteristics is used to accurately monitor the type-dependent flow field. A conservative switching scheme is employed to transition from the supersonic marching procedure to a subsonic relaxation algorithm and vice versa. The newly developed computer program can handle arbitrary geometries with fuselage, canard, wing, flow through nacelle, vertical tail and wake components at combined angles of attack and sideslip. Results are obtained for a variety of configurations that include a Langley advanced fighter concept with fuselage centerline nacelle, Rockwell's Advanced Tactical Fighter (ATF) with wing mounted nacelles, and the Shuttle Orbiter configuration. Comparisons with available experiments were good. Author

N87-17671*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
TOP-MOUNTED INLET PERFORMANCE FOR A V/STOL FIGHTER/ATTACK AIRCRAFT CONFIGURATION
DONALD B. SMELTZER Jan. 1987 215 p
(NASA-TM-88210; A-86110; NAS 1.15:88210) Avail: NTIS HC A10/MF A01 CSCL 01A

Inlet flow-field and compressor-face performance data were obtained for a 0.095-scale model of vertical/short take-off landing (V/STOL) fighter/attack aircraft configuration with twin top-mounted inlets. Tests were conducted at Mach numbers from 0.6 to 2.0 and angles of attack and sideslip up to 27 deg. and 12 deg., respectively. Reynolds number was held constant at 9.8 x 10 to the 6th power per meter. The effects of inlet location, wing leading-edge extension (LEX) planform area, canopy-dorsal integration, variable incidence canards, and wing leading- and trailing-edge flap deflections were determined. The results show that at Mach numbers up to 0.9, distortion is relatively low (20% or less) at all angles of attack and sideslip. However, at Mach numbers of 1.2 and above, operation may be restricted because of either high distortion or low pressure recovery (80% or less), or both. These difficulties may be overcome with alterations to the LEX/canopy/body juncture. Author

N87-17673# Universal Energy Systems, Inc., Dayton, Ohio.
CALCULATION OF VISCOUS TRANSONIC FLOWS ABOUT A SUPERCRITICAL AIRFOIL Final Report, Aug. 1983 - Nov. 1984
MIGUEL R. VISBAL Jul. 1986 94 p
(Contract F33615-83-C-3000)
(AD-A173519; AFWAL-TR-86-3013) Avail: NTIS HC A05/MF A01 CSCL 20D

A critical examination of several aspects of the numerical simulation of high Reynolds number transonic airfoil flows is presented. Subcritical and supercritical flow fields about an aft-cambered airfoil were generated by solving the mass-averaged Navier-Stokes equations with turbulence incorporated through an algebraic eddy viscosity model. The governing equations were solved on curvilinear body-fitted grids utilizing two different algorithms., i.e., MacCormack's explicit and Beam-Warming implicit. The numerical uncertainties associated with different schemes, grid resolution, artificial viscosity and far field boundary placement were investigated and found to be of the same order of magnitude or less than the corresponding uncertainties in the available experimentat data. Comparison of computed and experimental results showed good prediction of all the essential flow features. However, detailed comparison of velocity profiles pointed out deficiencies of the turbulence model downstream of the shock/boundary layer interaction in the airfoil cove and in the near-wake. Thin-layer and Navier-Stokes computer results were found in excellent agreement with each other. However, the Euler equations failed to provide a a reasonable approximation of the flow due to the dramatic viscous-inviscid interaction effects for supercritical airfoils. GRA

N87-17682# Oxford Univ. (England). Dept. of Engineering Science.
A COMPARISON OF AERODYNAMIC MEASUREMENTS OF THE TRANSONIC FLOW THROUGH A PLANE TURBINE CASCADE IN FOUR EUROPEAN WIND TUNNELS
N. C. BAINES, P. I. KING, M. L. OLDFIELD, R. KIOCK (Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick, West Germany), H. HOHEISEL, G. RAMM, F. LEHTHAUS, F. KOST, and C. H. SIEVERDING (Von Karman Inst. for Fluid Dynamics, Rhode-Saint-Genese, Belgium) 1986 42 p Presented at 8th Symposium on Measuring Techniques for Transonic and Supersonic Flow in Cascades and Turbomachines, Genoa, Italy, 24-25 Oct. 1985
(OUEL-1624/86; ETN-87-98926) Avail: NTIS HC A03/MF A01
The VKI-1 turbine blade profile was tested in plane cascades at subsonic and transonic conditions. Measurements included blade surface pressure distributions and wake traverse measurements over ranges of Mach and Reynolds numbers, together with Schlieren photographs. The results from four tunnels enabled deductions to be made about the nature and scale of external influences, including tunnel dimensions and geometry, and the importance of cascade parameters such as axial velocity density ratio. The different measurement techniques employed, their suitability, and accuracy are also discussed, particularly the problems of measurement in the wake region downstream of the cascade. ESA

N87-17683# Technische Hogeschool, Delft (Netherlands). Inst. for Wind Energy.
TIP VANE DRAG MEASUREMENTS ON THE FULL SCALE EXPERIMENTAL WIND TURBINE
A. BRUINING May 1986 135 p Sponsored by the Netherlands Ministry of Economic Affairs
(IW-R517; ETN-87-99082) Avail: NTIS HC A07/MF A01
Drag on 3 sets of tip vanes incorporating an LA 5055 and NACA 23012 airfoil section was measured. The drag level of the tip vane is high due to a high level of induced drag. There is no significant difference between the drag of the LA and the NACA airfoil. In oversynchronous operation the measured drag is a little lower than in undersynchronous operation. Calculations show that the measured drag level only can be explained by summing the calculated induced drag, the two-dimensional airfoil drag and interference drag (of same order as the two-dimensional airfoil drag) and neglecting any self propelling effect of the tip vanes. A self propelling effect might be expected when the tilt angle of the tip vane is too big in relation to the axial flow expansion. ESA

N87-17684# Eidgenoessisches Flugzeugwerk, Emmen (Switzerland). Research and Testing Dept.
THE INFLUENCE OF A 90 DEG STING SUPPORT ON THE AERODYNAMIC COEFFICIENTS OF THE INVESTIGATED AIRCRAFT MODEL
H. KAMBER 5 May 1986 35 p In GERMAN; ENGLISH summary
(F+W-FO-1839; ETN-87-99093) Avail: NTIS HC A03/MF A01
A wind tunnel investigation of influence of a sting support with an angle-of-attack range of 110 deg to the model is described. The influence on the aerodynamic coefficients of a larger object in the detached region of downwash of a wing is discussed. The influence of the sting support is small in the whole angle-of-attack range. The influence of an object in the region of downwash of the wing can influence the aerodynamic coefficients. ESA

N87-17685# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Goettingen (West Germany). Abteilung Stabilitaet und Antwort.
ON THE PREDICTION OF THE AEROELASTIC BEHAVIOR OF LIFTING SYSTEMS DUE TO FLOW SEPARATION Ph.D. Thesis - Technische Univ., Brunswick, West Germany
HARTMUT ZINGEL Jul. 1986 155 p In GERMAN; ENGLISH summary Report will also be announced as translation (ESA-TT-1043)
(DFVLR-FB-86-35; ISSN-0171-1342; ETN-87-99173) Avail: NTIS HC A08/MF A01; DFVLR, Cologne, West Germany DM 51.50
The prediction of structural vibrations on the basis of linear equations of motion is described for the case of a trapezoidal wing model. The unsteady aerodynamic quantities are determined in wind tunnel experiments. The dynamic response behavior at separated flow measured on a freely vibrating model in a wind tunnel was approximated by a calculated prediction. For coupled vibrations, simplified equations of motion can be used. ESA

N87-18513# Office National d'Etudes et de Recherches Aerospatiales, Paris (France).
BOUNDED RANDOM OSCILLATIONS: MODEL AND NUMERICAL SOLUTION FOR AN AIRFOIL
F. POIRION and J. J. ANGELINI *In its* La Recherche Aerospatiale, Bimonthly Bulletin, Number 1985-6, 229/November-December 1985 p 45-54 Jul. 1986
Avail: NTIS HC A04/MF A01; HC available at ONERA, Paris, France FF 75; original report available at ONERA, Paris, France, FF 75
An automatic control model for an airplane flying in vertical wind turbulence is proposed using a multi-valued stochastic differential equation: d(xi sub t) is an element of b(xi sub t)dt + sigma(xi sub t)dW sub t - the partial derivative of Z sub G(xi sub t)dt. Three different numerical ways are then given to solve the boundary value problem numerically to determine the stationary solution Xi sub t of the multi-values stochastic equation.
Author (ESA)

03

AIR TRANSPORTATION AND SAFETY

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

A87-24174
A SYSTEMS APPROACH TO SAFE AIRSPACE OPERATIONS
RICHARD CLARKE ICAO Bulletin, vol. 41, Sept. 1986, p. 33-35.
An effective way of linking airspace system planning to the achievement of the requisite level of operational safety is through the application of system safety management and engineering to ensure maximum integration and minimum system oversights. System safety design has a life-cycle orientation that follows a program from concept development, through operation, to eventual disposal. The effectiveness of man/machine interfaces is ensured, and a hazard-identification process is implemented in place of the more conventional failure-identification orientation. O.C.

A87-25836
AIRCREW AUTOMATED ESCAPE SYSTEMS REQUIREMENTS FORMULATION, EVALUATION, TEST AND ACCEPTANCE
FREDERICK C. GUILL (U.S. Navy, Crew Systems Div., Washington, DC) SAFE Journal, vol. 6, Winter 1986, p. 14-26.
The present evaluation of the development history of the U.S. Navy's design and testing of automated escape systems and their components notes substantial changes over time in the role of Navy escape system expert in the assessment and selection of proposed systems to ensure optimal tradeoffs among all competing risks, needs, and constraints. Current acquisition procedures are more highly documented than in the past. Revisions incorporated by various military specifications have formalized the lessons

learned in the management of ejection seat development programs. O.C.

A87-25845
AVIATION SAFETY - A REVIEW OF THE 1985 RECORD
OLOF FRITSCH and JOSE SANTAMARIA (International Civil Aviation Organization, Air Navigation Bureau, Montreal, Canada) ICAO Bulletin, vol. 41, Oct. 1986, p. 15-17.

The role of ICAO in maintaining aviation safety is discussed. The accident rate (number of fatalities/100 million passengers-kilometers) is utilized to determine safety. A graph of accident rates from 1966-1985 is analyzed, and it is observed that safety has improved since 1975 and fluctuated only slightly from 1975 to 1985. The accident/incident data reporting computer program aimed at accident prevention is decribed. ICAO standards for emergency planning at airports and rescue and fire-fighting requirements are examined. Consideration is given to methods for improving safety standards such as the developing new fire-resistant materials and establishing quantiative limits on smoke and toxic combustion products. I.F.

A87-25848
WIND SHEAR REVISITED
O. K. TRUNOV (Gosudarstvennyi Nauchno-Issledovatel'skii Institut Grazhdanskogo Vozdushnogo Flota, Moscow, USSR) ICAO Bulletin, vol. 41, Oct. 1986, p. 26-28.

To ensure air safety in the presence of wind shear it is recommended that typical wind shear patterns be identified, the effect of wind shear on an aircraft be assessed, and operational methods and technical equipment for countering wind shear be developed. The effects of wind shear on aircraft design and performance characteristics are examined. Wind shear is studied using mathematical models and flight testing. Various procedures for countering wind shear are described. I.F.

A87-27602
COLLISION RISK IN THE WIDE OPEN SPACES
W. G. SCULL (British Gliding Association, England) and W. A. ON WAUGH (Toronto, University, Canada) Aerospace (UK) (ISSN 0305-0831), vol. 13, Dec. 1986, p. 15-17. refs

The application of scientific risk-assessment and risk-management techniques to aviation is discussed, using the UK open Flight Information Region (FIR) as an example. Consideration is given to the problems of perceived risk and biases in estimating the risk of death or severe injury; the general difficulty of obtaining accurate data; assessment of FIR collision risks on the basis of government traffic censuses, airmiss reports, and the frequency with which pilots or carriers choose FIR rather than airway routes; and management of FIR risks by improving radar services and/or extending control zones. The need for more extensive data and for consistent application of risk-management techniques is indicated. T.K.

N87-17686*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
SIMULATION INVESTIGATION OF THE EFFECT OF THE NASA AMES 80-BY 120-FOOT WIND TUNNEL EXHAUST FLOW ON LIGHT AIRCRAFT OPERATING IN THE MOFFETT FIELD TRAFFFIC PATTERN
BARRY G. STREETER Feb. 1986 33 p
(NASA-TM-86819; A-85372; NAS 1.15:86819) Avail: NTIS HC A03/MF A01 CSCL 01C

A preliminary study of the exhaust flow from the Ames Research Center 80 by 120 Foot Wind Tunnel indicated that the flow might pose a hazard to low-flying light aircraft operating in the Moffett Field traffic pattern. A more extensive evaluation of the potential hazard was undertaken using a fixed-base, piloted simulation of a light, twin-engine, general-aviation aircraft. The simulated aircraft was flown through a model of the wind tunnel exhaust by pilots of varying experience levels to develop a data base of aircraft and pilot reactions. It is shown that a light aircraft would be subjected to a severe disturbance which, depending upon entry condition and pilot reaction, could result in a low-altitude stall or cause damage to the aircraft tail structure. Author

N87-17687# Aerospace Medical Research Labs., Wright-Patterson AFB, Ohio.
THE DERIVATION OF LOW PROFILE AND VARIABLE COCKPIT GEOMETRIES TO ACHIEVE 1ST TO 99TH PERCENTILE ACCOMMODATION
KENNETH W. KENNEDY Mar. 1986 25 p
(AD-A173454; AAMRL-TR-86-016) Avail: NTIS HC A02/MF A01 CSCL 12A

This study was undertaken to serve three objectives: (1) to derive new cockpit geometries in which the techniques of vertical aircraft ejection seat adjustment move the small pilot toward his/her controls and the large pilot away from them, thus avoiding the incompatibilities associated with adjusting the small pilot up and aft, away from hand controls, and the large pilot down and forward, toward hand controls; (2) to demonstrate the relative ease with which the engineer can accommodate to the 1st to 99th percentile range of male body sizes within the USAF, including reach capability; and (3) to demonstrate appropriate techniques in using the AAMRL Drawing Board Manikins in the derivation of basic geometries of ejection seats and of cockpits. Design requirements are: (1) vertical seat adjustment should be for the purpose of bringing the pilot's eyes to a 15 degree Down Vision Line; and (2) all pilots within the anthropometric design range should able to avoid thrusting their knees forward of the Ejection Clearance Line by assuming the correct ejection posture, even though they might have adjusted the seat to a considerably different position than recommended for their body size. Low Profile and Variable Cockpit Geometries are derived in detailed step by step demonstrations. GRA

04

AIRCRAFT COMMUNICATIONS AND NAVIGATION

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

A87-24172
RSM-870 - AN AUTONOMOUS MODE-S COMPATIBLE SSR BEACON
ALAIN SCRIBOT (Thomson-CSF, Division Systemes Defense et Controle, Bagneux, France) ICAO Bulletin, vol. 41, Sept. 1986, p. 20-24.

The RSM-870 transmitter/receiver, together with the AS-809 large vertical aperture antenna, constitute the major elements of the ICAO's Mode-S compatible secondary surveillance radars. The RSM-870 can be used in any of three configurations: (1) as an autonomous beacon station, with track data being displayed locally in synthetic digitized form, integrated in a multiradar configuration, or associated with the data of a remote primary radar; (2) in association with a terminal area or approach radar, with data display in synthetic form; and (3) in association with a long range L-band en-route primary radar, to track dense traffic. O.C.

A87-24175
THE EVOLUTION IN ATC SYSTEM DESIGN
HAKAN WESTERMARK (Ericsson Radio Systems AB, Stockholm, Sweden) ICAO Bulletin, vol. 41, Sept. 1986, p. 40, 41.

The features and performance characteristics of the Swedish 'Airwatch' ATC system, which employs a state-of-the-art distributed system architecture are discussed. The task of software upgrading is noted to be inherently simpler and more easily predictable in terms of cost and time, in virtue of the clear overview that results from a distributed environment. The open-endedness of the system design facilitates the maintenance of compatibility with international standards, since novel technology modules can be added as they become available. Critical nodes are duplicated to ensure fail-safe operation. O.C.

A87-24719#
LOW COST DOPPLER AIDED STRAPDOWN INERTIAL NAVIGATION SYSTEM
XIN YUAN and ZAIXIN YU (Nanjing Aeronautical Institute, People's Republic of China) Acta Aeronautica et Astronautica Sinica, vol. 7, Oct. 1986, p. 471-481. In Chinese, with abstract in English. refs

This paper presents a Doppler-aided strapdown inertial navigation system which adopts low accuracy inertial sensors. The configuration and dynamic equations of the integrated system are discussed and derived. One optimum Kalman filter and four suboptimum Kalman filters are designed and evaluated. A covariance analysis of the integrated system performance is completed. The results of the covariance analysis indicate that the integrated system which adopts the gyros with a random drift of 0.1 deg/h and the accelerometers with a bias of 10 to the -4th g can achieve the navigation accuracy of 1 nm/h by means of the Kalman filter. Author

A87-26003
TEST AND FLIGHT EVALUATION OF PRECISION DISTANCE MEASURING EQUIPMENT
K. BECKER, A. MUELLER (Standard Elektrik Lorenz AG, Stuttgart, West Germany), and K. HURRASS (DFVLR, West Germany) Airport Forum (ISSN 0002-2802), vol. 16, Oct. 1986, p. 71, 72, 74 (3 ff.).

A new type of precision distance measuring equipment (DME/P), which is to be utilized on microwave landing systems, is described. The DME/P is based on two modes for the initial and final approach phases. The ground transponder and airborne transceiver for the DME/P are examined and the instrumentation accuracy and measured multipath immunity are evaluated. It is detected that the DME/P has an instrumentation accuracy of better than 30 ns and permits simulation of multipath by adding of echo replies to the direct reply pulses. The DME/P system was flight tested using a newly developed avionics flight evaluation system; graphs of the performance of the DME/P are presented. The operational benefits of the DME/P are discussed. I.F.

N87-16812# Federal Aviation Administration, Washington, D.C. Air Traffic Control Radar Beacon System Analysis Team.
AIR TRAFFIC CONTROL RADAR BEACON SYSTEM TRANSPONDER PERFORMANCE STUDY AND ANALYSIS. VOLUME 2: APPENDIXES Final Report
Sep. 1986 397 p
(DOT/FAA/FS-86/1-VOL-2) Avail: NTIS HC A17/MF A01

Detailed test procedures, collected data, and other related background material on radar beacon system transponders are presented. Author

05

AIRCRAFT DESIGN, TESTING AND PERFORMANCE

Includes aircraft simulation technology.

A87-23458* Cincinnati Univ., Ohio.
THE ROLE OF COMPUTERIZED SYMBOLIC MANIPULATION IN ROTORCRAFT DYNAMICS ANALYSIS
MARCELO R. M. CRESPO DA SILVA (Cincinnati, University, OH) and DEWEY H. HODGES (U.S. Army, Army Aeromechanics Laboratory, Moffett Field, CA) Computers and Mathematics with Applications (ISSN 0097-4943), vol. 12A, no. 1, 1986, p. 161-172. refs
(Contract DAAG29-84-G-0041; NAG2-274)

The potential role of symbolic manipulation programs in development and solution of the governing equations for rotorcraft dynamics problems is discussed and illustrated. Nonlinear equations of motion for a helicopter rotor blade represented by a rotating beam are developed making use of the computerized symbolic manipulation program MACSYMA. The use of computerized symbolic manipulation allows the analyst to concentrate on more meaningful tasks, such as establishment of physical assumptions, without being sidetracked by the tedious and trivial details of the algebraic manipulations. Furthermore, the resulting equations can be produced, if necessary, in a format suitable for numerical solution. A perturbation-type solution for the resulting dynamical equations is shown to be possible with a combination of symbolic manipulation and standard numerical techniques. This should ultimately lead to a greater physical understanding of the behavior of the solution than is possible with purely numerical techniques. The perturbation analysis of the flapping motion of a rigid rotor blade in forward flight is presented, for illustrative purposes, via computerized symbolic manipulation with a method that bypasses Floquet theory. Author

A87-23738
AEROELASTIC STABILITY ANALYSIS OF A COMPOSITE BEARINGLESS ROTOR BLADE
CHANG-HO HONG and INDERJIT CHOPRA (Maryland, University, College Park) American Helicopter Society, Journal (ISSN 0002-8711), vol. 31, Oct. 1986, p. 29-35. refs
(Contract DAAG29-83-K-0002)

The aeroelastic stability of flap bending, lead-lag bending and torsion of a bearingless composite blade in hover is investigated. The analysis is formulated for a bearingless configuration consisting of a single flexbeam with a wrap-around type torque tube and the pitch links located at the leading edge and trailing edge of the torque tube. For analysis, the outboard main blade and the torque tube are assumed to be made of metals (isotropic materials) and the flexbeam is assumed to be an I-section made of three laminates, tip and bottom flanges and web. Each laminate is composed of a number of laminae with arbitrary ply orientation. The constitutive relations of an orthotropic laminar are used and the strain-displacement relations are modified for an open section. Numerical results are calculated for selected bearingless blade configurations, categorized as symmetric and antisymmetric, based on the lay-up of laminae in the flexbeam. A systematic study is made to identify the importance of the stiffness coupling terms on blades stability with changing fiber orientation and for different configurations. Author

A87-23739* Syracuse Univ., N. Y.
FREE VIBRATION CHARACTERISTICS OF MULTIPLE LOAD PATH BLADES BY THE TRANSFER MATRIX METHOD
V. R. MURTHY and ARUN M. JOSHI (Syracuse University, NY) American Helicopter Society, Journal (ISSN 0002-8711), vol. 31, Oct. 1986, p. 43-50. refs
(Contract NAG2-306)

The determination of free vibrational characteristics is basic to any dynamic design, and these characteristics can form the basis for aeroelastic stability analyses. Conventional helicopter blades are typically idealized as single-load-path blades, and the transfer matrix method is well suited to analyze such blades. Several current helicopter dynamic programs employ transfer matrices to analyze the rotor blades. In this paper, however, the transfer matrix method is extended to treat multiple-load-path blades, without resorting to an equivalent single-load-path approximation. With such an extension, these current rotor dynamic programs which employ the transfer matrix method can be modified with relative ease to account for the multiple load paths. Unlike the conventional blades, the multiple-load-path blades require the introduction of the axial degree-of-freedom into the solution process to account for the differential axial displacements of the different load paths. The transfer matrix formulation is validated through comparison with the finite-element solutions. Author

A87-23740
STABILIZATION OF HELICOPTER BLADE FLAPPING
ROBERT A. CALICO and WILLIAM E. WIESEL (USAF, Institute of Technology, Wright-Patterson AFB, OH) American Helicopter Society, Journal (ISSN 0002-8711), vol. 31, Oct. 1986, p. 59-64. refs

The equations of motion for a rigid helicopter blade hinged at its root are presented. The stability of the blade in forward flight is investigated using Floquet theory, and the results are compared to previous studies. An application of Floquet theory is developed which permits the design of active control systems in non-hover flight conditions using the normal vehicle collective and cyclic pitch control system. These techniques allow the direct removal of unstable roots, leaving stable modes unchanged. These methods are applied to single and two-bladed rotors, and stability of the design controllers is investigated throughout the expected flight regime. Author

A87-24035*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
EQUIVALENT PLATE ANALYSIS OF AIRCRAFT WING BOX STRUCTURES WITH GENERAL PLANFORM GEOMETRY
GARY L. GILES (NASA, Langley Research Center, Hampton, VA) (Structures, Structural Dynamics and Materials Conference, 27th, San Antonio, TX, May 19-21, 1986, Technical Papers, p. 333-342) Journal of Aircraft (ISSN 0021-8669), vol. 23, Nov. 1986, p. 859-864. Previously cited in issue 18, p. 2610, Accession no. A86-38837. refs

A87-24904*# General Electric Co., Cincinnati, Ohio.
EVALUATION OF CAPILLARY REINFORCED COMPOSITES FOR ANTI-ICING
SAMUEL W. CIARDULLO, STEPHEN C. MITCHELL, and RONALD D. ZERKLE (General Electric Co., Cincinnati, OH) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 11 p.
(Contract NAS3-24386)
(AIAA PAPER 87-0023)

This paper discusses the evaluation of glass capillary reinforced advanced composite structures for anti-icing purposes. The concept involves embedding glass capillary tubes on the surface of a composite structure and ducting heated air through the tubes. A computer program was developed to predict the anti-icing performance of such tubes and a test program was conducted to demonstrate the actual performance of this system. Test data and analytical code results were in excellent agreement. Both indicate the feasibility of using capillary tubes for surface heating in order to combat ice accumulation on advanced composite structures. Author

A87-24905*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
A HEATER MADE FROM GRAPHITE COMPOSITE MATERIAL FOR POTENTIAL DEICING APPLICATION
CHING-CHEH HUNG (NASA, Lewis Research Center, Cleveland, OH), MICHAEL E. DILLEHAY, and MARK STAHL (Cleveland State University, OH) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 8 p. Previously announced in STAR as N87-12559. refs
(AIAA PAPER 87-0025)

A surface heater was developed using a graphite fiber-epoxy composite as the heating element. This heater can be thin, highly electrically and thermally conductive, and can conform to an irregular surface. Therefore it may be used in an aircraft's thermal deicing system to quickly and uniformly heat the aircraft surface. One-ply of unidirectional graphite fiber-epoxy composite was laminated between two plies of fiber glass-epoxy composite, with nickel foil contacting the end portions of the composite and partly exposed beyond the composites for electrical contact. The model heater used brominated P-100 fibers from Amoco. The fiber's electrical resistivity, thermal conductivity and density were 50 micro ohms per centimenter, 270 W/m-K and 2.30 gm/cubic cm, respectively. The electricity was found to penetrate through the composite in the transverse direction to make an acceptably low foil-composite contact resistance. When conducting current, the heater temperature increase reached 50 percent of the steady state value within 20 sec. There was no overheating at the ends of the heater provided there was no water corrosion. If the foil-composite bonding failed during storage, liquid water exposure was found to oxidize the foil. Such bonding failure may be avoided if perforated nickel foil is used, so that the composite plies can bond to each other through the perforated holes and therefore lock the foil in place. Author

A87-24918*# Wichita State Univ., Kans.
EXPERIMENTAL, WATER DROPLET IMPINGEMENT DATA ON TWO-DIMENSIONAL AIRFOILS, AXISYMMETRIC INLET AND BOEING 737-300 ENGINE INLET
M. PAPADAKIS (Wichita State University, KS), E. ELANGOVAN, G. A. FREUND, JR., and M. D. BREER (Boeing Military Airplane Co., Wichita, KS) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 15 p. refs
(Contract NAG3-566)
(AIAA PAPER 87-0097)

An experimental method has been developed to determine the droplet impingement characteristics on two- and three-dimensional bodies. The experimental results provide the essential droplet impingement data required to validate particle trajectory codes, used in aircraft icing analyses and engine inlet particle separator analyses. A body whose water droplet impingement characteristics are required is covered at strategic locations by thin strips of moisture absorbing (blotter) paper, and then exposed to an air stream containing a dyed-water spray cloud. Water droplet impingement data are extracted from the dyed blotter strips, by measuring the optical reflectance of the dye deposit on the strips, using an automated reflectometer. Impingement efficiency data obtained for a NACA 65(2)015 airfoil section, a supercritical airfoil section, and Being 737-300 and axisymmetric inlet models are presented in this paper. Author

A87-25026
THE V-22 TILT-ROTOR LARGE-SCALE ROTOR PERFORMANCE/WING DOWNLOAD TEST AND COMPARISON WITH THEORY
MICHAEL A. MCVEIGH (Bell-Boeing, Philadelphia, PA) (European Rotorcraft Forum, 11th, London, England, Sept. 10-13, 1985) Vertica (ISSN 0360-5450), vol. 10, no. 3-4, 1986, p. 281-297. refs

Rotor performance and wing download data acquired by testing a large-scale model of the rotor and wing for the V-22 multimission tilt rotor aircraft is presented. Performance of the rotor was measured in isolation and with a scale model of the V-22 wing in place. The effect of the opposite rotor was simulated by using a large image plane. It was determined that the isolated rotor maximum figure of merit was 0.808. With the image plane in place, rotor thrust was slightly reduced compared to the isolated rotor value and was caused by the development of a region of recirculating flow near the image plane/wing junction. The wing download and the distribution of the load was determined. With flaps deflected the ratio of download to thrust was 0.093. Comparisons with theory are presented. Author

A87-25027* Boeing Vertol Co., Philadelphia, Pa.
THE DEVELOPMENT OF ADVANCED TECHNOLOGY BLADES FOR TILT-ROTOR AIRCRAFT
HAROLD R. ALEXANDER (Boeing Vertol Co., Philadelphia, PA), MARTIN D. MAISEL (NASA, Ames Research Center; U.S. Army, Aeromechanics Laboratory, Moffett Field, CA), and DEMO J. GIULIANETTI (NASA, Ames Research Center, Moffett Field, CA) (European Rotorcraft Forum, 11th, London, England, Sept. 10-13, 1985) Vertica (ISSN 0360-5450), vol. 10, no. 3-4, 1986, p. 315-339. refs

The paper discusses the development and ground testing of blades for the XV-15 tilt-rotor demonstrator aircraft. This work was performed under contract NAS2-11250 with NASA Ames Research Center. These blades, known as the Advanced Technology Blades (ATB), replace the rectangular, steel blades which were part of the XV-15 original design. The materials used in the primary structure of the ATB are fiberglass and high strain graphite epoxy laminates. This facilitates the use of 43 deg of nonlinear twist, a nonuniform tapered planform and thin airfoils required for aerodynamic efficiency. Instrumentation life is extended by encapsulating gages and wiring in the composite structure. Tip shells and cuff fairings are removable to provide access to tip weights and retention hardware; they are also replaceable with alternate research configurations. Extensive laboratory testing has validated predicted strength characteristics. Hover testing has demonstrated performance significantly superior to that predicted by contemporary methodology. Key elements of the test rig used for rotor performance measurement were developed as an ancillary part of the present program. The performance testing included measurement of near- and far-field noise. Induced inflow velocity distributions were also determined and photographs of tip vortex condensation trails were taken. These are providing guidance for modifications to hover peformance codes. Author

A87-25029* Maryland Univ., College Park.
PREDICTION OF BLADE STRESSES DUE TO GUST LOADING
GUNJIT BIR and INDERJIT CHOPRA (Maryland, University, College Park) (European Rotorcraft Forum, 11th, London, England, Sept. 10-13, 1985) Vertica (ISSN 0360-5450), vol. 10, no. 3-4, 1986, p. 353-377. refs
(Contract NAG1-375)

An analysis is developed for investigating the response of a rotor-fuselage system in a three-dimensional gust field wherein the gust velocity conponents can have arbitrary variation in space and time. Each rotor blade undergoes flap bending, lag bending and torsional deflections. The blades are divided into beam elements and each element consists of fifteen nodal degrees of freedom. Quasi-steady strip theory is used to obtain the aerodynamic loads. Unsteady aerodynamic effects are introduced through dynamic inflow modeling. Dynamic stall and reverse flow effects are also included. The fuselage is allowed five degrees of freedom: vertical, longitudinal, lateral, pitch and roll motions. The gust response equations are linearized about the vehicle trim state and the blade steady-state deflected position, and then solved by time integration. The blade bending moments, which determine blade stresses, are evaluated using the force summation technique. Systematic studies are made to identify the importance of several parameters including dynamic stall, forward speed, lag stiffness, gust profile, gust penetration rate and gust velocity direction. Author

A87-25437
THE ELECTRIC JET
FRED REED Air and Space (ISSN 0886-2257), vol. 1, Dec. 1986-Jan. 1987, p. 42-48.

A comprehensive discussion of electronic control design and performance effects on advanced fighter aircraft, as exemplified by the F-16, is presented. Attention is given to the differences in center of gravity position that are encountered in subsonic and supersonic flight, the consequences for fighter maneuverability of varying degrees of stability, the role of digital flight controls in maintaining the flight paths of low stability fighter designs, and the severe maneuverability constraint exerted by the pilot's capacity for withstanding no more than 10 Gs. O.C.

A87-25522
DYNAMIC LOADING OF AIRCRAFT DURING GROUND OPERATIONS [DYNAMICKE ZATIZENI LETOUNU PRI POZEMNICH REZIMECH PROVOZU]
LADISLAV BOUCHAL Zpravodaj VZLU (ISSN 0044-5355), no. 4, 1986, p. 205-211. refs

The paper is concerned with a set of problems associated with calculations of the dynamic loads acting on aircraft during ground operations. In particular, determinations are made of the loads acting on the landing gear during normal landing, take-off acceleration, and passing over an obstacle. Input variables, computer printouts, and graphic representations of results are included. V.L.

A87-25837
THE USAF'S CREST PROGRAM - PHASE I
A. MICHAEL HIGGINS (USAF, Aerospace Medical Div., Wright-Patterson AFB, OH) and EDWARD O. ROBERTS (USAF, Flight Dynamics Laboratory, Wright-Patterson AFB, OH) SAFE Journal, vol. 6, Winter 1986, p. 38-45. refs

The U.S. Air Force's Crew Escape Technologies (CREST) development program attempts to achieve, through full scale testing of novel, advanced ejection seat designs, a reduction of fatalities and major injuries in future aircraft ejections. Attention is presently given to the activities and findings of the recently concluded, 14-month 'Phase I' system design segment of the CREST program, and an evaluation is made of several key development efforts directly supporting the program. Phase I considered cockpit integration, trade studies, system requirements, test planning, and cost proposals for escape technologies. O.C.

A87-25873#
MISSION ADAPTIVE WINGS FOR FUTURE COMBAT AIRCRAFT
K. TAMILMANI and G. SIVAGNANAM (Directorate of Aeronautics, Bangalore, India) Aeronautical Society of India, Journal (ISSN 0001-9267), vol. 38, May 1986, p. 147-150.

Advances in technology have increased the defence threat in battle environment considerably, necessitating the fighter aircraft to operate often in the off-design conditions. Variable sweep, CCV concepts and mission-adaptive wings (MAW) allow current aircraft to fly throughout a broad spectrum of speed and altitude efficiently. The best means of achieving the optimum performance during the entire mission can be through use of MAW. By suitably varying the flexible contour of the wing, peak aerodynamic efficiency can be maintained throughout the mission. Cruise camber control, direct lift control, maneuver load control, gust load alleviation, maneuver camber control, and roll control are the different modes during which combat benefits can be enormous. Reduction in parasitic drag, improved drag polar, improved weapon delivery, and terrain following are the other benefits. 'Open box' type of construction of MAW simplifies manufacture and reduces the cost too. Author

A87-25877
VEHICLE VIBRATION PREDICTION - WHY AND HOW
S. P. KING (Westland, PLC, Yeovil, England) IN: Industrial vibration modelling: Polymodel 9; Proceedings of the Ninth Annual Conference, Newcastle-upon-Tyne, England, May 21, 22, 1986 . Dordrecht, Martinus Nijhoff Publishers, 1987, p. 3-19.

Modeling techniques for analyzing vehicle vibrations and modifying designs to reduce or eliminate them are discussed, using detailed examples from the development of the Lynx helicopter. Topics addressed include the sources of noise in helicopters, vibration-related problems (passenger discomfort, structural fatigue, and reduced reliability of electronic equipment), the advantages of models, stability vs excitation models, computer programs used in constructing and analyzing models (e.g., NASTRAN, ASAS, WISDOM, and SYSTAN), and problem areas (structural damping, fuel mass, and nonlinearities). The accuracy of current predictions is demonstrated, and some future trends (structural optimization, improved techniques for using test data to adjust models, and active control technology) are considered. Diagrams, graphs, and drawings are provided. T.K.

A87-25971#
INVESTIGATION OF THE POSSIBILITY OF AVOIDING THE RESONANCE OF A HELICOPTER ROTOR BLADE BY THE MODIFICATION OF ITS PARAMETERS. I [BADANIA MOZLIWOSCI UNIKNIECIA REZONANSU LOPATY WIRNIKA SMIGLOWCA PRZEZ ZMIANE JEJ PARAMETROW. I]
JAROSLAW STANISLAWSKI (Instytut Lotnictwa, Warsaw, Poland) Technika Lotnicza i Astronautyczna (ISSN 0040-1145), vol. 41, July 1986, p. 4-6. In Polish.

The influence of modifications of mass-stiffness characteristics on the natural frequencies of a rotor blade is revealed. A comparison is made between the sensitivities of the natural frequencies to the parametric modifications of individual rotor blades. K.K.

A87-25974#
INVESTIGATION OF THE POSSIBILITY OF AVOIDING THE RESONANCE OF A HELICOPTER ROTOR BLADE BY THE MODIFICATION OF PARAMETERS. II [BADANIE MOZLIWOSCI UNIKNIECIA REZONANSU LOPATY WIRNIKA SMIGLOWCA PRZEZ ZMIANE JEJ PARAMETROW. II]
JAROSLAW STANISLAWSKI (Instytut Lotnictwa, Warsaw, Poland) Technika Lotnicza i Astronautyczna (ISSN 0040-1145), vol. 41, Aug. 1986, p. 5-7. In Polish. refs

A87-26035
F/A-18 HORNET: RELIABILITY DEVELOPMENT TESTING - AN UPDATE
W. R. ROGGER (McDonnell Aircraft Co., Saint Louis, MO) IN: Institute of Environmental Sciences, Annual Technical Meeting, 32nd, Dallas and Fort Worth, TX, May 6-8, 1986, Proceedings . Mount Prospect, IL, Institute of Environmental Sciences, 1986, p. 86-92.

The characteristics of the Operational Mission Environments (OMEs) used to accelerate the identification of failure modes and provide corrective action early in the Reliability Development Test (RDT) program of the F/A-18 Hornet are discussed. Different OMEs are needed for the develoment test, burn-in, and All Equipment test, because of the different results expected. The operationally realistic environments and test acceleration generated more failures than traditional reliability testing, and half-life vibration, 750 hours vibration simulation, and high thermal rate cycling were all up-front tests. R.R.

A87-27120* Veneklasen (Paul A.) and Associates, Santa Monica, Calif.
PREDICTION OF LIGHT AIRCRAFT INTERIOR SOUND PRESSURE LEVEL FROM THE MEASURED SOUND POWER FLOWING IN TO THE CABIN
MAHABIR S. ATWAL (Paul A. Veneklasen and Associates, Santa Monica, CA), KAREN E. HEITMAN (NASA, Langley Research Center, Hampton, VA), and MALCOLM J. CROCKER (Auburn University, AL) IN: Inter-noise 86 - Progress in noise control; Proceedings of the International Conference on Noise Control Engineering, Cambridge, MA, July 21-23, 1986. Volume 2 . Poughkeepsie, NY, Noise Control Foundation, 1986, p. 1045-1048. NASA-supported research.

The validity of the room equation of Crocker and Price (1982) for predicting the cabin interior sound pressure level was experimentally tested using a specially constructed setup for simultaneous measurements of transmitted sound intensity and interior sound pressure levels. Using measured values of the reverberation time and transmitted intensities, the equation was used to predict the space-averaged interior sound pressure level for three different fuselage conditions. The general agreement between the room equation and experimental test data is considered good enough for this equation to be used for preliminary design studies. I.S.

A87-27299
NEW TECHNOLOGY AND ITS APPLICATIONS TO MINI-RPVS
ROBERT E. NETTLES (Lockheed Corp., Austin, TX) Unmanned Systems, vol. 5, Summer 1986, p. 10-19, 22, 23, 40-42.

The design and capabilities of the Aquila air vehicle, an example of a mini-RPV, and the integration of new technology into the Aquila vehicle are described. The Aquila is fabricated from Kevlar-epoxy and graphite-epoxy composites, has a 24 hp two-stroke-cycle two-cylinder engine, a power to weight ratio of 1.2 lbs/hp, and a specific fuel consumption of less than 0.066 lb/hp-hr during cruise flight. The use of electronic engine control technology to improve the fuel consumption of the vehicle is examined. Consideration is given to the day and night payloads of the RPVs, the uses of RPVs as signal intelligence collectors and to detect, process, locate, and verify radio frequency emitters, and the design of the ground control station for Aquila. The navigation, guidance, and flight control avionics system, the use of a single two-axial cable to replace the multiple communications and control signal cables, and the communications datalink are discussed. I.F.

A87-27330#
VIBRATION CHARACTERISTICS OF A SWEPT BACK ROTOR BLADE
TOMOARI NAGASHIMA, TAKEICHIRYO HIROSE, YOSHIHARU SUGIYAMA, SADAKANE NISHIMURA, and GIZO HASEGAWA Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 34, no. 393, 1986, p. 42-52. In Japanese, with abstract in English. refs

Using a finite-rotating-beam-element model with variable cross section, the vibration characteristics of a swept-back rotor blade are analyzed. To grasp the effects of tip geometries on the natural frequencies and mode shapes, vibration tests on model blades with various planforms are also conducted. The node lines of the rotating blades are measured remotely utilizing synchronized still video pictures on a CRT. Comparisons of numerical results with experimental ones show good coincidence, and the usefulness of the proposed method is ascertained. Author

A87-27331
WINDSHIELDS - MORE THAN GLASS AND PLASTICS
JAMES H. BRAHNEY Aerospace Engineering (ISSN 0736-2536), vol. 6, Dec. 1986, p. 28-34.

The designing of aircraft transparencies is examined. Aircraft transparencies designers must account for human factors, supportability, integration, combat threats, and natural hazards when designing transparencies. Most transparencies for tactical aircraft include at least one ply of acrylic and polycarbonate, an

interlayer, outer liner, and a protective coating. Since windshields have a basic composition, design variations involve changing the laminate thickness, stacking sequence, coating, and supporting frames. Polycarbonate advantages and disadvantages, interlayers, the use of an indium-tin-oxide coating for protection against environmental hazards, and adhesives are discussed. The need to change the structure surrounding the transparency in order for the structure and not the transparencies to absorb impacts is studied. The transparency designs are unique to each tactical aircraft and examples of aircraft transparencies are presented.
I.F.

A87-27333
WHY ACCUMULATORS?
Aerospace Engineering (ISSN 0736-2536), vol. 6, Dec. 1986, p. 70-74.

The effects of higher operating pressure and higher density fluids on the accumulators of aircraft hydraulic systems are examined. An accumulator is a cylinder separated into two halves with gas on one side and hydraulic fluid on the other and it stores and absorbs energy. The functions and operation of the accumulator are described. The relationship between the accumulator's isothermal performance and compressibility factor is analyzed. The development of seals that can withstand higher pressure and the use of bellow-type accumulators in hydraulic systems are studied. The effectiveness of bellow-type accumulators is compared with that of piston-type accumulators and it is observed that the bellow-type accumulators are more effective due to the heat transfer capabilities of the bellows. I.F.

A87-27334
REMOTELY PILOTED VEHICLES JOIN THE SERVICE
PETER GWYNNE High Technology (ISSN 0277-2981), vol. 7, Jan. 1987, p. 38, 40-43.

The use of remotely piloted vehicles (RPVs) for such tasks as surveillance and signal monitoring is studied. The development of RPVs weighing under 600 lbs and between 5000-15,000 lbs is discussed. RPV systems consist of air vehicles, a ground control station, two portable control stations and two remote receiving stations, and a single launcher. Consideration is given to U.S. Navy and Army specifications for the RPVs and the use of RPVs to pilot aircraft. The advantages and disadvantages of the Army's RPV (Aquila) are examined. I.F.

N87-16813# Stanford Univ., Calif. Dept. of Aeronautics and Astronautics.
IDENTIFICATION OF A DYNAMIC MODEL OF A HELICOPTER FROM FLIGHT TESTS Ph.D. Thesis
GARTH W. MILNE Dec. 1986 297 p
Avail: Issuing Activity

Techniques for identifying continuous models of dynamic systems were applied to the unstable longitudinal hover dynamics of a CH-47B Chinook helicopter. The equation error method with carefully filtered 7.18 Hz data produced good pitch transfer function models. Frequency response plots for increasing order models were used to determine the model order. The linear inter-sample equivalent produced better continuous models from identified ARMA models than the zero order hold assumption. The 300% overshoot in the vertical acceleration step response arising from dynamic inflow and rotor coning was also identified. The MIMO Maximum Likelihood identification method with process and measurement noise was then examined. High Kalman gain increases the high-frequency weighting, increasing sensitivity to unmodeled dynamics. Low-noise sensors and the absence of measurement noise above 3 Hz (following pre-filtering to remove rotor noise) resulted in high Kalman gains and singular measurement noise covariance estimates, requiring use of the Maine-Iliff MMLW3 algorithm formulation. A discrete gradient version of this algorithm was developed for the PC-MATLAB language on IBM-PC type computers, and was used for longitudinal derivative identification. The algorithm is attractive for instructional use. A User's Manual is included. Author

N87-16814 Michigan Univ., Ann Arbor.
OPTIMAL TURNING AT HIGH ANGLE OF ATTACK OF SUPERSONIC AND HYPERSONIC VEHICLES Ph.D. Thesis
JAEMYONG LEE 1986 230 p
Avail: Univ. Microfilms Order No. DA8621320

The objective is to investigate the contribution of thrust angle of attack on the optimum turn of supersonic and hypersonic vehicles. The first part is concerned with the minimum time turning of a supersonic aircraft. Optimum trajectories including the effect of thrust angle of attack were studied using the Maximum Principle. Use of the domain of maneuverability, switching theory, and the Generalized Legendre Clebsch condition provides insight into the structure of the control and the optimality of the singular control. The problem of aerocruise of hypersonic vehicles with thrust angle was studied in the second part. A judicious choice of coordinate frame simplifies the relations between the aerodynamic turn and the corresponding changes in the inclination and the nodal angle. A new approach to solving the problem of achieving specified changes in both inclination and nodal angle without using numerical iterative methods is proposed. The influence of the key parameters, such as the initial argument of latitude, speed, cruise altitude, angle of attack, and thrust angle of attack is analyzed. The analytic solution giving the optimal thrust angle of attack is developed for the first time. It is shown to be accurate when compared with the numerical solution. Finally, an extremely accurate analytic solution for computing the trajectory with inclination changes of up to 40 deg. is developed. Dissert. Abstr.

N87-16815*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
FLIGHT INVESTIGATION OF THE EFFECT OF TAIL CONFIGURATION ON STALL, SPIN, AND RECOVERY CHARACTERISTICS OF A LOW-WING GENERAL AVIATION RESEARCH AIRPLANE
H. PAUL STOUGH, III, JAMES M. PATTON, JR., and STEVEN M. SLIWA Feb. 1987 125 p
(NASA-TP-2644; L-16194; NAS 1.60:2644) Avail: NTIS HC A06/MF A01 CSCL 01C

Flight tests were performed to investigate the stall, spin, and recovery characteristics of a low-wing, single-engine, light airplane with four interchangeable tail configurations. The four tail configurations were evaluated for effects of varying mass distribution, center-of-gravity position, and control inputs. The airplane tended to roll-off at the stall. Variations in tail configuration produced spins ranging from 40 deg to 60 deg angle of attack and turn rates of about 145 to 208 deg/sec. Some unrecoverable flat spins were encountered which required use of the airplane spin chute for recovery. For recoverable spins, antispin rudder followed by forward wheel with ailerons centered provided the quickest spin recovery. The moderate spin modes agreed very well with those predicted from spin-tunnel model tests, however, the flat spin was at a lower angle of attack and a slower rotation rate than indicated by the model tests. Author

N87-16816*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
IDENTIFICATION AND PROPOSED CONTROL OF HELICOPTER TRANSMISSION NOISE AT THE SOURCE
JOHN J. COY (Army Research and Technology Labs., Cleveland, Ohio), ROBERT F. HANDSCHUH, DAVID G. LEWICKI, RONALD G. HUFF, EUGENE A. KREJSA, and ALLAN M. KARCHMER 1987 23 p Proposed for presentation at the NASA/Army Rotorcraft Technology Conference, Moffett Field, Calif., 17-19 Mar. 1987
(NASA-TM-89312; NAS 1.15:89312; USAAVCOM-TR-87-C-2)
Avail: NTIS HC A02/MF A01 CSCL 01C

Helicopter cabin interiors require noise treatment which is expensive and adds weight. The gears inside the main power transmission are major sources of cabin noise. Work conducted by the NASA Lewis Research Center in measuring cabin interior noise and in relating the noise spectrum to the gear vibration of the Army OH-58 helicopter is described. Flight test data indicate that the planetary gear train is a major source of cabin noise and that other low frequency sources are present that could dominate the cabin noise. Companion vibration measurements were made in a transmission test stand, revealing that the single largest contributor to the transmission vibration was the spiral bevel gear mesh. The current understanding of the nature and causes of gear and transmission noise is discussed. It is believed that the kinematical errors of the gear mesh have a strong influence on that noise. The completed NASA/Army sponsored research that applies to transmission noise reduction is summarized. The continuing research program is also reviewed. Author

N87-16817# De Havilland Aircraft Co. of Canada Ltd., Downsview (Ontario).
PERFORMANCE DATA AEROC 8.2.AC.20, ISSUE 5, DASH 8, SERIES 100
Nov. 1986 90 p
Avail: NTIS HC A05/MF A01

The performance data for operations and route analysis are presented. The detailed description of the Dash 8 100 Series is given. All performance data are given with the deicing system off. All fuel consumption data are based on engine manufacture's specifications. Payload range, block fuel and time at constant cruise altitude is given, as is block time and fuel at optimum cruise altitude. Maximum permissible takeoff and landing weight is given along with takeoff and landing field lengths. Author

N87-16818# De Havilland Aircraft Co. of Canada Ltd., Downsview (Ontario).
PERFORMANCE DATA AEROC 8.2.AC.20(300), ISSUE 1
Sep. 1986 68 p
Avail: NTIS HC A04/MF A01

The performance data for operations and route analysis are presented. All performance data are given with the deicing system off. Block time and fuel data are given. Corrections for weights, temperatures, and wind speeds are contained on the charts. B.G.

N87-16819*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
AFTI/F-111 MAW FLIGHT CONTROL SYSTEM AND REDUNDANCY MANAGEMENT DESCRIPTION
RICHARD R. LARSON Feb. 1987 72 p
(NASA-TM-88267; H-1368; NAS 1.15:88267) Avail: NTIS HC A04/MF A01 CSCL 01C

The wing on the NASA F-111 transonic aircraft technology (TACT) airplane was modified to provide flexible leading and trailing edge flaps; this modified wing is known as the mission adaptive wing (MAW). A dual digital primary fly-by-wire flight control system was developed with analog backup reversion for redundancy. This report discusses the functions, design, and redundancy management of the flight control system for these flaps. Author

N87-16820*# National Aeronautics and Space Administration. Dryden (Hugh L.) Flight Research Center, Edwards, Calif.
DESIGN AND INITIAL APPLICATION OF THE EXTENDED AIRCRAFT INTERROGATION AND DISPLAY SYSTEM: MULTIPROCESSING GROUND SUPPORT EQUIPMENT FOR DIGITAL FLIGHT SYSTEMS
RICHARD D. GLOVER Jan. 1987 93 p
(NASA-TM-86740; H-1296; NAS 1.15:86740) Avail: NTIS HC A05/MF A01 CSCL 01C

A pipelined, multiprocessor, general-purpose ground support equipment for digital flight systems has been developed and placed in service at the NASA Ames Research Center's Dryden Flight Research Facility. The design is an outgrowth of the earlier aircraft interrogation and display system (AIDS) used in support of several research projects to provide engineering-units display of internal control system parameters during development and qualification testing activities. The new system, incorporating multiple 16-bit processors, is called extended AIDS (XAIDS) and is now supporting the X-29A forward-swept-wing aircraft project. This report describes the design and mechanization of XAIDS and shows the steps whereby a typical user may take advantage of its high throughput and flexible features. Author

N87-16821*# National Aeronautics and Space Administration. Dryden (Hugh L.) Flight Research Center, Edwards, Calif.
DIGITAL PROGRAM FOR CALCULATING STATIC PRESSURE POSITION ERROR
J. BLAIR JOHNSON, TERRY J. LARSON, and JULES M. FICKE Feb. 1987 28 p
(NASA-TM-86726; H-1284; NAS 1.15:86726) Avail: NTIS HC A03/MF A01 CSCL 01C

A computer program written to calculate the static pressure position error of airspeed systems contains five separate methods for determining position error, of which the user may select from one to five at a time. The program uses data from both the test aircraft and the ground-based radar to calculate the error. In addition, some of the methods require rawinsonde data or an atmospheric analysis, or both. The program output lists the corrections to Mach number, altitude, and static pressure that are due to position error. Reference values such as angle of attack, angle of sideslip, indicated Mach number, indicated pressure altitude, stagnation pressure, and total temperature are also listed. Author

N87-16822# Fairchild Industries, Inc., Farmingdale, N.Y.
ASSESSMENT OF DAMAGE TOLERANCE REQUIREMENTS AND ANALYSIS. VOLUME 1: EXECUTIVE SUMMARY Final Technical Report, Sep. 1982 - Nov. 1985
MEIR LEVY Sep. 1986 429 p
(Contract F33615-82-C-3215)
(AD-A175110; AFWAL-TR-86-3003-VOL-1) Avail: NTIS HC A19/MF A01 CSCL 20K

A structural test program of a typical aircraft structural configuration was conducted to assess the current Air Force damage tolerance design requirements defined in MIL-A-83444. The specimens, made of 2024-T3XX and 7075-T6XX, were subjected to randomized flight-by-flight spectra, representative of fighter/trainer and bomber/cargo-type loading spectra, respectively, and to constant amplitude loading spectrum. A total of 72 specimens were tested. The test results were correlated with analytical predictions using the crack growth method and combined method. As a result of this study, a recommendation is provided to the validity of MIL-A-83444, to develop guidelines for selection of critical crack locations, and to assess the state-of-the-art analytical capabilities in predicting crack growth and crack initiation time. This volume, Volume 1 of a five-volume report, presents an Executive Summary of the entire program. GRA

N87-17691*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
STRUCTURAL AND AERODYNAMIC LOADS AND PERFORMANCE MEASUREMENTS OF AN SA349/2 HELICOPTER WITH AN ADVANCED GEOMETRY ROTOR
RUTH M. HEFFERNAN and MICHEL GAUBERT (Societe Nationale Industrielle Aerospatiale, Marignane, France) Nov. 1986 423 p
(NASA-TM-88370; A-86423; NAS 1.15:88370) Avail: NTIS HC A18/MF A01 CSCL 01C

A flight test program was conducted to obtain data from an upgraded Gazelle helicopter with an advanced geometry, three bladed rotor. Data were acquired on upper and lower surface chordwise blade pressure, blade bending and torsion moments, and fuselage structural loads. Results are presented from 16 individual flight conditions, including level flights ranging from 10 to 77 m/sec at 50 to 3000 m altitude, turning flights up to 2.0 g, and autorotation. Rotor aerodynamic data include information from 51 pressure transducers distributed chordwise at 75, 88, and 97% radial stations. Individual tranducer pressure coefficients and airfoil section lift and pitching moment coefficients are presented, as are steady state flight condition parameters and time dependence rotor loads. All dynamic data are presented as harmonic analysis coefficients. Author

N87-17692*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
CORRELATION OF SA349/2 HELICOPTER FLIGHT-TEST DATA WITH A COMPREHENSIVE ROTORCRAFT MODEL
GLORIA K. YAMAUCHI, RUTH M. HEFFERNAN, and MICHEL GAUBERT (Societe Nationale Industrielle Aerospatiale, Marignane, France) Feb. 1987 56 p Presented at the 12th European Rotorcraft Forum, Garmisch-Fartenkirchen, West Germany, 22-25 Sep. 1986
(NASA-TM-88351; A-86385; NAS 1.15:88351) Avail: NTIS HC A04/MF A01 CSCL 01C

A comprehensive rotorcraft analysis model was used to predict blade aerodynamic and structural loads for comparison with flight test data. The data were obtained from an SA349/2 helicopter with an advanced geometry rotor. Sensitivity of the correlation to wake geometry, blade dynamics, and blade aerodynamic effects was investigated. Blade chordwise pressure coefficients were predicted for the blade transonic regimes using the model coupled with two finite-difference codes. Author

N87-17693*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
EFFECTS OF EMPENNAGE SURFACE LOCATION ON AERODYNAMIC CHARACTERISTICS OF A TWIN-ENGINE AFTERBODY MODEL WITH NONAXISYMMETRIC NOZZLES
FRANCIS J. CAPONE and GEORGE T. CARSON, JR. Feb. 1985 79 p
(NASA-TP-2392; L-15825; NAS 1.60:2392) Avail: NTIS HC A05/MF A01 CSCL 01C

An investigation has been conducted in the Langley 16-Foot Transonic Tunnel to determine the effects of empennage surface location and vertical tail cant angle on the aft-end aerodynamic characteristics of a twin-engine fighter-type configuration. The configuration featured two-dimensional convergent-divergent nozzles and twin-vertical tails. The investigation was conducted with different empennage locations that included two horizontal and three vertical tail positions. Vertical tail cant angle was varied from -10 deg to 20 deg for one selected configuration. Tests were conducted at Mach number 0.60 to 1.20 and at angles of attack -3 to 9 deg. Nozzle pressure ratio was varied from jet off to approximately 9, depending upon Mach number. Tail interference effects were present throughout the range of Mach numbers tested and found to be either favorable or adverse, depending upon test condition and model configuration. At a Mach number of 0.90, adverse interference effects accounted for a significant percentage of total aft-end drag. Interference effects on the nozzle were generally favorable but became adverse as the horizontal tails were moved from a mid to an aft position. The configuration with nonaxisymmetric nozzles had lower total aft-end drag with tails-off than a similar configuration with axisymmetric nozzles at Mach numbers of 0.60 and 0.90. Author

N87-17694*# McDonnell-Douglas Corp., Long Beach, Calif.
DC-10 WINGLET FLIGHT EVALUATION Summary Report, Aug. 1980 - Apr. 1982
A. B. TAYLOR Washington NASA Dec. 1983 66 p
(Contract NAS1-15327)
(NASA-CR-3748; NAS 1.26:3748; ACEE-17-FR-2836A) Avail: NTIS HC A04/MF A01 CSCL 01C

Results of a flight evaluation of winglets on a DC-10 Series 10 aircraft are presented. For sensitive areas of comparison, effects of winglets were determined back-to-back with and without winglets. Basic and reduced-span winglet configurations were tested. After initial encounter with low-speed buffet, a number of acceptable configurations were developed. For maximum drag reduction at both cruise and low speeds, lower winglets were required, having leading edge devices on upper and lower winglets for the latter regime. The cruise benefits were enhanced by adding outboard aileron droop to the reduced-span winglet aircraft. Winglets had no significant impact on stall speeds, high-speed buffet boundary, and stability and control. Flutter test results agreed with predictions and ground vibration data. Flight loads measurement, provided in a concurrent program, also agreed with predictions. It was estimated that a production version of the aircraft, using the reduced-span winglet and aileron droop, would yield a 3-percent reduction in fuel burned with capacity payload. This range was 2% greater than with winglets. A 5% reduction in takeoff distance at maximum takeoff weight would also result. Author

N87-17695*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
CALCULATED PERFORMANCE, STABILITY AND MANEUVERABILITY OF HIGH-SPEED TILTING-PROP-ROTOR AIRCRAFT
WAYNE JOHNSON, BENTON H. LAU, and JEFFREY V. BOWLES Sep. 1986 45 p
(NASA-TM-88349; A-86379; NAS 1.15:88349) Avail: NTIS HC A03/MF A01 CSCL 01C

The feasibility of operating tilting-prop-rotor aircraft at high speeds is examined by calculating the performance, stability, and maneuverability of representative configurations. The rotor performance is examined in high-speed cruise and in hover. The whirl-flutter stability of the coupled-wing and rotor motion is calculated in the cruise mode. Maneuverability is examined in terms of the rotor-thrust limit during turns in helicopter configuration. Rotor airfoils, rotor-hub configuration, wing airfoil, and airframe structural weights representing demonstrated advance technology are discussed. Key rotor and airframe parameters are optimized for high-speed performance and stability. The basic aircraft-design parameters are optimized for minimum gross weight. To provide a focus for the calculations, two high-speed tilt-rotor aircraft are considered: a 46-passenger, civil transport and an air-combat/escort fighter, both with design speeds of about 400 knots. It is concluded that such high-speed tilt-rotor aircraft are quite practical. Author

N87-17696# Loughborough Univ. of Technology (England). Dept. of Transport Technology.
A REVIEW OF THE PERFORMANCE OF SWEPT TIP HELICOPTER MAIN ROTOR BLADES AND AN ANALYSIS OF AEROACOUSTICAL EFFECTS M.S. Thesis
C. J. TRIGG 1986 138 p
(ETN-87-98936) Avail: NTIS HC A07/MF A01

The performance and effects of swept tip main rotor blades were studied, showing that the use of sweepback on the tips is advantageous. Although it is difficult to separate the effects of sweepback from the effects of other aerodynamic variables, there is sufficient evidence to justify the use of sweepback at the design stage and for post-design modification to improve the overall performance of a helicopter. Research into advanced planforms produced tips which show significant improvements in model and flight testing by utilizing a combination of variables in addition to sweepback. Sweepback on blade tips modifies the acoustic flow fields to yield benefits in rotational and broadband noise levels. ESA

N87-17697# Messerschmitt-Boelkow-Blohm G.m.b.H., Ottobrunn (West Germany).
INDUSTRIAL APPLICATION OF STRUCTURAL OPTIMIZATION IN AIRCRAFT CONSTRUCTION
HEINRICH WELLEN and KLAUS HERTEL 1986 15 p Presented at NATO Advanced Study Institute on Computer-Aided Optimal Design, Troia, Portugal, Jul. 1986
(MBB-UT-270-86; ETN-87-98973) Avail: NTIS HC A02/MF A01

The industrial application of structural optimization with the Structural Analysis and Redesign System (STARS) in aircraft construction is reviewed. Large and complicated components made of metal and composite materials can be weight-optimized with the methods used in STARS. Weight savings over conventional component designs are possible. Development costs can be reduced at shorter process times. Per iteration step the computing cost for optimization runs amount to one to three times the cost of stress analysis (depending on the optimization method employed). ESA

N87-17698# Aeronautical Research Inst. of Sweden, Stockholm. Structures Dept.
EIGENVALUE ANALYSIS OF 2D AIRCRAFT FUSELAGE BEAM MODEL AND FUSELAGE AIR CAVITY USING A SYMMETRIC FLUID-STRUCTURE INTERACTION FINITE ELEMENT FORMULATION
PETER J. E. GOERANSSON and FREDRIK C. DAVIDSSON Nov. 1986 18 p
(FFA-TN-1986-70; ETN-87-99114) Avail: NTIS HC A02/MF A01

An eigenvalue analysis for a two dimensional model of an aircraft fuselage and the passenger compartment was performed. The uncoupled eigenvalues and eigenvectors as well as the coupled were calculated. The effect of the air on the fuselage structure results in a lowering of the frequencies while the modes remain the same. The eigenfrequencies for the air cavity are increased but the modes are much like the uncoupled modes. However, for modes where the frequencies in the uncoupled solutions are close together, the coupling results in large shifts and new eigenmodes. ESA

N87-17753*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
THE MARS AIRPLANE
J. R. FRENCH *In* NASA. Marshall Space Flight Center Manned Mars Missions. Working Group Papers, Volume 1, Section 1-4 p 406-414 May 1986
Avail: NTIS HC A22/MF A01 CSCL 01C

The concept of the Mars airplane was developed as a potential vehicle for unmanned Mars exploration. It is suggested that its most appropriate use would be as an unmanned adjunct to a manned mission. Functions such as reconnaissance, exploration, remote delivery of instruments, etc., are possible. Several operational aspects of such a vehicle are unique compared to Earth operating aircraft. Author

06

AIRCRAFT INSTRUMENTATION

Includes cockpit and cabin display devices; and flight instruments.

A87-25882
A PROCEDURE FOR THE MECHANICAL DESIGN OF MILITARY AIRCRAFT HEAD-UP-DISPLAYS TO WITHSTAND BIRD-STRIKE LOADS
R. A. WHALE, J. M. OKEEFFE, and B. RIGGALL (Structural Dynamics Research Corp.; GEC Avionics, Ltd., Rochester, England) IN: Industrial vibration modelling: Polymodel 9; Proceedings of the Ninth Annual Conference, Newcastle-upon-Tyne, England, May 21, 22, 1986 . Dordrecht, Martinus Nijhoff Publishers, 1987, p. 227-243.

The modeling procedures employed in redesigning the F-16 head-up-display (HUD) system to withstand bird-strike loads transmitted to it through the cockpit canopy are described and illustrated with drawings, diagrams, and graphs. High-speed film records of bird-strike tests were analyzed, and a linear finite-element model approximating the nonlinear response of the HUD-canopy structure was constructed and refined via repeated correlations to the test data. The model was found to predict accurately the natural frequencies of the structure, the dominance of the 52-Hz first mode after bird impact, and the contributions of the higher-frequency modes, but its conservative assumptions caused it to predict levels of strain about four times higher than those measured in the tests. This discrepancy was reduced to a factor of 1.75 by incorporating more detailed damping data and accounting for preliminary structural modifications. T.K.

N87-16823# Rome Air Development Center, Griffiss AFB, N.Y.
ICNIA (INTEGRATED COMMUNICATIONS NAVIGATION IDENTIFICATION AVIONICS) HF TRANSMITTER SYSTEM PRELIMINARY STUDY Report, Apr. 1983 - Dec. 1984
GEORGE A. PFEIFFER Jul. 1986 31 p
(AD-A173013; RADC-TM-86-4) Avail: NTIS HC A03/MF A01 CSCL 17B

The ICNIA HF Transmitter System Preliminary Study describes an investigation to determine if it is feasible to develop and fabricate an airborne HF/VHF power amplifier, antenna coupler, and antenna for high speed, high performance aircraft having future application in integrated CNI avionics systems. A key objective was to investigate and validate an airborne antenna with low reactive components that could be fabricated into an aircraft frame. The study shows that it is feasible to design and fabricate HF/VHF equipment for small high speed, high performance aircraft that can be integrated into CNI avionics systems. GRA

07

AIRCRAFT PROPULSION AND POWER

Includes prime propulsion systems and systems components, e.g., gas turbine engines and compressors; and onboa rd auxiliary power plants for aircraft.

A87-23731#
DIGITAL SIMULATION OF THE GAS TURBINE ENGINE PERFORMANCE
YEI-CHIN CHAO and REN-CHUN HO (National Cheng Kung University, Tainan, Republic of China) Chinese Society of Mechanical Engineers, Journal (ISSN 0257-9731), vol. 7, Oct. 1986, p. 319-328. refs

Digital simulation of gas-turbine engine performance is a means to estimate all the engine performance parameters at the design point to a more accurate extent. This is an easy approach to simulate the complex gas-turbine engine, and it can also be regarded as a foundation on which the complicated off-design-point analysis is based. The present work is based on numerical analysis by digital computer, assuming a quasi-one-dimensional flow field and the gas mixture obtained from the combustion of air and fuel (CHx) as the working fluid. The thermodynamic properties of this gas mixture are assumed to be continuous functions of temperature and fuel-air ratio. Simulation of the turbojet engine, separated-flow turbofan engine mixed-flow turbofan engine, and turbojet engine and turbofan engine with afterburner is carried out. The application of the computer program developed to determine the important performance parameters (compression ratio, bypass ratio, etc.) of the turbofan engine, and the reason for the improved performance of a turbofan engine with a constant area mixer, are explained by practical examples. Author

A87-24007#
BENEFITS OF BLADE SWEEP FOR ADVANCED TURBOPROPS
F. B. METZGER and C. ROHRBACH (United Technologies Corp., Hamilton Standard Div., Windsor Locks, CT) Journal of Propulsion and Power (ISSN 0748-4658), vol. 2, Nov.-Dec. 1986, p. 534-540. Previously cited in issue 19, p. 2755, Accession no. A85-41420. refs

A87-24612
FADEC FOR FIGHTER ENGINES
CHARLES GILSON Interavia (ISSN 0020-5168), vol. 41, Nov. 1986, p. 1324-1326.

Full Authority Digital Engine Control (FADEC) technology is rapidly becoming a standard feature of military gas turbine engines, reliably relieving the pilot from frequent and complex engine operation managements tasks. FADEC systems offer lower weight and reduced specific fuel consumption than the hydromechanical systems they replace, in virtue of miniaturization and more accurate fuel metering, respectively. FADEC also improves the precision and repeatability of engine control in such operations as performance limiting and accelerations. Attention is given to state-of-the-art proprietary offerings in the field of FADEC systems, and to projections of future design features and performance capabilities for such units in next-generation fighter aircraft. O.C.

A87-24940#
FINITE AMPLITUDE WAVES IN RAMJET COMBUSTORS
T. G. YIP (Ohio State University, Columbus) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 6 p. refs
(AIAA PAPER 87-0221)

The profiles of finite amplitude waves at different locations in a combustor have been calculated based onn the solution of the piston problem in nonlinear wave theory. The wave source is the unsteady heat release in a burning vortex. Existing data on the heat release rate is used in the calculation. Numerical results of finite amplitude waves propagating in reacting liquid hydrogen - air mixture in a ramjet combustor is also presented. The results indicate that the transition from finite amplitude to shock wave could take place in a ramjet combustor. Author

A87-24944*# Texas A&M Univ., College Station.
COMPUTATIONAL AEROACOUSTICS OF PROPELLER NOISE IN THE NEAR AND FAR FIELD
D. W. FORSYTH and K. D. KORKAN (Texas A & M University, College Station) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 63 p. refs
(Contract NAS3-354)
(AIAA PAPER 87-0254)

Techniques for applying the NASPROP-E computer code (Bober et al., 1983) to characterize the acoustic field of a transonic propfan are described and demonstrated for the case of the SR-3 propfan. It is pointed out that NASPROP E accounts for the nonlinear quadrupole, monopole, and dipole noise sources. The approach used, based on that of White (1984) and Korkan et al. (1985 and 1986), is described in detail, and the results of simulations employing different (reflective and nonreflective) inflow-outflow boundary conditions and azimuthal mesh spacings are presented in graphs and briefly discussed. T.K.

A87-25050
REDUCING THE COST OF AERO ENGINE RESEARCH AND DEVELOPMENT
P. C. RUFFLES (Rolls-Royce, PLC, Derby, England) Aerospace (UK) (ISSN 0305-0831), vol. 13, Nov. 1986, p. 10-19.

Although the earliest, and simplest, of the gas turbine aircraft engine technology development projects proceeded at comparatively modest cost, gradual increases in engine complexity conspired by the early 1970s to make further research and development prohibitively expensive, substantially reducing the numbers of this industry's innovative products. Attention is presently given to the nearly 50-percent research and development cost reductions achieved in the course of the last decade through the use of demonstration engine programs prior to full development. Attention is given to the generation of a technology base, and the economies obtainable through multiple applications of a given engine core design and 'right the first time' design and validation efforts. O.C.

A87-25265
THEORY AND ANALYSIS OF AIRCRAFT TURBOMACHINES (2ND REVISED AND ENLARGED EDITION) [TEORIIA I RASCHET AVIATSIONNYKH LOPATOCHNYKH MASHIN /2ND REVISED AND ENLARGED EDITION/]
KONSTANTIN VASILEVIC KHOLSHCHEVNIKOV, OLEG NAUMOVICH EMIN, and VLADILEN TIKHONOVICH MITROKHIN Moscow, Izdatel'stvo Mashinostroenie, 1986, 432 p. In Russian. refs

The book is concerned with the theoretical fundamentals of turbines and with the characteristics of the working process of axial-flow, centrifugal, and combined compressors and of axial-flow and centripetal turbines. In particular, attention is given to the mathematical models and principal equations of turbomachines, similarity and modeling in the theory of turbines, thermodynamic processes in turbomachines and their efficiency, and the aerodynamics of flow and losses in the flow path of turbomachines. Also discussed are the performance characteristics of turbomachines and methods of their experimental determination, unstable operation of compressors, and optimization of the parameters of turbines of various types. V.L.

A87-25396*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
THE EFFECT OF CIRCUMFERENTIAL AERODYNAMIC DETUNING ON COUPLED BENDING-TORSION UNSTALLED SUPERSONIC FLUTTER
D. HOYNIAK (NASA, Lewis Research Center, Cleveland, OH) and S. FLEETER (Purdue University, West Lafayette, IN) ASME, Transactions, Journal of Turbomachinery (ISSN 0889-504X), vol. 108, Oct. 1986, p. 253-260. Previously announced in STAR as N86-21513. refs
(ASME PAPER 86-GT-100)

A mathematical model developed to predict the enhanced coupled bending-torsion unstalled supersonic flutter stability due to alternate circumferential spacing aerodynamic detuning of a turbomachine rotor. The translational and torsional unsteady aerodynamic coefficients are developed in terms of influence coefficients, with the coupled bending-torsion stability analysis developed by considering the coupled equations of this aerodynamic detuning on coupled bending-torsion unstalled supersonic flutter as well as the verification of the modeling are then demonstrated by considering an unstable 12 bladed rotor, with Verdon's uniformly spaced Cascade B flow geometry as a baseline. However, with the elastic axis and center of gravity at 60 percent of the chord, this type of aerodynamic detuning has a minimal effect on stability. For both uniform and nonuniform circumferentially space rotors, a single degree of freedom torsion mode analysis was shown to be appropriate for values of the bending-torsion natural frequency ratio lower than 0.6 and higher 1.2. When the elastic axis and center of gravity are not coincident, the effect of detuning on cascade stability was found to be very sensitive to the location of the center of gravity with respect to the elastic axis. In addition, it was determined that when the center of gravity was forward of an elastic axis located at midchord, a single degree of freedom torsion model did not accurately predict cascade stability. Author

A87-25411#
LOW CYCLE FATIGUE LIFE TESTING RESEARCH OF AN AEROENGINE CASING
RUIGANG PU (Shenyang Aeroengine Research Institute, People's Republic of China) Journal of Aerospace Power, vol. 1, July 1986, p. 11-14. In Chinese, with abstract in English.

This paper presents in detail the method of low-cycle fatigue-life testing research on engine casings. The following aspects are considered: the determination of standard cycle load, testing samples, and the design of connections; stress testing and cycle testing under synchronously loaded conditions at several points of a fully-size case; and the determination of approved cycle life and usage life. Author

A87-25421#
INTEGRATED DYNAMIC MODEL OF TWO-VARIABLE SUPERSONIC INLET-ENGINE COMBINATION
JIANBO YANG and YANSHEN GUAN (Northwestern Polytechnical University, Xian, People's Republic of China) Journal of Aerospace Power, vol. 1, July 1986, p. 63-68. In Chinese, with abstract in English. refs

An integrated dynamic model of a two-variable (normal shock position and engine speed) inlet-engine combination is formulated on the basis of the idea put forward by Guan et al. (1984), but the effect of engine flow feedback on the inlet during the transient period is taken into consideration, and the matrix-fraction-description method is applied to transforming frequency domain into state space domain in the model. The results of a sample digital simulation for the NASA 48-cm-inlet J85 engine combination show that the method of formulation is satisfactory. Author

A87-25422#

DEVELOPMENT OF HIGH BY-PASS RATIO TURBOFAN ENGINES

GUANG CHEN (Beijing Institute of Aeronautics and Astronautics, People's Republic of China) Journal of Aerospace Power, vol. 1, July 1986, p. 69-75. In Chinese, with abstract in English. refs

The development of the second and the third generations of high-bypass-ratio turbofan engines, as well as the technical measures for improving the performance of these engines, are summarized and reviewed in this paper. Compared with their predecessors, the second and the third generations of high-bypass-ratio turbofan engines have much lower SFC, fewer parts, a lower rate of performance deterioration, and superior maintainability and reliability, as well as some other advantages. To achieve this, a lot of significant advanced technologies have been developed and put in practice. Remarks on aeroengine development in China are included. Author

A87-25717#

DESIGN AND DEVELOPMENT OF A POWER TAKEOFF SHAFT

DOMENICK J. GARGIULO (Grumman Aerospace Corp., Bethpage, NY) Journal of Aircraft (ISSN 0021-8669), vol. 23, Dec. 1986, p. 876-880. Previously cited in issue 01, p. 12, Accession no. A86-10971.

A87-25884

A WHOLE-SYSTEM ANALYSIS OF RECUPERATED GAS TURBINES

D. LIOR and B. GAL-OR (Technion - Israel Institute of Technology, Haifa) International Journal of Turbo and Jet-Engines (ISSN 0334-0082), vol. 3, no. 1, 1986, p. 21-31. refs

An attempt is made to arrive at a unified methodology encompassing the various parameters affecting both heat exchanger and gas turbine in recuperated powerplant systems, especially at partial load levels; this is presented in terms of overhaul equations containing all the geometric and thermodynamic variables affecting the system at variable load levels. This approach should be especially useful in the design of tank propulsion systems, which normally operate at partial power levels. The methodology is applied in the analysis of a normal gas turbine cycle, estimating the values of the optimal pressure drops required to obtain maximal thermal efficiencies. O.C.

A87-25911#

NUMERICAL DETERMINATION OF THE DYNAMIC CHARACTERISTICS OF A COMPOSITE BLADE

P. GEOFFROY (ONERA, Chatillon-sous-Bagneux, France) (Colloquium on Current Trends in Structural Computation, Bastia, France, Nov. 1985) La Recherche Aerospatiale (English Edition) (ISSN 0379-380X), no. 2, 1986, p. 55-62. refs

This paper presents some numerical results concerning the vibratory behavior of a composite blade of a high speed propeller. The numerical methods are described along with the degenerate thick shell element of the ASTRONEF finite element code used in this study. The computed eigenvalues and nodal lines are compared with experimental values and with those calculated using the SAMCEF finite element program. The calculated data show a good agreement with experimental values and underline the advantages of the degenerate thick shell element. Author

A87-25969#

ANALYSIS OF AIRCRAFT PISTON ENGINE FAILURES. I [ANALIZA USZKODZEN LOTNICZYCH SILNIKOW TLOKOWYCH. I]

ANDRZEJ ADAMOWICZ and MIECZYSLAW PIGLAS (Instytut Techniczny Wojsk Lotniczych, Warsaw, Poland) Technika Lotnicza i Astronautyczna (ISSN 0040-1145), vol. 41, June 1986, p. 4-6. In Polish.

Typical aircraft piston engine failures are described. Consideration is given to the impact of these failures on flight safety. K.K.

A87-25973#

ANALYSIS OF AIRCRAFT PISTON ENGINE FAILURES. II [ANALIZA USZKODZEN LOTNICZYCH SILNIKOW TLOKOWYCH. II]

ANDRZEJ ADAMOWICZ and MIECZYSLAW PIGLAS (Instytut Techniczny Wojsk Lotniczych, Warsaw, Poland) Technika Lotnicza i Astronautyczna (ISSN 0040-1145), vol. 41, July 1986, p. 18-21. In Polish. refs

A87-26304

OPTIMIZATION OF A METHOD FOR DETERMINING THE FATIGUE LIMIT OF THE BLADES OF GAS TURBINE ENGINES [OPTIMIZATSIIA METODA OPREDELENIIA PREDELA VYNOSLIVOSTI LOPATOK GTD]

B. F. BALASHOV, V. P. KHARKOV, and Z. KH. IUROVSKII Problemy Prochnosti (ISSN 0556-171X), Nov. 1986, p. 21-23. In Russian.

A standard method for the fatigue testing of the blades of gas turbine engines is investigated by means of a probabilistic computer simulation. The results of the simulation are then used to recommend ways of optimizing the test procedure. The level of confidence of the fatigue limit determinations based on the recommended test procedures is evaluated. Details of the simulation procedure are included. V.L.

A87-26307

THE EFFECT OF TEMPERATURE, PROTECTIVE COATINGS, AND SERVICE HISTORY ON THE FATIGUE STRENGTH OF GAS-TURBINE ENGINE BLADES MADE FROM THE HIGH-TEMPERATURE CAST ALLOY EP539LM [VLIIANIE TEMPERATURY, ZASHCHITNYKH POKRYTII I EKSPLUATATSIONNOI NARABOTKI NA SOPROTIVLENIE USTALOSTI RABOCHIKH LOPATOK GTD IZ LITEINOGO ZHAROPROCHNOGO SPLAVA EP539LM]

V. I. ROMANOV, B. A. GRIAZNOV, A. A. RABINOVICH, O. G. ZHIRITSKII, I. S. MALASHENKO (AN USSR, Institut Problem Prochnosti, Kiev, Ukrainian SSR) et al. Problemy Prochnosti (ISSN 0556-171X), Nov. 1986, p. 47-52. In Russian.

A procedure for the fatigue testing of the blades of gas-turbine engines at high temperatures and loading frequencies is described with particular reference to blades made from the high-temperature cast alloy EP539LM with various protective coatings. The heating of test specimens is done by high-frequency current; mechanical loading is carried out using an electrodynamic excitation and high-Q oscillatory systems. It is shown that, as a rule, protective coatings somewhat reduce the fatigue strength of the alloy, with the exception of slurry-diffusion Al-Si coatings. Optimum overall protection, however, is provided by a multicomponent electron-beam Co-Cr-Al-Y coating. V.L.

A87-27477#

DESIGN OF SWIRL SIMULATORS

CHENGYI PENG, FENG LIN, and KUNYUAN ZHANG (Nanjing Aeronautical Institute, People's Republic of China) Journal of Aerospace Power, vol. 1, Oct. 1986, p. 103-106, 181, 182. In Chinese, with abstract in English. refs

A method for designing swirl simulators is presented. In this method, the number, circumferential position, geometry, and angle of attack of the blades may vary. The computation goes step by step from the blade section up to the final section in order to determine the desired flow pattern. Comparison of the computational result with the desired result guides the modification of the blade arrangement. Swirl patterns given in the literature for real aircraft inlets have been simulated using the method, and test results are shown to be satisfactory. C.D.

A87-27478#
CONVERGENCE OF PERFORMANCE CALCULATION OF TWIN SPOOL TURBOJET AND TURBOFAN
XINGJIAN ZHU, XUEYU WANG, QINGJIN YAN, and XUELIANG ZHANG (Beijing Institute of Aeronautics and Astronautics, People's Republic of China) Journal of Aerospace Power, vol. 1, Oct. 1986, p. 107-110, 182. In Chinese, with abstract in English.

The steady state performance of a twin spool turbojet and turbofan using a multivariable nonlinear equation is demonstrated. A method of iteration, the (n + 1) points residue method, is adapted to solve the equation. A set of seven-variable equations is reduced to a combination of one three-variable equation set and two two-variable equation sets. The order reduction method is used to obtain iteration convergence. Test values are determined for unknown quantities, and their variable ranges in the iteration process are confined in accordance with the physical model of the engine. Satisfactory results can be achieved with this approach not only in calculating the steady state performance under any flight conditions and throttle settings, but also in calculating the dynamic state performance. C.D.

A87-27481#
EFFECTS OF THREE CENTRES OF BLADE ON FLUTTERING
CHENGSHENG ZHANG and ZHAOHONG SONG (Beijing Institute of Aeronautics and Astronautics, People's Republic of China) Journal of Aerospace Power, vol. 1, Oct. 1986, p. 121-124, 184. In Chinese, with abstract in English. refs

The effects of three blade centers, the aerodynamic center (AC), the center of gravity (COG), and the center of torsion (COT), on blade fluttering is studied. A structural model of the coupling between bending and torsion is presented, considering the aerodynamic loads as functions of the velocities of the blade vibration. The complex eigenvalue equations are solved using the iteration approach. It is concluded that a blade with a forward COT is more stable than a blade with a rearward one. The stability of a blade with forward COT is improved when the AC is between the COG and the COT. A blade with rearward COT is unstable when the AC is between the COG and the COT. A blade whose AC located at the leading edge is the best. C.D.

A87-27485#
DYNAMIC SIMULATION RESEARCH ON DIGITAL SPEED CONTROL SYSTEM OF AEROENGINE
MIN TIAN and CHIHUA WU (Northwestern Polytechnical University, Xian, People's Republic of China) Journal of Aerospace Power, vol. 1, Oct. 1986, p. 141-144, 187. In Chinese, with abstract in English.

This paper describes real time dynamic simulation research on the digital speed control system of an aeroengine under small perturbation conditions. The control calculation approach has been programmed for a microcomputer. The proportional derivative control is applied to the large error region and the proportional control to the small error region. Furthermore, in the small error region, the large proportional constant control is adopted if the error increment tends to increase, and the small proportional constant control is employed when it tends to decrease. For the sake of normal operation in the digital speed control system, the influence of the high frequency disturbance, the overspeed and spillover in the microcomputer have been eliminated. Finally, the flow chart of the program and the real time simulation tests are demonstrated. The test results and some useful conclusions are also presented. Author

A87-27491#
VIBRATION SPECTRUM ANALYSIS OF A TURBOPROP ENGINE IN STARTING PROCESS
JINGHAI GAO and LIANRUI HE (Harbin Engine Manufacturing Co., People's Republic of China) Journal of Aerospace Power, vol. 1, Oct. 1986, p. 164-166, 190. In Chinese, with abstract in English.

This paper describes how the FFT (Fast Fourier Transform) technique is applied to the spectrum analysis of the vibration signals recorded in starting process of a turboprop engine and what features of its spectrum have been found out. Based on analyzing the vibration data recorded from 174 starting processes, the basic rules of vibration in starting of the engine are found and essential differences between normal and troubled engines are clarified. Vibration divergence in hot and cold startings and the influences of thermal deformation of the engine rotors on the vibration are also investigated. This work has accumulated data and experiences for fault diagnosis and monitoring in starting of the engine. Author

A87-27492#
CONSTRUCTIONAL IMPROVEMENTS IN A TURBOPROP ENGINE
YANXIAO YAN (Harbin Engine Manufacturing Co., People's Republic of China) Journal of Aerospace Power, vol. 1, Oct. 1986, p. 167-169, 191. In Chinese, with abstract in English.

The principal constructional improvements in the reducer, compressor, combustor, turbine and bearings of a turboprop engine are summarized. Practice shows that the constructional improvements in the reducer and the turbine are of the most importance in prolonging the service life of this turboprop engine. Author

A87-27493#
AN EXPERIMENTAL STUDY ON DISTRIBUTION OF COLD AND HOT AIRFLOWS IN COMBUSTOR
LIXIAO MO (Gas Turbine Establishment, People's Republic of China) Journal of Aerospace Power, vol. 1, Oct. 1986, p. 170-172, 191. In Chinese, with abstract in English.

The flow distribution in an annular combustor at different Mach numbers and heating ratios was investigated experimentally. An empirical relationship for coordination between the cold and the hot flow distributions has been established with the aid of the least squares method based on the experimental results. The data calculated are in good agreement with the test ones. Therefore, the aim of the study is realized that the empirical formula enables the combustor flow distribution at different Mach numbers and heating ratios to be predicted according to the flow distribution at a given low Mach number with cold air flow. Author

A87-27536
PROPELLER PSEUDONOISE
R. LEGENDRE (ONERA, Chatillon-sous-Bagneux, France) La Recherche Aerospatiale (ISSN 0379-380X), no. 6, 1985, p. 73-76.

A technique is presented for calculating the displacement pseudonoise generated by, e.g., an aircraft propeller or lift motions in a 'steady' flow. A general solution is defined for the Helmholtz linearized unsteady isentropic aerodynamic equation. Unsteadiness, necessary for the production of noise, is present because of the motion induced in air through which the propeller rotates. The air is unsteady relative to calm air in the far-field. The model is useful for subtracting the displacement pseudonoise effects in the near-field when acquiring acoustic data around aircraft in wind tunnels. M.S.K.

N87-16824 Rolls-Royce Ltd., Derby (England).
LOW ASPECT RATIO TURBINE DESIGN AT ROLLS-ROYCE
S. E. MORGAN 5 Aug. 1986 92 p Presented at a Von Karman Inst. for Fluid Dynamics Lecture, Rhode-Saint-Genese, Belgium, 10 May 1984
(PNR90338; ETN-87-98778) Avail: NTIS HC A05

Low aspect ratio turbine design considerations are reviewed, and a computer aided design package is presented. A low aspect ratio HP stator design featuring a parabolic vortex distribution is described. ESA

N87-16825*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
OUTDOOR TEST STAND PERFORMANCE OF A CONVERTIBLE ENGINE WITH VARIABLE INLET GUIDE VANES FOR ADVANCED ROTORCRAFT PROPULSION
JACK G. MCARDLE Dec. 1986 25 p Prepared for presentation at the 1987 Rotorcraft Technology Conference, Moffett Field, Calif., 17-19 Mar. 1987; sponsored in part by NASA and Army
(NASA-TM-88939; E-3384; NAS 1.15:88939) Avail: NTIS HC A02/MF A01 CSCL 21E

A variable inlet guide van (VIGV) type convertible engine that could be used to power future high-speed rotorcraft was tested on an outdoor stand. The engine ran stably and smoothly in the turbofan, turboshaft, and dual (combined fan and shaft) power modes. In the turbofan mode with the VIGV open fuel consumption was comparable to that of a conventional turbofan engine. In the turboshaft mode with the VIGV closed fuel consumption was higher than that of present turboshaft engines because power was wasted in churning fan-tip airflow. In dynamic performance tests with a specially built digital engine control and using a waterbrake dynamometer for shaft load, the engine responded effectively to large steps in thrust command and shaft torque. Previous mission analyses of a conceptual X-wing rotorcraft capable of 400-knot cruise speed were revised to account for more fan-tip churning power loss than was originally estimated. The new calculations confirm that using convertible engines rather than separate lift and cruise engines would result in a smaller, lighter craft with lower fuel use and direct operating cost. Author

N87-16828*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
OVER-THE-WING PROPELLER Patent
JOSEPH L. JOHNSON, JR., inventor (to NASA) and E. RICHARD WHITE, inventor (to NASA) (Kentron International, Inc., Hampton, Va.) 16 Dec. 1986 9 p Continuation of US-Patent-Appl-SN-661478, dated 16 Oct. 1984, abandoned
(NASA-CASE-LAR-13134-2; US-PATENT-4,629,147; US-PATENT-APPL-SN-846462; US-PATENT-CLASS-244-55; US-PATENT-CLASS-244-130) Avail: US Patent and Trademark Office CSCL 21E

This invention is an aircraft with a system for increasing the lift drag ratio over a broad range of operating conditions. The system positions the engines and nacelles over the wing in such a position that gains in propeller efficiency is achieved simultaneously with increases in wing lift and a reduction in wing drag. Adverse structural and torsional effects on the wings are avoided by fuselage mounted pylons which attach to the upper portion of the fuselage aft of the wings. Similarly, pylon-wing interference is eliminated by moving the pylons to the fuselage. Further gains are achieved by locating the pylon surface area aft of the aircraft center of gravity, thereby augmenting both directional and longitudinal stability. This augmentation has the further effect of reducing the size, weight and drag of empennage components. The combination of design changes results in improved cruise performance and increased climb performance while reducing fuel consumption and drag and weight penalties.
Official Gazette of the US Patent and Trademark Office

N87-16831# United Technologies Research Center, East Hartford, Conn.
UNSTEADY AERODYNAMICS OF A ROTATING COMPRESSOR BLADE ROW IN INCOMPRESSIBLE FLOW. VOLUME 1: EXPERIMENTAL FACILITIES, PROCEDURES AND SAMPLE DATA Final Report, Jun. 1981 - Aug. 1985
LARRY W. HARDIN and FRANKLIN O. CARTA 31 Aug. 1985 98 p
(Contract F49620-81-C-0088)
(AD-A173043; UTRC/R85-915767-3; AFOSR-86-0863TR) Avail: NTIS HC A05/MF A01 CSCL 21E

An experiment was conducted on a heavily instrumented isolated model compressor rotor to study the unsteady aerodynamic response of the blade row to a circumferential inlet flow distortion with non-oscillating blades, and to blade oscillation in an undistorted flow. To accomplish this, miniature pressure transducers were imbedded in the blades and the unsteady pressure time histories were recorded as the blades were subjected to these conditions. Both phases of the experiment were performed over a wide range of flow coefficient, from (c sub x)/(u sub m) = 0.6 to 0.95 in 0.05 steps, and data were taken at each condition for disturbances characterized by one, two, and four per revolution waves. Steady-state data were also acquired and were found to agree with baseline data obtained from an earlier experiment using the same model geometry. Volume 1 describes the purpose of the experiment, the test rig and model hardware, the data system, and the techniques used to acquire and reduce the data. Some sample data taken at the design condition, (c sub x)/(u sub m) = 0.8 are also included. GRA

N87-16832# United Technologies Research Center, East Hartford, Conn.
UNSTEADY AERODYNAMICS OF A ROTATING COMPRESSOR BLADE ROW AT LOW MACH NUMBER. VOLUME 2: ANALYSIS OF EXPERIMENTAL RESULTS AND COMPARISON WITH THEORY Final Report, Jun. 1981 - May 1986
LARRY W. HARDIN and FRANKLIN O. CARTA 6 Jun. 1986 176 p
(Contract F49620-81-C-0088)
(AD-A173044; UTRC/R86-915767-4) Avail: NTIS HC A09/MF A01 CSCL 20D

This volume contains an analysis of the data and compares the steady and unsteady results of this experiment with both analytical predictions and experimental data from previous work. The bulk of the data analysis was made for results taken at the blade midspan. There were two major findings. It was found that the unsteady oscillatory pressures were in excellent agreement with the unsteady potential flow theory of Verdon and Caspar for all conditions in which the flow was essentially two-dimensional. Also, the measured steady pressures were in good agreement with the steady potential flow predictions (and with previous steady experimental data) when the measured exit angle was the imposed down stream boundary condition for the analysis. This volume also offers some hypotheses to explain some of the details observed in the pressure and skin friction gage time histories and relates some previously published flow visualization results to these observations. GRA

N87-16833# United Technologies Research Center, East Hartford, Conn.
UNSTEADY AERODYNAMICS OF A ROTATING COMPRESSOR BLADE ROW AT LOW MACH NUMBER. VOLUME 3: EXPERIMENTAL DATA BASE AND USERS MANUAL Final Report, Jun. 1981 - May 1986
LARRY W. HARDIN and FRANKLIN O. CARTA 27 May 1986 447 p
(Contract F49620-81-C-0088)
(AD-A173045; UTRC/R85-915767-5) Avail: NTIS HC A19/MF A01 CSCL 20D

This last volume is intended to serve as an index and a users guide to the data obtained. It contains extensive plots of the unsteady data taken during the experiment, and a description of the data reduction procedures used to store the data in description of the data reduction procedures used to store the data in Fourier coefficient form. These data are stored on a set of archival tapes at AFOSR. This volume contains an index to the specific data files stored on the tapes, by name, as well as format information and instructions for reading the data into disk files. FORTRAN programs for reading and manipulating the data are also provided. GRA

N87-16834# Rolls-Royce Ltd., Leavesden (England).
IMPACT OF IPS AND IRS CONFIGURATION ON ENGINE INSTALLATION DESIGN
J. R. BALLARD 2 Jun. 1986 14 p Previously announced as N87-10070 Sponsored by the UK Ministry of Defence Procurement Executive
(PNR90324; ETN-87-98773) Avail: NTIS HC A02/MF A01

It is argued that helicopter engine design should be coordinated with engine and airframe mounted separator performance characteristics to ensure that optimized designs can be offered to customers with very different operational requirements. A design method which allows the erosion reduction characteristics of engine and airframe IPS designs to be taken into account during engine design is outlined. An IPS design optimized for European operations can be efficiently adapted for extreme climate conditions; IRS designs can be integrated with IPS scavenge requirements to produce a low signature engine installation. ESA

N87-16835# Rolls-Royce Ltd., Derby (England).
MANUFACTURING CELL FOR THE V2500 VARIABLE VANES
J. MCSHERRY and A. J. HILL 2 Apr. 1986 8 p Presented at the International Conference on Computer-Aided Production Engineering, Edinburgh, Scotland, 2 Apr. 1986
(PNR90330; ETN-87-98777) Avail: NTIS HC A02/MF A01

The conceptual design of a manufacturing cell for the production of the first four stages of stators of the variable pitch type for a turbofan aircraft engine is presented. The philosophies which were developed during the initial investigation covering aspects such as work holding, tooling, inspection, manning, and control systems are outlined. The technical solutions offered from stand alone numerical control machines to a full flexible manufacturing system are discussed. ESA

N87-16836# Rolls-Royce Ltd., Derby (England).
REDUCING THE COST OF AERO ENGINE RESEARCH AND DEVELOPMENT
P. C. RUFFLES 5 Aug. 1986 12 p
(PNR90341; ETN-87-98779) Avail: NTIS HC A02/MF A01

Cost reductions in aircraft engine R and D due to computer aided design and fuller demonstration programs prior to full engine development are discussed. ESA

N87-16838# Rolls-Royce Ltd., Derby (England).
COMPONENT LIFING
A. C. PICKARD 10 Jun. 1986 29 p Presented at the Inst. of Metals Conference on Mechanical Behavior of Superalloys, 10-11 Jun. 1986
(PNR90346; ETN-87-98781) Avail: NTIS HC A03/MF A01

Failure mechanisms which can occur in an aircraft engine component in service are categorized into low life failures, macroscopically nonlocalized damage accumulation, and macroscopically localized damage accumulation. The methods used to avoid these failure mechanisms are discussed. Fatigue life prediction is highlighted and the traditional initiation life calculation method is compared with fracture mechanics methods. The importance of performing full scale component tests for highly stressed gas turbine parts is emphasized, from the traditional lifing viewpoint and to validate fracture mechanics based calculations. Fracture mechanics fatigue life predictions are compared with full scale component rig test results. ESA

N87-16839# Rolls-Royce Ltd., Derby (England).
OBSERVATION OF ICE/WATER FORMATIONS ON A MODEL INTAKE SECTION SUBJECTED TO SIMULATED CLOUD CONDITIONS
S. J. DOWNS 6 May 1986 19 p Presented at the 3rd International Workshop on the Atmospheric Icing of Structures, Vancouver, British Columbia, 6-8 May 1986
(PNR90347; ETN-87-98782) Avail: NTIS HC A02/MF A01

A full-scale two-dimensional section of a typical aero engine intake was mounted downstream of a 15 in. icing tunnel and enclosed in ducting, the walls of which were shaped to simulate the airflow distribution for a typical descent flight condition. The tunnel was fitted with water spray nozzles of variable atomizing air pressure, enabling selection of the required water droplet size for a given water input, to simulate an icing cloud. The model was fitted with a mock-up section of anti-icing system. A tunnel total air temperature of 2 C and water droplet volume median diameter of 20 microns were maintained throughout testing. The temperature recorded by the thermocouple at entry to the piccolo pipe increases as ice built up, and falls as the ice shed, indicating that the ice acted as an insulator. Flowing water on the cowl surface tends to limit ice formation. The addition of air into the anti-icing system at 11 to 13 C does not change the water flow patterns, but where ice formed with no air input, ice accretion is severely limited. ESA

N87-16840# Rolls-Royce Ltd., Derby (England).
FUTURE TRENDS IN PROPULSION
S. C. MILLER and H. W. BENNETT 5 Aug. 1986 17 p Previously announced in IAA as A86-48979
(PNR90349; ETN-87-98784) Avail: NTIS HC A02/MF A01

Trends in civil and military aircraft propulsion are discussed. In civil designs, increase in bypass ratio will improve fuel consumption, the exact configuration being speed-dependent, but the advance must be achieved in a cost effective way. In military designs, while the configuration may be less likely to change, major improvements in weight and cost will appear. The V/STOL aircraft will move from subsonic to supersonic. Hypersonic propulsion will require radical new concepts. Computer assistance will increasingly apply to all phases from design through to production. ESA

N87-16841# Rolls-Royce Ltd., Derby (England).
AN APPROACH TO AE MONITORING DURING THE RIG SHOP TESTING OF LARGE CFRP AERO-ENGINE COMPONENTS
T. J. HOLROYD and P. E. COX 21 Jul. 1986 8 p Presented at the 2nd International Symposium on Acoustic Emission from Reinforced Composites, Montreal, Canada, 21-25 Jul. 1986 Sponsored by UK Ministry of Defence Procurement Executive
(PNR90350; ETN-87-98785) Avail: NTIS HC A02/MF A01

The detection and location of damage as it occurs during the rig shop testing of large CFRP aero-engine components using multichannel acoustic emission (AE) is discussed. Attenuative isolation using multiple high frequency transducers shows promise as a means of locating the AE activity from large composite structures. Good immunity from background noise can be achieved. High rates of activity do not cause such a system to latch up. The reduction of channel costs is important for such a system to be practical. Effective means of characterizing material attenuation and in-situ sensitivity are central to the success of this approach. Scanned gas jet attenuation mapping and the concepts of preamplifier substations and disposable transducers are important steps towards the implementation of the attenuative isolation approach. ESA

N87-16842# Rolls-Royce Ltd., Derby (England).
GAS TURBINE MATERIALS: A REVIEW
J. D. ALEXANDER and D. DRIVER 2 Apr. 1986 23 p Presented at the Materials in Aerospace Conference, England, 2-4 Apr. 1986; sponsored by RAE
(PNR90356; ETN-87-98788) Avail: NTIS HC A02/MF A01

Developments in manufacturing methods for aircraft engine materials are discussed. The coupling of microstructural and process control is noted. Turbine disk materials, compressor disk materials, and turbine blade materials are described. Turbine blade thermal protection is illustrated. ESA

N87-16843# Rolls-Royce Ltd., Derby (England). Lubrication and Transmission Technology Div.
THE TECHNOLOGY OF ADVANCED PROP-FAN TRANSMISSIONS
J. DOMINY and B. F. RAYNER 23 Sep. 1986 8 p
(PNR90357; ICAS-86-3.10.1; ETN-87-98789) Avail: NTIS HC A02/MF A01

The advances in transmission technology that are necessary if the maximum installed efficiency of the powerplant is to be achieved by aerospace turboprop and ultra high bypass designs are outlined. Gears will continue to be designed to achieve a virtually infinite life thus life itself will not benefit from improved fatigue performance. This can, however, be used to carry higher loads while still meeting the necessary life criteria, but since life is inversely proportional to load to the third power, very substantial increases in fatigue performance are required to make any useful difference to the load capacity of a gear. Similarly, there is unlikely to be any significant rise in efficiency, partly because the current efficiency levels are already very high and partly because the new transmissions will be inherently less efficient than those currently in service. The greatest changes will be in the lubrication system and the lubricant itself. ESA

N87-16844# Rolls-Royce Ltd., Derby (England).
AIRCRAFT DERIVATIVE GAS TURBINE DEVELOPMENT IN CHINA
23 Sep. 1986 9 p Repr. from International Aviation, no. 4, 1986 p 15-16 In ENGLISH and CHINESE
(PNR90359; TRANSL-18511; ETN-87-98790) Avail: NTIS HC A02/MF A01

Use of aircraft engine derived gas turbines as electricity generator, prime mover for the automotive vehicle and locomotive, marine mechanical prime mover, water (suction) pump, and air compressor is described. The gas turbine employs much of the advanced technology and experience from the aero engine industry, so the cost of development is minimal. This type of gas turbine uses light oil (paraffin, diesel) natural gas crude oil, heavy oil, and low calorific value fuels. ESA

N87-16845# Rolls-Royce Ltd., Derby (England).
OPERATIONAL AIDS TO ENGINE DEVELOPMENT
D. S. PEARSON 24 Sep. 1986 15 p
(PNR90362; ETN-87-98792) Avail: NTIS HC A02/MF A01

Computer aided design of aircraft engines is assessed. Economic, technical, and social factors are reviewed. ESA

N87-16846# Office National d'Etudes et de Recherches Aerospatiales, Paris (France). Direction de l'Energetique.
APPLICATION OF FLOW CALCULATION METHODS TO TRANSONIC AND SUPERSONIC AXIAL TURBOMACHINES [APPLICATION DES METHODES DE CALCUL D'ECOULEMENT DANS LES TURBOMACHINES AXIALES TRANSSONIQUES ET SUPERSONIQUES]
GEORGES MEAUZE 4 Mar. 1986 18 p In FRENCH
(Contract DRET-84-34-001)
(ONERA-RTS-80/7103-EY; ETN-87-98808) Avail: NTIS HC A02/MF A01

A three-dimensional (3D) inviscid calculation method was applied to a mobile compressor wheel and to a complete turbine stage. An important deficiency of the conservation of the flow rate between the upstream region, the interblade channel, and downstream in the 3D calculation of a compressor or turbine wheel, was strongly reduced by a treatment of the boundary conditions. The 3D calculation of a complete stage was improved and applied to several compressor and turbine configurations. This calculation uses certain simplifying hypotheses, such as periodicity for each interblade channel, and the identity of the radial evolutions of the azimuthal averages at the common frontier which separates the calculation domains relative to each wheel. ESA

N87-17700*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
SPECTRUM-MODULATING FIBER-OPTIC SENSORS FOR AIRCRAFT CONTROL SYSTEMS
GLENN BEHEIM and KLAUS FRITSCH (John Carroll Univ., Cleveland, Ohio) 1987 9 p Presented at the 1st International Military and Government Fiber-Optic and Communications Exposition, Washington, D.C., 18-19 Mar. 1987; sponsored by the Fiber-Optic Communications Association
(NASA-TM-88968; E-3436; NAS 1.15:88968) Avail: NTIS HC A02/MF A01 CSCL 01D

A family of fiber-optic sensors for aircraft engine control systems is described. Each of these sensors uses a spectrum-modulation method to obtain an output which is largely independent of the fiber link transmissivity. A position encoder is described which uses a code plate to digitally modulate the sensor output spectrum. Also described are pressure and temperature sensors, each of which uses a Fabry-Perot cavity to modulate the sensor output spectrum as a continuous function of the measurand. A technique is described whereby a collection of these sensors may be effectively combined to perform a number of the measurements which are required by an aircraft-engine control system. Author

N87-17701*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
EXPERIMENTAL EVALUATION OF A TRANSLATING NOZZLE SIDEWALL RADIAL TURBINE
RICHARD J. ROELKE and CASIMIR ROGO (Teledyne CAE, Toledo, Ohio) 1987 22 p Proposed for presentation at the 69th Symposium of the AGARD Propulsion and Energetics Panel on Technology for Advanced Aero Engine Components, Paris, France, 4-8 May 1987
(NASA-TM-88963; E-3419; NAS 1.15:88963) Avail: NTIS HC A02/MF A01 CSCL 21E

Studies have shown that reduced specific fuel consumption of rotorcraft engines can be achieved with a variable capacity engine. A key component in such an engine in a high-work, high-temperature variable geometry gas generator turbine. An optimization study indicated that a radial turbine with a translating nozzle sidewall could produce high efficiency over a wide range of engine flows but substantiating data were not available. An experimental program with Teledyne CAE, Toledo, Ohio was undertaken to evaluate the moving sidewall concept. A variety of translating nozzle sidewall turbine configurations were evaluated. The effects of nozzle leakage and coolant flows were also investigated. Testing was done in warm air (121 C). The results of the contractual program were summarized. Author

N87-17703# Cincinnati Univ., Ohio. Dept. of Aerospace Engineering and Engineering Mechanics.
A STUDY OF COMPRESSOR EROSION IN HELICOPTER ENGINE WITH INLET SEPARATOR
W. TABAKOFF and A. HAMED Aug. 1986 90 p
(Contract DAAG29-82-K-0029)
(AD-A173288; REPT-86-55; ARO-18560.29-EG) Avail: NTIS HC A05/MF A01 CSCL 21E

Performance of aircraft engines, operating in areas where the atmosphere is polluted by small solid particles, can suffer due to blade surface erosion, which can lead to significant reduction in engine efficiency, due to the change in blade surfaces, tip leakages and blade pressure distribution. Presented are the results of an investigation of the solid particle dynamics and the resulting blade erosion through a helicopter engine with inlet particle separator. Particle trajectories are computed in the inlet separator which is characterized by considerable hub and tip contouring and radial variation in the swirling vane shape. The nonseparated particle trajectories are determined through the deswirling vanes and the five stage axial and one stage radial compressors. Impact data for a very large number of ingested particles is used to calculate the resulting blade surface erosion. The erosion pattern indicates the location of maximum blade erosion. In addition, the distribution of particle impact data is presented to suggest possible procedures to reduce the erosion in the critically affected blade areas. GRA

N87-17704# Tennessee Univ. Space Inst., Tullahoma.
CONTAMINATION AND DISTORTION OF STEADY FLOW FIELD INDUCED BY VARIOUS DISCRETE FREQUENCY DISTURBANCES IN AIRCRAFT GAS TURBINES Annual Report, 1 Jan. - 31 Dec. 1985
M. KUROSAKA 16 Apr. 1986 181 p
(Contract AF-AFOSR-0049-83)
(AD-A173294; AFOSR-86-0820TR) Avail: NTIS HC A09/MF A01 CSCL 21E

The objective of this investigation was to acquire a fundamental understanding of two aerothermodynamic effects of vortices as related to aircraft gas turbines: (1) the total temperature and total pressure separation; and (2) the negative entropy spots. In the period covered here, the theoretical explanation for (1) has been finished and it was found that the separation of total temperature and pressure is caused by the time-varying static pressure field around vortices; they were in favorable agreement with the preliminary experimental results obtained by an aspiration probe. Preparations for the search of negative entropy spots around vortices were also made. GRA

N87-17705# Naval Postgraduate School, Monterey, Calif.
AN EXPERIMENTAL INVESTIGATION OF SOOT SIZE AND FLOW FIELDS IN A GAS TURBINE ENGINE AUGMENTOR TUBE
DAVE J. URICH Jun. 1986 65 p
(AD-A173570) Avail: NTIS HC A04/MF A01 CSCL 21B

An instrumented augmentor tube was constructed and used to obtain velocity and temperature profile measurements as a function of augmentor inlet to gas generator nozzle spacing for use in Phoenics computer code validation. Additionally, optical particle size measurement instrumentation in the form of a three wavelength transmission device and a two forward-angle scattering device using a helium-neon laser was designed, constructed and used for determining the effects of the augmentor flow on the change in soot size across the length. Various smoke suppressant fuel additives were also evaluated for their effect on the soot size changes across the augmentor tube length. The initial tests indicated that particle size increased significantly across the augmentor tube length. GRA

N87-17707# Rolls-Royce Ltd., Derby (England).
USE OF COMPOSITES IN PROPULSION SYSTEMS
A. G. KITCHING and J. MARSHALL 29 Jul. 1986 44 p
(PNR-90323; ETN-87-98772) Avail: NTIS HC A03/MF A01

The increasing use of composite materials in aircraft engines since the 1960's is reviewed. Technological and economic factors are discussed. ESA

08

AIRCRAFT STABILITY AND CONTROL

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

A87-23976*# National Aeronautics and Space Administration. Flight Research Center, Edwards, Calif.
A FLIGHT-PATH-OVERSHOOT FLYING QUALITIES METRIC FOR THE LANDING TASK
DONALD T. BERRY (NASA, Flight Research Center, Edwards, CA) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 9, Nov.-Dec. 1986, p. 609-613. Previously cited in issue 07, p. 849, Accession no. A86-19820.

A87-23977#
CROSS COUPLING IN PILOT-VEHICLE SYSTEMS
R. A. HESS (California, University, Davis) and D. C. WATSON Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 9, Nov.-Dec. 1986, p. 614-620. Previously cited in issue 21, p. 3052, Accession no. A85-43845. refs

A87-23978*# Instituto de Investigaciones Electricas, Mexico City (Mexico).
SENSITIVITY ANALYSIS OF AUTOMATIC FLIGHT CONTROL SYSTEMS USING SINGULAR-VALUE CONCEPTS
ALFREDO HERRERA-VAILLARD (Instituto de Investigaciones Electricas, Cuernavaca, Mexico), JAMES PADUANO, and DAVID DOWNING (Kansas, University, Lawrence) (Guidance, Navigation and Control Conference, Snowmass, CO, Aug. 19-21, 1985, Technical Papers, p. 342-348) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 9, Nov.-Dec. 1986, p. 621-626. Previously cited in issue 22, p. 3230, Accession no. A85-45914. refs
(Contract NCC2-293)

A87-23988#
A HIGHLY ACCURATE FEEDBACK APPROXIMATION FOR HORIZONTAL VARIABLE-SPEED INTERCEPTIONS
HENDRIKUS G. VISSER (Fokker, Amsterdam, Netherlands) and JOSEF SHINAR (Technion - Israel Instiute of Technology, Haifa) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 9, Nov.-Dec. 1986, p. 691-698. Research supported by the Technion VPR-Seniel Ostrow Research Fund. Previously cited in issue 21, p. 3051, Accession no. A85-43843. refs

A87-24028#
SELF-INDUCED ROLL OSCILLATIONS MEASURED ON A DELTA WING/CANARD CONFIGURATION
JOSEPH KATZ (San Diego State University, CA) and DANIEL LEVIN (Technion Research and Development Foundation, Ltd., Haifa, Israel) Journal of Aircraft (ISSN 0021-8669), vol. 23, Nov. 1986, p. 814-819. Research supported by the Technion - Israel Institute of Technology. Previously cited in issue 21, p. 3052, Accession no. A85-43871. refs

A87-24034#
ADAM - AN AEROSERVOELASTIC ANALYSIS METHOD FOR ANALOG OR DIGITAL SYSTEMS
THOMAS NOLL, MAXWELL BLAIR, and JOHN CERRA (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) Journal of Aircraft (ISSN 0021-8669), vol. 23, Nov. 1986, p. 852-858. Previously cited in issue 01, p. 12, Accession no. A86-10943. refs

A87-24715#
A DIGITAL SIMULATION TECHNIQUE FOR DRYDEN ATMOSPHERIC TURBULENCE MODEL
ZHENYAN ZHAO, YELUN XIAO, and YIJIAN SHI (Beijing Institute of Aeronautics and Astronautics, People's Republic of China) Acta Aeronautica et Astronautica Sinica, vol. 7, Oct. 1986, p. 433-443. In Chinese, with abstract in English. refs

The Dryden model is usually used in studying the response of flight vehicles to atmospheric turbulence. For a modern flight simulator, it is necessary to generate random winds (in Dryden model or sometimes others) with a digital computer. In this paper, a theoretically strict new method to meet this purpose is proposed. By this method, a three-dimensional atmospheric turbulence can be obtained which contains three components of wind velocity and three components of wind velocity gradient. The reliability of this method is checked by comparing the theoretical autocorrelation value. A numerical example has shown a satisfactory result. Finally, some proposals concerning the use of this mathematical model in a flight simulator are given. Author

A87-24722#
THE ROTATING NOSE METHOD FOR CONTROLLING ASYMMETRIC FORCES AT HIGH ANGLE OF ATTACK
XINZHI YU, YONGNIAN YANG, ZE WU, DAXUAN WANG, and ZONGDONG WANG (Northwestern Polytechnical University, Xian, People's Republic of China) Acta Aeronautica et Astronautica Sinica, vol. 7, Oct. 1986, p. 494-498. In Chinese, with abstract in English.

The rotating nose method and its mechanism which control asymmetric forces at high angle of attack are discussed. A large number of tests have been done. The results of the tests show that the method is justifiable, the explanation of the mechanism is reasonable, and the asymmetric forces can be reduced to a permissible range, even to zero. Author

A87-24724#
THE ELIMINATION OF LIMIT CYCLES OF AN AIRCRAFT FLIGHT CONTROL SYSTEM-LINEAR MODEL FOLLOWING APPROACH
JINYUAN GAO and ZONGJI CHEN (Beijing Institute of Aeronautics and Astronautics, People's Republic of China) Acta Aeronautica et Astronautica Sinica, vol. 7, Oct. 1986, p. 510-514. In Chinese, with abstract in English.

In order to eliminate limit cycles of an aircraft flight control system, a linear model following scheme is adopted in this paper. It presents theoretical analysis and simulation results of this approach which shows that the linear model following approach can eliminate limit cycles of the aircraft flight control system effectively. Author

A87-24946*# Rice Univ., Houston, Tex.
QUASI-STEADY FLIGHT TO QUASI-STEADY FLIGHT TRANSITION IN A WINDSHEAR - TRAJECTORY GUIDANCE
A. MIELE, T. WANG (Rice University, Houston, TX), and W. W. MELVIN (Delta Air Lines, Inc., Atlanta, GA) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 24 p. Research supported by Boeing Commercial Aircraft Co. refs
(Contract NAG1-516)
(AIAA PAPER 87-0271)

The control (via the angle of attack) of the vertical flight of an aircraft taking off at maximum power in a horizontal wind shear with downdraft is investigated analytically. Optimal trajectories to recover the initial path inclination or to recover quasi-steady flight (the relative values of the velocity, path inclination, and angle of attack) are derived using a Chebyshev approach and shown to be nearly identical in the shear but divergent after the shear. These results are then applied to construct a trajectory-guidance control comprising a variable-gamma guidance scheme for the shear trajectory, a constant-gamma guidance scheme for the immediate postshear trajectory, and a constant-rate-of-climb guidance scheme for the aftershear trajectory. Numerical results demonstrating the near-optimal performance of the control are presented in tables and graphs. T.K.

A87-24994*# Ford Aerospace and Communications Corp., Palo Alto, Calif.
CONTROL OF AIRCRAFT LANDING APPROACH IN WIND SHEAR
PETER YAOHWA CHU (Ford Aerospace and Communication Corp., Palo Alto, CA) and ARTHUR E. BRYSON, JR. (Stanford University, CA) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 10 p. refs
(Contract NAG2-191)
(AIAA PAPER 87-0632)

Wind and wind shear components are estimated and used for controlling an externally-blown flap STOL aircraft and a B-727 during landing approach under the JAWS microburst profile. A combination of feedforward and feedback concepts is used. The objective is tracking of airspeed and glide slope. Both an asymptotic disturbance rejection scheme, which is equivalent to MIMO zero assignment, and a linear quadratic scheme prove to be successful. Higher angle-of-attack is used only after thrust saturation. Downdraft is found to be more difficult to counter for STOL aircraft than is horizontal wind shear. A third design formulation based on successive loop closure is also presented. A 'Wind Shear Penetration Index' is described, which offers a simple and quantitative evaluation of an aircraft's ability to safely penetrate a wind shear. This index is particularly useful if used with Doppler radars. Author

A87-25521
NUMERICAL-ANALYTICAL CALCULATION OF AIRCRAFT CONTROL SYSTEMS [CISLICOVE-ANALYTICKY NAVRH SYSTEMU RIZENI LETOUNU]
MILAN FALTUS Zpravodaj VZLU (ISSN 0044-5355), no. 4, 1986, p. 197-203. In Czech. refs

Principal methods for calculating the kinematics of aircraft control systems are presented, and it is shown how a control system can be separated into individual four-element mechanisms. Of the methods used for four-joint systems, particular attention is given to iteration, vector, and complex algebra methods. Further, a method for analyzing the kinematics of a three-dimensional four-joint mechanism is derived using a matrix transformation. The method is shown to be readily implemented on a computer. V.L.

A87-27532
BOUNDED RANDOM OSCILLATIONS - MODEL AND NUMERICAL SOLUTION FOR AN AIRFOIL
F. POIRION and J. J. ANGELINI (ONERA, Chatillon-sous-Bagneux, France) La Recherche Aerospatiale (ISSN 0379-380X), no. 6, 1985, p. 45-54. refs

A method is presented for assessing the effects limitations in the response speed and amplitude of the control surfaces of aircraft have on the quality of the control laws calculated without considering the restraints on the control surfaces. The commands are issued to adjust for turbulence, and the effects of the control surface limitations must be computed a posteriori. A many-valued stochastic differential equation is used to model the motion of the control surface and the system of boundary layer phenomena. Finite difference and Galerkin techniques are defined for obtaining a steady-state solution. Good agreement is obtained from the solution methods when compared with results from a stochastic simulation. M.S.K.

N87-16847 Kansas Univ., Lawrence.
DEVELOPMENT OF A SENSITIVITY ANALYSIS TECHNIQUE FOR MULTILOOP FLIGHT CONTROL SYSTEMS Ph.D. Thesis
ALFREDO HERRERA-VAILLARD 1986 175 p
Avail: Issuing Activity

The development and application of a sensitivity analysis technique for multiloop flight control systems is presented. This analysis yields very useful information on the sensitivity of the relative-stability criteria of the control system, with variations or uncertainties in the system and the controller elements. The sensitivity analysis technique developed is based on the computation of the singular values and singular-value gradients of a feedback-control system. The use of singular values to obtain a relative stability criterion for sampled-data systems is also explored with promising results. The sensitivity analysis technique was applied to a continuous yaw/roll damper stability augmentation system of a typical business jet, and the results show that the analysis is very useful in determining the system elements which have the largest effect on the relative stability of the closed-loop system. The relative stability criteria based on the concept of singular values were applied to a single-loop yaw damper system and a mutliloop yaw/roll damper system of a business jet. Dissert. Abstr.

N87-16849*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
PILOTED SIMULATOR STUDY OF ALLOWABLE TIME DELAYS IN LARGE-AIRPLANE RESPONSE
WILLIAM D. GRANTHAM, PAUL M. SMITH (PRC Kentron, Inc., Hampton, Va.), LEE H. PERSON, JR., ROBERT T. MEYER (Lockheed-Georgia Co., Marietta), and STEPHEN A. TINGAS Feb. 1987 69 p
(NASA-TP-2652; L-16149; NAS 1.60:2652) Avail: NTIS HC A04/MF A01 CSCL 01C

A piloted simulation was performed to determine the permissible time delay and phase shift in the flight control system of a specific large transport-type airplane. The study was conducted with a six degree of freedom ground-based simulator and a math model similar to an advanced wide-body jet transport. Time delays in discrete and lagged form were incorporated into the longitudinal, lateral, and directional control systems of the airplane. Three experienced pilots flew simulated approaches and landings with random localizer and glide slope offsets during instrument tracking as their principal evaluation task. Results of the present study suggest a level 1 (satisfactory) handling qualities limit for the effective time delay of 0.15 sec in both the pitch and roll axes, as opposed to a 0.10-sec limit of the present specification (MIL-F-8785C) for both axes. Also, the present results suggest a level 2 (acceptable but unsatisfactory) handling qualities limit for an effective time delay of 0.82 sec and 0.57 sec for the pitch and roll axes, respectively, as opposed to 0.20 sec of the present specifications for both axes. In the area of phase shift between cockpit input and control surface deflection,the results of this study, flown in turbulent air, suggest less severe phase shift limitations for the approach and landing task-approximately 50 deg. in pitch and 40 deg. in roll - as opposed to 15 deg. of the present specifications for both axes. Author

N87-17708*# Boeing Vertol Co., Philadelphia, Pa.
DEVELOPMENT OF ADOCS CONTROLLERS AND CONTROL LAWS. VOLUME 2: LITERATURE REVIEW AND PRELIMINARY ANALYSIS Final Report, Jan. 1981 - Jun. 1984
KENNETH H. LANDIS and STEVEN I. GLUSMAN Mar. 1985 163 p Prepared for Army Research and Technology Labs., Moffett Field, Calif.
(Contract NAS2-10880; DA PROJ. 1L2-63211-D-315)
(NASA-CR-177339-VOL-2; NAS 1.26:177339-VOL-2; D210-12323-VOL-2; USAAVSCOM-TR-84-A-7-VOL-2) Avail: NTIS HC A08/MF A01 CSCL 01C

The Advanced Cockpit Controls/Advanced Flight Control System (ACC/AFCS) study was conducted by the Boeing Vertol Company as part of the Army's Advanced Digital/Optical Control System (ADOCS) program. Specifically, the ACC/AFCS investigation was aimed at developing the flight control laws for the ADOCS demonstrator aircraft which will provide satisfactory handling qualities for an attack helicopter mission. The three major elements of design considered are as follows: Pilot's integrated Side-Stick Controller (SSC) -- Number of axes controlled; force/displacement characteristics; ergonomic design. Stability and Control Augmentation System (SCAS)--Digital flight control laws for the various mission phases; SCAS mode switching logic. Pilot's Displays--For night/adverse weather conditions, the dynamics of the superimposed symbology presented to the pilot in a format similar to the Advanced Attack Helicopter (AAH) Pilot Night Vision System (PNVS) for each mission phase as a function of ACAS characteristics; display mode switching logic. Findings from the literature review and the analysis and synthesis of desired control laws are reported in Volume 2. Conclusions drawn from pilot rating data and commentary were used to formulate recommendations for the ADOCS demonstrator flight control system design. The ACC/AFCS simulation data also provide an extensive data base to aid the development of advanced flight control system design for future V/STOL aircraft. Author

N87-17709*# Boeing Vertol Co., Philadelphia, Pa.
DEVELOPMENT OF ADOCS CONTROLLERS AND CONTROL LAWS. VOLUME 3: SIMULATION RESULTS AND RECOMMENDATIONS Final Report, Jan. 1981 - Jun. 1984
KENNETH H. LANDIS and STEVEN I. GLUSMAN Mar. 1985 328 p Prepared for Army Research and Technology Labs., Moffett Field, Calif.
(Contract NAS2-10880; DA PROJ. 1L2-63211-D-315)
(NASA-CR-177339-VOL-3; NAS 1.26:177339-VOL-3; D210-12323-VOL-3; USAAVSCOM-TR-84-A-7-VOL-3) Avail: NTIS HC A15/MF A01 CSCL 01C

The Advanced Cockpit Controls/Advanced Flight Control System (ACC/AFCS) study was conducted by the Boeing Vertol Company as part of the Army's Advanced Digital/Optical Control System (ADOCS) program. Specifically, the ACC/AFCS investigation was aimed at developing the flight control laws for the ADOCS demonstator aircraft which will provide satisfactory handling qualities for an attack helicopter mission. The three major elements of design considered are as follows: Pilot's integrated Side-Stick Controller (SSC) -- Number of axes controlled; force/displacement characteristics; ergonomic design. Stability and Control Augmentation System (SCAS)--Digital flight control laws for the various mission phases; SCAS mode switching logic. Pilot's Displays--For night/adverse weather conditions, the dynamics of the superimposed symbology presented to the pilot in a format similar to the Advanced Attack Helicopter (AAH) Pilot Night Vision System (PNVS) for each mission phase is a function of SCAS characteristics; display mode switching logic. Results of the five piloted simulations conducted at the Boeing Vertol and NASA-Ames simulation facilities are presented in Volume 3. Conclusions drawn from analysis of pilot rating data and commentary were used to formulate recommendations for the ADOCS demonstrator flight control system design. The ACC/AFCS simulation data also provide an extensive data base to aid the development of advanced flight control system design for future V/STOL aircraft. Author

N87-17710*# Sikorsky Aircraft, Stratford, Conn.
UH-60 BLACK HAWK ENGINEERING SIMULATION MODEL VALIDATION AND PROPOSED MODIFICATIONS Final Report, May 1983 - Jun. 1984
THADDEUS T. KAPLITA Jan. 1986 125 p
(Contract NAS2-11570; DA PROJ. 1L2-62209-AH-76)
(NASA-CR-177360; NAS 1.26:177360; USAAVSCOM-TR-85-A-2; SER-70982) Avail: NTIS HC A06/MF A01 CSCL 01C

The engineering simulation model of the UH-60A Black Hawk was validated using comparisons of model time histories with flight test data and updated to improve the fidelity of the model. The flight test data, acquired by the Army Aviation Engineering Flight Activity and consisting of 90 time histories of transient responses to step and pulse control inputs and 16 sets of steady flight data, were processed and compared to corresponding model time histories and trim data by Sikorsky. The current UH-60A model was judged to provide an acceptably accurate simulation for use as an analytical tool, certain unsatisfactory areas were identified and potential approaches to produce a more representative simulation were evaluated. Author

N87-17711*# Lockheed-California Co., Burbank.
DEVELOPMENT OF AN ADVANCED PITCH ACTIVE CONTROL SYSTEM AND A REDUCED AREA HORIZONTAL TAIL FOR A WIDE-BODY JET AIRCRAFT Executive Summary, Dec. 1978 - Apr. 1983
WILEY A. GUINN 1 Feb. 1984 64 p
(Contract NAS1-15326)
(NASA-CR-172283; NAS 1.26:172283; LR-30463) Avail: NTIS HC A04/MF A01 CSCL 01C

The development of an advanced pitch active control system (PACS) and a reduced area horizontal tail for a wide-body jet transport (L-1011) with a flying horizontal stabilizer is discussed. The advanced PACS control law design objectives were to provide satisfactory handling qualities for aft c.g. flight conditions to negative static stability margins of 10 percent and to provide good maneuver control column force gradients for nonlinear stability flight conditions. Validity of the control laws were demonstrated by piloted flight simulation tests on the NASA Langley Visual Motion Simulator. Satisfactory handling qualities were actually demonstrated to a negative 20 percent static stability margin. The PACS control laws were mechanized to provide the system architecture that would be suitable for an L-1011 flight test program to a negative stability margin of 3 percent which represents the aft c.g. limits of the aircraft. Reduced area horizontal tail designs of 30 and 38 percent with respect to the L-1011 standard tail were designed, fabricated and wind tunnel tested. Drag reductions and weight savings of the 30 percent smaller tail would provide an L/D benefit of about 2% and the 38% small tail L/D benefit would be about 3 percent. However, forward c.g. limitations would have to be imposed on the aircraft because the maximum horizontal tail lift goal was not achieved and sufficient aircraft nose-up control authority was not available. This limitation would not be required for a properly designed new aircraft. Author

N87-17712*# Lockheed-California Co., Burbank.
EXTENDED FLIGHT EVALUATION OF A NEAR-TERM PITCH ACTIVE CONTROL SYSTEM Contractor Report, Dec. 1982 - Jun. 1983
WILEY A. GUINN, CRAIG S. WILLEY, and MICHAEL G. CHONG 21 Dec. 1983 71 p
(Contract NAS1-15326)
(NASA-CR-172266; NAS 1.26:172266; LR-30533) Avail: NTIS HC A04/MF A01 CSCL 01C

Fuel savings can be achieved by moving the center of gravity of an aircraft aft which reduces the static stability margin and consequently the trim drag. However, flying qualities of an aircraft with relaxed static stability can be significantly degraded. The flying qualities can be restored by using a pitch active control system (PACS). This report documents the work accomplished during a follow-on program (see NASA CR-165951 for initial program report) to perform extended flight tests of a near-term PACS. The program included flying qualities analyses, piloted flight simulation tests, aircraft preparation and flight tests to demonstrate that the near-term PACS provided good flying qualities within the linear static stability envelope to a negative 3% static stability margin. Author

N87-17713*# Lockheed-California Co., Burbank.
DEVELOPMENT OF AN ADVANCED PITCH ACTIVE CONTROL SYSTEM FOR A WIDE BODY JET AIRCRAFT Final Report
WILEY A. GUINN, JERRY J. RISING, and WALT J. DAVIS 1 Feb. 1984 169 p
(Contract NAS1-15326)
(NASA-CR-172277; NAS 1.26:172277; LR-30644) Avail: NTIS HC A08/MF A01 CSCL 01C

An advanced PACS control law was developed for a commercial wide-body transport (Lockheed L-1011) by using modern control theory. Validity of the control law was demonstrated by piloted flight simulation tests on the NASA Langley visual motion simulator. The PACS design objective was to develop a PACS that would provide good flying qualities to negative 10 percent static stability margins that were equivalent to those of the baseline aircraft at a 15 percent static stability margin which is normal for the L-1011. Also, the PACS was to compensate for high-Mach/high-g instabilities that degrade flying qualities during upset recoveries and maneuvers. The piloted flight simulation tests showed that the PACS met the design objectives. The simulation demonstrated good flying qualities to negative 20 percent static stability margins for hold, cruise and high-speed flight conditions. Analysis and wind tunnel tests performed on other Lockheed programs indicate that the PACS could be used on an advanced transport configuration to provide a 4 percent fuel savings which results from reduced trim drag by flying at negative static stability margins. Author

N87-17714*# Boeing Vertol Co., Philadelphia, Pa.
DEVELOPMENT OF ADOCS CONTROLLERS AND CONTROL LAWS. VOLUME 1: EXECUTIVE SUMMARY Final Report, Jan. 1981 - Jun. 1984
KENNETH H. LANDIS and STEVEN I. GLUSMAN Mar. 1985 82 p Prepared for Army Research and Technology Labs., Moffett Fielf, Calif.
(Contract NAS2-10880; DA PROJ. 1L2-63211-D-315)
(NASA-CR-177339-VOL-1; NAS 1.26:177339-VOL-1; D210-12323-VOL-1; USAAVSCOM-TR-84-A-7-VOL-1) Avail: NTIS HC A05/MF A01 CSCL 01C

The Advanced Cockpit Controls/Advanced Flight Control System (ACC/AFCS) study was conducted by the Boeing Vertol Company as part of the Army's Advanced Digital/Optical Control System (ADOCS) program. Specifically, the ACC/AFCS investigation was aimed at developing the flight control laws for the ADOCS demonstrator aircraft that will provide satisfactory handling qualities for an attack helicopter mission. The three major elements of design considered during the study are as follows: Pilot's integrated Side-Stick Controller (SSC) -- Number of axes controlled; force/displacement characteristics; ergonomic design. Stability and Control Augmentation System (SCAS)--Digital flight control laws for the various mission phases; SCAS mode switching logic. Pilot's Displays--For night/adverse weather conditions, the dynamics of the superimposed symbology presented to the pilot in a format similar to the Advanced Attack Helicopter (AAH) Pilot Night Vision System (PNVS) for each mission phase as a function of SCAS characteristics; display mode switching logic. Volume 1 is an Executive Summary of the study. Conclusions drawn from analysis of pilot rating data and commentary were used to formulate recommendations for the ADOCS demonstrator flight control system design. The ACC/AFCS simulation data also provide an extensive data base to aid the development of advanced flight control system design for future V/STOL aircraft. Author

N87-17715*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
THE APPLICATION OF QUADRATIC OPTIMAL COOPERATIVE CONTROL SYNTHESIS TO A CH-47 HELICOPTER
BARBARA K. TOWNSEND Sep. 1986 23 p
(NASA-TM-88353; A-86388; NAS 1.15:88353) Avail: NTIS HC A02/MF A01 CSCL 01C

A control-system design method, Quadratic Optimal Cooperative Control Synthesis (CCS), is applied to the design of a Stability and Control Augmentation Systems (SCAS). The CCS design method is different from other design methods in that it does not require detailed a priori design criteria, but instead relies on an explicit optimal pilot-model to create desired performance. The design model, which was developed previously for fixed-wing aircraft, is simplified and modified for application to a Boeing Vertol CH-47 helicopter. Two SCAS designs are developed using the CCS design methodology. The resulting CCS designs are then compared with designs obtained using classical/frequency-domain methods and Linear Quadratic Regulator (LQR) theory in a piloted fixed-base simulation. Results indicate that the CCS method, with slight modifications, can be used to produce controller designs which compare favorably with the frequency-domain approach. Author

N87-17716*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
VALIDATION OF A REAL-TIME ENGINEERING SIMULATION OF THE UH-60A HELICOPTER
MARK G. BALLIN Feb. 1987 205 p
(NASA-TM-88360; A-86407; NAS 1.15:88360) Avail: NTIS HC A10/MF A01 CSCL 01C

A real-time simulation of the UH-60A Black Hawk Helicopter based on the Sikorsky Gen Hel mathematical model is compared with flight test data and Sikorsky's nonreal-time computer program. An overview of the mathematical model is given, including a description of updates and expansion of the model by NASA. Also, real-time programming requirements and techniques are explained. The simulation displays very good agreement with flight test data and excellent with the nonreal-time program on which it is based. The large dedication of effort required to develop the real-time program suggests a need for development of generalized techniques for real-time simulation of high-fidelity physical models of rotorcraft. Author

09

RESEARCH AND SUPPORT FACILITIES (AIR)

Includes airports, hangars and runways; aircraft repair and overhaul facilities; wind tunnels; shock tubes; and aircraft engine test stands.

A87-23746

ATF PROPULSION TESTS WILL DRIVE OPERATIONS AT ARNOLD FACILITY

JAY C. LOWNDES Aviation Week and Space Technology (ISSN 0005-2175), vol. 125, Oct. 13, 1986, p. 49-52, 57.

The activities of the U.S. Air Force's Arnold Engineering Development Center will be dominated through the end of this decade by the propulsion system testing requirements of the ATF program. This Air Force facility was designed to eliminate uncertainties associated with engine performance and engine-airframe compatibility prior to a new aircraft's first flight. The controls of the Aeropropulsion Systems Test Facility for real time testing of full scale hardware operate much like an autopilot. Test objectives encompass aeromechanical performance determinations, mappings of nonrecoverable stalls, and STOL behavior determination. Engine/airframe compatibility uncertainty should as a result be reduced to zero. O.C.

A87-24611

MISSION SIMULATORS

PIERRE CONDOM Interavia (ISSN 0020-5168), vol. 41, Nov. 1986, p. 1295-1299.

An evaluation is made of the state-of-the-art in single-mission and multirole air combat simulators, including those involving a cockpit mockup that is situated within a dome (on whose inner surface flight imagery are projected) and a novel type which employs fiber-optics to project realistic flight imagery onto pilot helmet-mounted screens. A basic differentiation must be made between air-to-ground mission simulators, which resemble airline pilot-training systems, and air-to-air simulators, which necessarily require two or three interactive simulation units for one-against-one and one-against-two combat. Attention is given to the most important proprietary systems currently available. O.C.

A87-25279

CLOSED-LOOP MACH NUMBER CONTROL IN A BLOWDOWN TRANSONIC WIND TUNNEL

HITOSHI MIWA, MAMORU SATO, SEIZO SAKAKIBARA, and KAZUAKI TAKASHIMA (National Aerospace Laboratory, Chofu, Japan) IN: Fluid control and measurement; Proceedings of the International Symposium, Tokyo, Japan, Sept. 2-5, 1985. Volume 1 . Oxford, England and New York, Pergamon Press, 1986, p. 515-520. refs

The closed-loop Mach-number control developed for the 0.3 x 1.0-m blowdown transonic wind tunnel of the National Aerospace Laboratory (Japan) is described. The primary features of the wind tunnel are reviewed and illustrated with drawings; the determination of the Mach number from direct pressure measurements is explained; PI/PID control of hydraulically actuated valves is characterized; and performance results indicating excellent reproducibility (error 0.002 or less) are presented in graphs. T.K.

A87-25719#

DYNAMIC SUPPORT INTERFERENCE IN HIGH-ALPHA TESTING

L. E. ERICSON and J. P. REDING (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA) Journal of Aircraft (ISSN 0021-8667), vol. 23, Dec. 1986, p. 889-896. Previously cited in issue 10, p. 1341, Accession no. A86-24746. refs

A87-25721*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

EXPLORATORY FLUTTER TEST IN A CRYOGENIC WIND TUNNEL

STANLEY R. COLE (NASA, Langley Research Center, Hampton, VA) (Structures, Structural Dynamics, and Materials Conference, 26th, Orlando, FL, Apr. 15-17, 1985, Technical Papers. Part 2, p. 426-434) Journal of Aircraft (ISSN 0021-8669), vol. 23, Dec. 1986, p. 904-911. Previously cited in issue 13, p. 1851, Accession no. A85-30369. refs

A87-25846

A REVIEW OF MODERN X-RAY SCREENING DEVICES

A. KOTOWSKI (Astrophysics Research Corp., Long Beach, CA) ICAO Bulletin, vol. 41, Oct. 1986, p. 22, 23.

The application of X-ray devices to the screening of luggage at airports is studied. Screening machines currently utilize a digital video storage unit, and constant potential X-ray generators and images are acquired via linear X-ray sensor arrays. A test for measuring the performance of screening systems is described. Zoom or electronic image magnification, color displays, gamma enhancement, and edge enhancement have been employed to improve the images obtained by the screening devices. The limitations of an X-ray screening machine are examined. Various proposals for improving airport screening are discussed. I.F.

A87-25847

A NEW RANGE OF INITIAL INTERVENTION VEHICLES FORESEEN

J. TANGUY (Service Technique de la Navigation Aerienne, Paris, France) ICAO Bulletin, vol. 41, Oct. 1986, p. 24, 25.

A vehicle for improving the capabilities of the rescue and fire-fighting services (RFFS) at airports is described. The need for a lightweight vehicle with a large volume of extinguishing power is discussed. The French Air Navigation Technical Service has studied the use of powder and foam agents on a 6000-liter water vehicle to improve RFFS efficiency on three-dimensional fires. The prototype 6000-liter vehicle being developed has a total loaded mass of 15 tons and a 440-HP engine. The proposed chassis design and fire-fighting equipment for the vehicle are examined. I.F.

A87-25870#

AN AUTOMATIC TEST SYSTEM FOR A FIGHTER AIRCRAFT

T. S. SUNDRESH, M. K. GOVIND, P. SARATCHANDRAN, and C. SUBRAMANIAN (Hindustan Aeronautics, Ltd., Aircraft Design Bureau, Bangalore, India) Aeronautical Society of India, Journal (ISSN 0001-9267), vol. 38, May 1986, p. 113-128.

An automatic test system (ATS) for a fighter aircraft is described, which is contemporary in nature with respect to similar systems developed abroad and is expected to cut down maintenance, provide consistency and accuracy in measurements, and generate extensive data for preventive maintenance. Consideration is given to the major components of the ATS, i.e., the ground unit, a cockpit data entry terminal (CODET), data concentrators, and a 20-mA current loop serving as a digital data link between the computer and the CODET/data concentrators. The ATS has been tested and proved with respect to systems installed on a fighter aircraft. I.S.

A87-25871#
BIRD STRIKE TEST FACILITY
V. K. KALYANAM and V. VITTAL Aeronautical Society of India, Journal (ISSN 0001-9267), vol. 38, May 1986, p. 129-133. refs

Aircraft are built to withstand normal flight loads with enforced factor of safety using the available empirical formulas, taking into account every type of stress and hazards. Bird strikes are among the hazards taken into account at the design stage. Extrapolation of these formula at transonic speeds of aircraft is not realistic, and so it becomes imperative to make an experimental study. The internationally accepted standard is that aircraft components should be able to withstand the impact of 1.00-kg bird when an aircraft is flying at its maximum flight speed up to altitudes of 762 m. Author

A87-26001
AIRPORT LIGHTING
H. FRIEDLI Airport Forum (ISSN 0002-2802), vol. 16, Oct. 1986, p. 28-30, 32 (3 ff.).

An airport's lighting system is examined using the Zurich, Switzerland airport as an example. The lighting structure contains energy supplies, energy distribution, feed and regulating equipment, remote control equipment, emergency power supplies, and monitoring systems. General runway lighting consists of: (1) approach, (2) runway, (3) taxiway, and (4) glide path lighting; the functions of each form of lighting are described. The arrangement of the lights, the characteristics of the light distribution, the luminosity intensity, and the cost of the lighting system are analyzed. The functions, construction, and safety and reliability of the lighting control system are discussed. Consideration is given to the parallel and series feed systems, the behavior of the lamps in terms of the two feed systems, and the power supply for the lighting system. Diagrams of a runway lighting system are presented. I.F.

A87-26002
NEW DEVELOPMENTS IN AIRFIELD LIGHTING
MANFRED MOMBERGER Airport Forum (ISSN 0002-2802), vol. 16, Oct. 1986, p. 39, 41-42 (6 ff.).

Products and techniques for improving airfield lighting are discussed. The design and development of lighting components are examined in terms of cost reduction. Consideration is given to the low energy consumption, maintenance requirements, brightness control, power costs, and the differences between the FAA and ICAO standards for lighting systems. The standard lighting systems provided and the new products developed by various private companies are described. I.F.

A87-27490#
A COMPUTER CONTROLLED VIBRATORY FATIGUE TEST RIG WITH PROGRAMMED LOADING FOR BLADING
QIXIN LU and ZHONGLIANG ZHUANG (Nanjing Aeronautical Institute, People's Republic of China) Journal of Aerospace Power, vol. 1, Oct. 1986, p. 161-163, 190. In Chinese, with abstract in English. refs

The design and technical features of a computer-controlled, closed-cycle servoelectrical test rig for simulating random field loads on an axial flow compressor blade by programmed step loading are briefly described. Using this rig, the fatigue life distribution of compressor blading was automatically tested under a simulated flight block load spectrum. This advanced technique for inspecting fatigue life and quality in blade production can be used to enhance flight reliability. C.D.

N87-16850 Stanford Univ., Calif.
THE INFLUENCE OF WIND-TUNNEL WALLS ON DISCRETE FREQUENCY NOISE Ph.D. Thesis
MARIANNE MOSHER 1986 243 p
Avail: Univ. Microfilms Order No. DA8619794

Enclosures partial or complete, significantly affect the sound field of a source contained in the enclosure. In particular, wind-tunnel walls effect measurements of the sound field of an aircraft model thereby complicating noise measurements of aircraft in wind tunnels. This work examines the effect of the wind tunnel on sound fields. The acoustic field from a known source in a wind tunnel has been modeled as an acoustic source in uniform subsonic flow, in an infinitely long duct with constant cross-section. The acoustic impedance boundary condition at the wall allows sound absorption. The problem of an aeroacoustic source in a duct is formulated as an inhomogeneous integro-differential equation for the acoustic pressure on the duct surface. Several sample programs are studied in a rectangular duct with and without flow. A simple model problem, for which an analytic approximation exists, demonstrates that the numerical calculation correctly solves the numerical model. The acoustic fields for many simple sources are examined. The acoustic field from a simple model of helicopter noise is studied in the duct. Results show that the presence of the duct significantly changes the acoustic field. For a given source, the region in the duct near the source resembling the free field increases as the wall adsorption increases. Outside this near field the sound depends mostly on the product of source wave number with duct cross dimension. Dissert. Abstr.

N87-16851*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
A DISTRIBUTED DATA ACQUISITION SYSTEM FOR AERONAUTICS TEST FACILITIES
DENNIS L. FRONEK, ROBERT N. SETTER, PHILIP Z. BLUMENTHAL, and ROBERT R. SMALLEY 1987 8 p Proposed for presentation at the International Instrumentation Symposium, Las Vegas, Nev., 3-8 May 1987; sponsored by the Instrument Society of America
(NASA-TM-88961; E-3417; NAS 1.15:88961) Avail: NTIS HC A02/MF A01 CSCL 14B

The NASA Lewis Research Center is in the process of installing a new data acquisition and display system. This new system will provide small and medium sized aeronautics test facilities with a state-of-the-art real-time data acquisition and display system. The new data system will provide for the acquisition of signals from a variety of instrumentation sources. They include analog measurements of temperatures, pressures, and other steady state voltage inputs; frequency inputs to measure speed and flow; discrete I/O for significant events, and modular instrument systems such as multiplexed pressure modules or electronic instrumentation with a IEEE 488 interface. The data system is designed to acquire data, convert it to engineering units, compute test dependent performance calculations, limit check selected channels or calculations, and display the information in alphanumeric or graphical form with a cycle time of one second for the alphanumeric data. This paper describes the system configuration, its salient features, and the expected impact on testing. Author

N87-16852# Royal Aircraft Establishment, Farnborough (England).
DEVELOPMENTS IN DATA ACQUISITION AND PROCESSING USING AN ADVANCED COMBUSTION RESEARCH FACILITY
J. B. BULLARD, F. S. E. WHITCHER, and R. V. STEEDEN Jul. 1986 22 p Presented at the AGARD Propulsion and Energetics Panel 67th Symposium on Advanced Instrumentation for Propulsion Components, Philadelphia, Pa., 19-23 May 1986
(RAE-TM-P1089; BR100238; ETN-87-98913) Avail: NTIS

A combustion rig to acquire rapid and detailed information on the combustion processes occurring within a sector of large annular gas turbine combustors operating over a range of inlet pressures and temperatures representative of engine conditions was designed. Gas samples are extracted using a probe positioned within the volume under examination and transferred to a system designed to perform analyses with a point-to-point cycle time less than 30 sec. A computer controls and synchronizes the probe positioning and gas analysis function, and presents coordinated results to rig controllers. The system is capable of automatic traversing within a prescribed volume or of control by a dummy traverse gear which permits tracing of air and fuel flows. ESA

N87-16853# Army Cold Regions Research and Engineering Lab., Hanover, N. H.

FROST ACTION PREDICTIVE TECHNIQUES FOR ROADS AND AIRFIELDS: A COMPREHENSIVE SURVEY OF RESEARCH FINDINGS

T. C. JOHNSON, R. L. BERG, E. J. CHAMBERLAIN, and D. M. COLE Dec. 1986 52 p
(Contract FHWA-8-3-0187)
(DOT/FAA/PM-85/23; CRREL-86-18) Avail: NTIS HC A04/MF A01

Findings from a six-year field and laboratory program of frost-action research in four principal areas are summarized. Research on the first topic, frost-susceptibility index tests, led to selection of the Corps of Engineers frost design soil classification system as a useful method at the simplest level of testing. At a much more complex level, a new freezing test combined with a CBR test after thawing is recommended as an index of susceptibility to both frost heave and thaw weakening. Under the second topic, a soil column and dual gamma system were developed and applied to obtain soil data used in improving and validating a mathematical model of frost heave, the objective of the third research topic. The model was effectively improved, a probabilistic component was added, and it was successfully tested against field and laboratory measurement of frost heave. A thaw consolidation algorithm was added, which was shown to be useful in predicting the seasonal variation in resilient modulus of granular soils, the objective of the fourth topic. A laboratory testing procedure was developed for assessing the resilient modulus of thawed soil at various stages of the recovery process, as a function of the applied stress and the soil moisture tension, which increases as the soil gradually desaturates during recovery. The procedure was validated. Author

N87-16854# G B Lab., Inc., Santa Ana, Calif.

DEVELOPMENT OF A DRAG MEASUREMENT SYSTEM FOR THE CERF 6-FOOT SHOCK TUBE Technical Report, 28 Sep. 1984 - 1 Mar. 1986

GEORGE H. BURGHART 31 Mar. 1986 39 p
(Contract DNA001-84-C-0438; DNA PROJ. Q93-QMXA)
(AD-A173087; GBL-86-036R; DNA-TR-86-119) Avail: NTIS HC A03/MF A01 CSCL 14B

An instrumentation system was developed permitting the direct measurement of drag forces on flat plates in a precursed and/or dusty shock tube flow environment. The system was designed for very high frequency response to track the rapid changes in the shock tube flow. A fully self-contained data acquisition unit with solid state memory was also designed and built for this application. The system was fielded in the CERF 6-foot Shock Tube at Kirtland AFB, New Mexico. GRA

N87-17718*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

POTENTIAL BENEFITS OF MAGNETIC SUSPENSION AND BALANCE SYSTEMS

PIERCE L. LAWING, DAVID A. DRESS, and ROBERT A. KILGORE Feb. 1987 43 p
(NASA-TM-89079; NAS 1.15:89079) Avail: NTIS HC A03/MF A01 CSCL 14B

The potential of Magnetic Suspension and Balance Systems (MSBS) to improve conventional wind tunnel testing techniques is discussed. Topics include: elimination of model geometry distortion and support interference to improve the measurement accuracy of aerodynamic coefficients; removal of testing restrictions due to supports; improved dynamic stability data; and stores separation testing. Substantial increases in wind tunnel productivity are anticipated due to the coalescence of these improvements. Specific improvements in testing methods for missiles, helicopters, fighter aircraft, twin fuselage transports and bombers, state separation, water tunnels, and automobiles are also forecast. In a more speculative vein, new wind tunnel test techniques are envisioned as a result of applying MSBS, including free-flight computer trajectories in the test section, pilot-in-the-loop and designer-in-the-loop testing, shipboard missile launch simulation, and optimization of hybrid hypersonic configurations. Also addressed are potential applications of MSBS to such diverse technologies as medical research and practice, industrial robotics, space weaponry, and ore processing in space. Author

N87-17719# Army Engineer Waterways Experiment Station, Vicksburg, Miss. Geotechnical Lab.

PROBABILISTIC AND RELIABILITY ANALYSIS OF THE CALIFORNIA BEARING RATIO (CBR) DESIGN METHOD FOR FLEXIBLE AIRFIELD PAVEMENTS Final Report

YU T. CHOU Aug. 1986 46 p
(AD-A173231; WES-TR-GL-86-15) Avail: NTIS HC A03/MF A01 CSCL 13B

The California Bearing Ratio (CBR) design method for flexible airfield pavements was analyzed using a probabilistic approach. The design parameters considered were the load P (or the equivalent single-wheel load), the sub-grade CBR, the tire contact area A, and the pavement total thickness t. The expected value and variance of the dependent variable performance factor, alpha (which is logarithmically related to the number of passes to failure) were estimated by using the Taylor series expansion and the Rosenblueth method. Differences in computed results between the two methods were found to be small, although the derivation of the expressions for Taylor series expansion was very complicated. A procedure was developed to estimate the reliability of the designed pavement system based on known variabilities of design parameters. Results of the reliability analysis indicate that prediction of pavement performance is most influenced by variations of pavement thickness and is least influenced by variations of tire contact. The effects of variations of wheel load and subgrade CBR are identical. The weighting factors for parameters t, CBR, P, and A, in general, are approximately 1, 0.34, 0.34, and 0.01, respectively. GRA

N87-17721# Messerschmitt-Boelkow-Blohm G.m.b.H., Ottobrunn (West Germany).

EUROPEAN TRANSONIC WIND TUNNEL (ETW) MODEL TECHNOLOGY. INVESTIGATIONS OF THE TRANSIENT TEMPERATURE AND STRESS BEHAVIOR OF ETW MODELS [ETW - MODELLTECHNOLOGIE. UNTERSUCHUNGEN ZUM TRANSIENTEN TEMPERATUR- UND SPANNUNGSVERHALTEN VON ETW - MODELLEN]

A. ZACHARIAS 1986 46 p In GERMAN
(MBB-LKE-123/S/PUB-242; ETN-87-98972) Avail: NTIS HC A03/MF A01

The results of experimental and theoretical investigations of the transient temperature and stress behavior of models under European Wind Tunnel (ETW) conditions are presented. The cryogenic wind tunnel technology imposes high materials requirements. The applied measurement techniques require further software and hardware developments. The conditioning of the model before the measurements has to be performed with a well-balanced speed in order to avoid high stresses. The ETW operation for commercial-development measurements involves substantial risks. The fundamentals and proposals for the construction and handling of models in the ETW are presented. ESA

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CHEMISTRY AND MATERIALS

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

A87-23431#

COMPARATIVE RATES OF HEAT RELEASE FROM FIVE DIFFERENT TYPES OF TEST APPARATUSES

VYTENIS BABRAUSKAS (NBS, Center for Fire Research, Gaithersburg, MD) Journal of Fire Sciences (ISSN 0734-9041), vol. 4, Mar.-Apr. 1986, p. 148-159. refs

Previously reported rates of heat release using five different bench-scale test methods are compared with each other and against a limited series of large-scale tests. The materials tested were low-flammability wall lining materials, of a construction similar as might be used for aircraft cabin walls. Based on the peak values at different irradiances, three of the methods gave similar results: the Cone Calorimeter, the FMRC Flammability Apparatus, and the Flame Height Apparatus. The other data, from the OSU calorimeter in the thermopile mode and the OSU calorimeter in the oxygen-consumption mode, gave results typically 1/2 of the first three methods. Simple techniques for predicting full-scale performance from bench-scale data are emerging. The preliminary application of these appears promising. Author

A87-24401

THE STRUCTURE AND PROPERTIES OF BINARY MAGNESIUM-LITHIUM ALLOYS DURING DIE CASTING [STRUKTURA I SVOISTVA DVOINYKH MAGNIEVOLITIEVYKH SPLAVOV PRI LIT'E POD DAVLENIEM]

L. V. NIKULIN, G. L. LYKASOVA, and N. M. SHKLIAEVA (Peronskii Politekhnicheskii Institut, Perm, USSR) Metallovedenie i Termicheskaia Obrabotka Metallov (ISSN 0026-0819), no. 10, 1986, p. 59-62. In Russian.

The structure and mechanical properties of binary Mg-Li alloys are investigated experimentally with a view to developing new structural alloys for die casting. In particular, the mechanical properties and the hardness of Mg-Li alloys are determined as a function of Li content. It is shown that an optimum combination of strength and ductile characteristics is obtained in die-cast alloys with an alpha-beta structure. The higher strength of die-cast specimens in comparison with permanent-mold cast specimens is explained by the higher degree of grain refinement in the former. It is also noted that beta Mg-Al alloys, which are characterized by high specific strength, are of particlar interest from the standpoint of the production of ultralight cast aircraft components. V.L.

A87-25127

AN ANALYSIS OF THE COMBUSTION OF A TURBULENT SUPERSONIC NONISOBARIC HYDROGEN JET IN SUPERSONIC WAKE FLOW OF AIR [RASCHET GORENIIA TURBULENTNOI SVERKHZVUKOVOI NEIZOBARICHESKOI STRUI VODORODA V SPUTNOM SVERKHZVUKOVOM POTOKE VOZDUKHA]

S. I. BARANOVSKII, A. S. NADVORSKII, and V. A. PERMINOV Fizika Goreniia i Vzryva (ISSN 0430-6228), vol. 22, July-Aug. 1986, p. 14-18. In Russian. refs

A two-dimensional mathematical model of turbulent supersonic flow based on simplified Navier-Stokes equations is used to investigate the effect of heat evolution on the static pressure and processes in the mixing layer. With reference to results obtained for the combustion of a turbulent supersonic hydrogen jet in supersonic wake flow of air, it is shown that heat evolution may lead to a significant (up to 25 percent) increase in pressure, an increase in the jet range, and a deterioration of mixing. It is also shown that the dimensionless excess velocity profile in the mixing layer of the reacting jet cannot be described by the Schlichting curve. V.L.

A87-25423#

A STUDY ON FATIGUE CRACK PROPAGATION SUPERIMPOSING HIGH CYCLES ON LOW CYCLES FOR TURBINE MATERIALS

BAILIN TU, KANGMIN NIU, ZHANGAN WANG, and MINGGAO YAN (Beijing Institute of Aeronautical Materials, People's Republic of China) Journal of Aerospace Power, vol. 1, July 1986, p. 76-78. In Chinese, with abstract in English.

Crack propagation under combined fatigue (superimposing high-frequency vibration with lower amplitude on low cycles with higher amplitude) and its fractographic features are studied for GH36 alloy. Experimental results show that the high-cycle damage will be a main factor when the amplitude ratio of high cycle to low cycle is larger than 0.98. Then, the surface deformation just ahead of the crack tip is decreased, each wide striation consisting of a number of parallel substriations produced by vibration stress, and the cyclic hardening is increased. In this case, the measured FCG rate is basically independent of the LCF damage. Author

A87-25872#

COMPOSITES DESIGN ALLOWABLES

J. JAYARAMAN (Aeronautical Development Establishment, Structures Div., Bangalore, India) Aeronautical Society of India, Journal (ISSN 0001-9267), vol. 38, May 1986, p. 135-140. refs

A method that can be used to determine the static design allowables for composites using prepregs as the basic construction material is described. Consideration is given to the structure of the composite data bank (that includes the data on material type, system type, laminate type, data type, and material property type), the design allowables approach, and the basic composite design data required for the tests. A comprehensive test program to be followed for obtaining the design allowables is outlined. I.S.

A87-25970#

PRESENT-DAY METALLIC MATERIALS EMPLOYED IN THE STRUCTURES OF AIRCRAFT AND HELICOPTERS USED AND MANUFACTURED IN POLAND [WSPOLCZESNE MATERIALY METALOWE STOSOWANE W KONSTRUKCJACH SAMOLOTOW I SMIGLOWCOW UZYTKOWANYCH I WYTWARZANYCH W POLSCE]

RYSZARD KROL Technika Lotnicza i Astronautyczna (ISSN 0040-1145), vol. 41, June 1986, p. 7-10. In Polish. refs

High-temperature and titanium alloys used in aircraft engineering are examined with particular attention given to their distinguishing characteristics and chemical compositions. Data on metal alloy applications in different types of aircraft and helicopters are provided. K.K.

A87-25975#

THE APPLICATION OF NEW CERAMIC MATERIALS IN THE CONSTRUCTION OF AIRCRAFT GAS-TURBINE ENGINES [ZASTOSOWANIE NOWYCH CERAMIK W BUDOWIE SILNIKOW TURBINOWYCH]

RYSZARD GRUCHALSKI (WSK, Rzeszow, Poland) Technika Lotnicza i Astronautyczna (ISSN 0040-1145), vol. 41, Aug. 1986, p. 20, 21. In Polish.

Research carried out by Western manufacturers of aircraft gas turbine engines is examined. Attention is given to the application of new sintered materials and ceramic castings in turbine production. Results of strength tests are presented along with design examples. K.K.

A87-26105

HIGH-TEMPERATURE BEHAVIOR OF DIFFERENT COATINGS IN HIGH-PERFORMANCE GAS TURBINES AND IN LABORATORY TESTS

L. PEICHL and G. JOHNER (MTU Motoren- und Turbinen-Union Muenchen GmbH, Munich, West Germany) Journal of Vacuum Science and Technology A (ISSN 0734-2101), vol. 4, Nov.-Dec. 1986, p. 2583-2592. refs

Typical features of the different modes of high-temperature surface attack are presented using results of failure analysis of turbine parts and of laboratory experiments. At very high temperatures, interactions take place between the coatings, which are indispensable in this temperature range, and the base metal. Some examples are described that have been gained from cyclic oxidation tests with a nickel-base single-crystal alloy and different types of coatings. The development of a broad diffusion zone and the depletion of beta phase of the coatings indicate that interdiffusion plays an important role in determining the coating life. In a particular temperature range platelike phases precipitate in the matrix close to the coating. Kirkendall porosity, which frequently occurs at the coating substrate interface at very high temperatures, can markedly reduce the adhesive strength. The behavior of coated parts under mechanical loading is influenced by the coating-substrate combination. Some examples are shown describing creep and thermal fatigue properties of coated components. Author

A87-27242
PLASTICS - A BIRDSEYE VIEW INTO THE FUTURE
Advanced Materials and Processes (ISSN 0026-0665), vol. 131, Jan. 1987, p. 32-34, 39, 40, 43.

Advanced plastics being developed in U.S. and Japanese government, academic, and industry laboratories are listed and briefly characterized in a general survey. Consideration is given to biomedical materials; improved blends, alloys, and composites; membranes and barriers; electrically conducting plastics; high-temperature materials; plastics with improved toughness; fire-resistant and clean-burning plastics; and high-strength fibers. T.K.

A87-27332
ENGINE OILS NO LONGER SUITABLE FOR GEARBOXES?
JAMES H. BRAHNEY Aerospace Engineering (ISSN 0736-2536), vol. 6, Dec. 1986, p. 66-69.

The development of separate lubricants for helicopter engines and gearboxes is being studied. Problems encountered with the oil currently used in helicopter transmissions and engines are examined. It has been determined that it is necessary to develop an oil for gas turbine engines which has improved thermal-oxidative stability and greater cleanliness, and the gearbox oil needs improved load-carrying capacity and corrosion resistance to extend the service life of helicopter transmissions. Research in the areas of nonester based lubricants and various additives is discussed. I.F.

A87-27560
ALUMINIUM ALLOYS FOR AIRFRAMES - LIMITATIONS AND DEVELOPMENTS
C. J. PEEL (Royal Aircraft Establishment, Materials and Structures Dept., Farnborough, England) (Institute of Metals, Conference on Materials at Their Limits, University of Birmingham, England, Sept. 25, 1985) Materials Science and Technology (ISSN 0267-0836), vol. 2, Dec. 1986, p. 1169-1175. refs

Aluminum alloys have been the predominant choice of material used in the construction of civil and military aircraft since World War II. They are, however, subject to competition from other materials, particularly titanium and carbon fiber reinforced composite. Some of the developments that have occurred with conventional alloys are considered and the limitations to further exploitation are defined in terms of availability, cost, structural efficiency, and compatibility with existing manufacturing technology. Some new prospects for aluminum-base materials are considered, including conventional alloys, metal matrix composites, and powder alloys. Author

N87-16883*# Lockheed-California Co., Burbank.
FLIGHT SERVICE EVALUATION OF ADVANCED COMPOSITE AILERONS ON THE L-1011 TRANSPORT AIRCRAFT Annual Flight Service Report
R. H. STONE Jul. 1986 14 p
(Contract NAS1-15069)
(NASA-CR-178170; NAS 1.26:178170; LR-31032; AFSR-4)
Avail: NTIS HC A02/MF A01 CSCL 11D

This report covers flight evaluation of composite inboard ailerons on the L-1011 under Contract NAS 1-15069 for a period of five years. This is the fourth annual report of the maintenance evaluation program, and covers the period from May 1985 when the third yearly inspections were completed, through July 1986. Four shipsets of graphite/epoxy composite inboard ailerons were installed on L-1011 aircraft for this maintenance evaluation program. These include two Delta aircraft and two TWA aircraft. A fifth shipset of composite ailerons was installed in 1980 on Lockheed's flight test L-1011. One instance of minor damage was observed on one of the composite ailerons and was repaired. No other maintenance actions have occurred on any of the composite parts except for repainting of areas with paint loss. Flight hours on the airline components at the time of inspection ranged from 12,051 to 14,046 hours, after approximately 4 years of service. Author

N87-16884*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
COMPARISON OF COMPOSITE ROTOR BLADE MODELS: A COUPLED-BEAM ANALYSIS AND AN MSC/NASTRAN FINITE-ELEMENT MODEL
ROBERT V. HODGES (Army Aviation Systems Command, St. Louis, Mo.), MARK W. NIXON, and LAWRENCE W. REHFIELD (Georgia Inst. of Tech., Atlanta) Mar. 1987 16 p
(Contract DA PROJ. 1L1-61102-AH-45)
(NASA-TM-89024; L-16207; NAS 1.15:89024; AVSCOM-TM-87-B-2) Avail: NTIS HC A02/MF A01 CSCL 11D

A methodology was developed for the structural analysis of composite rotor blades. This coupled-beam analysis is relatively simple to use compared with alternative analysis techniques. The beam analysis was developed for thin-wall single-cell rotor structures and includes the effects of elastic coupling. This paper demonstrates the effectiveness of the new composite-beam analysis method through comparison of its results with those of an established baseline analysis technique. The baseline analysis is an MSC/NASTRAN finite-element model built up from anisotropic shell elements. Deformations are compared for three linear static load cases of centrifugal force at design rotor speed, applied torque, and lift for an ideal rotor in hover. A D-spar designed to twist under axial loading is the subject of the analysis. Results indicate the coupled-beam analysis is well within engineering accuracy. Author

N87-16897# Princeton Univ., N. J. Dept. of Mechanical and Aerospace Engineering.
FUELS COMBUSTION RESEARCH Annual Technical Report, 1 Oct. 1985 - 30 Sep. 1986
F. L. DRYER, I. GLASSMAN, and F. A. WILLIAMS 31 Oct. 1986 62 p
(Contract F49620-86-C-0006)
(AD-A175040; AFOSR-86-2107TR) Avail: NTIS HC A04/MF A01 CSCL 21B

After great progress related to soot formation in normal diffusion flames, studies of near sooting inverse diffusion flames were begun to determine controlling precursors. Stable, temperature controlled inverse diffusion flames have been successfully developed and numerous chemical samples extracted and analyzed. Observed trends are being studied. The side chain oxidation of n-butyl benzene was found to follow the same processes as the smaller n-alkyl benzenes; abstraction, alkyl group displacement and thermal cleavage. The results have led to development of a simple general, mechanistic model for the oxidation of n-alkyl benzenes. Combustion property observations of isolated boron droplets were extended to boron/JP-10 slurries with various solid loadings. Some physical understanding of observed droplet-burning and disruption behavior was developed. Quasi-spherical hollow shells of the boron agglomerate with blowholes support the hypothesis of the formation of the impermeable shell and subsequent disruption of the primary slurry droplet. Boron suspension (cloud) combustion in the hot reaction products of a flat-flame burner has been pursued. The boric acid fluctuation bands were identified spectroscopically, and conditions for their flame occurrence measured. The work progresses toward establishment of ignition conditions and combustion times of 0.1 to 5 micronboron particles. GRA

N87-16905# Rolls-Royce Ltd., Derby (England).
CORROSION/OXIDATION PROTECTION OF HIGH TEMPERATURE MATERIAL
G. W. MEETHAM 2 Apr. 1986 22 p Presented at the Materials in Aerospace Conference, England, 2-4 Apr. 1986; *sponsored by* RAE
(PNR90355; ETN-87-98787) Avail: NTIS HC A02/MF A01

Corrosion resistant coatings of gas turbine blades are discussed. Thermal barrier coatings are described. Applications in aircraft engines are recalled. ESA

N87-17858*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
LONG-TERM ENVIRONMENTAL EFFECTS AND FLIGHT SERVICE EVALUATION OF COMPOSITE MATERIALS
H. BENSON DEXTER Jan. 1987 188 p
(NASA-TM-89067; NAS 1.15:89067) Avail: NTIS HC A09/MF A01 CSCL 11D

Results of a NASA-Langley sponsored research program to establish the long term effects of realistic flight environments and ground based exposure on advanced composite materials are presented. The effects of moisture, ultraviolet radiation, aircraft fuels and fluids, sustained stress, and fatigue loading are reported. Residual strength and stiffness as a function of exposure time and exposure location are reported for seven different material systems after 10 years of worldwide outdoor exposure. Flight service results of over 300 composite components installed on rotorcraft and transport aircraft are included. Over 4 million total component flight hours were accumulated on various aircraft since initiation of flight service in 1973. Service performance, maintenance characteristics, and residual strength of numerous composite components installed on commercial and military aircraft are reported as a function of flight hours and years in service. Residual strength test results of graphite/epoxy spoilers with 10 years of worldwide service and over 28,000 flight hours are reported. Author

N87-17860*# Boeing Commercial Airplane Co., Seattle, Wash.
DURABILITY AND DAMAGE TOLERANCE OF LARGE COMPOSITE PRIMARY AIRCRAFT STRUCTURE (LCPAS)
JOHN E. MCCARTY and WILLIAM G. ROESELER Washington NASA Jan. 1984 23 p
(Contract NAS1-16863)
(NASA-CR-3767; NAS 1.26:3767; D6-49579) Avail: NTIS HC A02/MF A01 CSCL 11D

Analysis and testing addressing the key technology areas of durability and damage tolerance were completed for wing surface panels. The wing of a fuel-efficient, 200-passenger commercial transport airplane for 1990 delivery was sized using graphite-epoxy materials. Coupons of various layups used in the wing sizing were tested in tension, compression, and spectrum fatigue with typical fastener penetrations. The compression strength after barely visible impact damage was determined from coupon and structural element tests. One current material system and one toughened system were evaluated by coupon testing. The results of the coupon and element tests were used to design three distinctly different compression panels meeting the strength, stiffness, and damage-tolerance requirements of the upper wing panels. These three concepts were tested with various amounts of damage ranging from barely visible impact to through-penetration. The results of this program provide the key technology data required to assess the durability and damage-tolerance capability or advanced composites for use in commercial aircraft wing panel structure. Author

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ENGINEERING

Includes engineering (general); communications and radar; electronics and electrical engineering; mechanics and heat transfer; instrumentation and photography; lasers and masers; mechanical engineering; quality assurance and reliability; and structural mechanics.

A87-23614
MOBILE CARS INSTRUMENT FOR COMBUSTION AND PLASMA DIAGNOSTICS
TORGER J. ANDERSON, GREGORY M. DOBBS, and ALAN C. ECKBRETH (United Technologies Research Center, East Hartford, CT) Applied Optics (ISSN 0003-6935), vol. 25, Nov. 15, 1986, p. 4076-4085. refs

The compact and easily transportable CARS system for combustion and plasma diagnostics presented is adaptable to a wide variety of test environments and experiments, as well as capable of withstanding high noise and vibration levels. The system incorporates remotely controlled operation capabilities in order to keep operating personnel and delicate components from noisy, hazardous environments. Attention is given to the system's application to single-pulse temperature and concentration measurements in such frequently encountered combustion systems as gas turbines, diesel engines, and plasma-process applications. Initial measurement demonstrations have been accomplished for a supersonic combustor flow. O.C.

A87-23627
FOUNDATION OF POTENTIAL FLOWS
L. MORINO (Boston University, MA) IN: Computational methods in potential aerodynamics . Billerica, MA/Berlin, Computational Mechanics Publications/Springer-Verlag, 1985, p. 3-17.

The fundamental equations governing the motion of perfect fluid are presented in this section. Specifically, continuity equation, Euler equations, and entropy equation are obtained starting from the fundamental principles of conservation of mass, momentum and energy, along with Gibbs thermodynamics with the restriction that fluid is perfect (that is, inviscid and adiabatic). These equations are used to prove that, if a flow field is initially isentropic and irrotational and no shocks arise, then the field remains irrotational, except for the points emanating from the trailing edge (wake). The equation for the velocity potential is then obtained. Author

A87-23628
REVIEW OF THE HISTORICAL DEVELOPMENT OF SURFACE SOURCE METHODS
J. L. HESS (Douglas Aircraft Co., Long Beach, CA) IN: Computational methods in potential aerodynamics . Billerica, MA/Berlin, Computational Mechanics Publications/Springer-Verlag, 1985, p. 21-37. refs

Surface-source-type panel methods for the computation of incompressible inviscid potential flow problems are reviewed, taking theoretical, numerical, and practical aspects into consideration. The history of these techniques is traced from two-dimensional and axisymmetric methods to methods for three-dimensional nonlifting and lifting flows, higher-order three-dimensional formulations, and the development of input and output processors. T.K.

A87-24033*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
MEASUREMENT AND PREDICTION OF MODEL-ROTOR FLOWFIELDS
F. KEVIN OWEN and MICHAEL E. TAUBER (NASA, Ames Research Center, Moffett Field, CA) Journal of Aircraft (ISSN 0021-8669), vol. 23, Nov. 1986, p. 843-851. Previously cited in issue 19, p. 2737, Accession no. A85-40683. refs

A87-24037
PREDICTING THE ONSET OF HIGH CYCLE FATIGUE DAMAGE - AN ENGINEERING APPLICATION FOR LONG CRACK FATIGUE THRESHOLD DATA
B. E. POWELL and T. V. DUGGAN (Portsmouth Polytechnic, England) International Journal of Fatigue (ISSN 0142-1123), vol. 8, Oct. 1986, p. 187-194. Research sponsored by Rolls-Royce, Ltd. refs
(Contract AF-AFOSR-82-0077; F49620-83-C-0116)

Fatigue crack propagation rates have been measured for two titanium-based aeroengine disk alloys using compact tension test-pieces. The loading block employed simulates two features of the engine flight pattern. A major stress cycle represents the start-stop operation which leads to low cycle fatigue. In-flight vibrations, which may give rise to high cycle fatigue, are represented by superimposed minor cycles of high frequency. The threshold values associated with the minor cycles have been used to predict the onset of minor cycle activity. These predictions are successful for Ti-6Al-4V, while for Ti-5331S they are found to be either accurate or safe. Ti-5331S exhibits the greater fatigue lives by virtue of a marginally greater resistance to the onset of minor cycle crack growth combined with slower major cycle crack growth rates prior to this event. Author

A87-24718#
THE MODEL OF THE VARIABLE SPEED CONSTANT FREQUENCY CLOSED-LOOP SYSTEM OPERATING IN GENERATING STATE
DAOHONG DING (Nanjing Aeronautical Institute, People's Republic of China) Acta Aeronautica et Astronautica Sinica, vol. 7, Oct. 1986, p. 461-470. In Chinese, with abstract in English.

The variable speed constant frequency (USCF) electrical power system is a new type of aircraft power supply, which contains an alternating generator and a cycloconverter. This sums up the work of the cycloconverter and obtains four fundamental classes of circuit construction of the closed-loop system, which have twelve operating models. A mathematical model for each fundamental class of the circuit construction is introduced. These mathematical models can be used in digital simulation. Author

A87-24938#
TIP VORTEX CORE MEASUREMENTS ON A HOVERING MODEL ROTOR
T. L. THOMPSON (McDonnell-Douglas Helicopter Co., Mesa, AZ), O. J. KWON, J. L. KEMNITZ, N. M. KOMERATH (Georgia Institute of Technology, Atlanta), and R. B. GRAY AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 13 p. refs
(Contract DAAG29-82-K-0094)
(AIAA PAPER 87-0209)

Detailed measurements with a laser Doppler velocimeter have been performed in the tip region and in the tip vortex core of a single-bladed model rotor in hover. The testing was conducted at a rotor tip speed of 32 m/s, a Reynolds numbers of 280,000, and at two values of the rotor thrust coefficient, .0022 and .0057. A flow visualization study verified the steadiness of the tip vortex trajectory in the near wake and supplied information necessary to construct a grid for the measurement of velocity in the vortex core. Velocity in the inner vortex core was measured using a computer-controlled, off-axis receiving optics system. The core self-induced velocity components were isolated from these data and are presented as a function of the core radial coordinate. The core circulatory velocity was in reasonable agreement with a fixed-wing vortex core model. The axial velocity profile indicates a peak in the direction of blade rotation at the center of the core. Author

A87-24943#
VISUALIZATION OF UNSTEADY SEPARATED FLOW ABOUT A PITCHING DELTA WING
F. T. GILLIAM, J. B. WISSLER, J. M. WALKER (U.S. Air Force Academy, Colorado Springs, CO), and M. C. ROBINSON (Colorado, University, Boulder) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 13 p. refs
(AIAA PAPER 87-0240)

Unsteady separated flows produced by three different delta wings driven with constant pitch rates were investigated using high speed flow visualization. The large scale vortices produced were initially similar to those produced above delta wings driven sinusoidally. Subsequently, the vortices either convected away from the wing or were broken up by the complex three-dimensional flow field. Both initiation and development of the leading edge vortices were dependent upon planform geometry and nondimensional pitch rate. Variations in vortex characteristics and duration with spanwise position were also noted. Smoke wire visualization proved a valuable tool in assessing the three-dimensional characteristics of the unsteady flow field. Author

A87-24958*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
A SURVEY OF SIMULATION AND DIAGNOSTIC TECHNIQUES FOR HYPERSONIC NONEQUILIBRIUM FLOWS
SURENDRA P. SHARMA and CHUL PARK (NASA, Ames Research Center, Moffett Field, CA) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 18 p. refs
(AIAA PAPER 87-0406)

The possible means of simulating nonequilibrium reacting flows in hypersonic environments, and the required diagnostic techniques, are surveyed in two categories: bulk flow behavior and determination of chemical rate parameters. Flow visualization of shock shapes for validation of computational-fluid dynamic calculations is proposed. The facilities and the operating conditions necessary to produce the required nonequilibrium conditions, the suitable optical techniques, and their sensitivity requirements, are surveyed. Shock-tubes, shock-tunnels, and ballistic ranges in a wide range of sizes and strengths are found to be useful for this purpose, but severe sensitivity requirements are indicated for the optical instruments, which can be met only by using highly-collimated laser sources. Likewise, for the determination of chemical parameters, this paper summarizes the quantities that need to be determined, required facilities and their operating conditions, and the suitable diagnostic techniques and their performance requirements. Shock tubes of various strengths are found to be useful for this purpose. Vacuum ultraviolet absorption and fluorescence spectroscopy and coherent anti-Stokes Raman spectroscopy are found to be the techniques best suited for the measurements of the chemical data. Author

A87-25291* Jet Propulsion Lab., California Inst. of Tech., Pasadena.
DROPLET FIELD VISUALIZATION AND CHARACTERIZATION VIA DIGITAL IMAGE ANALYSIS
M. A. HERNAN, P. PARIKH, and V. SAROHIA (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) IN: Fluid control and measurement; Proceedings of the International Symposium, Tokyo, Japan, Sept. 2-5, 1985. Volume 2 . Oxford, England and New York, Pergamon Press, 1986, p. 731-738. DOT-FAA-supported research.

This paper describes techniques that have been developed at JPL for visualization and measurements of droplet fields in a moving airstream. The techniques have been applied to a variety of problems which include simulation of heavy rain conditions in a wind tunnel, engine ingestion of wheel spray, analysis of fuel nozzle sprays and aerodynamic breakup of non-Newtonian liquids. The approach pursued here is direct imaging using a pulsed laser illumination source, followed by digital processing of photographic images. A laser double pulse technique has been used for determination of droplet velocities. Laser induced fluorescence has been used to enhance droplet definition in photographic images. The image processing software developed is capable of distinguishing between out-of-focus and in-focus drops, retaining only the latter for size determination. Author

A87-25417#
TRANSIENT OPERATING LINE INDICATOR AND ITS APPLICATION
ZONGYUAN WANG and JINYAN FANG (Northwestern Polytechnical University, Xian, People's Republic of China) Journal of Aerospace Power, vol. 1, July 1986, p. 41-46. In Chinese, with abstract in English.

A special instrument is presented for monitoring the transient process in a turbojet engine, which is called a transient operating line indicator. The instrument consists of analog computing circuits. It demonstrates the real-time flow rate and the pressure ratio of the engine, which are calculated from the total pressure and the static pressure at the inlet and the total pressure at the exist of the compressor. By means of this instrument the transient operating line of the engine can be plotted with an x-y recorder. The description, the circuits, and the performance of this instrument are given in this paper. The various transient processes of turbojet engine, such as acceleration, deceleration and surge, have been studied with this instrument. Author

A87-25598
THE FUNDAMENTALS OF BODY-FREEDOM FLUTTER
LL. T. NIBLETT (Royal Aircraft Establishment, Farnborough, England) Aeronautical Journal (ISSN 0001-9240), vol. 90, Nov. 1986, p. 373-377. refs

The object of this paper is to uncover the nature of the destabilizing coupling that is the major cause of body-freedom flutter and to see whether a simple cure for the flutter can be found. To do this frequency-coalescence theory is applied to a simple aircraft. It is shown that the aircraft is liable to flutter if it has a sweptforward wing and a positive 'tail-off' cg margin or a sweptback wing and a negative cg margin but a simple cure for the flutter does not appear to exist. Author

A87-25822
MICROFOCUS RADIOGRAPHY OF JET ENGINES
MICHAEL J. BAGNELL (TFI Corp., New Haven, CT) and BRUCE KOTZIAN (Northwest Orient Airline, Minneapolis, MN) Materials Evaluation (ISSN 0025-5327), vol. 44, Dec. 1986, p. 1466, 1467.

The use of microfocus radiography to inspect jet aircraft engine liners is discussed. The procedures for inspecting with a high-energy microfocus X-ray system are described. Examples of the application of microfocus to engine inspections are presented. I.F.

A87-25823
NDT OF JET ENGINES - AN INDUSTRY SURVEY. I
Materials Evaluation (ISSN 0025-5327), vol. 44, Dec. 1986, p. 1477, 1478, 1480-1482, 1484, 1485.

Various NDT techniques for inspecting jet engines are examined. The use of borescopes to visually inspect for apparent damage to internal structures of the engines, in particular combustion chamber liners, is discussed. Flexible fiber optics, guide tubes, and imaging have been employed to improve borescopes. Consideration is given to the application of liquid penetration testing, IR testing, leak testing, holography, flow measurements, vibration testing, material characterization, and acoustic microscopy to NDT of jet engines. I.F.

A87-25842#
EXPERIMENTAL STUDY OF THE BREAKDOWN OF A VORTEX GENERATED BY A DELTA WING
D. PAGAN and J. L. SOLIGNAC (ONERA, Chatillon-sous-Bagneux, France) La Recherche Aerospatiale (English Edition) (ISSN 0379-380X), no. 3, 1986, p. 29-51. refs

A vortex generated by a delta wing and subjected to an adverse pressure gradient inducing its breakdown has been investigated by laser sheet visualizations and field measurements performed with directional multihole probes and three-dimensional laser Doppler velocimetry. These tests were carried out in a wind tunnel with a one meter diameter test section and an upstream velocity of 14.5 m/s. The vortex flow was carefully probed at many stations to define its mean and turbulent properties accurately. The breakdown manifests itself as an abrupt disorganization of the vortex with occurrence of a stagnation point on the axis. The bursted vortex mean structure comprises a large recirculation zone in which the rotation has significantly slowed down. Furthermore, the flow is the seat of large-scale low-frequency fluctuations on which a smaller-scale turbulence is superimposed. Author

A87-25843#
SEPARATION STRUCTURES ON CYLINDRICAL WINGS
H. WERLE (ONERA, Chatillon-sous-Bagneux, France) La Recherche Aerospatiale (English Edition) (ISSN 0379-380X), no. 3, 1986, p. 53-74. refs

The main types of separation appearing in succession or together on cylindrical wings, in particular at high angles of attack, have been gone over in review in recent visualizations in various ONERA water tunnels. From all of this data, generated at low velocity, a certain number of schemes have been developed to characterize the structures observed on the upper surfaces of rectangular wings at zero or negative sweep, thereby complementing a previous study that concerned only positive sweep. This analysis distinguishes between full wings and wall-mounted half-wings, and covers the effects due to the main flow, configuration and form parameters. Author

A87-25869#
EFFECT OF STATIC INPLANE LOADS AND BOUNDARY CONDITIONS ON THE FLUTTER OF FLAT RECTANGULAR PANELS
A. JOSHI and B. R. SOMASHEKAR (National Aeronautical Laboratory, Bangalore, India) Aeronautical Society of India, Journal (ISSN 0001-9267), vol. 38, May 1986, p. 105-112. refs

The present study examines the problem of flutter of flat rectangular panels subjected to static inplane loads, using the classical thin-plate theory and an approximate two-dimensional unsteady aerodynamic theory. The resulting governing differential equation is transformed into a set of algebraic equations using Galerkin's modal analysis method. These equations are solved to obtain the neutral stability points in terms of the critical (flutter) frequency and the critical (flutter) dynamic pressure. The results are obtained for various cases of panel aspect ratio, panel thickness ratio, boundary condition, and type and variation of the inplane loads. The study shows that the flutter mode is determined primarily by the first and the second vibration modes. Panel boundary conditions are found to influence the magnitudes of the flutter frequency and the dynamic pressure, though the nature of variation with inplane loads remains similar. The elasticity of the support is also examined, to arrive at simple analytical expressions for both the flutter frequency and the flutter dynamic pressure which are reasonably accurate. The present study brings out the fact that the series solution procedure is very useful in tackling the problems of panel flutter when the inplane shear loads or loads varying along the edges are present. Author

A87-25876
INDUSTRIAL VIBRATION MODELLING: POLYMODEL 9; PROCEEDINGS OF THE NINTH ANNUAL CONFERENCE, NEWCASTLE-UPON-TYNE, ENGLAND, MAY 21, 22, 1986
J. CALDWELL, ED. (Newcastle-upon-Tyne Polytechnic, England) and R. BRADLEY, ED. (Glasgow, University, Scotland) Conference sponsored by the North East Polytechnics Mathematical Modelling and Computer Simulation Group. Dordrecht, Martinus Nijhoff Publishers, 1987, 259 p. For individual items see A87-25877 to A87-25882.

The application of mathematical modeling techniques and computer simulations to solve industrial vibration problems is discussed in reviews and reports. Subject areas addressed are vehicular vibrations, acoustics, fluid/structural vibrations, and special problems and developing areas. Consideration is given to a statistical discrete-element theory of vehicle response, mathematical modeling of ship vibrations, FEM predictions of panel transmission loss and radiation efficiency, the free vibration of laminated orthotropic thin cylindrical shells with free edges, and bird-strike-resistant mechanical designs for aircraft head-up displays. T.K.

A87-25878
APPLICATIONS OF THE STATISTICAL DISCRETE ELEMENT THEORY TO VEHICLE RESPONSE
R. BRADLEY (Glasgow, University, Scotland) IN: Industrial vibration modelling: Polymodel 9; Proceedings of the Ninth Annual Conference, Newcastle-upon-Tyne, England, May 21, 22, 1986 . Dordrecht, Martinus Nijhoff Publishers, 1987, p. 33-47. refs

The statistical-discrete-element method (SDEM) developed by Jones (1968 and 1980) to model the effects of atmospheric turbulence on aircraft is generalized to treat the response of any vehicle to fluctuating external stimuli. The primary features of the SDEM are reviewed; the responses of linear and nonlinear systems to different types of gusts are analyzed; the generalized SDEM formulation is derived; and applications to a land vehicle on rough terrain, response prediction using filters, and multiple-parameter tuning are described and illustrated with diagrams and graphs. T.K.

A87-25913#
METHOD FOR ANALYZING FOUR-HOT-WIRE PROBE MEASUREMENTS
G. PAILHAS and J. COUSTEIX (ONERA, Centre d'Etudes et de Recherches de Toulouse, France) La Recherche Aerospatiale (English Edition) (ISSN 0379-380X), no. 2, 1986, p. 79-86.

Strongly turbulent, sheared three-dimensional flows are characterized here by means of a four-hot-wire probe. A technique of data reduction with an easy directional calibration involving no hot-wire law with directional sensitivity coefficients, has been developed to determine the mean velocity field simultaneously with Reynolds stresses in complex flows. Author

A87-26111
COATINGS FOR PERFORMANCE RETENTION
R. V. HILLERY (General Electric Co., Aircraft Engine Business Group, Cincinnati, OH) Journal of Vacuum Science and Technology A (ISSN 0734-2101), vol. 4, Nov.-Dec. 1986, p. 2624-2628. refs

Performance and performance retention are becoming increasingly important in today's gas turbine engines. Materials advances have provided the intrinsic strength and temperature increases to push the capability of today's engines, and coatings have been an integral part of that advancement. Specifically, in the performance retention area, coatings and seal systems have become increasingly important in both compressor and turbine components. A brief review of the coating systems presently in use and in development is presented and areas in which the technology might be heading are considered. Author

A87-26114
DIP PROCESS THERMAL BARRIER COATINGS FOR GAS TURBINES
IBRAHIM M. ALLAM (University of Petroleum and Minerals, Dhahran, Saudi Arabia) and DAVID J. ROWCLIFFE (SRI, International, Menlo Park, CA) Journal of Vacuum Science and Technology A (ISSN 0734-2101), vol. 4, Nov.-Dec. 1986, p. 2652-2655. Research supported by the University of Petroleum and Minerals.
(Contract F49620-81-K-0009)

A new concept to apply zirconia-based thermal barrier coatings on cobalt base alloys has been developed. Contrary to plasma spraying or electron beam vaporization, the new process produces a dense and highly adherent zirconia coating that resists thermal cycling and penetration by corrosive molten salts. The new method is based on thermally growing a ZrO2-based layer from a Zr-rich alloy, predeposited on a Y-rich substrate by hot dipping. The coating consists of an outer ZrO2/Y2O3 layer and an inner oxide-metal composite layer next to the substrate surface. The outer oxide layer acts as a thermal barrier, while the inner layer acts as a graded seal that improves the adhesion of the coating to the substrate. Thermal cycling experiments showed that the coating has a good resistance to spallation between room temperature and 1100 C. Author

A87-26676
MANUFACTURING APPLICATIONS OF LASERS; PROCEEDINGS OF THE MEETING, LOS ANGELES, CA, JAN. 23, 24, 1986
PETER K. CHEO, ED. (United Technologies Research Center, East Hartford, CT) Meeting sponsored by SPIE. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers (SPIE Proceedings. Volume 621), 1986, 148 p. For individual items see A87-26677 to A87-26679.
(SPIE-621)

The present conference encompasses topics in laser material processing for industrial applications, laser applications in microelectronics, laser inspection and quality control, and laser diagnostics and measurements. Attention is given to the laser welding of cylinders, production laser hardfacing of jet engine turbine blades, production laser welding of gears, electric arc augmentation for laser cutting of mild steel, laser-assisted etching for microelectronics, and laser fabrication of interconnect structures on CMOS gate arrays. Also discussed are angle-scanning laser interferometry for film thickness measurements, the application of heterodyne interferometry to disk drive technology, and CARS applications to combustion diagnostics. O.C.

A87-26677
APPLYING LASERS FOR PRODUCTIVITY AND QUALITY
DAVID W. PORTER (Pratt and Whitney, East Hartford, CT) IN: Manufacturing applications for lasers; Proceedings of the Meeting, Los Angeles, CA, Jan. 23, 24, 1986 . Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1986, p. 9-16.

An account is given of the features and benefits of computer-controlled laser processing of aircraft gas turbine engine components as employed by a major manufacturer. Attention is given to NC laser welding, hardfacing, drilling, and cutting. The use of automated CW YAG laser welding has led to an overall 93-percent saving in processing time. Hardfacing of turbine blade shroud notch areas reduces wear on abutting surfaces. Drilling with ruby lasers proceeds at 1 pulse/sec. Cutting may be conducted by either Nd:YAG or CO2 systems. O.C.

A87-26678
PRODUCTION LASER HARDFACING OF JET ENGINE TURBINE BLADES
R. F. DUHAMEL, C. M. BANAS, and R. L. KOSENSKI (United Technologies Research Center, East Hartford, CT) IN: Manufacturing applications for lasers; Proceedings of the Meeting, Los Angeles, CA, Jan. 23, 24, 1986 . Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1986, p. 31-39. refs

A high wear point exists at the notch between adjacent blades forming the outer shroud of a jet engine turbine stage. This notch is commonly hardfaced to reduce wear and improve turbine blade endurance. Until recently, the blades were manually hardfaced by the gas tungsten arc process. A laser hardfacing process was developed for this application which has increased production rates and reduced rework requirements. The laser's precise energy control, inherent repeatability, and ability to be automated are the principal reasons for these process improvements. Laser hardfacing fundamentals and process development are described. Production equipment characteristics are reviewed and unique features of the process are identified. Finally, the results of several years of production hardfacing experiences are discussed. Author

A87-26679
CARS APPLICATIONS TO COMBUSTION DIAGNOSTICS
ALAN C. ECKBRETH (United Technologies Research Center, East Hartford, CT) IN: Manufacturing applications for lasers; Proceedings of the Meeting, Los Angeles, CA, Jan. 23, 24, 1986 . Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1986, p. 116-124. refs

Attention is given to broadband or multiplex CARS of combustion processes, using pulsed lasers whose intensity is sufficiently great for instantaneous measurement of medium properties. This permits probability density functions to be assembled from a series of single-pulse measurements, on the basis of which the true parameter average and the magnitude of the turbulent fluctuations can be ascertained. CARS measurements have been conducted along these lines in diesel engines, gas turbine combustors, scramjets, and solid rocket propellants. O.C.

A87-27100
THE FRACTURE-MECHANICS BASIS OF QUALITY REQUIREMENTS FOR HIGHLY LOADED AIRCRAFT-ENGINE DISKS [DER WERKSTOFFMECHANISCHE HINTERGRUND FUER QUALITAETSFORDERUNGEN AN HOCHBEANSPRUCHTE SCHEIBEN FUER LUFTFAHRTTRIEBWERKE]
P. ESSLINGER, H. HUFF, and G. KOENIG (MTU Motoren- und Turbinen-Union Muenchen GmbH, Munich, West Germany) Zeitschrift fuer Werkstofftechnik (ISSN 0049-8688), vol. 17, Oct. 1986, p. 357-363. In German.

Techniques for estimating the service life of turbine disks fabricated from high-strength materials are evaluated on the basis of experimental data on Ni-based alloys. The effects of defects on low-cycle-fatigue (LCF) life are explored, and conventional methods based on the number of cycles to crack initiation are shown to be unreliable for these materials. An alternative approach based on measurements relating the defect diameter to the number of cycles to fracture is described and demonstrated. Requirements for disk materials subject to LCF loading are defined in terms of crack-propagation velocity, critical crack size, and maximum defect diameter, and the implications of these criteria for processing and NDE technology are discussed. T.K.

A87-27174#
THE VIBRATION OF ROTATING CYLINDRICAL SHELLS
TAKASHI SAITO and MITSURU ENDO (Tokyo Institute of Technology, Japan) JSME, Bulletin (ISSN 0021-3764), vol. 29, Oct. 1986, p. 3505-3509. refs

The free vibration of rotating cylindrical shells is examined in reference to that of a thin rotating ring. The results of the experiment and the theoretical analysis for four kinds of boundary conditions are presented. It is found that the dependence of the frequencies upon the rotating speeds is insignificantly affected by the boundary conditions, and thus can be represented by the simple relation for a thin rotating ring, provided that the frequencies and rotating speeds are normalized by the natural frequencies of a nonrotating cylindrical shell. Author

A87-27473#
FLOW THROUGH CHANNELS INTERCONNECTED BY SLOT(S)
E. G. TULAPURKARA, S. C. RAJAN, K. A. DAMODARAN (Indian Institute of Technology, Madras, India), N. BALACHANDRAN, and K. L. SOLANKI Aeronautical Society of India, Journal (ISSN 0001-9267), vol. 38, Feb. 1986, p. 43-47.

Flow through slot(s) is of practical interest as a first step in the analysis of flow through similar passages in gas turbine combustor chamber walls and the like. Attention is presently given to the results of an experimental investigation of flow entering a channel that is blocked at its back end, and exits from a lower channel that is blocked at its front end; the two channels are interconnected by one, two, or three slots. The streamline pattern, extent of separated regions, relative mass flow through slots and pressure loss are discussed. O.C.

A87-27529
RAPID CONVERGENCE NUMERICAL METHODS FOR CALCULATING REACTIVE FLOWS
F. DUPOIRIEUX and D. SCHERRER (ONERA, Chatillon-sous-Bagneux, France) (Institut National de Recherche en Informatique et en Automatique, Journees sur la Simulation Numerique des Phenomenes de Combustion, Valbone, France, May 21-24, 1985, ONERA TP no. 1985-43) La Recherche Aerospatiale (English Edition) (ISSN 0379-380X), no. 5, 1985, p. 39-48. Previously cited in issue 23, p. 3401, Accession no. A85-47294. refs

N87-17001*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
ANALYSIS OF VISCOUS TRANSONIC FLOW OVER AIRFOIL SECTIONS
DENNIS L. HUFF, JIUNN-CHI WU (Georgia Inst. of Tech., Atlanta), and L. N. SANKAR Jan. 1987 32 p Presented at the 25th Aerospace Sciences Meeting, Reno, Nev., 12-15 Jan. 1987; sponsored by AIAA
(NASA-TM-88912; E-3340; NAS 1.15:88912; AIAA-87-0420)
Avail: NTIS HC A03/MF A01 CSCL 20D

A full Navier-Stokes solver has been used to model transonic flow over three airfoil sections. The method uses a two-dimensional, implicit, conservative finite difference scheme for solving the compressible Navier-Stokes equations. Results are presented as prescribed for the Viscous Transonic Airfoil Workshop to be held at the AIAA 25th Aerospace Sciences Meeting. The NACA 0012, RAE 2822 and Jones airfoils have been investigated for both attached and separated transonic flows. Predictions for pressure distributions, loads, skin friction coefficients, boundary layer displacement thickness and velocity profiles are included and compared with experimental data when possible. Overall, the results are in good agreement with experimental data. Author

N87-17010# Rolls-Royce Ltd., Derby (England).
OBSERVATIONS ON THE TURBULENT STRUCTURE IN AN UNSTEADY, NORMAL SHOCK/BOUNDARY-LAYER INTERACTION
L. C. SQUIRE (Cambridge Univ., England) and J. A. EDWARDS 24 Sep. 1986 8 p Repr. from ICAS
(PNR90361; ICAS-86-1.2.2; ETN-87-98791) Avail: NTIS HC A02/MF A01

The turbulence structure in an interaction between an oscillating normal shock and a thick turbulent boundary layer was studied using optical methods. The results from the optical studies, together with mean and fluctuating surface pressures are used to illuminate the effects of unsteadiness on the interaction. Failure of the main tunnel window interrupted the tests, but the Schlieren and shadowgraph photography, holographic interferometry, and dynamic Schlieren methods are shown to be valuable. ESA

N87-17020# Department of the Air Force, Washington, D.C.
UNITIZED HIGH TEMPERATURE PROBES Patent Application
FREDERICK J. KOMANETSKY, inventor (to Air Force) 3 Jul. 1986 16 p
(AD-D012508; US-PATENT-APPL-SN-882101) Avail: NTIS HC A02/MF A01 CSCL 14B

The invention comprises a single piece metallic probe manufactured from high temperature material. The probe has integral kiel heads for static instrumentation and is formed in an airfoil shape that minimizes its negative effects on the engine flow stream. In the preferred embodiment of the invention the probe is manufactured by electrical discharge machining from a single piece of stock material. Other aspects of the preferred embodiment of the invention comprise an integral platform for attachment of the probe to an engine housing and static sensors mounted in integral kiel heads positioned on the leading edge of the probe airfoil. It is also preferred that the probe be manufactured from a high temperature material such as an Inconel nickel alloy. In an alternate embodiment of the invention the probe body may be manufactured by a casting method such as powdered metallurgy and finished machined by electrical discharge machining. GRA

N87-17032# Royal Aircraft Establishment, Farnborough (England).
DIFFUSION WELDING OF COMPONENT PARTS IN THE AVIATION AND SPACE INDUSTRIES
J. DISAM and D. MIETRACH Apr. 1986 12 p Transl. into ENGLISH of conference paper "Diffusionsschweissen von Bauteilen in der Luft-und Raumfahrt" presented at the International Conference on Brazing, High-Temperature Brazing and Diffusion Welding, 1981 Conference held in Duesseldorf, West Germany, 21-22 Sep. 1981; sponsored by German Welding Society
(RAE-TRANS-2147) Avail: NTIS HC A02/MF A01

Investigations were performed and successfully completed on the materials combinations titanium/titanium, steel/steel, titanium/aluminum, titanium/permenorm, and aluminum/aluminum. Experience gained during the ZKP flap-track program, as well as during the manufacturing of heat pipes for space technology, was used for diffusion bonding of further components such as titanium/steel connections for TV-satellites. Superplastically formed/diffusion bonded titanium components, as well as different material combinations will be used to an increasing extent for civil and military aircraft in the future. In this context, examples are given from civil and military programs. Comments are made on materials and materials combinations. Costs are compared with costs for components manufactured by conventional methods. Trends in the USA show that in the future increasing emphasis will be laid on the joining of semi-finished products having quasi-final contours such as titanium castings and powder-metallurgical parts by, for example, diffusion bonding in order to cut the structural costs in airframe construction drastically. Author

N87-17048# Materials Research Labs., Ascot Vale (Australia).
GRINDING OF STEEL: A CASE STUDY
G. R. WILMS and R. L. AGHAN Aug. 1986 14 p
(AD-A174649; MRL-TN-504) Avail: NTIS HC A02/MF A01 CSCL 13H

A description is given of grinding studies aimed at overcoming a production problem on the dry grinding of hardened steel gears for aircraft gas turbine engines, in which grinding abuse in the form of both a softening and hardening of the steel led to high rejection rates. By using a combination of reduced grinding wheel speed and graded finishing cuts, gears could be produced without showing any signs of grinding abuse. A feature of the grinding was the occurrence of redeposition, and the extent of the microstructural changes in relation to redeposition under different grinding conditions is discussed. GRA

N87-17051# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). Structures and Materials Panel.
ADVANCED JOINING OF AEROSPACE METALLIC MATERIALS
Loughton, England Jul. 1986 270 p In ENGLISH and FRENCH Meeting held in Oberammergau, West Germany, 11-13 Sep. 1985
(AGARD-CP-398; ISBN-92-835-0397-X; AD-A173979) Avail: NTIS HC A12/MF A01

The papers contained in this report provide a review of the state-of-the-art of advanced joining techniques currently available to the manufacturers of aerospace equipment and identify newly emerging techniques and joining problems. Computational weld mechanics, diffusion bonding and superplastic forming, electron-beam welding, tungsten inert gas welding, inspection methods, and repair techniques are addressed.

N87-17055# Messerschmitt-Boelkow-Blohm G.m.b.H., Augsburg (West Germany). Materials and Technologies.
ECONOMICAL MANUFACTURING AND INSPECTION OF THE ELECTRON-BEAM-WELDED TORNADO WING BOX
JUERGEN BERGGREEN *In* AGARD Advanced Joining of Aerospace Metallic Materials 7 p Jul. 1986
Avail: NTIS HC A12/MF A01

The Tornado wing box is an extensively electron-beam-welded titanium 6Al4V-alloy component. The design and the manufacturing steps are described with emphasis on joining and inspection techniques. As EB-welding requires expensive investments and operations the manufacturing costs have been cut by several means which are shown. The advantages of EB-welding on the material's side and the experience gained with this technique meanwhile allow the use of EB-welding for major titanium structures even with thick cross sections as a well-known and established and no longer uneconomic advanced joining method. Author

N87-17057# British Aerospace Aircraft Group, Bristol (England). Civil Aircraft Div.
DIFFUSION BONDING IN THE MANUFACTURE OF AIRCRAFT STRUCTURE
D. STEPHEN and S. J. SWADLING *In* AGARD Advanced Joining of Aerospace Metallic Materials 17 p Jul. 1986
Avail: NTIS HC A12/MF A01

Over the last twenty years, considerable aerospace research and development effort has been directed to the development of the diffusion bonding (DB) process as a means of manufacture of low cost structures. To date the main thrust of these developments have been associated with titanium which has inherent metallurgical characteristics which make this material ideally suited for joining by this technique. For these titanium alloys which exhibit superplastic properties, the combined processes of superplastic forming (SPF) and DB considerably extend the range of low cost and structurally efficient titanium aerospace components which can be manufactured; even as replacements for conventionally fabricated aluminum alloy components. Recent developments in the SPF of high strength aluminums and metal matrix composites has stimulated work in the field of DB of aluminum. It is thought that in the longer term this field of DB could have the highest levels of application. This paper details the range of aerospace structural forms which can and are currently being manufactured using the diffusion bonding process. The process options, bond integrity, and nondestructive test (NDT) aspects are discussed. Author

N87-17059# Technische Univ., Munich (West Germany).
BONDING OF SUPERALLOYS BY DIFFUSION WELDING AND DIFFUSION BRAZING
P. ADAM and L. STEINHAUSER *In* AGARD Advanced Joining of Aerospace Metallic Materials 6 p Jul. 1986
Avail: NTIS HC A12/MF A01

Several developments of diffusion welded and diffusion bonded superalloy turbine engine parts, blades, vanes, and bliscs, are summarized. The description of results comprises nondestructive testing of parts and mechanical testing of material samples. Results are mainly presented as conclusions on the expense of detailed test results which would require individual parts/material problem presentations. Author

N87-17063# Rolls-Royce Ltd., Derby (England).
NDT OF ELECTRON BEAM WELDED JOINTS (MICRO-FOCUS AND REAL TIME X-RAY)
R. G. TAYLOR *In* AGARD Advanced Joining of Aerospace Metallic Materials 4 p Jul. 1986
Avail: NTIS HC A12/MF A01

The introduction of electron beam welding (EBW) into the aero engine industry in the early 1960's has presented many new problems for non-destructive testing (NDT). Highlighted among these are the following particular problems: (1) accessibility the use of EBW has resulted in the design of many box-like components which makes it difficult, or impossible, to apply conventional NDT methods satisfactorily; (2) center-line defect orientation; and (3) extremely narrow welds which makes the detection of defects by normal radiography very unreliable. The traditional NDT methods such as conventional X-ray, fluorescent penetrant, magnetic particle, together with the occasional use of eddy current and, where accessibility permits, ultrasonics, have been extensively used for the inspection of EBW fabrications. However, the use of these methods has created considerable limitations in defect detection where extremely small defects (under 1mm) must be detected to quarantee a successful life cycle. Initially, these limitations only applied to parts manufactured by EBW, but during recent years, EBW has been increasingly used during the repair and overhaul of aero engine engine components and the NDT limitations now extend into these areas. Recently, significant developments have taken place which has enabled micro-focus X-ray techniques to be used in place of conventional X-ray on EBW and this has resulted in a considerable improvement in defect detection capabilities. An additional bonus has been the reduction in inspection costs and an improvement in productivity. Author

N87-17067# Hughes Helicopters, Culver City, Calif. Materials, Processes and Standards Dept.
INERTIA WELDING OF NITRALLOY N AND 18 NICKEL MARAGING 250 GRADE STEELS FOR UTILIZATION IN THE MAIN ROTOR DRIVE SHAFT FOR THE AR-64 MILITARY HELICOPTER PROGRAM
A. G. HIRKO and L. L. SOFFA *In* AGARD Advanced Joining of Aerospace Metallic Materials 9 p Jul. 1986
Avail: NTIS HC A12/MF A01

Preproduction feasibility studies were performed on laboratory type inertia welded specimens of Nitralloy N and 18 Nickel Maraging 250 Grade Steel prior to a full-scale engineering development program. The full-scale program consisted of producing scaled down drive shaft components to produce engineering test parts and to develop process control parameters for guide lines in the production program. Initial studies consisted of a metallurgical development program to arrive at a satisfactory post aging cycle for the composite or dual alloy drive shaft. In addition, metallurgical and static and dynamic tests were made from coupons excised from inertia-welded assemblies to establish structural behavior. Several sub-scale inertia-welded test specimens were tested in torsion loading to develop flight structural performance. Torsion tests showed the inertia weld exhibited strength characteristics equal or better than the parent metal for the Nitralloy N alloy component. The improved two-alloy, inertia-welded components show an approximate weight saving of 10 to 15 pounds over a drive shaft produced from Nitralloy N. This is due to a higher strength/weight ratio of 18 Nickel Maraging 250 Grade Steel as compared to Nitralloy N. M.G.

N87-17070# National Aerospace Lab., Amsterdam (Netherlands).
EVALUATION OF DDH AND WELD REPAIRED F100 TURBINE VANES UNDER SIMULATED SERVICE CONDITIONS
A. J. A. MOM, N. M. MADHAVA (Chromalloy Div.-Oklahoma, Midwest City), G. A. KOOL, and M. DEAN (Turbine Support Europa, Tilburg, Netherlands) *In* AGARD Advanced Joining of Aerospace Metallic Materials 9 p Jul. 1986 Previously announced as N86-32762
Avail: NTIS HC A12/MF A01

Cost and delivery times of high technology turbine components are a strong impetus for the development of advanced repair processes with the ability of complete restoration of unserviceable components. One of such advanced processes, diffusion densification healing (DDH), was applied for repair of cracked and unserviceable F100 turbine vanes. The DDH process was evaluated under simulated service test conditions with respect to the conventional weld/patch coat repair procedure. The evaluation shows that the DDH process is a remarkably effective restoration process, resulting in strongly improved test behavior in relation to the original weld/patch coat procedure. Additional advantages are that scrap rates during repair are likely to be considerably reduced and that for the future some relaxation of current repair limits might even be considered. Author

N87-17071# Liburdi Engineering Ltd., Burlington (Ontario).
REPAIR TECHNIQUES FOR GAS TURBINE COMPONENTS
J. LIBURDI and P. LOWDEN *In* AGARD Advanced Joining of Aerospace Metallic Materials 12 p Jul. 1986
Avail: NTIS HC A12/MF A01

Areas in which the state of the art in gas turbine repair technology needs to be advanced are discussed. A large part of the discussion deals with current inadequacies of weld repair techniques for high strength superalloys and with possible areas for improvement. In particular, the problems of poor weldability and the low strength of conventional weld repairs are examined, with emphasis on areas for further development including; welding with matching filler metals, pre-weld heat treatment and preparation, modification of welding techniques and post-weld hot isostatic pressing (HIPing) and heat treatment. Another area of discussion is the need for improved techniques for resurfacing and repair of airfoil damage. Two techniques appear to be promising for this application; diffusion brazing and vacuum plasma spraying. The importance of NDT limitations and mechanical analysis with regard to the development and implementation of novel repair techniques is emphasized. Disregard of these factors can lead to repairs which are substantially cosmetic in nature. Author

N87-17077# European Space Agency, Paris (France).
STRUCTURAL ANALYSIS
Jun. 1986 384 p Transl. into ENGLISH of "Strukturberechnung", DFVLR, Brunswick, West Germany, rept. DFVLR-Mitt-84-21, Nov. 1984 365 p Presented at Conference on Structural Mechanics, Brunswick, West Germany, 7 Jun. 1984 Original language document was announced as N86-71570
(ESA-TT-917; DFVLR-MITT-84-21; ETN-87-98814) Avail: NTIS HC A17/MF A01; original German version available from DFVLR, Cologne, West Germany DM 95

Coupling of tension and torsion in rods; field consistency in finite element analysis, bucking and post-buckling behavior of small shells; optimization of axially compressed carbon fiber reinforced plastic cylinders; a substructure technique applied to fracture mechanics of composites; stress intensity factors as indicators of crack propagation in unidirectional laminates; and static aeroelastic phenomena of composite wings are discussed.
ESA

N87-17078# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick (West Germany). Inst. fuer Strukturmechanik.

RESEARCH ON STRUCTURAL ANALYSIS AT THE DFVLR, BRUNSWICK

BODO GEIER (Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick, West Germany) *In its* Structural Analysis p 7-42 Jun. 1986 Transl. into ENGLISH of "Strukturberechnung", DFVLR, Brunswick, West Germany, Nov. 1984 p 9-40 Original language document was announced as N85-29314

Avail: NTIS HC A17/MF A01; original German version available from DFVLR, Cologne, West Germany DM 95

The science of structural mechanics is reviewed, emphasizing computational problems in aerospace research. Light weight construction with composite materials is defined as the central topic. In an assessment of the present state of the art, it is concluded that a very satisfactory situation is achieved in the analysis of linear problems, but not in the solution of nonlinear problems and in structural optimization. ESA

N87-17079# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick (West Germany). Inst. fuer Strukturmechanik.

TORSION-TENSION COUPLING IN RODS

DIETER PETERSEN *In its* Structural Analysis p 43-76 Jun. 1986 Transl. into ENGLISH of "Strukturberechnung", DFVLR, Brunswick, West Germany, Nov. 1986 p 41-72 Original language document was announced as N85-29315

Avail: NTIS HC A17/MF A01; original German version available from DFVLR, Cologne, West Germany DM 95

The treatment of torsion-tension coupling in rods under finite deformations is discussed. Analyses containing higher order terms due to geometric nonlinearities show inconsistency. The differences of three analyses are discussed via numerical examples. Extremely light constructions in aviation and astronautics can neither abandon rod structures nor give up the demand for a precise analysis. ESA

N87-17085# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick (West Germany). Inst. fuer Strukturmechanik.

THE STATIC AEROELASTICITY OF A COMPOSITE WING

MATTHIAS PIENING *In its* Structural Analysis p 335-383 Jun. 1986 Transl. into ENGLISH of "Strukturberechnung", DFVLR, Brunswick, West Germany, Nov. 1984 p 319-364 Original language document was announced as N85-29321

Avail: NTIS HC A17/MF A01; original German version available from DFVLR, Cologne, West Germany DM 95

A procedure for parametric investigations of the static-aeroelastic behavior of anisotropic wings with average to large aspect ratio was developed. By exploiting the directional stiffness properties of a composite material, coupling of bending and torsional deformations can be achieved. This can be used to influence the spanwise lift distribution, the internal structural forces, and the permissible flying speeds limited by the aeroelastic behavior of the wing. Static divergence can be avoided and forward wing sweep can be realized. The differential equations describing the aeroelastic behavior of a beamlike wing structure are solved by applying the multiple shooting method. Examples show the effects of fiber orientations on lift distributions of a composite wing. ESA

N87-17094# Aeronautical Research Inst. of Sweden, Stockholm. Structures Dept.

FATIGUE LIFE AND FASTENER FLEXIBILITY OF SINGLE SHEAR RIVETED AND BOLTED JOINTS

BJOERN PALMBERG Jun. 1986 50 p

(Contract FMV-FFL-82250-85-076-73-001)

(FFA-TN-1986-35; ETN-87-98905) Avail: NTIS HC A03/MF A01

Fatigue life and fastener flexibility were investigated using open hole specimens, no load transfer specimens, and double row, four columns, single shear joints (S50) made from a 2 mm thick sheet of the aluminum alloy 7475-T761 fastened with rivets and Hi-lok. Computerized flight simulations show that fatigue lives of specimens with Hi-lok fasteners are much longer than for riveted specimens. The fastener flexibilities of riveted joints (S50) are much higher than for joints with Hi-lok fasteners. Fastener flexibility seems to depend on the stress level, the size of individual load cycles, the peak and the trough in a load cycle, and the number of applied flights. ESA

N87-18057*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

FOUR SPOT LASER ANEMOMETER AND OPTICAL ACCESS TECHNIQUES FOR TURBINE APPLICATIONS

MARK P. WERNET 1987 16 p Proposed for presentation at the 12th International Congress on Instrumentation in Aerospace Simulation Facilities, Williamsburg, Va., 22-25 Jun. 1987; sponsored by IEEE Aerospace and Electric Systems Society and NASA Langley Research Center

(NASA-TM-88972; E-3440; NAS 1.15:88972) Avail: NTIS HC A02/MF A01 CSCL 14B

A time-of-flight anemometer (TOFA) system, utilizing a spatial lead-lag filter for bipolar pulse generation was constructed and tested. This system, called a Four Spot Laser Anemometer, was specifically designed for use in high speed, turbulent flows in the presence of walls or surfaces. The TOFA system uses elliptical spots to increase the flow acceptance angle to be comparable with that of a fringe type anemometer. The tightly focused spots used in the Four Spot yield excellent flare light rejection capabilities. Good results were obtained to 75 microns normal to a surface, with a f/2.5 collecting lens. This system is being evaluated for use in a warm turbine facility. Results from both a particle lag velocity experiment and boundary layer profiles will be discussed. In addition, an analysis of the use of curved windows in a turbine casing will be presented. Curved windows, matching the inner radius of the turbine casing, preserve the flow conditions, but introduce astigmatic aberrations. A correction optic was designed that virtually eliminates these astigmatic aberrations throughout the intrablade survey region for normal incidence. Author

N87-18094# Royal Aircraft Establishment, Farnborough (England).

DIFFUSION WELDING OF COMPONENT PARTS IN THE AVIATION AND SPACE INDUSTRIES

J. DISAM and D. MIETRACH 29 Dec. 1986 14 p Transl. into ENGLISH of proceedings of the International Conference on Brazing, High-Temperature Brazing and Diffusion Welding, 1981 Conference held in Essen, West Germany, 21-22 Sep. 1981; sponsored by the German Welding Society

(BLL-LIB-TRANS-2147-(5207.00)) Avail: British Library Lending Div., Boston Spa, Engl.

Investigations were carried out and successfully completed on the material combinations titanium/titanium, steel/steel, titanium/aluminum, titanium/permenorm and aluminum/aluminum. Experience gained during the flap-track program as well as during the manufacture of heat pipes for space technology has been used for diffusion bonding of further components such as titanium/steel connections for TV-satellites. Superplastically formed/diffusion bonded titanium components as well as different material combinations will be used to an increasing extent for civil and military aircraft in future. In this context, examples are given from civil and military programs. Comments are made on materials and materials combinations, and costs are compared with costs for components manufactured by conventional methods. Trends in the USA show that in the future increasing emphasis will be laid on the joining of semi-finished products having quasi-final contours such as titanium castings and powder-metallurgical parts by, for example, diffusion bonding in order to cut the structural costs in airframe construction drastically. Author

N87-18098# Massachusetts Inst. of Tech., Cambridge. Dept. of Ocean Engineering.
DYNAMICS OF FULL ANNULAR ROTOR RUB M.S. Thesis
SEAN J. STACKLEY Jun. 1986 132 p
(AD-A173311) Avail: NTIS HC A07/MF A01 CSCL 20K

Four modes of possible rotor motion are defined: synchronous precession (without rub), partial rub, full annular synchronous rub and reverse whirl. A model is developed to investigate the relationships between a rotational system's characteristic parameters and the conditions of equilibrium for the full annular rub motion. The dynamics of an unconstrained rotor with unbalance are first established. The impact of constraining the rotor's motion by a rigid casing with a finite clearance is then analyzed. For any given system, the speed regimes in which full annular synchronous rub is in equilibrium are defined as a function of the system's unbalance, clearance, rotor stiffness, damping and the coefficient of friction between the rotor and casing. The rigid stator restriction is subsequently alleviated and the equilibrium conditions for full annular synchronous rub are reanalyzed. Additionally, reverse whirl as a possible stable mode of rotor motion is studied. Specific rotational systems are then analyzed according to the model developed to demonstrate the effect of varying particular parameters. GRA

N87-18113*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
FURTHER GENERALIZATION OF AN EQUIVALENT PLATE REPRESENTATION FOR AIRCRAFT STRUCTURAL ANALYSIS
GARY L. GILES Feb. 1987 13 p Presented at the 28th AIAA/ASME/ASCE/AHS *Structures, Structural Dynamics and* Materials Conference, Monterey, Calif., 6-8 Apr. 1987
(NASA-TM-89105; NAS 1.15:89105; AIAA-87-0721-CP) Avail: NTIS HC A02/MF A01 CSCL 20K

Recent developments from a continuing effort to provide an equivalent plate representation for aircraft structural analysis are described. Previous work provided an equivalent plate analysis formulation that is capable of modeling aircraft wing structures with a general planform such as cranked wing boxes. However, the modeling is restricted to representing wing boxes having symmetric cross sections. Further developments, which are described, allow modeling of wing cross sections having asymmetries that can arise from airfoil camber or from thicknesses being different in the upper and lower cover skins. An implementation of thermal loadings, which are described as temperature distributions over the planform of the cover skins, has been included. Spring supports have been added to provide for a more general set of boundary conditions. Numerical results are presented to assess the effect of wing camber on the static and dynamic response of an example wing structure under pressure and thermal loading. These results are compared with results from a finite element analysis program to indicate how well a cambered wing box can be represented with an equivalent plate formulation. Author

N87-18115*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
ANALYTICAL FLUTTER INVESTIGATION OF A COMPOSITE PROPFAN MODEL
K. R. V. KAZA, O. MEHMED, G. V. NARAYANAN (Sverdrup Technology, Inc., Cleveland, Ohio), and D. V. MURTHY (Toledo Univ., Ohio) 1987 24 p Proposed for presentation at the 28th Structures, Structural Dynamics and Materials Conference, Monterey, Calif., 6-8 Apr. 1987; sponsored by AIAA, ASME, AHS and ASEE
(NASA-TM-88944; E-3392; NAS 1.15:88944; AIAA-87-0738)
Avail: NTIS HC A02/MF A01 CSCL 20K

A theoretical model and an associated computer program for predicting subsonic bending-torsion flutter in propfans are presented. The model is based on two-dimensional unsteady cascade strip theory and three-dimensional steady and unsteady lifting surface aerodynamic theory in conjunction with a finite element structural model for the blade. The analytical results compare well with published experimental data. Additional parametric studies are also presented illustrating the effects on flutter speed of steady aeroelastic deformations, blade setting angle, rotational speed, number of blades, structural damping, and number of modes. Author

N87-18116*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
ANALYTICAL AND EXPERIMENTAL INVESTIGATION OF MISTUNING IN PROPFAN FLUTTER
KRISHNA RAO V. KAZA, ORAL MEHMED, MARC WILLIAMS (Purdue Univ., West Lafayette, Ind.), and LARRY A. MOSS (Sverdrup Technology, Inc., Cleveland, Ohio) 1987 21 p Proposed for presentation at the 28th Structures, Structural Dynamics and Materials Conference, Monterey, Calif., 6-8 Apr. 1987; sponsored by AIAA, ASME, AHS and ASEE
(NASA-TM-88959; E-3412; NAS 1.15:88959; AIAA-87-0739)
Avail: NTIS HC A02/MF A01 CSCL 20K

An analytical and experimental investigation of the effects of mistuning on propfan subsonic flutter was performed. The analytical model is based on the normal modes of a rotating composite blade and a three-dimensinal subsonic unsteady lifting surface aerodynamic theory. Theoretical and experimental results are compared for selected cases at different blade pitch angles, rotational speeds, and free-stream Mach numbers. The comparison shows a reasonably good agreement between theory and experiment. Both theory and experiment showed that combined mode shape, frequency, and aerodynamic mistuning can have a beneficial or adverse effect on blade damping depending on Mach number. Additional parametric results showed that alternative blade frequency mistuning does not have enough potential for it to be used as a passive flutter control in propfans similar to the one studied. It can be inferred from the results that a laminated composite propfan blade can be tailored to optimize its flutter speed by selecting the proper ply angles. Author

N87-18117*# Pratt and Whitney Aircraft, East Hartford, Conn. Engineering Div.
CREEP FATIGUE LIFE PREDICTION FOR ENGINE HOT SECTION MATERIALS (ISOTROPIC) Annual Report
VITO MORENO, DAVID NISSLEY, and LI-SEN JIM LIN Mar. 1985 141 p
(Contract NAS3-23288)
(NASA-CR-174844; NAS 1.26:174844; PWA-5894-34; AR-2)
Avail: NTIS HC A07/MF A01 CSCL 20K

The first two years of a two-phase program aimed at improving the high temperature crack initiation life prediction technology for gas turbine hot section components are discussed. In Phase 1 (baseline) effort, low cycle fatigue (LCF) models, using a data base generated for a cast nickel base gas turbine hot section alloy (B1900+Hf), were evaluated for their ability to predict the crack initiation life for relevant creep-fatigue loading conditions and to define data required for determination of model constants. The variables included strain range and rate, mean strain, strain hold times and temperature. None of the models predicted all of the life trends within reasonable data requirements. A Cycle Damage Accumulation (CDA) was therefore developed which follows an exhaustion of material ductility approach. Material ductility is estimated based on observed similarities of deformation structure between fatigue, tensile and creep tests. The cycle damage function is based on total strain range, maximum stress and stress amplitude and includes both time independent and time dependent components. The CDA model accurately predicts all of the trends in creep-fatigue life with loading conditions. In addition, all of the CDA model constants are determinable from rapid cycle, fully reversed fatigue tests and monotonic tensile and/or creep data. Author

N87-18121*# Akron Univ., Ohio. Dept. of Mechanical Engineering.
STRUCTURAL PROPERTIES OF IMPACT ICES ACCRETED ON AIRCRAFT STRUCTURES Final Report
R. J. SCAVUZZO and M. L. CHU Jan. 1987 59 p
(Contract NAG3-479)
(NASA-CR-179580; NAS 1.26:179580) Avail: NTIS HC A04/MF A01 CSCL 01C

The structural properties of ice accretions formed on aircraft surfaces are studied. The overall objectives are to measure basic structural properties of impact ices and to develop finite element analytical procedures for use in the design of all deicing systems. The Icing Research Tunnel (IRT) was used to produce simulated natural ice accretion over a wide range of icing conditions. Two different test apparatus were used to measure each of the three basic mechanical properties: tensile, shear, and peeling. Data was obtained on both adhesive shear strength of impact ices and peeling forces for various icing conditions. The influences of various icing parameters such as tunnel air temperature and velocity, icing cloud drop size, material substrate, surface temperature at ice/material interface, and ice thickness were studied. A finite element analysis of the shear test apparatus was developed in order to gain more insight in the evaluation of the test data. A comparison with other investigators was made. The result shows that the adhesive shear strength of impact ice typically varies between 40 and 50 psi, with peak strength reaching 120 psi and is not dependent on the kind of substrate used, the thickness of accreted ice, and tunnel temperature below 4 C. Author

N87-18124# Southwest Research Inst., San Antonio, Tex.
NONLINEAR FRACTURE MECHANICS ANALYSIS WITH BOUNDARY INTEGRAL METHOD Final Report, 2 Apr. 1984 - 30 May 1986
T. A. CRUSE and E. Z. POLCH 30 May 1986 101 p
(Contract F49620-84-C-0042)
(AD-A173216; SWRI-06-8044; AFOSR-86-0862TR) Avail: NTIS HC A06/MF A01 CSCL 20K

The first goal of the originally proposed program was to extend an existing planar elastic fracture mechanics analysis based on the BIE methodology to the analysis of plastic zones around cracks. The second proposed goal was to establish fundamental results for crack tip elastoplastic behavior, based on a numerical and analytical study of the elastoplastic BIE formulation. The third proposed goal was to establish the credibility of the elastoplastic BIE formulation relative to the finite element method for refined numerical analysis of the nonlinear fracture mechanics problem, and to apply the capability to important problems of fatigue crack growth modeling for advanced aerospace structures. The goal for the second year of the effort was to extend the research to the problem of modeling crack extension under elastoplastic conditions. This report summarizes key findings of the current research effort. The next section summarizes the basic two-dimensional elastoplastic formulation and applications. Included in this work are the preliminary applications of the new method to crack extension into prior plastic zones. The next section reports on the use of the new BIE formulation for elastic crack extension. This new result allows for the direct computation of crack weight functions. The last section reports on some recent work, for the 3D BIE fracture mechanics formulation. Some contrast with the 2D formulation is noted. Further work on the 3D problem is expected in the subsequent research program. GRA

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GEOSCIENCES

Includes geosciences (general); earth resources and remote sensing; energy production and conversion; environment pollution; geophysics; meteorology and climatology; and oceanography.

A87-23778
SUPER WIDE FIELD OF VIEW PERSPECTIVE IMAGE TRANSFORMATION BY PIXEL TO PIXEL MAPPING
KRISHNA MUDUNURI and JOHN T. HOOKS, JR. (LTV Aerospace and Defense Co., Vought Missiles and Advanced Programs Div., Dallas, TX) IN: American Congress on Surveying and Mapping and American Society for Photogrammetry and Remote Sensing, Annual Convention, Washington, DC, Mar. 16-21, 1986, Technical Papers. Volume 4 . Falls Church, VA, American Congress on Surveying and Mapping and American Society for Photogrammetry and Remote Sensing, 1986, p. 26-33.

A pixel to pixel mapping algorithm has been used to generate positionally displaced perspective imagery from a high-resolution scanned image with a field-of-view of 360 degrees in azimuth and 100 degrees in elevation. The positionally displaced envelope for the synthesized perspective imagery is determined to be a sphere. Camera station parameters for the high-resolution source image are determined by resection, using a photogrammetric package developed by LTVAD, that utilizes scanned images for measuring the control point locations. The imagery generated by the mapping scheme discussed in this paper are being used as a data base in a United States Navy flight training simulator. Author

A87-24362
COMPARATIVE EVALUATION OF WEATHER CONDITIONS AT MOSCOW-AREA AIRPORTS DURING WHICH FLIGHTS ARE CANCELLED [SRAVNITEL'NAIA OTSENKA NELETNYKH USLOVII POGODY V AEROPORTAKH MOSKOVSKOGO AEROUZLA]
E. S. IZNOSKOVA IN: Aviation and satellite climatology . Moscow, Gidrometeoizdat, 1985, p. 18-29. In Russian.

A87-24366
DETERMINATION OF VISIBILITY AT AIRPORTS [K VOPROSU OB OPREDELENII DAL'NOSTI VIDIMOSTI V AEROPORTAKH]
IA. M. GOLNIK IN: Aviation and satellite climatology . Moscow, Gidrometeoizdat, 1985, p. 63-69. In Russian.

Methodological aspects of the determination of visibility at airports are discussed. Visual and instrumented determinations of visibility can diverge by more than 20 percent, the absolute values of the divergence decreasing with deterioration of visibility. The determination of threshold detection values for visual and instrument flight rules is considered, and a nomogram is presented for transforming visibility data from one threshold value to the other. B.J.

A87-24746
ON NOCTURNAL WIND SHEAR WITH A VIEW TO ENGINEERING APPLICATIONS
K.-P. WITTICH, J. HARTMANN, and R. ROTH (Hannover, Universitaet, Hanover, West Germany) Boundary-Layer Meteorology (ISSN 0006-8314), vol. 37, Nov. 1986, p. 215-226. DFG-supported research. refs

Wind shear data from 14 clear nights with low-level jet development are analyzed up to heights of 200 m. Temporal variations of the magnitude of the shear vector and of the power-law exponent p are shown. The frequencies of occurrence of maximum shear and of p are examined and the effect of the product of the geostrophic surface wind speed and mean layer temperature gradient on the shear is investigated. Author

A87-25251

PROBLEMS IN WEATHER FORECASTING AND AVIATION METEOROLOGY [VOPROSY PROGNOZOV POGODY I AVIATSIONNOI METEOROLOGII]

R. A. IAGUDIN, ED. and I. P. FADEEVA, ED. Moscow, Gidrometeoizdat (Zapadno-Sibirskii Regional'nyi Nauchno-Issledovatel'skii Institut, Trudy, No. 68), 1985, 116 p. In Russian. For individual items see A87-25252 to A87-25263.

Topics discussed include the relationship between circulation processes in the troposphere and stratosphere, a systematic comparison between hemispheric meteorological fields on the basis of harmonic analysis, a study of heat transfer between the ocean and the atmosphere on the basis of ship measurements, and the use of the method of canonical correlations for meteorological forecasting. Attention is also given to the time variability of visibility at Tolmachevo Airport, temperature fluctuations in the free atmosphere with reference to aviation meteorology, the vertical profile of wind and temperature in the boundary layer in the case of strong ground winds near Ural and Siberian airports, and a regression method for predicting wind velocity and direction near the Eniseisk Airport. B.J.

A87-25258

STRUCTURE OF THE TIME VARIABILITY OF THE METEOROLOGICAL VISIBILITY RANGE AT TOLMACHEVO AIRPORT [O STRUKTURE VREMENNOI IZMENCHIVOSTI METEOROLOGICHESKOI DAL'NOSTI VIDIMOSTI V AEROPORTU TOLMACHEVO]

D. A. OSIPOV and V. M. TOKAREV IN: Problems in weather forecasting and aviation meteorology . Moscow, Gidrometeoizdat, 1985, p. 63-67. In Russian.

A87-25259

INVESTIGATION OF EXTREME TEMPERATURE VALUES IN THE FREE ATMOSPHERE [OB ISSLEDOVANII EKSTREMAL'NYKH ZNACHENII TEMPERATURY V SVOBODNOI ATMOSFERE]

V. N. BARAKHTIN, N. V. SPITSINA, and N. I. ZIMAKOV IN: Problems in weather forecasting and aviation meteorology . Moscow, Gidrometeoizdat, 1985, p. 68-75. In Russian. refs

The paper presents results of a statistical analysis of extreme deviations of temperature from mean values in the free atmosphere on the basis of daily aerological and synoptic data. The repeatability of extreme values of this parameter is calculated for four points of the Moscow-Irkutsk flight path. A pattern recognition method is used to choose useful features for the prediction of significant semidiurnal temperature fluctuations in the upper troposphere and lower stratosphere. The results are of interest in connection with weather forecasting for purposes of aviation. B.J.

A87-25260

STATISTICAL ANALYSIS OF EXTREME VERTICAL TEMPERATURE GRADIENTS IN THE 6-20 KM LAYER OVER THE MOSCOW-IRKUTSK FLIGHT PATH [STATISTICHESKII ANALIZ EKSTREMAL'NYKH VERTIKAL'NYKH GRADIENTOV TEMPERATURY V SLOE 6-20 KM NA TRASSE MOSKVA-IRKUTSK]

V. N. BARAKHTIN and N. I. ZIMAKOV IN: Problems in weather forecasting and aviation meteorology . Moscow, Gidrometeoizdat, 1985, p. 75-80. In Russian. refs

A87-25261

CHARACTERISTICS OF THE VERTICAL WIND AND TEMPERATURE PROFILE IN THE BOUNDARY LAYER IN THE CASE OF STRONG GROUND WINDS NEAR URAL AND SIBERIAN AIRPORTS [KHARAKTERISTIKI VERTIKAL'NOGO PROFILIA VETRA I TEMPERATURY V POGRANICHNOM SLOE PRI SIL'NYKH VETRAKH U ZEMLI V RAIONAKH AEROPORTOV URALA I SIBIRI]

E. A. MOROZOVA IN: Problems in weather forecasting and aviation meteorology . Moscow, Gidrometeoizdat, 1985, p. 80-84. In Russian.

A87-25262

SPACE-TIME CHARACTERISTICS OF VERTICAL WIND SHEARS ABOVE CERTAIN AIRPORTS OF THE URAL-SIBERIAN REGION [PROSTRANSTVENNO-VREMENNYE KHARAKTERISTIKI VERTIKAL'NYKH SDVIGOV VETRA NAD NEKOTORYMI AEROPORTAMI URALO-SIBIRSKOGO REGIONA]

T. V. DAVIDOVICH IN: Problems in weather forecasting and aviation meteorology . Moscow, Gidrometeoizdat, 1985, p. 84-94. In Russian. refs

A87-25263

REGRESSION METHOD FOR PREDICTING WIND VELOCITY AND DIRECTION AT CIRCUIT ALTITUDE AT ENISEISK AIRPORT [REGRESSIONNYI METOD PROGNOZA SKOROSTI I NAPRAVLENIIA VETRA NA VYSOTE KRUGA V AEROPORTU ENISEISK]

L. I. GANTSEVICH IN: Problems in weather forecasting and aviation meteorology . Moscow, Gidrometeoizdat, 1985, p. 104-109. In Russian.

A87-25548#

STORM STRUCTURE DURING AIRCRAFT LIGHTNING STRIKE EVENTS

ALAN R. BOHNE and ALBERT C. CHMELA (USAF, Geophysics Laboratory, Bedford, MA) Journal of Geophysical Research (ISSN 0148-0227), vol. 91, Nov. 20, 1986, p. 13291-13298. refs

A small set of in situ aircraft and ground-based radar data acquired during the 1981 and 1982 Joint Agency Turbulence Experiment is used to study the relationship of aircraft lightning strikes to storm precipitation, turbulence severity, and wind shear. The strikes were found to be strongly correlated with vertical drafts, predominantly downdrafts. Strikes were also well correlated with regions of strong turbulence. However, since most strong turbulence episodes encountered by the aircraft were not associated with lightning, use of lightning location methods to map hazardous turbulence within storms is considered unreliable. The strikes occurred in storm regions having a radar reflectivity factor between 25 and 35 dBZ (dBZ represents 10 log Z, where Z is the reflectivity factor). These regions were generally on the boundaries of the dominant storm precipitation cores. Storm wind shear was frequently high in regions near aircraft strikes. Author

A87-25994

THE MATHEMATICS OF INTERACTION BETWEEN A LIGHTNING ROD ON EARTH AND A STEP LEADER DUE TO LIGHTNING

ABUL RASHID IN: Aerospace Applications Conference, Steamboat Springs, CO, Feb. 1-8, 1986, Digest . New York, Institute of Electrical and Electronics Engineers, Inc., 1986, 17 p. refs

Starting from the work of Sommerfeld, mathematical formulas for the electromagnetic fields produced by step leader charges due to lightning are developed. It is shown that these fields have directive properties and that due to the relativistic effects, the maximum field occurs in the direction at which the step leader is moving. These electromagnetic properties of the step leader are combined with the amplification factor of a lightning rod to determine a striking distance which depends upon the direction of motion of the step leader, the amplification factor of a lightning rod and the air breakdown field intensity at the lightning rod. Author

A87-27108

REALIZATION OF AN AIRPORT NOISE MONITORING SYSTEM FOR DETERMINING THE TRAFFIC FLOW IN THE SURROUNDINGS OF A MILITARY AIRBASE

G. BEKEBREDE (Nationaal Lucht- en Ruimtevaartlaboratorium, Amsterdam, Netherlands) IN: Inter-noise 86 - Progress in noise control; Proceedings of the International Conference on Noise Control Engineering, Cambridge, MA, July 21-23, 1986. Volume 1 . Poughkeepsie, NY, Noise Control Foundation, 1986, p. 711-716.

A permanent outdoor noise monitoring system was realized by the Netherlands National Aerospace Laboratory in the vicinity of the Brueggen military airbase. The system was designed to determine the traffic flow per flight route over Dutch territory. Attention is given to the research preceding the realization, the realization itself, and the operational experience. It is noted that a feasibility study preceding the installation of such a noise monitoring system is highly useful. K.K.

A87-27111
AIRPORT NOISE POLLUTION AND ADVERSE HEALTH EFFECTS
S. R. LANE IN: Inter-noise 86 - Progress in noise control; Proceedings of the International Conference on Noise Control Engineering, Cambridge, MA, July 21-23, 1986. Volume 2 . Poughkeepsie, NY, Noise Control Foundation, 1986, p. 799-804. refs

Evidence of adverse health effects attributed to airport noise exposure is presented. Generally, the symptoms identified with airport noise range from anxiety and chronic nervousness to depression and debilitation, leading often to an increased use of prescription and nonprescription drugs, to deterioration in health and to premature death in elderly persons. In a study for the Los Angeles International Airport for the year of 1972, significant increments of nervous breakdowns, birth defects (teratism), and mortality rates due to the noise-induced stress were found. It is estimated that, unless immediate noise-mitigating actions are taken, 100,000 mental cases, 6500 birth defects, and 20,000 deaths due to aircraft noise are to be expected between now and the year 2000. I.S.

A87-27112
A CITIZEN ACOUSTICIAN'S OBSERVATIONS OF AIRCRAFT NOISE
NANCY SPINKA TIMMERMAN IN: Inter-noise 86 - Progress in noise control; Proceedings of the International Conference on Noise Control Engineering, Cambridge, MA, July 21-23, 1986. Volume 2 . Poughkeepsie, NY, Noise Control Foundation, 1986, p. 925-930.

Observations on the impact of aircraft noise on one family living for 10 years in the vicinity (about 2.5 miles) of an international airport are presented. The subjective assessments of speech and sleep interferences and annoyance caused by overflying aircraft during various times of a year, times of a day, and types of weather with respect to other typical background noises (cars, trains, children, etc.) are compared with standard methods of assessing aircraft noise, such as EPNL, L(eq), L(dn), and NEF. It is argued that the noise descriptors currently in use around airports do not fully describe the actual impact. The nonuniformities in the aircraft noise impact caused by local weather conditions, the time of the day, and nonuniform urban residential ambients are not accounted for by the equivalent energy descriptors, which average the impact over the entire year. I.S.

A87-27113
HOW TO LIMIT THE RESIDENTIAL AREA AFFECTED BY AIRCRAFT NOISE AROUND AN AIRPORT
THOMAS J. MEYER IN: Inter-noise 86 - Progress in noise control; Proceedings of the International Conference on Noise Control Engineering, Cambridge, MA, July 21-23, 1986. Volume 2 . Poughkeepsie, NY, Noise Control Foundation, 1986, p. 931-934.

Various factors which must be taken into consideration in land use planning around airport areas and the possible means of restricting the residential area affected by the aircraft noise are examined. The aircraft are classified according to the levels of their noise emission, and it is concluded, on the basis of the aircraft mix nowadays used at airports, that for airports with not more than 800 aircraft movements, an ECNL of more than 55 dB(A) need not occur outside an area of 15 km radius around the airport. The paper demonstrates the degree to which it is possible to influence the extension of residential areas affected by aircraft noise above an ECNL considered to be essential for land use planning. I.S.

A87-27114
AN INTERNATIONAL STUDY OF THE INFLUENCE OF RESIDUAL NOISE ON COMMUNITY DISTURBANCE DUE TO AIRCRAFT NOISE
I. D. DIAMOND and J. G. WALKER (Southampton, University, England) IN: Inter-noise 86 - Progress in noise control; Proceedings of the International Conference on Noise Control Engineering, Cambridge, MA, July 21-23, 1986. Volume 2 Poughkeepsie, NY, Noise Control Foundation, 1986, p. 941-946.

An international method for estimating aircraft noise was developed on the basis of concurrent noise measurements and social surveys carried out at the Paris-Orly, Amsterdam-Schipol, and Glasgow Airports. One of the aims of the study was to identify the influence of noise other than aircraft (residual noise) on the community disturbance from the aircraft noise. Thus, within each of the identified aircraft-noise areas two residual noise zones were identified, one with high levels of residual noise and the other with low. The questionnaires included questions designed to assess the levels of annoyance and of the activity disturbance. The results indicate that annoyance from aircraft increases steadily with increases in aircraft noise, but that the level of the annoyance due to residual noise does not influence the levels of annoyance with the aircraft noise and vice versa. With regard to annoyance from all noise, the best noise index was the total index ('LEQ') which averages both aircraft and residual noise. I.S.

A87-27115
THE NEED FOR A REPRESENTATIVE INTERNATIONAL NOISE STANDARD
RICHARD A. DEEDS (Air Line Pilots Association, San Jose, CA) IN: Inter-noise 86 - Progress in noise control; Proceedings of the International Conference on Noise Control Engineering, Cambridge, MA, July 21-23, 1986. Volume 2 . Poughkeepsie, NY, Noise Control Foundation, 1986, p. 959-964. refs

The Aviation Safety and Noise Act passed in 1979 has called for the establishment of uniform systems of measuring noise and for the determination of the exposure of individuals, but did not allow the mandatory imposition of the projected standards on the airport operators or states. As a result, the advisory standards of the Federal Air Regulation Part 150 developed by the U.S. Department of Transportation are not followed, and the nonuniform local noise metrics and standards imposed by various airports and states have often pressured air carriers and the FAA to fly marginally safe noise abatement procedures. The establishment of a single standard throughout the United States that will serve as a guidepost for the national airports and the entire aviation industry is strongly recommended. It is argued that having a single standard would force the courts to use that standard as a method in determining liabilities and ultimately would establish a stable foundation from which all procedures would be judged. I.S.

A87-27116
JACKSON HOLE AIRPORT - A CASE STUDY OF DUAL NOISE METRICS IN THE AIRPORT NOISE CONTROL PLAN
PAUL DUNHOLTER (Mestre Greve Associates, Newport Beach, CA) IN: Inter-noise 86 - Progress in noise control; Proceedings of the International Conference on Noise Control Engineering, Cambridge, MA, July 21-23, 1986. Volume 2 . Poughkeepsie, NY, Noise Control Foundation, 1986, p. 969-972.

The noise problems at the Jackson Hole Airport, located within a National Park, have been located in areas that, based upon the LDN criterion alone, would not be expected to have a severe noise problem. The development of an Airport Access Plan and Noise Control Plan that place limits on noise levels in terms of both LDN and single event noise levels is described. The elements of the Airport Access Plan include placing a single event noise limit for both commercial and general aviation aircraft, placing a cap on the total number of high-noise operations, and an incentive program to encourage use of quieter aircraft. In the two years in which the Noise Control Plan has been in place, the aircraft LDN noise levels have reduced by 1 to 2 decibels, and the total number of single event disturbances has been reduced, while the total number of passengers at the airport has increased. I.S.

A87-27117
LDN DICTATES LOCAL OPTIONS - WHY?
TOMAS E. FIRLE (Port of San Diego, CA) IN: Inter-noise 86 - Progress in noise control; Proceedings of the International Conference on Noise Control Engineering, Cambridge, MA, July 21-23, 1986. Volume 2 . Poughkeepsie, NY, Noise Control Foundation, 1986, p. 973-978.

It is argued that the single noise descriptor, Ldn, is not only inadequate to give a realistic picture of the impact of the aircraft noise but biases local noise abatement options. It can lead to abatement programs which may be quite irrelevant to the diverse groups of people affected by aircraft operations; as a result, reduction of the 'impact area' can be achieved while the airport neighbors may actually experience considerably more disruptions or at more sensitive times than before. It is shown that noise reduction programs based on the Ldn criterion ignore the geographical and time zone location of airports, do not take into consideration the large variation in the time distibution of nighttime flights at different airports, the aircraft fleet mix, and the changes in the environment, and are inadequate for the assessment of the annoyance factor. I.S.

N87-17106# Joint Publications Research Service, Arlington, Va.
DEVELOPMENT OF NEW AVIATION TECHNOLOGY FOR GRAVIMETRIC SURVEYING Abstract Only
K. YE. BESYELOV, P. D. BAGDATLISHVILI, and V. O. BAGRAMYANTS *In its* USSR Report: Earth Sciences (JPRS-UES-86-005) p 38-39 7 May 1986 Transl. into ENGLISH from Ekspress Informatsiya: Morskaya Geologiya i Geofizika (Moscow, USSR), no. 11, 1985 p 1-5
Avail: NTIS HC A05/MF A01

In a standard cardan mounting, a gravimetric instrument requires 4 to 6 minutes to settle before measurements can be performed. This makes gravimetric surveying from helicopters quite difficult and reduces the accuracy of the surveys. A restraining device has been suggested for use with the new technology of airborne gravimetric surveying to fix the instrument in position and protect it from contact with the walls and to allow readings to be made 15 to 20 seconds after the restraining system is released. Tests have shown the success of this instrument when used in combination with a winch, which is necessary to create safer conditions for application of the new technology. When the winch is used, the time required to place the gravimetric instrument on the ground is reduced, the amplitude of rocking of the instrument as the observation point is approached through the air is greatly reduced and the quality of observations is improved, since they can be made at heights greater than 30 meters. When observations are made over the shelf, a float on a 2- to 3-meter cable some 15 to 17 meters from the gravimeter can be used as a reference point and the helicopter can be placed in a position such that the float is within view of the pilot, making it easier to maintain the helicopter hovering above the observation point. Author

N87-17271# National Severe Storms Lab., Norman, Okla.
APPLICATION OF DOPPLER RADAR AND LIDAR TO DIAGNOSE ATMOSPHERIC PHENOMENA
R. J. DOVIAK, M. EILTS, V. MAZUR, M. SACHIDANANDA, and D. S. ZRNIC *In* ESA Proceedings of the 1986 International Geoscience and Remote Sensing Symposium (IGARSS '86) on Remote Sensing: Today's Solutions for Tomorrow's Information Needs, Volume 1 p 661-666 Aug. 1986
Avail: NTIS HC A99/MF E03; ESA, Paris, France, 3 volume set $90 Member States, AU, CN, and NO (+20% others)

Observations and comparison of measurements of wind, waves, and turbulence, made with Doppler radar, lidar, and in-situ sensors, are presented. Applications to the detection of weather hazards to safe flight are discussed. A method to estimate rainfall with a polarization diversity Doppler radar is shown to be less sensitive to drop size distribution variations than commonly used Z-R relations. The Doppler radar is also used to observe characteristics of lightning produced plasma channels which exhibit vertical accelerations caused by buoyancy acting on the hot plasma and interaction with Earth's magnetic field. ESA

N87-17378# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Oberpfaffenhofen (West Germany).
DFVLR FLIGHT OPERATION ACTING AS A USEFUL SERVICE UNIT FOR ERS-1
HEINZ FINKENZELLER *In* ESA Proceedings of an ESA Workshop on ERS-1 Wind and Wave Calibration p 99-100 Sep. 1986
Avail: NTIS HC A11/MF A01

Preparation for ERS-1 scatterometer campaigns on Dornier 228.101 aircraft are summarized. Flight tests of payloads and the flexibility of the aircraft are described. ESA

N87-17422# Instituto Nacional de Tecnica Aeroespacial, Madrid (Spain). Dept. de Estructuras y Materiales Estructurales.
GROUND VIBRATION TESTS [ENSAYO DE VIBRACION EN TIERRA]
RAFAEL GONZALO UGARTEL 1986 13 p In SPANISH; ENGLISH summary
(ETN-87-98847) Avail: NTIS HC A02/MF A01

Ground vibration tests are used to improve and to ratify the dynamic model of aircraft prototypes. The goal is to verify the absence of flutter. The basic dynamic equations and the basis of the semiautomatic procedure developed to isolate resonance modes and to determine all modal parameters are shown. All necessary equipment and their layouts are exposed. The tests performed on the Attas aircraft are commented upon. ESA

N87-18278*# Electro Magnetic Applications, Inc., Denver, Colo.
LINEAR AND NONLINEAR INTERPRETATION OF THE DIRECT STRIKE LIGHTNING RESPONSE OF THE NASA F106B THUNDERSTORM RESEARCH AIRCRAFT Final Report
T. H. RUDOLPH and R. A. PERALA Washington NASA Dec. 1983 165 p
(Contract NAS1-16984)
(NASA-CR-3746; NAS 1.26:3746; EMA-83-R-21) Avail: NTIS HC A08/MF A01 CSCL 04B

The objective of the work reported here is to develop a methodology by which electromagnetic measurements of inflight lightning strike data can be understood and extended to other aircraft. A linear and time invariant approach based on a combination of Fourier transform and three dimensional finite difference techniques is demonstrated. This approach can obtain the lightning channel current in the absence of the aircraft for given channel characteristic impedance and resistive loading. The model is applied to several measurements from the NASA F106B lightning research program. A non-linear three dimensional finite difference code has also been developed to study the response of the F106B to a lightning leader attachment. This model includes three species air chemistry and fluid continuity equations and can incorporate an experimentally based streamer formulation. Calculated responses are presented for various attachment locations and leader parameters. The results are compared qualitatively with measured inflight data. Author

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MATHEMATICAL AND COMPUTER SCIENCES

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

A87-23991*# Toledo Univ., Ohio.
AIRCRAFT CONTROL DESIGN USING IMPROVED TIME-DOMAIN STABILITY ROBUSTNESS BOUNDS
R. K. YEDAVALLI (Toledo, University, OH) and Z. LIANG (Stevens Institute of Technology, Hoboken, NJ) (Guidance, Navigation and Control Conference, Snowmass, CO, Aug. 19-21, 1985, Technical Papers, p. 467-472) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 9, Nov.-Dec. 1986, p. 710-714. Previously cited in issue 22, p. 3319, Accession no. A85-45927. refs
(Contract F33615-84-K-3606; NAG1-578)

A87-24852
DIRECT MODEL REFERENCE ADAPTIVE CONTROL FOR A CLASS OF MIMO SYSTEMS
KENNETH M. SOBEL (Lockheed-California Co., Burbank) and HOWARD KAUFMAN (Rensselaer Polytechnic Institute, Troy, NY) IN: Control and dynamic systems: Decentralized/distributed control and dynamic systems. Part 3 . Orlando, FL, Academic Press, Inc., 1986, p. 245-314. refs

Model reference adaptive control algorithms are presented for MIMO systems which do not necessarily satisfy the perfect model-following conditions; these algorithms also obviate an explicit on-line identifier or full state feedback. The asymptotic stability of the first of the two adaptive algorithms for continuous systems given is ensured through a strictly positive real stabilized plant transfer matrix; in the second, bounded error stability is ensured by a certain, and again strictly positive real, auxiliary transfer matrix. Attention is given to the importance of the continuous positive real lemmas in the stability proofs of the adaptive algorithms. O.C.

A87-24947*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
APPLICATIONS OF COLOR GRAPHICS TO COMPLEX AERODYNAMIC ANALYSIS
ROBERT P. WESTON (NASA, Langley Research Center, Hampton, VA) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 7 p.
(AIAA PAPER 87-0273)

A variety of uses for color graphics in the display of large sets of complex aerodynamic data in two and three dimensions are summarized. These methods improve the ability of a scientific researcher to interactively review three-dimensional displays of aircraft panel geometries for the purposes of eliminating errors, and allow him to rapidly display an assortment of smooth-shaded, color-coded illustrations for his experimental and computational results. Author

A87-26094
ARTIFICIAL INTELLIGENCE AND SIMULATION
WILLARD M. HOLMES, ED. San Diego, CA, Society for Computer Simulation, 1985, 81 p. For individual items see A87-26095 to A87-26097.

The research and development of AI are discussed. Papers are presented on an expert system for chemical process control, an ocean surveillance information fusion expert system, a distributed intelligence system and aircraft pilotage, a procedure for speeding innovation by transferring scientific knowledge more quickly, and syntax programming, expert systems, and real-time fault diagnosis. Consideration is given to an expert system for modeling NASA flight control room usage, simulating aphasia, a method for single neuron recognition of letters, numbers, faces, and certain types of concepts, integrating AI and control system approach, testing an expert system for manufacturing, and the human memory. I.F.

A87-26096
THE DISTRIBUTED INTELLIGENCE SYSTEM AND AIRCRAFT PILOTAGE
LEIGHTON L. SMITH (Central Florida, University, Orlando, FL) IN: Artificial intelligence and simulation . San Diego, CA, Society for Computer Simulation, 1985, p. 26-28. refs

The application of a distributed intelligence system to aircraft pilotage is examined. A distributed intelligence system is a complex man-machine system in which an artificial intelligent operating component (AIOC) operates the system and a person manages the system. The need for a symbiotic and synergistic relationship between the AIOC and the person is discussed. It is suggested that further research in the areas of man-machine communications, man-machine compatibility, and physiological and psychological relationships between people and machines is required. I.F.

A87-27534
COMMISSIONING OF THE 'AERONAUTIQUE' COMPUTER AT ONERA
C. LECOMTE (ONERA, Chatillon-sous-Bagneux, France) La Recherche Aerospatiale (ISSN 0379-380X), no. 6, 1985, p. 65-67.

A 3 yr lease on a Cray-1S2000 vector computer was signed in 1983 by an association of comprising ONERA and aerospace manufacturers. One of two such machines leased at the time for French researchers, the 'Aeronautique' Cray is used for proprietary or classified work. The machine has 2 Mbyte RAM, a disk capacity of 6 Gbits, and can directly access a Cyber 855 at a data rate of 6 Mbps. Industrial partners have remote access to the computer over a coaxial cable. Techniques being applied to enhance and secure data transfer rates and security of the data for the remote users are summarized. M.S.K.

N87-18329*# Kansas Univ. Center for Research, Inc., Lawrence. Flight Research Lab.
VORSTAB: A COMPUTER PROGRAM FOR CALCULATING LATERAL-DIRECTIONAL STABILITY DERIVATIVES WITH VORTEX FLOW EFFECT
C. EDWARD LAN Jan. 1985 260 p
(Contract NAG1-134)
(NASA-CR-172501; NAS 1.26:172501; CRINC-FRL-516-2) Avail: NTIS HC A12/MF A01 CSCL 09B

A computer program based on the Quasi-Vortex-Lattice Method of Lan is presented for calculating longitudinal and lateral-directional aerodynamic characteristics of nonplanar wing-body combination. The method is based on the assumption of inviscid subsonic flow. Both attached and vortex-separated flows are treated. For the vortex-separated flow, the calculation is based on the method of suction analogy. The effect of vortex breakdown is accounted for by an empirical method. A summary of the theoretical method, program capabilities, input format, output variables and program job control set-up are described. Three test cases are presented as guides for potential users of the code. Author

N87-18337# Aeronautical Research Labs., Melbourne (Australia).
A FLIGHT DYNAMIC SIMULATION PROGRAM IN AIR-PATH AXES USING ACSL (ADVANCED CONTINUOUS SIMULATION LANGUAGE)
P. W. GIBBENS Jun. 1986 101 p
(AD-A173849; ARL-AERO-TM-380) Avail: NTIS HC A06/MF A01 CSCL 12A

The six degrees of freedom dynamic equations of motion have been programmed in the Advanced Continuous Simulation Language (ACSL) for use in aircraft simulations at ARL. Air-path axes were chosen for the integration of the force equations, and body axes for the integration of the moment equations. The use of quaternions for the determination of the direction cosines has been described. GRA

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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.

A87-24978*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
HIGH-SPEED PROPELLER NOISE PREDICTIONS - EFFECTS OF BOUNDARY CONDITIONS USED IN BLADE LOADING CALCULATIONS
M. NALLASAMY (NASA, Lewis Research Center; Sverdrup Technology, Inc., Cleveland, OH), B. J. CLARK, and J. F. GROENEWEG (NASA, Lewis Research Center, Cleveland, OH) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 25 p. Previously announced in STAR as N87-14957. refs
(AIAA PAPER 87-0525)

The acoustics of an advanced single rotation SR-3 propeller at cruise conditions are studied employing a time-domain approach. The study evaluates the acoustic significance of the differences in blade pressures computed using nonreflecting rather than hard wall boundary conditions in the three-dimensional Euler code solution. The directivities of the harmonics of the blade passing frequency tone and the effects of chordwise loading on tone directivity are examined. The results show that the maximum difference in the computed sound pressure levels due to the use of blade pressure distributions obtained with the nonreflecting rather than the hard wall boundary conditions is about 1.5 dB. The blade passing frequency tone directivity obtained in the present study shows good agreement with jetstar flight data. Author

A87-25316*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
AN EULER CODE CALCULATION OF BLADE-VORTEX INTERACTION NOISE
J. C. HARDIN (NASA, Langley Research Center, Hampton, VA) and S. L. LAMKIN (PRC Kentron, Inc., Hampton, VA) ASME, Transactions, Journal of Vibration, Acoustics, Stress, and Reliability in Design (ISSN 0739-3717), vol. 109, Jan. 1987, p. 29-36. refs
(ASME PAPER 86-WA/NCA-3)

An Euler code has been developed for calculation of noise radiation due to the interaction of a distributed vortex with a Joukowski airfoil. THe time-dependent incompressible flow field is first determined and then integrated to yield the resulting sound production through use of the elegant low-frequency Green's function approach. This code has several interesting numerical features involved in the vortex motion and in continuous satisfaction of the Kutta condition. In addition, it removes the limitations on Reynolds number and is much more efficient than an earlier Navier-Stokes code. Results indicate that the noise production is due to the deceleration and subsequent acceleration of the vortex as it approaches and passes the airfoil. Predicted acoustic levels and frequencies agree with measured data although a precise comparison would require the strength, size, and position of the incoming vortex to be known. Author

A87-25844#
INTERNAL ACOUTICS IN TURBOMACHINERY
R. LEGENDRE La Recherche Aerospatiale (English Edition) (ISSN 0379-380X), no. 3, 1986, p. 75-79.

A turbomachine is a mechanism with variable geometry, precluding steady flow. But all unsteady flows generate acoustic waves in a turbomachine which may couple with blade vibrations. Fortunately, the natural frequencies of acoustic waves are generally very far from the natural frequencies of the blades. However, the experimental study of internal acoustics is still of use. Author

A87-25849
RESEARCH CONTINUES ON SODAR WIND-SHEAR DETECTION
ALAIN DONZIER and JEAN-MICHEL FAGE (Remtech, S.A., Velizy-Villacoublay, France) ICAO Bulletin, vol. 41, Oct. 1986, p. 29-31.

The use of sodars for wind shear detection is studied. Sodars have been employed to the measure wind shear during heavy rain; Doppler sodar measurements are compared to aircraft measurements, and good agreement is observed. The advantages of sodar wind shear detection systems are discussed. The design of a megasodar which will be able to obtain wind speed and direction measurements along the glide path is described. The megasodar is a cellular structure with a single fixed antenna and provides three-dimensional measurements. The feasibility of megasodars is assessed for various frequencies, and it is reported that the megasodars are capable of providing accurate wind data. I.F.

A87-26332
VIBRATIONS OF A CYLINDRICAL PANEL IN A TURBULENT PRESSURE PULSATION FIELD [KOLEBANIIA TSILINDRICHESKOI PANELI V POLE TURBULENTNYKH PUL'SATSII DAVLENIIA]
B. M. EFIMTSOV Akusticheskii Zhurnal (ISSN 0320-7919), vol. 32, July-Aug. 1986, p. 536-538. In Russian. refs

Experimental data are presented on the vibrations of a cylindrical panel of small curvature located at the surface of an aircraft in a zone where its vibrations are determined by the effect of the pressure pulsations of a turbulent boundary layer. An expression is obtained which provides an accurate description of the effect of the spatial-temporal structure of the field of the wall pressure pulsations of the turbulent boundary layer on the induced vibrations of thin plates and shells. This expression makes it possible to determine, with a high level of confidence, the vibrations of thin-walled structures in a turbulent boundary layer for arbitrary Mach numbers (at least, for Mach 1.61 or less) if they are known for any other (e.g., low) Mach number. V.L.

A87-27101
INTER-NOISE 86 - PROGRESS IN NOISE CONTROL; PROCEEDINGS OF THE INTERNATIONAL CONFERENCE ON NOISE CONTROL ENGINEERING, CAMBRIDGE, MA, JULY 21-23, 1986. VOLUMES 1 & 2
ROBERT LOTZ, ED. (Digital Equipment Corp., Maynard, MA) Conference organized by the Institute of Noise Control Engineering of the U.S.A. and MIT; Sponsored by the International Institute of Noise Control Engineering. Poughkeepsie, NY, Noise Control Foundation, 1986. Vol. 1, 878 p.; vol. 2, 744 p. For individual items see A87-27102 to A87-27121.

The conference presents papers on legislative structure and engineering manpower in noise abatement legislation in Australia, fluid borne noise generation and transmission in hydraulic piping systems, and the application of the Fast Field Program to outdoor sound propagation. Other topics include a prediction model for airport ground noise propagation, diffraction by a barrier with finite acoustic impedance, sound propagation over curved barriers, the damping capacity of graphite epoxy composites in a vacuum, the realization of an airport noise monitoring system for determining the traffic flow in the surroundings of a military airbase, and the prediction of aircraft noise around airports by a simulation procedure. Papers are also presented on the effects of weather conditions on airport noise prediction, a prediction of the light aircraft interior sound pressure level from the measured sound pressure flowing into the cabin, and measurements with reference sources in the ISO 3740 series. K.K.

A87-27103
APPLICATION OF THE FAST FIELD PROGRAM TO OUTDOOR SOUND PROPAGATION
RICHARD RASPET and RICHARD K. WOLF (U.S. Army, Construction Engineering Research Laboratory, Champaign, IL) IN: Inter-noise 86 - Progress in noise control; Proceedings of the International Conference on Noise Control Engineering, Cambridge, MA, July 21-23, 1986. Volume 1 . Poughkeepsie, NY, Noise Control Foundation, 1986, p. 419-424. refs

The application of the Fast Field Program to three types of sound propagation problems is described. Consideration is given to sound propagation for low flying aircraft, sound propagation for ground run ups, and infrasound and sound propagation from wind turbines. It is concluded that the Fast Field Program can produce useful estimates of sound level under varying atmospheric conditions. It is noted that turbulent scattering effects must be incorporated into the Fast Field program to produce accurate results in the shadow zone. K.K.

A87-27104
A PREDICTION MODEL FOR AIRPORT GROUND NOISE PROPAGATION
R. M. TAYLOR IN: Inter-noise 86 - Progress in noise control; Proceedings of the International Conference on Noise Control Engineering, Cambridge, MA, July 21-23, 1986. Volume 1 . Poughkeepsie, NY, Noise Control Foundation, 1986, p. 431-436. refs

A prediction model for airport ground noise propagation is developed. The fundamentals of noise propagation are discussed with attention given to geometric spreading, air absorption, diffraction over (and/or around) intervening obstructions, and the effect of the ground surface. Meteorological effects on sound propagation are also investigated. With regard to model validation, for a temperature inversion or positive wind gradient, results are obtained which are comparable to the noise levels measured at the considered airport under conditions of wind from source to receiver. K.K.

A87-27109
PREDICTION OF AIRCRAFT NOISE AROUND AIRPORTS BY A SIMULATION PROCEDURE
U. ISERMANN, K. MATSCHAT, and E.-A. MUELLER (Max-Planck-Institut fuer Stroemungsforschung, Goettingen, West Germany) IN: Inter-noise 86 - Progress in noise control; Proceedings of the International Conference on Noise Control Engineering, Cambridge, MA, July 21-23, 1986. Volume 1 . Poughkeepsie, NY, Noise Control Foundation, 1986, p. 717-722. refs

An aircraft noise simulation procedure is described in which the flight path of an aircraft is represented by a series of discrete points passed at constant time intervals. The airspeed, engine power, and spatial orientation of the aircraft together with the spectrum and directivity of the emitted sound are calculated for each point using an operational and acoustic data base. Ultimately, sound propagation laws are used to calculate the noise time history at a fixed location on the ground as well as the related single event noise level. It is found that the noise durations calculated by the simulation procedure are in agreement with measured data and with a theoretical relation obtained by a model study. It is also shown that the sound exposure in the vicinity of a 180-deg turn differs from that of a straight fly-by at the same distance by up to 1.5 dB. K.K.

A87-27110
EFFECTS OF WEATHER CONDITIONS ON AIRPORT NOISE PREDICTION
J. B. LARGE (Southampton, University, England) IN: Inter-noise 86 - Progress in noise control; Proceedings of the International Conference on Noise Control Engineering, Cambridge, MA, July 21-23, 1986. Volume 1 . Poughkeepsie, NY, Noise Control Foundation, 1986, p. 723-726.

The noise environment in communities adjacent to London's Heathrow Airport terminal was analyzed to establish how changes in meteorological conditions affect single event noise levels and noise exposure. Aircraft taxiing to and from the terminal area and the operation of auxiliary power units were taken to be the sources of the noise. Tables are provided which reveal the percentage of occasions on which meteorological conditions would cause actual noise levels to exceed or to be below predicted noise levels by about 10 dB. K.K.

A87-27118
AIRCRAFT NOISE DESCRIPTOR AND ITS APPLICATION
JUICHI IGARASHI (Kobayasi Institute of Physical Research, Kokubunji, Japan) IN: Inter-noise 86 - Progress in noise control; Proceedings of the International Conference on Noise Control Engineering, Cambridge, MA, July 21-23, 1986. Volume 2 . Poughkeepsie, NY, Noise Control Foundation, 1986, p. 985-988.

The methods and indices used in Japan to evaluate aircraft noise and the government-enforced countermeasures are discussed. The ECPNL descriptor was modified so as to make the new descriptor, WECPNL', approximately equivalent to Lden, and the noise contours were calculated for each airport in Japan. The government enforced the policy of land purchase within the WECPNL' of 85, and the houses within the value of 75 were declared as needing insulation. The noise descriptor Leq or Ldn has been used to describe human responses to various kinds of noises. However, a single value descriptor was found to have a limit of applicability, because the human response is not a linear function of a sound level. Another defect of the descriptor is a failure to represent the human response adequately for a small number of flights. It is noted that the house vibration caused by low-frequency components of aircraft noise cannot yet be evaluated. I.S.

A87-27119
A MOBILE AIRCRAFT FLYOVER NOISE DATA ACQUISITION AND ANALYSIS SYSTEM FOR THE CALCULATION OF REFERENCE NOISE METRICS
DAVID J. ROTH (Douglas Aircraft Co., Long Beach, CA) IN: Inter-noise 86 - Progress in noise control; Proceedings of the International Conference on Noise Control Engineering, Cambridge, MA, July 21-23, 1986. Volume 2 . Poughkeepsie, NY, Noise Control Foundation, 1986, p. 1009-1012.

A field data analysis system (FDAS) was constructed for data normalization and calculations of the certification noise metrics (such as effective perceived noise level) or airport monitor noise metrics (such as single event noise exposure level) for flyover noise certification of tested aircraft. The FDAS is a microcomputer system consisting of two processors used synchronously, an HP-9836 processor for data acquisition/analysis and another for graphics output. The FDAS hardware and software are described, and the flyover noise analysis functional flow diagram is discussed. The performance of the FDAS during flyover noise testing of commercial aircraft was excellent, and improved data acquisition/analysis schedules and cost savings were observed without degradation of data quality. I.S.

A87-27121
AN ALTERNATIVE INTENSITY TECHNIQUE FOR TRANSMISSION LOSS MEASUREMENTS OF LIGHT-WEIGHT STRUCTURES
MICHAEL BOCKHOFF (Centre Technique des Industries, Mecaniques, Senlis, France) IN: Inter-noise 86 - Progress in noise control; Proceedings of the International Conference on Noise Control Engineering, Cambridge, MA, July 21-23, 1986. Volume 2 . Poughkeepsie, NY, Noise Control Foundation, 1986, p. 1049-1052. CNES-supported research. refs

A novel intensity technique for transmission loss (TL) measurements is described where the TL is estimated by intensity measurements in front of (instead in back of) light-weight structures. Comparative measurements were carried out on a homogeneous Dural panel of 1.6 mm-thickness and a honeycomb structure of 25 mm-thickness. The structures were mounted in an opening between two small reverberant rooms, and an EDF reference source served for broad-band excitation. The intensity was measured at a distance of 10 cm on both sides of the structures; the space-averaged sound pressure in the source room was measured by a conventional sweeping technique. The results have shown that an approximation of the TL may be obtained by the measurements in front of the structure. However, reliable measurements, especially at high frequencies, need very carefully calibrated intensity meters; even then, the technique may be limited to structures with moderate transmission losses. I.S.

N87-17479*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
POWER CEPSTRUM TECHNIQUE WITH APPLICATION TO MODEL HELICOPTER ACOUSTIC DATA
R. M. MARTIN and C. L. BURLEY Washington Jun. 1986 68 p
(NASA-TP-2586; L-16070; NAS 1.60:2586) Avail: NTIS HC A04/MF A01 CSCL 20A

The application of the power cepstrum to measured helicopter-rotor acoustic data is investigated. A previously applied correction to the reconstructed spectrum is shown to be incorrect. For an exact echoed signal, the amplitude of the cepstrum echo spike at the delay time is linearly related to the echo relative amplitude in the time domain. If the measured spectrum is not entirely from the source signal, the cepstrum will not yield the desired echo characteristics and a cepstral aliasing may occur because of the effective sample rate in the frequency domain. The spectral analysis bandwidth must be less than one-half the echo ripple frequency or cepstral aliasing can occur. The power cepstrum editing technique is a useful tool for removing some of the contamination because of acoustic reflections from measured rotor acoustic spectra. The cepstrum editing yields an improved estimate of the free field spectrum, but the correction process is limited by the lack of accurate knowledge of the echo transfer function. An alternate procedure, which does not require cepstral editing, is proposed which allows the complete correction of a contaminated spectrum through use of both the transfer function and delay time of the echo process. Author

N87-17480*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
COMBUSTION NOISE FROM GAS TURBINE AIRCRAFT ENGINES MEASUREMENT OF FAR-FIELD LEVELS
EUGENE A. KREJSA 1987 8 p Proposed for presentation at the 1987 National Conference on Noise Control Engineering, University Park, Pa., 8-10 Jun. 1987
(NASA-TM-88971; E-3407; NAS 1.15:88971) Avail: NTIS HC A02/MF A01 CSCL 20A

Combustion noise can be a significant contributor to total aircraft noise. Measurement of combustion noise is made difficult by the fact that both jet noise and combustion noise exhibit broadband spectra and peak in the same frequency range. Since in-flight reduction of jet noise is greater than that of combustion noise, the latter can be a major contributor to the in-flight noise of an aircraft but will be less evident, and more difficult to measure, under static conditions. Several methods for measuring the far-field combustion noise of aircraft engines are discussed in this paper. These methods make it possible to measure combustion noise levels even in situations where other noise sources, such as jet noise, dominate. Measured far-field combustion noise levels for several turbofan engines are presented. These levels were obtained using a method referred to as three-signal coherence, requiring that fluctuating pressures be measured at two locations within the engine core in addition to the far-field noise measurement. Cross-spectra are used to separate the far-field combustion noise from far-field noise due to other sources. Spectra and directivities are presented. Comparisons with existing combustion noise predictions are made. Author

N87-17481*# General Electric Co., Cincinnati, Ohio. Aircraft Engine Business Group.
SIMULATED FLIGHT ACOUSTIC INVESTIGATION OF TREATED EJECTOR EFFECTIVENESS ON ADVANCED MECHANICAL SUPPRESORS FOR HIGH VELOCITY JET NOISE REDUCTION Final Contractor Report
J. F. BRAUSCH, R. E. MOTSINGER, and D. J. HOERST Washington NASA Nov. 1986 413 p
(Contract NAS3-23275)
(NASA-CR-4019; E-3134; NAS 1.26:4019; R85AEB518) Avail: NTIS HC A18/MF A01 CSCL 20A

Ten scale-model nozzles were tested in an anechoic free-jet facility to evaluate the acoustic characteristics of a mechanically suppressed inverted-velocity-profile coannular nozzle with an accoustically treated ejector system. The nozzle system used was developed from aerodynamic flow lines evolved in a previous contract, defined to incorporate the restraints imposed by the aerodynamic performance requirements of an Advanced Supersonic Technology/Variable Cycle Engine system through all its mission phases. Accoustic data of 188 test points were obtained, 87 under static and 101 under simulated flight conditions. The tests investigated variables of hardwall ejector application to a coannular nozzle with 20-chute outer annular suppressor, ejector axial positioning, treatment application to ejector and plug surfaces, and treatment design. Laser velocimeter, shadowgraph photograph, aerodynamic static pressure, and temperature measurement were acquired on select models to yield diagnositc information regarding the flow field and aerodynamic performance characteristics of the nozzles. Author

N87-17482*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
NOISE PROPAGATION FROM A FOUR-ENGINE, PROPELLER-DRIVEN AIRPLANE
WILLIAM L. WILLSHIRE, JR. Feb. 1987 41 p
(NASA-TM-89035; L-16179; NAS 1.15:89035) Avail: NTIS HC A03/MF A01 CSCL 20A

A flight experiment was conducted to investigate the propagation of periodic low-frequency noise from a propeller-driven airplane. The test airplane was a large four-engine, propeller-driven airplane flown at altitudes from 15 to 500 m over the end of an 1800-m-long, 22-element microphone array. The acoustic data were reduced by a one-third octave-band analysis. The primary propagation quantities computed were lateral attenuation and ground effects, both of which become significant at shallow elevation angles. Scatter in the measured results largely obscured the physics of the low-frequency noise propagation. Variability of the noise source, up to 9.5 dB over a 2-sec interval, was the major contributor to the data scatter. The microphones mounted at ground level produced more consistent results with less scatter than those mounted 1.2 m above ground. The ground noise levels were found to be greater on the port side than on the starboard side. Author

N87-17483*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
AIRCRAFT NOISE SYNTHESIS SYSTEM
DAVID A. MCCURDY and ROBERT E. GRANDLE Feb. 1987 43 p
(NASA-TM-89040; L-16140; NAS 1.15:89040) Avail: NTIS HC A03/MF A01 CSCL 20A

A second-generation Aircraft Noise Synthesis System has been developed to provide test stimuli for studies of community annoyance to aircraft flyover noise. The computer-based system generates realistic, time-varying, audio simulations of aircraft flyover noise at a specified observer location on the ground. The synthesis takes into account the time-varying aircraft position relative to the observer; specified reference spectra consisting of broadband, narrowband, and pure-tone components; directivity patterns; Doppler shift; atmospheric effects; and ground effects. These parameters can be specified and controlled in such a way as to generate stimuli in which certain noise characteristics, such as duration or tonal content, are independently varied, while the remaining characteristics, such as broadband content, are held constant. The system can also generate simulations of the predicted noise characteristics of future aircraft. A description of the synthesis system and a discussion of the algorithms and methods used to generate the simulations are provided. An appendix describing the input data and providing user instructions is also included. Author

N87-18399*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
CORRELATION OF HELICOPTER IMPULSIVE NOISE FROM BLADE-VORTEX INTERACTION WITH ROTOR MEAN INFLOW
ANDREW B. CONNOR and R. M. MARTIN Mar. 1987 23 p
(NASA-TP-2650; L-16145; NAS 1.60:2650) Avail: NTIS HC A02/MF A01 CSCL 20A

Data from a test made in the Langley 4 x 7 Meter Tunnel were parametrically studied with respect to the occurrence of blade-vortex interaction (BVI) as a function of tunnel speed and rotor angle of attack. Three microphones on the tunnel centerline forward of the model and one microphone forward and 45 degrees to the right provided the data. The rotor model was tested with a set of high-twist blades (-10 degrees) and a set of low-twist blades (-5 degrees) over the midspeed range (50 to 80 knots) at angles of attack ranging from -6 degrees (shallow climb) to 10 degrees (steep descent). The data from all four microphones indicated that the most probable time of occurrence of BVI is when the rotor descent is approximately equal to the rotor mean inflow velocity. However, some of the data showed no conclusive relationship to the mean inflow velocity. Author

N87-18401*# Bolt, Beranek, and Newman, Inc., Cambridge, Mass.
METHODS FOR DESIGNING TREATMENTS TO REDUCE INTERIOR NOISE OF PREDOMINANT SOURCES AND PATHS IN A SINGLE ENGINE LIGHT AIRCRAFT Final Report
RICHARD E. HAYDEN, PAUL J. REMINGTON, MARK A. THEOBALD, and JOHN F. WILBY Mar. 1985 312 p
(Contract NAS1-16138)
(NASA-CR-172546; NAS 1.26:172546; BBN-5422) Avail: NTIS HC A14/MF A01 CSCL 20A

The sources and paths by which noise enters the cabin of a small single engine aircraft were determined through a combination of flight and laboratory tests. The primary sources of noise were found to be airborne noise from the propeller and engine casing, airborne noise from the engine exhaust, structureborne noise from the engine/propeller combination and noise associated with air flow over the fuselage. For the propeller, the primary airborne paths were through the firewall, windshield and roof. For the engine, the most important airborne path was through the firewall. Exhaust noise was found to enter the cabin primarily through the panels in the vicinity of the exhaust outlet although exhaust noise entering the cabin through the firewall is a distinct possibility. A number of noise control techniques were tried, including firewall stiffening to reduce engine and propeller airborne noise, to stage isolators and engine mounting spider stiffening to reduce structure-borne noise, and wheel well covers to reduce air flow noise. Author

N87-18402*# Bolt, Beranek, and Newman, Inc., Canoga Park, Calif.
PROPELLER AIRCRAFT INTERIOR NOISE MODEL: USER'S MANUAL FOR COMPUTER PROGRAM Final Report
E. G. WILBY and L. D. POPE Jan. 1985 59 p
(Contract NAS1-15782)
(NASA-CR-172425; NAS 1.26:172425; REPT-5058) Avail: NTIS HC A04/MF A01 CSCL 20A

A computer program entitled PAIN (Propeller Aircraft Interior Noise) has been developed to permit calculation of the sound levels in the cabin of a propeller-driven airplane. The fuselage is modeled as a cylinder with a structurally integral floor, the cabin sidewall and floor being stiffened by ring frames, stringers and floor beams of arbitrary configurations. The cabin interior is covered with acoustic treatment and trim. The propeller noise consists of a series of tones at harmonics of the blade passage frequency. Input data required by the program include the mechanical and acoustical properties of the fuselage structure and sidewall trim. Also, the precise propeller noise signature must be defined on a grid that lies in the fuselage skin. The propeller data are generated with a propeller noise prediction program such as the NASA Langley ANOPP program. The program PAIN permits the calculation of the space-average interior sound levels for the first ten harmonics of a propeller rotating alongside the fuselage. User instructions for PAIN are given in the report. Development of the analytical model is presented in NASA CR 3813. Author

N87-18517# *Office National d'Etudes et de Recherches Aerospatiales, Paris (France).*
PROPELLER PSEUDONOISE
R. LEGENDRE *In its* La Recherche Aerospatiale, Bimonthly Bulletin, Number 1985-6, 229/November-December 1985 p 73-76 Jul. 1986
Avail: NTIS HC A04/MF A01; HC available at ONERA, Paris, France FF 75; original report available at ONERA, Paris, France, FF 75

A more accurate method is proposed for calculating displacement pseudonoise. Steadiness of flow prevents sound emission, which can only occur due to flaws in the steady state. It is not superfluous to compute displacement pseudonoise, but only for the purpose of subtracting it from noise measured in the near field which is moreover altered by many other causes. B.G.

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SOCIAL SCIENCES

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

A87-25926
PROPELLER AIRCRAFT NOISE LEGISLATION - A COMPREHENSIVE REVIEW
HANNO H. HELLER (DFVLR, Brunswick, West Germany) Progress in Aerospace Sciences (ISSN 0376-0421), vol. 23, no. 4, 1986, p. 239-342. refs

The history of the development of propeller aircraft noise certification by the ICAO is reviewed, and the pertinent document, 'ANNEX 16', which contains current 'Standards and Recommended Practices' for the noise certification of propeller-driven aircraft (both above and below a take-off mass of 5700) kg is described in detail. Direct experience in the day-to-day practice of conducting aircraft flyover noise measurements for purposes of noise certification is revealed, and potential pitfalls, loopholes, and the present uncertainties in the various procedures are examined. Newly proposed noise certification procedures, for propeller-driven aircraft not exceeding 5700 kg take-off mass, and for the aircraft above 5700 kg are described. Procedures for the calculation of effective perceived noise level and for the establishment of the validity of test results are presented. I.S.

N87-17526*# George Washington Univ., Hampton, Va. Joint Inst. for Advancement of Flight Sciences.
FLIGHT-VEHICLE STRUCTURES EDUCATION IN THE US: ASSESSMENT AND RECOMMENDATIONS
AHMED K. NOOR Washington NASA Feb. 1987 89 p
(Contract NGR09-010-078)
(NASA-CR-4048; NAS 1.26:4048) Avail: NTIS HC A05/MF A01 CSCL 05I

An assessment is made of the technical contents of flight-vehicle structures curricula at 41 U.S. universities with accredited aerospace engineering programs. The assessment is based on the technical needs for new and projected aeronautical and space systems as well as on the likely characteristics of the aerospace engineering work environment. A number of deficiencies and areas of concern are identified and recommendations are presented for enhancing the effectiveness of flight-vehicle structures education. A number of government supported programs that can help aerospace engineering education are listed in the appendix. Author

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GENERAL

N87-18518# Office National d'Etudes et de Recherches Aerospatiales, Paris (France).
ONERA 1946-1986 Activities Report
1986 76 p In FRENCH Original document contains color illustrations
(ETN-87-99158) Avail: NTIS HC A05/MF A01

The activities of the French national aerospace research institute from 1946 to 1986 in aircraft and helicopters, military systems, and space projects are described. ESA

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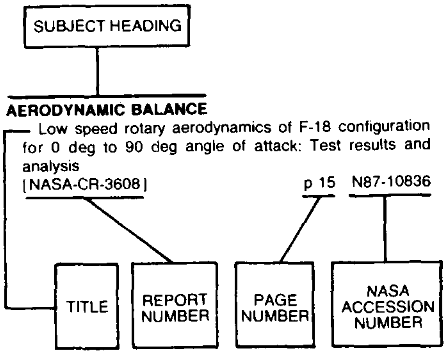

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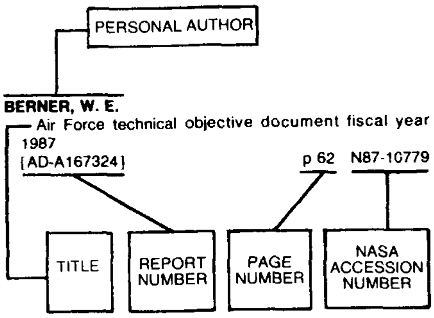

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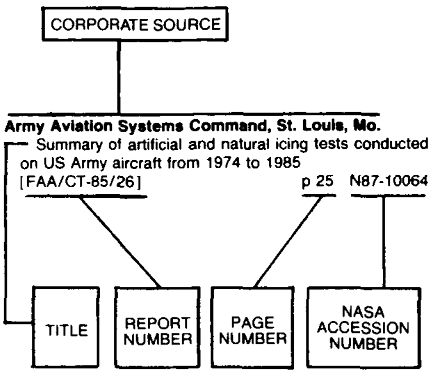

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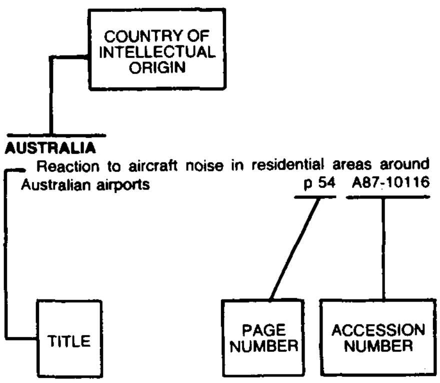

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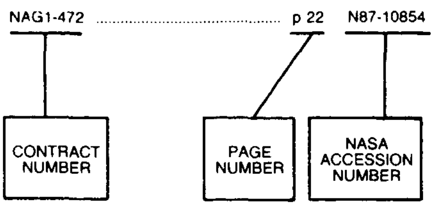

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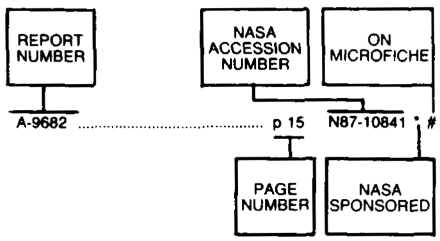

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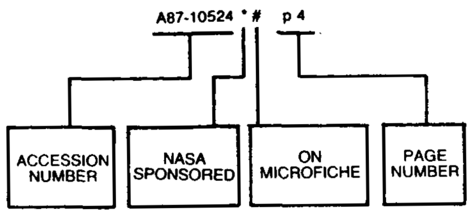

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