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Aeronautical Engineering
A Continuing Bibliography with Indexes

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National Aeronautics and Space Administration

Aeronautical Engineering Aeronautical Engineering Aeronautical Engineering Aeronautical Engineering Aeronautical Engineering Aeronautical Engineering Aeronautical Engineering Aeronautical Engineering Aeronautic Engineering Aeronautical Engineering

NASA SP-7037(243)

AERONAUTICAL ENGINEERING

A CONTINUING BIBLIOGRAPHY WITH INDEXES

(Supplement 243)

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 August 1989 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 423 reports, journal articles and other documents originally announced in August 1989 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.

TABLE OF CONTENTS

TYPICAL REPORT CITATION AND ABSTRACT

NASA SPONSORED

ON MICROFICHE

ACCESSION NUMBER → **N89-10029*#** North Carolina State Univ., Raleigh. Dept. of Mechanical and Aerospace Engineering. ← CORPORATE SOURCE

TITLE → **A TRANSONIC INTERACTIVE BOUNDARY-LAYER THEORY FOR LAMINAR AND TURBULENT FLOW OVER SWEPT WINGS Final Report**

AUTHORS → SHAWN H. WOODSON and FRED R. DEJARNETTE

Washington Oct. 1988 82 p ← PUBLICATION DATE

CONTRACT NUMBER → (Contract NCC1-22)

REPORT NUMBERS → (NASA-CR-4185; NAS 1.26:4185) Avail: NTIS HC A05/MF A01 ← PRICE CODE

COSATI CODE → CSCL 01A ← AVAILABILITY SOURCE

A 3-D laminar and turbulent boundary-layer method is developed for compressible flow over swept wings. The governing equations and curvature terms are derived in detail for a nonorthogonal, curvilinear coordinate system. Reynolds shear-stress terms are modeled by the Cebeci-Smith eddy-viscosity formulation. The governing equations are descretized using the second-order accurate, predictor-corrector finite-difference technique of Matsuno, which has the advantage that the crossflow difference formulas are formed independent of the sign of the crossflow velocity component. The method is coupled with a full potential wing/body inviscid code (FLO-30) and the inviscid-viscous interaction is performed by updating the original wing surface with the viscous displacement surface calculated by the boundary-layer code. The number of these global iterations ranged from five to twelve depending on Mach number, sweep angle, and angle of attack. Several test cases are computed by this method and the results are compared with another inviscid-viscous interaction method (TAWFIVE) and with experimental data. Author

TYPICAL JOURNAL ARTICLE CITATION AND ABSTRACT

NASA SPONSORED

ON MICROFICHE

ACCESSION NUMBER → **A89-12562*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

TITLE → **EFFICIENT VIBRATION MODE ANALYSIS OF AIRCRAFT WITH MULTIPLE EXTERNAL STORE CONFIGURATIONS**

AUTHOR → M. KARPEL (NASA, Langley Research Center, Hampton, VA; Israel Aircraft Industries, Ltd., Lod) Journal of Aircraft (ISSN 0021-8669), ← JOURNAL TITLE
vol. 25, Aug. 1988, p. 747-751. refs

A coupling method for efficient vibration mode analysis of aircraft with multiple external store configurations is presented. A set of low-frequency vibration modes, including rigid-body modes, represent the aircraft. Each external store is represented by its vibration modes with clamped boundary conditions, and by its rigid-body inertial properties. The aircraft modes are obtained from a finite-element model loaded by dummy rigid external stores with fictitious masses. The coupling procedure unloads the dummy stores and loads the actual stores instead. The analytical development is presented, the effects of the fictitious mass magnitudes are discussed, and a numerical example is given for a combat aircraft with external wing stores. Comparison with vibration modes obtained by a direct (full-size) eigensolution shows very accurate coupling results. Once the aircraft and stores data bases are constructed, the computer time for analyzing any external store configuration is two to three orders of magnitude less than that of a direct solution. Author

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SEPTEMBER 1989

01

AERONAUTICS (GENERAL)

A89-36900
THE MATURING OF COMMERCIAL AVIATION
DUANE W. FREER (International Civil Aviation Organisation, Montreal, Canada) Exxon Air World (ISSN 0014-5068), vol. 41, no. 1, 1989, p. 45-48.

Of all the major operational factors influencing the character of commercial aviation's development over the next 50 years, none will be so profound and pervasive in its influence as that of airport capacity and the difficulty of existing capacity's expansion. This fundamental constraint will necessarily influence commercial aircraft size and design as well as fleet composition, and lead to continued regulatory encroachments on 'freedom of airspace' and a widening of current ATC restrictions. Collision-avoidance systems will be employed globally, in conjunction with satellite navigation systems. Tilt-rotor VTOL aircraft are anticipated to be a major success among the most recent design innovations. O.C.

A89-37003#
THE PROBLEMS OF THE INFRARED STEALTH OF THE FLYING VEHICLES
YIHE YANG and CHANGCHENG BAI (Northwest Telecommunication Engineering Institute, Xian, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 9, Dec. 1988, p. B549-B554. In Chinese, with abstract in English. refs

The significance and direction of IR stealth research on military objects are discussed. The relationship bewteen IR stealth and anti-IR stealth and the technical design of the IR stealth are addressed. The research has significant value for the development of IR stealth research in China today. C.D.

A89-37875#
HYPERSONIC TECHNOLOGY FOR MILITARY APPLICATION
Research supported by USAF, Washington, DC, National Academy Press, 1989, 111 p.
(Contract F49620-87-C-0122)

This comprehensive consideration of technology-readiness and prospective technology development requirements associated with hypersonic-cruise vehicles generally and the National Aerospace Plane in particular presents the concensus that has emerged to date in the joint deliberations of the Committee on Hypersonic Technology for Military Application, the USAF Studies Board, the National Research Council, and the Commission on Engineering and Technical Systems. Attention is given to the severe aerothermodynamics of hypersonic vehicles and the materials requirements that they impose, as well as recent advancements in airframe/propulsion integration. The role of CFD in further, detailed characterizations of hypersonic flow is stressed. O.C.

A89-38514
FUNDAMENTALS OF AVIATION (4TH REVISED AND ENLARGED EDITION) [OSNOVY AVIATSII /4TH REVISED AND ENLARGED EDITION/]
BORIS K. GUSEV and VLADIMIR F. DOKIN Moscow, Izdatel'stvo Transport, 1988, 192 p. In Russian.

The present textbook contains the basics of aircraft and helicopter aerodynamics, general aircraft design, and operations. In particular, attention is given to the principal equations of gas motion, the structure of the earth atmosphere, and the principal concepts and laws of aerodynamics. The discussion also covers the principal components and systems of aircraft, the main types of powerplants and their systems, and the principal stages and types of flight. V.L.

A89-38800#
THE JOINED WING - THE BENEFITS AND DRAWBACKS. I [ZAMKNIETE SKRZYDLO - ZALETY I WADY. I]
STANISLAW DANILECKI (Warszawa, Politechnika, Warsaw, Poland) Technika Lotnicza i Astronautyczna (ISSN 0040-1145), vol. 43, Sept. 1988, p. 4-7. In Polish.

Problems encountered in the design of an aircraft with a joined wing are examined. The advantages and disadvantages of this configuration are assessed. B.J.

N89-22568*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
EVALUATION OF THE RIDE QUALITY OF A LIGHT TWIN ENGINE AIRPLANE USING A RIDE QUALITY METER
ERIC C. STEWART Jun. 1989 27 p
(NASA-TP-2913; L-16524; NAS 1.60:2913) Avail: NTIS HC A03/MF A01 CSCL 01/2

A ride quality meter was used to establish the baseline ride quality of a light twin-engine airplane planned for use as a test bed for an experimental gust alleviation system. The ride quality meter provides estimates of passenger ride discomfort as a function of cabin noise and vibration (acceleration) in five axes (yaw axis omitted). According to the ride quality meter, in smooth air the cabin noise was the dominant source of passenger discomfort, but the total discomfort was approximately the same as that for the smooth-air condition. The researcher's subjective opinion, however, is that the total ride discomfort was much worse in the moderate turbulence than it was in the smooth air. The discrepancy is explained by the lack of measurement of the low-frequency accelerations by the ride quality meter. Author

N89-22569*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
NASA'S PROGRAM ON ICING RESEARCH AND TECHNOLOGY
JOHN J. REINMANN, ROBERT J. SHAW, and RICHARD J. RANAUDO 1989 55 p Presented at the Symposium on Flight in Adverse Environmental Conditions, Gol, Norway, 8-12 May 1989; sponsored by AGARD
(NASA-TM-101989; E-4692; NAS 1.15:101989) Avail: NTIS HC A04/MF A01 CSCL 01/2

NASA's program in aircraft icing research and technology is reviewed. The program relies heavily on computer codes and modern applied physics technology in seeking icing solutions on a finer scale than those offered in earlier programs. Three major goals of this program are to offer new approaches to ice protection, to improve our ability to model the response of an aircraft to an icing encounter, and to provide improved techniques and facilities for ground and flight testing. This paper reviews the following program elements: (1) new approaches to ice protection; (2) numerical codes for deicer analysis; (3) measurement and prediction of ice accretion and its effect on aircraft and aircraft components; (4) special wind tunnel test techniques for rotorcraft icing; (5) improvements of icing wind tunnels and research aircraft; (6) ground de-icing fluids used in winter operation; (7) fundamental studies in icing; and (8) droplet sizing instruments for icing clouds. Author

N89-22570# Air Force Systems Command, Wright-Patterson AFB, OH. Foreign Technology Div.
ACTA AERONAUTICA ET ASTRONAUTICA SINICA (SELECTED ARTICLES)
7 Feb. 1989 41 p Transl. into ENGLISH from Hong Kong Xueboa (Peoples Republic of China), v. 8, no. 12, Dec. 1987 p B578-B584, B594-B600
(AD-A205128; FTD-ID(RS)T-0912-88) Avail: NTIS HC A03/MF A01 CSCL 01/2

The formula of requisite linear damping for overcoming landing-gear shimmy according to the point-contact theory is derived. However, the damping property of the hydraulis shimmy damper is mostly nonlinear. Two methods are presented to treat this case; the tangent method and the minimum equivalent linear damping method. Their correlation is also found. It is demonstrated by computation that both methods are effective and reliable. The requirements for measuring ground load on an aircraft is discussed. A practical data treatment method has been developed for the case that the measurement satisfy the minimum requirement. Although the method is illustrated with taxiing data, however, it is also applicable to the treatment of turning and braking load data. Author

02

AERODYNAMICS

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

A89-36186#
UNSTEADY INTERACTION EFFECTS ON A TRANSITIONAL TURBINE BLADE BOUNDARY LAYER
D. A. ASHWORTH (Rolls-Royce, PLC, Derby, England), J. E. LAGRAFF (Syracuse University, NY), and D. L. SCHULTZ (Oxford University, England) ASME, Transactions, Journal of Turbomachinery (ISSN 0889-504X), vol. 111, April 1989, p. 162-168. refs
(Contract AF-AFOSR-85-0295)

The behavior of the suction surface boundary layer of a transonic gas turbine rotor in a two-dimensional cascade under the influence of both free-stream turbulence and simulated nozzle guide vane wakes and shocks is discussed. Thin film resistance thermometers were used together with electrical analogs of the one-dimensional heat conduction equations to obtain wide-bandwidth heat transfer rate measurements in a short-duration wind tunnel. A direct relationship was found between the passage of wake disturbances and transient surface heat transfer enhancements. K.K.

A89-36901*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
EXTENSION AND APPLICATION OF FLUX-VECTOR SPLITTING TO CALCULATIONS ON DYNAMIC MESHES
W. KYLE ANDERSON, JAMES L. THOMAS, and CHRISTOPHER L. RUMSEY (NASA, Langley Research Center, Hampton, VA) (Computational Fluid Dynamics Conference, 8th, Honolulu, HI, June 9-11, 1987, Technical Papers, p. 546-558) AIAA Journal (ISSN 0001-1452), vol. 27, June 1989, p. 673, 674. Abridged. Previously cited in issue 18, p. 2800, Accession no. A87-42098.

A89-36902*# Michigan State Univ., East Lansing.
NUMERICAL AND EXPERIMENTAL EVALUATIONS OF THE FLOW PAST NESTED CHEVRONS
J. F. FOSS (Michigan State University, East Lansing), J. K. FOSS (Southern California, University, Los Angeles, CA), and P. R. SPALART (NASA, Ames Research Center, Moffett Field, CA) AIAA Journal (ISSN 0001-1452), vol. 27, June 1989, p. 675, 676.

An effort is made to contribute to the development of CFD by relating the successful use of vortex dynamics in the computation of the pressure drop past a planar array of chevron-shaped obstructions. An ensemble of results was used to compute the loss coefficient k, stimulating an experimental program for the assessment of the measured loss coefficient for the same geometry. The most provocative result of this study has been the representation of kinetic energy production in terms of vorticity source terms. O.C.

A89-36903#
LINEAR INSTABILITY WAVES IN SUPERSONIC TURBULENT MIXING LAYERS
SAAD A. RAGAB (Virginia Polytechnic Institute and State University, Blacksburg) and J. L. WU AIAA Journal (ISSN 0001-1452), vol. 27, June 1989, p. 677-686. Previously cited in issue 19, p. 2941, Accession no. A87-44948. refs
(Contract N00014-87-K-0168)

A89-36904*# High Technology Corp., Hampton, VA.
BOUNDARY-LAYER TRANSITION ON A CONE AND FLAT PLATE AT MACH 3.5
F.-J. CHEN, M. R. MALIK (High Technology Corp., Hampton, VA), and I. E. BECKWITH (NASA, Langley Research Center, Hampton, VA) AIAA Journal (ISSN 0001-1452), vol. 27, June 1989, p. 687-693. Previously cited in issue 07, p. 935, Accession no. A88-22303. refs

A89-36905*# Boeing Helicopter Co., Philadelphia, PA.
BLADE-VORTEX INTERACTION
DAVID R. POLING, LEO DADONE (Boeing Helicopters, Philadelphia, PA), and DEMETRI P. TELIONIS (Virginia Polytechnic Institute and State University, Blacksburg) AIAA Journal (ISSN 0001-1452), vol. 27, June 1989, p. 694-699. Previously cited in issue 09, p. 1193, Accession no. A87-24971. refs
(Contract NGT-47-004-801)

A89-36907#
WAKES OF FOUR COMPLEX BODIES OF REVOLUTION AT ZERO ANGLE OF ATTACK
VEYSEL ATLI (Istanbul Technical University, Turkey) AIAA Journal (ISSN 0001-1452), vol. 27, June 1989, p. 707-711. refs

The wakes of four complex bodies of revolution were investigated experimentally with a constant-temperature hot-wire anemometer. All tests were performed at a low Mach number (freestream Mach of about 0.1) and zero angle of attack. Mean and turbulence velocity profiles were obtained along and across the wakes. The structure of the axisymmetric wake and the effects of the geometric differences of the models on their wakes were investigated. Author

A89-36910#
POTENTIAL FLOW OVER BODIES OF REVOLUTION IN UNSTEADY MOTION
PABLO GARCIA-FOGEDA, D. D. LIU (Arizona State University, Tempe), and MING-SHIN WU AIAA Journal (ISSN 0001-1452), vol. 27, June 1989, p. 725-733. Research supported by the U.S. Army. Previously cited in issue 21, p. 3333, Accession no. A87-48651. refs

A89-36911*# Texas Univ., Austin.
SEPARATION SHOCK MOTION IN FIN, CYLINDER, AND COMPRESSION RAMP - INDUCED TURBULENT INTERACTIONS
D. S. DOLLING (Texas, University, Austin) and L. BRUSNIAK AIAA Journal (ISSN 0001-1452), vol. 27, June 1989, p. 734-742. Research sponsored by the U.S. Navy and NASA. refs
(Contract AF-AFOSR-86-0112)
In conjunction with new experimental results at Mach 5, an examination has been made of published data on unsteadiness of shock-induced turbulent boundary-layer separation. The data are all wall pressure fluctuation measurements made under the unsteady separation shock and are from interactions induced by compression ramps, blunt and sharp fins, and circular cylinders. There is little evidence of a link between the separation shock zero-crossing frequency and characteristic frequency of the incoming boundary layer. The low shock frequencies and low shock speeds, and the trends with changes in model geometric parameters and incoming boundary layer, suggest that turbulent or global fluctuations at the upstream boundary of the separated flow drive the shock motion. Author

A89-36912*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
EXPLICIT RUNGE-KUTTA METHOD FOR UNSTEADY ROTOR/STATOR INTERACTION
PHILIP C. E. JORGENSON and RODRICK C. CHIMA (NASA, Lewis Research Center, Cleveland, OH) AIAA Journal (ISSN 0001-1452), vol. 27, June 1989, p. 743-749. Previously cited in issue 10, p. 1477, Accession no. A88-27715. refs

A89-36914#
AERO-OPTICAL ANALYSIS OF COMPRESSIBLE FLOW OVER AN OPEN CAVITY
PHILIP E. CASSADY, STANLEY F. BIRCH, and P. JOHN TERRY (Boeing Aerospace, Seattle, WA) AIAA Journal (ISSN 0001-1452), vol. 27, June 1989, p. 758-762. Research supported by Boeing Aerospace and Boeing Commercial Airplanes. Previously cited in issue 19, p. 2941, Accession no. A87-44943. refs

A89-36922*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
SEPARATION CONTROL ON AN AIRFOIL BY PERIODIC FORCING
A. BAR-SEVER (NASA, Langley Research Center, Hampton, VA) AIAA Journal (ISSN 0001-1452), vol. 27, June 1989, p. 820, 821. refs
The introduction of transverse velocity fluctuations into a separated shear layer on an airfoil at high angles of attack is presently demonstrated to be an effective separation-control technique. Airfoil aerodynamic characteristics, including poststall lift and drag as well as maximum lift coefficient and stall angle, all exhibited improvements controlled forcing at 20 deg angle of attack led to an increased spreading of the mean velocity profile, together with increased turbulence activity; separation moved from the leading edge to about 80 percent of chord. O.C.

A89-36923#
MODELING OF DENSITY FLUCTUATIONS IN SUPERSONIC TURBULENT BOUNDARY LAYER
STEVEN A. LUTZ (Johns Hopkins University, Laurel, MD) AIAA Journal (ISSN 0001-1452), vol. 27, June 1989, p. 822, 823. Research sponsored by the U.S. Army. refs
(Contract N00039-87-C-5301)
A method is presented for the determination of the density fluctuation profile in a compressible, turbulent boundary layer which is based on the Crocco-Busemann temperature solutions' differential form. Local density fluctuations were determined on the basis of thermal anemometry; a comparison of model results with adiabatic-wall, supersonic turbulent boundary layer data has shown good agreement. Model results are unable to predict the quantitative behavior of nonadiabatic-wall, turbulent boundary layer data. O.C.

A89-36985#
A METHOD FOR SHOCK-FREE WING DESIGN
ZIQIANG ZHU (Beijing University of Aeronautics and Astronautics, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 9, Nov. 1988, p. A499-A508. In Chinese, with abstract in English. refs
A method for shock-free wing design using the 'fictitious gas' concept is introduced. The main points of this method are briefly described. Several fictitious gas laws are presented. A space-matching procedure adopted in supersonic flow region is concretely explained. The gain in two- or three-dimensional design conditions and off-design conditions is also discussed. Finally, an engineering approach for nearly shock-free wing design is introduced. Author

A89-36986#
TRANSFINITE INTERPOLATION METHOD FOR 3-D GRID GENERATIONS
JUNHUI LIU and TIEYOU MA (Beijing University of Aeronautics and Astronautics, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 9, Nov. 1988, p. A509-A514. In Chinese, with abstract in English.
This paper presents a study of transfinite interpolation grid generation. The developed procedure is used to generate two-dimensional grids around airfoils and three-dimensional ones around wing-body configurations. As a noniterative method, it requires less computational work and can be applied to different grid topologies. The computational results show the effectiveness of the present method. Author

A89-36987#
LATERAL INDUCED VELOCITY DISTRIBUTION OF A HELICOPTER ROTOR
SHICUN WANG (Nanjing Aeronautical Institute, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 9, Nov. 1988, p. A515-A520. In Chinese, with abstract in English. refs
In order to clarify the essential features of the lateral induced velocity distributions of a helicopter rotor, the contributions of circulations Gamma(0) and Gamma(1s) to the sine component of the induced velocity are analyzed based on classical vortex theory. Using the flapping condition of the rotor blade, a critical radius position is found. On the outboard blade (outside the critical radius position) the induced velocity on the advancing side is smaller than that on the retreating side, while on the inboard blade (inside of the critical radius position) the induced velocity on the advancing side is larger than that on the retreating side. This conclusion is experimentally verified. C.D.

A89-37355
AERODYNAMIC CHARACTERISTICS OF ARBITRARILY ROTATING BODIES IN A VARIABLE-DENSITY GAS [AERODINAMICHESKIE KHARAKTERISTIKI PROIZVOL'NO VRASHCHAIUSHCHIKHSIA TEL V GAZE RAZLICHNOI RAZREZHENNOSTI]
A. I. BUNIMOVICH and A. V. DUBINSKII Kosmicheskie Issledovaniia (ISSN 0023-4206), vol. 27, Mar.-Apr. 1989, p. 180-185. In Russian. refs

A89-37460
A NUMERICAL METHOD FOR THE ANALYSIS OF A FLIGHT VEHICLE WITH A SOLID FUSELAGE [CHISLENNYI METOD RASCHETA LETATEL'NOGO APPARATA S TELESNYM FIUZELIAZHEM]
E. D. KOVALEV, I. K. LIFANOV, A. A. MIKHAILOV, M. I. NISHT, and G. G. POLIKARPOV Zhurnal Vychislitel'noi Matematiki i Matematicheskoi Fiziki (ISSN 0044-4669), vol. 29, April 1989, p. 589-597. In Russian. refs
The paper is concerned with flow of an ideal incompressible fluid past (1) a plane with a fuselage in the form of a smooth closed surface and a plane wing and (2) a helicopter with a solid piecewise plane fuselage and a thin rotor. The problem is solved

by the method of discrete vortices based on the use of closed vortex filaments. V.L.

A89-37653*# Pennsylvania State Univ., University Park.
SHOCK STRUCTURE IN NON-CIRCULAR JETS
PHILIP J. MORRIS and THONSE R. S. BHAT (Pennsylvania State University, University Park) AIAA, Aeroacoustics Conference, 12th, San Antonio, TX, Apr. 10-12, 1989. 10 p. refs
(Contract NAG1-657)
(AIAA PAPER 89-1083)

The shock-cell structure of supersonic jets with non-circular exit geometry is modeled using a linearized analysis. The model takes into account the finite thickness of the jet shear layer using realistic velocity and density profiles. The effects of the shear layer turbulence are included by incorporating eddy-viscosity terms. A finite-difference numerical method is used to solve the steady linearized equations of motion. A body-fitted coordinate system is used to describe the shear layer. The variation of the pressure fluctuation with downstream distance is given for circular jets and for an elliptic jet of aspect ratio 2.0. Comparisons with experimental data are made. Difficulties with the numerical technique are also discussed. Author

A89-37776#
ON THE UNSTEADY LEADING EDGE SUCTION OF A SWEPTBACK WING
ZHENHAO LI (Chinese Helicopter Research and Development Institute, People's Republic of China) Acta Aerodynamica Sinica (ISSN 0258-1825), vol. 7, March 1989, p. 1-11. refs

The unsteady flowfield near the leading edge of an oscillating sweptback wing is obtained by using three-dimensional subsonic lifting surface theory. It is shown that this flowfield is composed of two parts: (1) a continuous part and (2) a singular part. The formula of leading edge suction is derived theoretically. The famous assumption that the leading edge suction depends only on the nature of the velocity at and perpendicular to this edge has been substantiated analytically and extended to unsteady flow. Author

A89-37777#
THE COMPUTATION OF THE VISCOUS/INVISCID INTERACTION
ZIQIANG ZHU (Beijing University of Aeronautics and Astronautics, People's Republic of China) Acta Aerodynamica Sinica (ISSN 0258-1825), vol. 7, March 1989, p. 12-25. In Chinese, with abstract in English. refs

Different computational methods and results of viscous/inviscid interaction are reviewed in this paper. The emphasis is placed on introduction to the computation of the weak interaction in the steady flow. The mathematical model of the weak interaction is described at first. Using direct coupling, some results of viscous/inviscid interaction are given in both incompressible and transonic flow. Why direct mode of boundary layer fails near separation is discussed. The inverse mode of boundary layer and the semiinverse coupling between viscous/inviscid interaction for flow with separation region are then described. Application in the three-dimensional case and strong interaction are also briefly reviewed in this paper. Author

A89-37778#
AN EXPLICIT MULTISTAGE FINITE-AREA METHOD FOR 2D TRANSONIC FLOW CALCULATIONS
LEI WANG and FENGGAN ZHUANG (Beijing Institute of Aeronautics and Astronautics, People's Republic of China) Acta Aerodynamica Sinica (ISSN 0258-1825), vol. 7, March 1989, p. 26-33. In Chinese, with abstract in English. refs

Based on the work of Jameson et al. (1981), an explicit multistage finite-area method is established and the formula for coefficients of the artificial viscosity terms is suggested in analogy to upwind schemes. The numerical results for NACA0012 and RAE2822 airfoils show that for the proposed method, effective capture of shock waves can be obtained and the suitable values of the coefficient of the added viscosity term do not have to be changed from case to case. Author

A89-37779#
ROTOR VORTEX WAKE DISTORTION AND ITS INDUCED VELOCITY IN GROUND EFFECT AT LOW SPEED
MAO SUN (Beijing University of Aeronautics and Astronautics, People's Republic of China) and H. C. CURTISS, JR. (Princeton University, NJ) Acta Aerodynamica Sinica (ISSN 0258-1825), vol. 7, March 1989, p. 35-41. In Chinese, with abstract in English. refs

The vortex wake and its induced velocity of a helicopter rotor operating near the ground at low forward speeds have been studied using a simplified free wake-ground vortex model. The vortex wake near the rotor plane is distorted significantly because of the flowfield of the ground and ground vortex, resulting in large variation on the induced velocity distribution at the rotor plane, especially near the rotor leading edge. The variation of the induced velocity distribution at the rotor plane caused by the ground and ground vortex through distorting the rotor near-wake is much larger than that induced directly by the ground and ground vortex. The free wake-ground vortex model can be used to predict the induced velocity distribution at the rotor plane with reasonable accuracy. Author

A89-37780#
THE EFFECTS OF VORTEX BREAKDOWN ON THE AERODYNAMIC PROPERTIES OF A WING AND THE ENGINEERING PREDICTING METHOD
HUIYANG MA (University of Science and Technology of China, Hefei, People's Republic of China) Acta Aerodynamica Sinica (ISSN 0258-1825), vol. 7, March 1989, p. 43-49. In Chinese, with abstract in English.

This paper introduces the effects of vortex breakdown on the longitudinal and lateral aerodynamic properties of a delta wing. On the foundation of experimental measurements the engineering predicting method is developed. Author

A89-37782#
INVESTIGATION OF MACH REFLECTION FOR A PLANAR MOVING SHOCK PROPAGATING INTO STEADY SUPERSONIC FLOW FIELD AROUND WEDGE
XIEZHEN YIN and ZHAOYUAN HAN (University of Science and Technology of China, Hefei, People's Republic of China) Acta Aerodynamica Sinica (ISSN 0258-1825), vol. 7, March 1989, p. 67-74. In Chinese, with abstract in English. refs

The experiment of Mach reflection for a planar moving shock propagating into a steady supersonic flowfield around a wedge was conducted in a double driver shock tunnel. The reflection phenomenon is pseudo-stationary. Reflections of four different types (RR, SMR, CMR and DMR) were observed in the experiment. The angles of the first-triple-point and the kink and the transition boundaries between various reflections were calculated. It is found that the angles and the transition boundaries in the plane depended on the steady supersonic flow Mach number ahead of the moving shock, whereas the boundaries in another plane do not. Author

A89-37785#
EXPERIMENTAL INVESTIGATION OF AERODYNAMIC HEATING BY FLOW THROUGH CONTROL SURFACE GAPS
GUIMING TANG (Chinese Academy of Sciences, Institute of Mechanics, Beijing, People's Republic of China) Acta Aerodynamica Sinica (ISSN 0258-1825), vol. 7, March 1989, p. 88-93. In Chinese, with abstract in English. refs

Detailed aerodynamic heating distributions were measured over a flat plate equipped with a flap and inside the gap between the plate and the flap in order to study the effects of gap width, flap deflection, Reynolds number, and Mach number on thermal environment in the flap gap. Various flap deflection angles with variable leakage were used. The results indicate that the ratio of gap heating rate to local plate value increases with flap deflection, free-stream Reynolds number, and increases with Mach number for turbulent external flow. In the case of attached flow on the plate ahead of the flap, turbulent heating distributions on both the plate and the flap are not affected by gap leakage. Within the gap, a separation bubble develops on the upstream face of the gap. The heating peak occurs at an attached point at a distance of two to three times the width of the gap from the entrance where low heating rate occurs. C.D.

A89-37787#

THE APPLICATION OF THE TWO-DIMENSIONAL UNSTEADY EULER EQUATIONS PERTURBATION SOLUTIONS ON THE SUPERSONIC RECTANGULAR WINGS

JINGSONG CHEN (Nanjing Aeronautical Institute, People's Republic of China) Acta Aerodynamica Sinica (ISSN 0258-1825), vol. 7, March 1989, p. 102-107. In Chinese, with abstract in English. refs

In this paper, the approximate analysis solutions of aerodynamic coefficients are given, which belong to plunging and pitching oscillating supersonic rectangular wings. The solutions are that the frequency perturbation solutions of two-dimensional unsteady Euler equations for oscillating supersonic flat plate combine with the loading coefficient analysis solution of the steady supersonic linearized theory for the rectangular wings. Numerical results are presented which confirm the accuracy and very high efficiency of the method. The present method is an efficient computation method of unified supersonic and hypersonic unsteady aerodynamic forces for rectangular wings. Author

A89-37790#

THE CONSTRAINT WAKE ANALYSIS FOR HOVERING ROTORS

WUJIANG LOU and CHICUN WANG (Nanjing Aeronautical Institute, People's Republic of China) Acta Aerodynamica Sinica (ISSN 0258-1825), vol. 7, March 1989, p. 117-122. In Chinese, with abstract in English. refs

The concept of the constraint wake analysis is applied to hovering helicopter rotors, which leads to the development of the Constraint Wake Analysis for Hovering Rotors (CWAHR). The CWAHR is characterized by a lifting line vortex system, a self-persevering hover wake model, an accelerated distorting formula, and a dual-exponential relation of the wake boundary which is derived from the prescribed wake equations and taken as a geometrical constraint of the procedure. The CWAHR shows higher accuracy when compared with other data sources, and a high convergent speed. It is believed that the CWAHR will be applicable for all rotor design geometries when further modifications are included. Author

A89-37791#

AF-2 SCHEME FOR SOLUTION OF AXIAL SYMMETRIC TRANSONIC INLET-FLOWFIELD

YINGKAI YANG (Chengdu Aircraft Co., Development Div., People's Republic of China), HUILI SHEN, and SHIJUN LUO (Northwestern Polytechnical University, Xian, People's Republic of China) Acta Aerodynamica Sinica (ISSN 0258-1825), vol. 7, March 1989, p. 123-129. In Chinese, with abstract in English. refs

An AF-2 scheme of the axisymmetric small transverse potential equation is formulated and applied in solving external and internal transonic flow about an IC inlet. A linearized analysis of stability for AF-2 scheme is carried out. Analysis shows that the stability of AF-2 is better than SLOR, and the speed of convergence of AF-2 is at least 10 times than that of SLOR. Author

A89-37792#

NONLINEAR SUPERSONIC POTENTIAL FLOW OVER SIDESLIP CONICAL BODIES, DELTA WINGS AND FUSELAGES

HONGQUAN CHEN and MINGKE HUANG (Nanjing Aeronautical Institute, People's Republic of China) Acta Aerodynamica Sinica (ISSN 0258-1825), vol. 7, March 1989, p. 130-134. In Chinese, with abstract in English. refs

The governing equation of supersonic nonlinear full-potential flow past aircraft in the spherical crossflow plane has the salient mathematical features of two-dimensional transonic potential flow. Thus, a marching technique can be developed through the application of Jameson's rotated difference scheme and line relaxation iteration for capture of both bow and embedded shocks. The results obtained by this technique in this paper are presented first for the sideslip conical bodies such as model delta wings of thin-elliptic cones and then for the nonconical bodies such as wings of practical configuration, noncircular sectional fuselages with their canopies, and are compared with available experiental data, Euler's equation solutions, and the results from linearized theories. A fixed-mesh nose shock fitting technique which reduces many mesh points so as to further reduce the computation time has been developed. Author

A89-37939

CONDENSATION PHENOMENA IN A TURBINE BLADE PASSAGE

S. A. SKILLINGS (Central Electricity Generating Board, Central Electricity Research Laboratories, Leatherhead, England) Journal of Fluid Mechanics (ISSN 0022-1120), vol. 200, March 1989, p. 409-424. refs

Experiments are performed to investigate the behavior of condensing steam flows in a turbine blade passage. The significance of droplet nucleation in modifying the single-phase flow structure is shown, and results are presented showing the change in shock wave pattern when inlet superheat and outlet Mach number are varied. Implications of these results for turbine performance are also discussed. S.A.V.

A89-38122

MACH NUMBER EFFECTS ON HIGH-ANGLES-OF-ATTACK AERODYNAMIC CHARACTERISTICS OF A CONE-CYLINDER WITH VARIOUS NOSE SHAPES

HIROTOSHI KUBOTA (Tokyo, University, Japan), KIYOSHI SATO, TATSUYA TANIKATSU (Institute of Space and Astronautical Science, Sagamihara, Japan), KOJIRO SUZUKI, TSUYOSHI ISHIHARA et al. IN: International Symposium on Space Technology and Science, 16th, Sapporo, Japan, May 22-27, 1988, Proceedings. Volume 1. Tokyo, AGNE Publishing, Inc., 1988, p. 709-714.

Static aerodynamic characteristics of nonyawed high-angle-of-attack cone-cylinders are investigated in transonic wind tunnel testing. The effects of Mach number and attack angle are discussed. The tripping wire method is adopted for side force alleviation and its effectiveness is studied. The schlieren photograph and the fluorescent mini-tuft method are used to visualize such high-speed vortex-dominant flow fields. Author

A89-38123

EXPERIMENTAL INVESTIGATION OF APPLICABILITY OF WAVERIDER CONFIGURATION TO HYPERSONIC TRANSPORT AND AEROSPACE-PLANE

KOICHI HOZUMI and SHIGEYA WATANABE (National Aerospace Laboratory, Chofu, Japan) IN: International Symposium on Space Technology and Science, 16th, Sapporo, Japan, May 22-27, 1988, Proceedings. Volume 1. Tokyo, AGNE Publishing, Inc., 1988, p. 715-724. refs

The aerodynamic characteristics of a series of cone-derived waverider configurations are examined with a view of the application of such configurations to the Hypersonic Transport. For an optimized configuration and its variations, six-component tests at $M = 7.1$ at angle of attack between -12 and 10 deg and side-slip angle of 0 deg are performed in a blow-down hypersonic wind tunnel. From comparisons between present aerodynamic data and those of conventional flat-bottom type configurations, high L/D and low lift characteristics of the present configurations are confirmed. The merits of the present cone-derived waveriders having high L/D and low lift characteristics relative to the aerodynamic behavior of HST configurations having high L/D and high lift characteristics are discussed. Author

A89-38124

NUMERICAL SIMULATION OF SUPERSONIC FLOWS PAST A SPACE-PLANE

SUSUMU TAKANASHI (National Aerospace Laboratory, Chofu, Japan), KISA MATSUSHIMA (Fujitsu, Ltd., Ota, Japan), and KOZO FUJII (Institute of Space and Astronautical Science, Sagamihara, Japan) IN: International Symposium on Space Technology and Science, 16th, Sapporo, Japan, May 22-27, 1988, Proceedings. Volume 1. Tokyo, AGNE Publishing, Inc., 1988, p. 731-742. refs

Supersonic flows past a research model of a spaceplane are simulated numerically. A single block O-C grid is generated around the model and the Reynolds-average thin-layer Navier-Stokes equations are solved using the implicit finite difference method based on an upwind TVD scheme. The predicted lift, drag, and moment are compared with experimental data, showing fairly good agreement. R.B.

A89-38125
HIGHLY-RESOLVED FLOWFIELD INDUCED BY MACH REFLECTION
TADAYOSHI SUGIMURA (Meijo University, Nagoya, Japan) and TOSHI FUJIWARA (Nagoya University, Japan) IN: International Symposium on Space Technology and Science, 16th, Sapporo, Japan, May 22-27, 1988, Proceedings. Volume 1. Tokyo, AGNE Publishing, Inc., 1988, p. 743-748. refs

The interaction between the chemical reaction and shear flow behind a Mach reflection shock is examined, focusing on the ignition mechanism caused by the interaction. Using the two-dimensional Euler equations where the incident Mach number is 3, the flow around a forward-facing step is solved, neglecting the chemical reaction. It is found that, by increasing the resolution, the flowfield is changed to generate a more conspicuous shear layer behind the first Mach reflection from the upper surface of the forward-facing step. R.B.

A89-38129
INVISCID, UNSTEADY, TRANSONIC AXISYMMETRIC FLOW WITH SHOCK WAVES - RESPONSE TO TIME AND SPACE-TIME DEPENDENT PERTURBATIONS
CARLOS FREDERICO EST ALVES (Centro Tecnico Aeroespacial, Instituto de Atividades Espaciais, Sao Jose dos Campos, Brazil) and DEMETRIO BASTOS-NETTO (Instituto de Pesquisas Espaciais, Sao Jose dos Campos, Brazil) IN: International Symposium on Space Technology and Science, 16th, Sapporo, Japan, May 22-27, 1988, Proceedings. Volume 1. Tokyo, AGNE Publishing, Inc., 1988, p. 775-780. refs

The problem of an inviscid, unsteady, transonic, axisymmetric flow is discussed and results are presented using analytical and numerical methods. The flow is described using the method of asymptotic expansions for the velocity potential. A weak shock was assumed to be present downstream of the throat and disturbances were assumed to exist at a given location, downstream of the shock. The occurrence of discontinuities in the solution near the throat and the shock leads to the need of inner solutions for these regions. Numerical results are given for known initial conditions and profiles. The imposed perturbations - which can be either time or space-time dependent - were chosen to be trigonometric and hypergeometric functions modulated by a step functional. Author

A89-38426
SOME PROPERTIES OF NONISENTROPIC TRANSONIC FLOWS [NEKOTORYE SVOISTVA NEIZENTROPICHESKIKH TRANSZVUKOVYKH TECHENII]
G. G. VILENSKII Leningradskii Universitet, Vestnik, Matematika, Mekhanika, Astronomiia (ISSN 0024-0850), Jan. 1989, p. 50-54. In Russian. refs

Solutions to the plane and axisymmetric Laval nozzle problem that are linear with respect to the longitudinal coordinate are obtained for an arbitrary entropy function using the transonic approximation. The use of physical variables results in an accurate representation of the flow pattern for any form of entropy. It is found that the change of the position of the sonic line relative to the crticial section may differ significantly from the classical case for small accelerations. The importance of considering the characteristics of vortex flows in the modeling of nonisentropic problems is emphasized. V.L.

A89-38427
APPROXIMATE CALCULATION OF SUPERSONIC FLOW PAST BODIES OF REVOLUTION WITH A FRONT SEPARATION ZONE AT A SMALL ANGLE OF ATTACK [PRIBLIZHENNYI RASCHET SVERKHZVUKOVOGO OBTEKANIIA TEL VRASHCHENIIA S PEREDNEI SRYVNOI ZONOI POD NEBOL'SHIM UGLOM ATAKI]
E. F. ZHIGALKO Leningradskii Universitet, Vestnik, Matematika, Mekhanika, Astronomiia (ISSN 0024-0850), Jan. 1989, p. 58-61. In Russian. refs

A computational model based on a modified coarse-particle method is applied to the analysis of the restructuring of supersonic flow past bodies of revolution with a front separation zone at a small angle of attack. Details of the numerical solution are presented for a circular cylinder and an axisymmetric disk-cylinder configuration in the path of supersonic flow at a small angle of attack. V.L.

A89-38432
CONSIDERATION OF THE EFFECT OF SURFACE ROUGHNESS ON REGIME COEFFICIENTS IN LOCAL INTERACTION THEORY [UCHET VLIIANIIA SHEROKHOVATOSTI POVERKHNOSTI NA KOEFFITSIENTY REZHIMA V TEORII LOKAL'NOGO VZAIMODEISTVIIA]
V. D. KHABALOV Leningradskii Universitet, Vestnik, Matematika, Mekhanika, Astronomiia (ISSN 0024-0850), Jan. 1989, p. 80-83. In Russian. refs

A simple numerical method is proposed for calculating regime coefficients and aerodynamic characteristics of bodies in free molecular flow of a rarefied gas. To improve the accuracy of aerodynamic calculations, the effect of surface roughness of the body is considered under the assumption that reflection from a smooth surface conforms to local interaction theory. The results indicate that the method proposed here can be used for calculating the aerodynamic characteristics of bodies with an accuracy sufficient for practical applications. V.L.

A89-38435
DEPENDENCE OF REGIME COEFFICIENTS ON REGIME PARAMETERS IN LOCAL INTERACTION THEORY [ZAVISIMOST' KOEFFITSIENTOV REZHIMA V TEORII LOKAL'NOGO VZAIMODEISTVIIA OT PARAMETROV REZHIMA]
O. A. AKSENOVA Leningradskii Universitet, Vestnik, Matematika, Mekhanika, Astronomiia (ISSN 0024-0850), Jan. 1989, p. 100-102. In Russian.

The dependence of regime coefficients on regime parameters (Re number and temperature factor) is determined in the context of local interaction theory. A known approximation of the impulse flow based on experimental data is transformed for a simple model using a decomposition in terms of Legendre polynomials. As a result, the calculation of the aerodynamic characteristics and regime coefficients is simplified without any loss of accuracy. V.L.

A89-38437
NONSTATIONARY SUPERSONIC FLOW PAST A BODY [O NESTATSIONARNOM SVERKHZVUKOVOM OBTEKANII TELA]
V. I. BOGATKO and G. A. KOLTON Leningradskii Universitet, Vestnik, Matematika, Mekhanika, Astronomiia (ISSN 0024-0850), Jan. 1989, p. 104-106. In Russian.

The problem of flow past a body moving with a variable supersonic velocity in a stationary gas is investigated analytically. In particular, the effect of the initial conditions on the characteristics of flow past a wedge-shaped body is examined using the formalism of singular perturbation theory. V.L.

A89-38438
STABILITY OF GAS FLOWS IN LAVAL NOZZLES [USTOICHIVOST' TECHENII GAZA V SOPLAKH LAVALIA]
A. G. KUZ'MIN Leningradskii Universitet, Vestnik, Matematika, Mekhanika, Astronomiia (ISSN 0024-0850), Jan. 1989, p. 108-110. In Russian. refs

Results of a study of the stability of transonic gas flows with respect to infinitely small nonstationary perturbations of nozzle wall shape and conditions at the nozzle inlet section are presented. Attention is also given to transonic MHD flows; the stability of these flows against stationary perturbations is analyzed. V.L.

A89-38445

A STUDY OF SHOCK WAVE RADIATION NEAR MODELS AT HYPERSONIC VELOCITIES IN AIR [ISSLEDOVANIE IZLUCHENIIA UDARNOGO SLOIA OKOLO MODELEI, LETIASHCHIKH V VOZDUKHE S GIPERZVUKOVYMI SKOROSTIAMI]

N. N. BAULIN, O. V. ZVEREV, N. N. PILIUGIN, and S. G. TIKHOMIROV (Moskovskii Gosudarstvennyi Universitet, Moscow, USSR) Teplofizika Vysokikh Temperatur (ISSN 0040-3644), vol. 27, Mar.-Apr. 1989, p. 306-311. In Russian. refs

A method is proposed for measuring the brightness of gas emission at a wavelength of 0.63 microns in a ballistic experiment. Experimental data are presented on the brightness of air emission in a shock layer near models moving at velocities of 4-6 km/s. Good agreement is obtained between the calculated and measured spectral emissivities of air, making it possible to determine temperature in the shock layer with an accuracy to within 7 percent. V.L.

A89-38553*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

AN EXPERIMENTAL AND COMPUTATIONAL STUDY OF ROTOR-VORTEX INTERACTIONS

FRANCIS X. CARADONNA, ROGER C. STRAWN (NASA, Ames Research Center; U.S. Army, Aeroflightdynamics Directorate, Moffett Field, CA), and JOHN O. BRIDGEMAN (Woodside Summit Group, Inc., Mountain View, CA) Vertica (ISSN 0360-5450), vol. 12, no. 4, 1988, p. 315-327. refs

An experimental and computational study has been performed on a close rotor-blade/vortex interaction. Surface pressure data was obtained from a rotor operating close to the tip-vortex from an upstream wing in a wind tunnel. Data was obtained for a wide range of blade-vortex proximities, orientations, and blade-tip Mach numbers (up to the transonic regime). A numerical model of these interactions was constructed using the unsteady, three-dimensional, full-potential rotor code called FPR. The model employed an undistorted full-field representation of the measured vortex. This simple model gave excellent comparisons with the data for a wide range of conditions, including parallel head-on interactions. Computational studies have also been performed on the manner of vortex representation and the influence of vortex-core size. Author

A89-38555*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

ANALYTICAL MODELING OF HELICOPTER STATIC AND DYNAMIC INDUCED VELOCITY IN GRASP

DONALD L. KUNZ (NASA, Ames Research Center; U.S. Army, Aeroflightdynamics Directorate, Moffett Field, CA) and DEWEY H. HODGES (Georgia Institute of Technology, Atlanta) (University of Missouri-Rolla, International Conference on Mathematical Modelling, 6th, Saint Louis, MO, Aug. 4-7, 1987) Vertica (ISSN 0360-5450), vol. 12, no. 4, 1988, p. 337-344. Previously announced in STAR as N88-10777. refs

The methodology used by the General Rotorcraft Aeromechanical Stability Program (GRASP) to model the characteristics of the flow through a helicopter rotor in hovering or axial flight is described. Since the induced flow plays a significant role in determining the aeroelastic properties of rotorcraft, the computation of the induced flow is an important aspect of the program. Because of the combined finite-element/multibody methodology used as the basis for GRASP, the implementation of induced velocity calculations presented an unusual challenge to the developers. To preserve the modelling flexibility and generality of the code, it was necessary to depart from the traditional methods of computing the induced velocity. This is accomplished by calculating the actuator disk contributions to the rotor loads in a separate element called the air mass element, and then performing the calculations of the aerodynamic forces on individual blade elements within the aeroelastic beam element. Author

A89-38578

MORE HELICOPTER AERODYNAMICS

RAY W. PROUTY Peoria, IL, PJS Publications, Inc., 1988, 114 p.

A comprehensive introductory treatment is presented for the operating principles, aerodynamics, and prospective design developments of rotary-wing aircraft, with attention to the complex aerodynamic interactions that arise between helicopter propulsion system and airframe components in such distinct operational phases as hover, fast forward flight, and maneuvering. The peculiarities of helicopter piloting that these complex interactions give rise to are discussed. Evaluations are given of the impact on helicopter design and performance of such emerging factors as fly-by-wire, low military observability, CFD, advancing-plate concept coaxial rotors, and 'smart' control systems. O.C.

A89-38614* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

ESTIMATION OF AIRCRAFT AERODYNAMIC PARAMETERS FROM FLIGHT DATA

VLADISLAV KLEIN (NASA, Langley Research Center; George Washington University, Hampton, VA) Progress in Aerospace Sciences (ISSN 0376-0421), vol. 26, no. 1, 1989, p. 1-77. refs

Several ways for obtaining aerodynamic parameters of an aircraft from flight data are presented. A brief description of data analysis from steady measurements is given, and a concept of system identification is introduced. This is followed by a mathematical model of an aircraft with aerodynamic forces and moments approximated either by polynomials or splines and a detailed treatment of two often-used techniques for parameter estimation. Because of renewed interest in frequency-domain analysis, one section of the paper is devoted to this problem. The methods are demonstrated in several examples using real flight data. Author

A89-38620

PULSATING FLOW OVER AN ELLIPSE AT AN ANGLE OF ATTACK

D. S. MATHIOULAKIS and D. P. TELIONIS (Virginia Polytechnic Institute and State University, Blacksburg) Journal of Fluid Mechanics (ISSN 0022-1120), vol. 201, April 1989, p. 99-121. refs

(Contract AF-AFOSR-82-0228)

Two-component LDV measurements are obtained over an ellipse at an angle of attack. Detailed information is provided for the stagnation region, the two separation regions and the two free shear layers. Steady and unsteady flow measurements are presented. Periodic disturbances in the oncoming stream are introduced and ensemble-averaged unsteady data are obtained. An integral picture of laminar flow over a lifting body with no sharp edges is thus presented, which is readily available for comparison with asymptotic or numerical calculations. Author

A89-38624* Florida State Univ., Tallahassee.

ON THE THREE FAMILIES OF INSTABILITY WAVES OF HIGH-SPEED JETS

CHRISTOPHER K. W. TAM and FANG Q. HU (Florida State University, Tallahassee) Journal of Fluid Mechanics (ISSN 0022-1120), vol. 201, April 1989, p. 447-483. refs

(Contract NAG1-421; N0014-87-J-1130)

An analytical and computational study of the normal-mode small-amplitude waves of high-speed jets is presented. Three families of instability waves have been identified: (1) the familiar Kelvin-Helmholtz instability waves; (2) supersonic instability waves; and (3) subsonic waves. It is demonstrated that the computed wave patterns and propagation characteristics of these three wave types are consistent with the findings of Oetel (1979, 1980, 1982). The subsonic waves are shown to be unstable only for jets with mixing layers of finite thickness. R.R.

A89-38873
ISOTHERMAL FLOW IN A GAS TURBINE COMBUSTOR - A BENCHMARK EXPERIMENTAL STUDY
P. KOUTMOS and J. J. MCGUIRK (Imperial College of Science and Technology, London, England) Experiments in Fluids (ISSN 0723-4864), vol. 7, no. 5, April 1989, p. 344-354. Research supported by the Ministry of Defence. refs

An experimental investigation of the three-dimensional flow field within a water model of a can-type gas turbine combustion chamber is presented. Flow visualization demonstrated that internal flow patterns simulated closely those expected in real combustors. The combustor comprised a swirl driven primary zone, annulus fed primary and dilution jets and an exit contraction nozzle. LDA measurements of the three mean velocity components and corresponding turbulence intensities were obtained to map out the flow development throughout the combustor. Besides providing information to aid understanding of the complex flow events inside combustors, the data are believed to be of sufficient quantity and quality to act as a benchmark test case for the assessment of the predictive accuracy of computational models for gas-turbine combustors. Author

A89-38939
NOTE ON THE LIFTING-SURFACE PROBLEM FOR A CIRCULAR WING IN INCOMPRESSIBLE FLOW
J. BOERSMA (Eindhoven, Technische Universiteit, Netherlands) Quarterly Journal of Mechanics and Applied Mathematics (ISSN 0033-5614), vol. 42, Feb. 1989, p. 55-64. refs

The lifting-surface problem for thin circular wings in steady incompressible potential flow is investigated analytically, with a focus on the solution obtained using linearized theory by Hauptman and Miloh (1986). The derivation is examined in detail, and numerical results for a plane wing and a wing with parabolic camber are presented in tables. It is shown that the solution of Hauptman and Miloh does not rigorously satisfy the prescribed-wing-downwash boundary condition and hence represents only an approximate solution to the problem. T.K.

A89-39034*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
THREE-DIMENSIONAL NAVIER-STOKES SIMULATIONS OF TURBINE ROTOR-STATOR INTERACTION. I - METHODOLOGY
MAN MOHAN RAI (NASA, Ames Research Center, Moffett Field, CA) Journal of Propulsion and Power (ISSN 0748-4658), vol. 5, May-June 1989, p. 305-319. Previously cited in issue 20, p. 3143, Accession no. A87-45386. refs

A89-39035#
NAVIER-STOKES COMPUTATIONS OF TWO- AND THREE-DIMENSIONAL CASCADE FLOWFIELDS
KAZUHIRO NAKAHASHI (Osaka Prefecture, University, Sakai, Japan), OSAMU NOZAKI, KAZUO KIKUCHI, and ATSUHIRO TAMURA (National Aerospace Laboratory, Tokyo, Japan) Journal of Propulsion and Power (ISSN 0748-4658), vol. 5, May-June 1989, p. 320-326. Previously cited in issue 18, p. 2807, Accession no. A87-42381. refs

A89-39038*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
NUMERICAL SIMULATION OF FLOW THROUGH A TWO-STRUT SCRAMJET INLET
AJAY KUMAR (NASA, Langley Research Center, Hampton, VA) Journal of Propulsion and Power (ISSN 0748-4658), vol. 5, May-June 1989, p. 341-345. refs

A three-dimensional, Reynolds-averaged Navier-Stokes code has been used to numerically analyze flow through a two-strut, supersonic combustion ramjet (scramjet) inlet configuration. It solves the governing equations in full conservation form using either a fully explicit or explicit-implicit method. An algebraic, two-layer eddy-viscosity model is used for turbulent flow calculations. The analysis allows inclusion of end effects that are caused by the aft placement of the cowl on the underside of the inlet. A special grid has been developed to accommodate the struts embedded in the inlet flowfield. Detailed numerical results are presented here for the two-strut configuration, and a comparison is made with the available experimental results. Author

A89-39039#
EXPERIMENTAL INVESTIGATION OF SHOCK WAVE/BOUNDARY-LAYER INTERACTIONS IN AN ANNULAR DUCT
RICHARD D. STOCKBRIDGE (Johns Hopkins University, Laurel, MD) Journal of Propulsion and Power (ISSN 0748-4658), vol. 5, May-June 1989, p. 346-352. Previously cited in issue 07, p. 930, Accession no. A88-22199. refs
(Contract N00039-87-C-5301)

A89-39185*# Kansas Univ., Lawrence.
EXPERIMENTAL INVESTIGATION OF DYNAMIC GROUND EFFECT
PAI-HUNG LEE, C. EDWARD LAN, and VINCENT U. MUIRHEAD (Kansas, University, Lawrence) Journal of Aircraft (ISSN 0021-8669), vol. 26, June 1989, p. 497, 498. Previously announced in STAR as N88-12458.
(Contract NAG1-616)

A 60-degree delta wing, an F-106B, and an XB-70 model with and without flap deflections were tested in static and dynamic ground effect in the 36-by-51-inch subsonic wind tunnel at the University of Kansas. Dynamic ground effect was measured with movable sting support. For flow visualization, a tufted wire grid was mounted on the movable sting behind the model. Test results showed that lift and drag increments in dynamic ground effect were always lower than static values. Effect of the trailing edge flap deflections on lift increments was slight. The fuselage reduced the lift increments at a given ground height. From flow visualization under static conditions, the vortex core was seen to enlarge as the ground was approached. Author

A89-39187#
INFLUENCE OF PITCHING MOTION 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) Journal of Aircraft (ISSN 0021-8669), vol. 26, June 1989, p. 503-508. Previously cited in issue 09, p. 1193, Accession no. A87-24970. refs
(Contract AF-AFOSR-85-0158)

A89-39188#
NUMERICAL SIMULATION OF THE UNSTEADY WAKE BEHIND AN AIRFOIL
D. T. MOOK, S. ROY, G. CHOKSI, and B. DONG (Virginia Polytechnic Institute and State University, Blacksburg) Journal of Aircraft (ISSN 0021-8669), vol. 26, June 1989, p. 509-514. Research supported by the United Technologies Corp. Previously cited in issue 09, p. 1191, Accession no. A87-24934. refs
(Contract AF-AFOSR-85-0158)

A89-39189*# Flow Research, Inc., Kent, WA.
OPTIMIZING ADVANCED PROPELLER DESIGNS BY SIMULTANEOUSLY UPDATING FLOW VARIABLES AND DESIGN PARAMETERS
MAGDI H. RIZK (Flow Research, Inc., Kent, WA) Journal of Aircraft (ISSN 0021-8669), vol. 26, June 1989, p. 515-522. Previously cited in issue 16, p. 2593, Accession no. A88-40718. refs
(Contract NAS3-24855)

A89-39190*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
EFFECT OF SPATIAL WIND GRADIENTS ON AIRPLANE AERODYNAMICS
DAN D. VICROY and ROLAND L. BOWLES (NASA, Langley Research Center, Hampton, VA) Journal of Aircraft (ISSN 0021-8669), vol. 26, June 1989, p. 523-530. Previously cited in issue 07, p. 938, Accession no. A88-22437. refs

A89-39191*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

UNSTEADY TRANSONIC SMALL-DISTURBANCE THEORY INCLUDING ENTROPY AND VORTICITY EFFECTS

JOHN T. BATINA (NASA, Langley Research Center, Hampton, VA) (Structures, Structural Dynamics and Materials Conference, 29th, Williamsburg, VA, Apr. 18-20, 1988, Technical Papers. Part 1, p. 520-529) Journal of Aircraft (ISSN 0021-8669), vol. 26, June 1989, p. 531-538. Previously cited in issue 12, p. 1819, Accession no. A88-32232. refs

A89-39192*# Virginia Polytechnic Inst. and State Univ., Blacksburg.

EFFECTS OF SWIRL AND HIGH TURBULENCE ON A JET IN A CROSSFLOW

M. S. KAVSAOGLU and J. A. SCHETZ (Virginia Polytechnic Institute and State University, Blacksburg) Journal of Aircraft (ISSN 0021-8669), vol. 26, June 1989, p. 539-546. Research supported by NASA. refs

An experimental study has been conducted on the effects of initial swirl and high turbulence in the exhaust of a circular jet injected from a flat plate at a 90-deg angle into a crossflow. The different jet types studied were low-exit turbulence (3 percent), high-exit turbulence (over 10 percent), and 40 and 58 percent swirl. Surface pressure distributions and mean velocity vector plots were obtained for all of these cases. For the surface pressure distribution tests, the jet to crossflow velocity ratios R were 2.2, 4, and 8 for most of the jet types. For the mean velocity vector plots, R = 4 was chosen. Turbulence information in the jet plume was also obtained for the low-exit turbulence case at R = 4. The results showed that the higher-exit turbulence reduced the penetration height, and it also reduced the surface area influenced by negative pressures. The swirl-caused asymmetric pressure distributions and the swirl effects were more pronounced for lower-velocity ratios. Author

A89-39196*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

RIBLET DRAG AT FLIGHT CONDITIONS

MICHAEL J. WALSH, WILLIAM L. SELLERS, III, and CATHERINE B. MCGINLEY (NASA, Langley Research Center, Hampton, VA) Journal of Aircraft (ISSN 0021-8669), vol. 26, June 1989, p. 570-575. Previously cited in issue 16, p. 2597, Accession no. A88-40764. refs

A89-39197#

BUFFETING CRITERIA FOR A SYSTEMATIC SERIES OF WINGS

D. G. MABEY (Royal Aircraft Establishment, Bedford, England) Journal of Aircraft (ISSN 0021-8669), vol. 26, June 1989, p. 576-582. refs

In 1970, wind-tunnel measurements were made by NASA of the buffeting on a systematic series of 11 swept wings mounted on top of a simple fuselage. The wings generally had a quarter chord swept 35 deg and an aspect ratio of 6. The emphasis in the original program was on the variation in the onset of buffeting due to wide variations in the wing geometry. In the present paper, approximate criteria for the severity of buffeting have been derived from these measurements. These criteria provide a more complete picture of the effect of variations in wing geometry on the wing buffeting. Author

A89-39349

NUMERICAL STUDY OF TURBULENCE MODEL IN A SUPERSONIC NOZZLE

A. NEBBACHE (Universite des Sciences et de la Technologie, Algiers, Algeria), D. ZEITOUN, M. IMBERT, R. BRUN (Aix-Marseille I, Universite, Marseille, France), and C. BEGUIER (Institut de Mecanique Statistique de la Turbulence, Marseille, France) European Journal of Mechanics, B/Fluids (ISSN 0750-7240), vol. 8, no. 2, 1989, p. 143-161. refs

The compressible turbulent two-dimensional flow of gas in a convergent-divergent nozzle is numerically determined. The algebraic closure model of Baldwin and Lomax is used and includes two characteristic turbulent length scales which are well adapted for both supersonic and transonic flows. A modification of the second scale is discussed. The results show a better stability of the calculation with this modification which also does not alter the mean velocity field determination. Author

A89-39461#

NUMERICAL CALCULATIONS OF HYPERSONIC NONEQUILIBRIUM FLOW OVER A BLUNT WEDGE

JIANWEI SHEN and ZHANGHUA QU (National University of Defense Technology, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 10, Jan. 1989, p. A67-A69. In Chinese, with abstract in English. refs

A numerical method is used to compute the hypersonic, nonequilibrium, viscous shock-layer flow over a blunt wedge. A truncated series is used to develop the differential equations at the stagnation streamline. As a result, the initial value for the viscous shock-layer equations can be improved. The continuity equation and the transversal momentum equation are solved in a coupled way, so that the calculations can be matched with the solutions at far downstream of the planar blunt-bodies. The numerical results are given and compared with those from other methods. Author

A89-39462#

A COMPUTATIONAL METHOD OF AERODYNAMICS FOR SUBSONIC, FULLY UNSTEADY WINGS AT HIGH ANGLES OF ATTACK IN TIME-DOMAIN

ZHENGYIN YE, LINGCHENG ZHAO, and YONGNIAN YANG (Northwestern Polytechnical University, Xian, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 10, Jan. 1989, p. A70-A73. In Chinese, with abstract in English.

A potential difference method for computing the aerodynamic loads on wings in fully unsteady, subsonic, high angles of attack flows with leading-edge or side-edge separations is presented. For this type of nonlinear problems, the developed method can provide the time-varying aerodynamic loads and the velocity fields in time domains. The numerical results show in good agreement with experimental data. Author

A89-39473#

A PHYSICAL MODEL OF THE STREAMWISE CORNER VORTEXES IN A COMPRESSOR CASCADE

YANPING TNAG and FANG CHEN (Beijing University of Aeronautics and Astronautics, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 10, Feb. 1989, p. B36-B43. In Chinese, with abstract in English. refs

The flow visualization by means of smoke and measurement of a three-dimensional flow field are conducted to investigate a physical model of the streamwise corner vortices in a compressor cascade. The experimental results describe not only the flow pattern and structural characteristics, but also the interaction of the corner vortices with the blade surface boundary layers in the cascade. Based on this physical model, the mechanism has been discussed in which high losses are caused by the corner vortices. Author

A89-39474#

THE APPLICATION OF DYNAMIC SCHLIEREN-PHOTON CORRELATION TECHNIQUE TO A SUPERSONIC SHEAR LAYER

LIPING XU (Beijing University of Aeronautics and Astronautics, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 10, Feb. 1989, p. B44-B51. In Chinese, with abstract in English. refs

By applying the dynamic schlieren-photon correlation technique to a two-dimensional separated supersonic shear layer, the convection velocity of large eddies inside the shear layer and the frequency of the self-sustaining oscillation of the shear layer induced by the shedding of large eddies have been obtained. The distribution of the turbulence intensity inside the shear layer can also be estimated. It has been observed that the large eddies in a high speed shear layer possess some special features. It is shown that the method has potential in the measurement of high-speed complex flows. Author

A89-39666
LIFETIME AEROFOIL CALCULATIONS USING VON MISES VARIABLES
RONALD M. BARRON (Windsor, University, Canada) and R. K. NAEEM Communications in Applied Numerical Methods (ISSN 0748-8025), vol. 5, April 1989, p. 203-210. Research supported by NSERC. refs

A natural-streamline coordinate system has been developed for steady two-dimensional incompressible lifting-flow problems. Flow equations with appropriate boundary conditions are presented in terms of von Mises coordinates (x,psi), where psi is the stream function for the flow. The finite-difference method is used to discretize the nonlinear elliptic equation describing the flow. Favorable agreement with available results is obtained. Author

N89-21762*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
THE NASA LANGLEY LAMINAR-FLOW-CONTROL EXPERIMENT ON A SWEPT SUPERCRITICAL AIRFOIL: BASIC RESULTS FOR SLOTTED CONFIGURATION
CHARLES D. HARRIS, CUYLER W. BROOKS, JR., PATRICIA G. CLUKEY, and JOHN P. STACK Washington Jun. 1989 121 p
(NASA-TM-4100; L-16474; NAS 1.15:4100) Avail: NTIS HC A06/MF A01 CSCL 01A

The effects of Mach number and Reynolds number on the experimental surface pressure distributions and transition patterns for a large chord, swept supercritical airfoil incorporating an active Laminar Flow Control suction system with spanwise slots are presented. The experiment was conducted in the Langley 8 foot Transonic Pressure Tunnel. Also included is a discussion of the influence of model/tunnel liner interactions on the airfoil pressure distribution. Mach number was varied from 0.40 to 0.82 at two chord Reynolds numbers, 10 and 20 x 1,000,000, and Reynolds number was varied from 10 to 20 x 1,000,000 at the design Mach number. Author

N89-21764 Iowa State Univ. of Science and Technology, Ames.
PRIMITIVE NUMERICAL SIMULATION OF CIRCULAR COUETTE FLOW Ph.D. Thesis
JAN FRANCISZEK HASIUK 1988 104 p
Avail: Univ. Microfilms Order No. DA8825399

The azimuthal-invariant, 3-D cylindrical, incompressible Navier-Stokes equations are solved to steady state for a finite-length, physically realistic model. The numerical method relies on an alternating-direction implicit (ADI) scheme that is formally second-order accurate in space and first-order accurate in time. The equations are linearized and uncoupled by evaluating variable coefficients at the previous time iteration. Wall grid clustering is provided by a Roberts transformation in radial and axial directions. Subject to no-slip, Dirichlet boundary conditions, except for the inner cylinder rotation velocity (impulsive start-up) and zero-flow initial conditions, nonturbulent solutions are obtained for sub- and supercritical Reynolds numbers of 100 to 400 for a finite geometry where R sub outer/R sub inner = 1.5, H/R sub inner = 0.73 and H/delta R = 1.5. An axially-stretched model solution is shown to asymptotically approach the 1-D analytic Couette solution at the cylinder midheight. Flowfield change from laminar to Taylor-vortex flow is discussed as a function of Reynolds number. Three-dimensional velocities, vorticity and streamfunction are presented via 2-D graphs and 3-D surface and contour plots. A Prandtl-Van Driest turbulence model based on an effective isotropic eddy viscosity hypothesis was applied resulting in accurate 1-D turbulent flow solutions assuming long cylinders. A small aspect ratio correction factor was empirically determined. Comparisons to experiment are very good. Extending the nonturbulent analysis, 3-D turbulent flow equations are developed for Prandtl-Van Driest and energy-dissipation turbulence models. The energy-dissipation model includes corrections for streamline curvature, system rotation, and low-Re effects. Dissert. Abstr.

N89-21765 Cranfield Inst. of Tech., Bedford (England).
THE USE OF THE COLLEGE OF AERONAUTICS WHIRLING ARM FACILITY TO DETERMINE THE EFFECT OF FLOW CURVATURE ON THE AERODYNAMIC CHARACTERISTICS OF AN OGIVE-CYLINDER BODY Ph.D. Thesis
D. I. T. P. LLEWELYN-DAVIES 1987 430 p
Avail: Univ. Microfilms Order No. BRDX83492

The aerodynamic characteristics of a simple ogive-cylinder body was determined in two flow fields, one a straight flow as generated by a wind tunnel and the other a flow of constant curvature as generated by the whirling arm method of test. Theoretical estimates were made for both flow conditions for comparison with the experimental results. This thesis divides itself naturally into three parts: (1) the redesign of the College of Aeronautics Whirling Arm facility to make it suitable for the experimental work; (2) the tests in straight flow, (these showed that the afterbody normal-force loadings were very sensitive to conditions in the base region and that the high loadings present over the last 10 pct of the body length were not predicted by the theoretical method used although it predicted the loading distributions over the rest of the body reasonably well); and (3) the tests in curved flow, which showed that there were high positive normal-force loadings present over the afterbody at both positive and negative pitch angles resulting in both increased normal-force and a further aft position of the center of pressure as compared with the results obtained in straight flow. These features were not predicted by the analytical method used initially. However, it was found that the general level of the experimental afterbody loading distributions was predicted by two other analysis programs based on inviscid slender-body and linear theory respectively, with the linear theory loading predictions agreeing very closely with experiment over both the forebody and afterbody. Dissert. Abstr.

N89-21766 Maryland Univ., College Park.
UNSTEADY FORCE CALCULATIONS ON CIRCULAR CYLINDERS AND ELLIPTICAL AIRFOILS WITH CIRCULATION CONTROL Ph.D. Thesis
VENKATRAMAN RAGHAVAN 1988 184 p
Avail: Univ. Microfilms Order No. DA8818204

A numerical method is developed to study unsteady circulation control aerodynamics airfoils. Two cases of unsteadiness are considered: the unsteadiness arising from an unsteady, periodic freestream and the unsteadiness due to unsteady blowing momentum. A simple solution for the potential flow is obtained using conformal mapping. In unsteady flows, reversed flow is found to be possible even though flow separation has not taken place. The finite difference method uses backward differences whenever reversed flow is encountered. Also unsteady separation point was determined by detecting the singularity at the separation point. Potential flow and boundary layer and walljet calculations are combined in an iterative procedure to get a converged solution. The solution provides the velocity and pressure fields which is used to determine the lift and drag forces under given freestream and jet momentum conditions. Pressure distribution obtained from the potential flow is used to calculate the lift and the pressure drag forces. Wall shear data obtained from the boundary layer flow gives the skinfriction drag. Satisfactory correlation of predicted results with experimental data is achieved for steady lift over circular cylinders as well as elliptic airfoils. Substantial changes due to unsteady effects were observed for thick airfoils at large blowing and reduced frequencies. Unsteady effects are bound to be more significant for unsteadiness in the freestream velocity than for the unsteadiness in the blowing momentum. Dissert. Abstr.

N89-21767 Purdue Univ., West Lafayette, IN.
NUMERICAL SOLUTIONS OF UNSTEADY INVISCID TRANSONIC TURBINE CASCADE FLOWS Ph.D. Thesis
RICHARD MCCREA MOORE 1988 266 p
Avail: Univ. Microfilms Order No. DA8825564

A numerical analysis was developed to solve two-dimensional inviscid transonic turbine-type cascade flowfields. This analysis combines accuracy comparable to that of the numerical method of characteristics with the efficiency of finite difference methods. The MacCormack explicit finite difference method is used to solve the unsteady Euler equations. Steady solutions are calculated as asymptotic solutions in time. A conservation variable formulation of the Kentzer method was developed in this investigation and is used to derive appropriate equations for the flowfield boundaries. The Kentzer method is based on characteristic theory, but uses a finite difference method, consistent with the method used at interior points, to integrate the appropriate boundary equations. A grid generator was developed to create C-type grids around cascade blades using techniques similar to the Poisson equation grid generation techniques developed by Steger and Sorensen. Two different planar turbine-type cascades were studied. The AACE II cascade blades are typical of the nozzle blades found in the first stator in a turbine. The GMA 400 cascade blades are typical of later turbine stator blades. Numerical studies were performed with maximum Mach numbers in the flowfields ranging from 0.8 to 1.35. Numerical results are verified using experimentally measured blade surface static pressure data. A numerical method of characteristics cascade flow solver was developed to provide a relative standard for numerical results. The MacCormack code and the characteristics code produce very similar results and both are in excellent agreement with the experimental results.
Dissert. Abstr.

N89-21768*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
STATIC INTERNAL PERFORMANCE OF CONVERGENT SINGLE-EXPANSION-RAMP NOZZLES WITH VARIOUS COMBINATIONS OF INTERNAL GEOMETRIC PARAMETERS
E. ANN BARE and FRANCIS J. CAPONE Washington May 1989 106 p
(NASA-TM-4112; L-16535; NAS 1.15:4112) Avail: NTIS HC A06/MF A01 CSCL 01A

An investigation was conducted in the Static Test Facility of the Langley 16-Foot Transonic Tunnel to determine the effects of five geometric design parameters on the internal performance of convergent single expansion ramp nozzles. The effects of ramp chordal angle, initial ramp angle, flap angle, flap length, and ramp length were determined. All nozzles tested has a nominally constant throat area and aspect ratio. Static pressure distributions along the centerlines of the ramp and flap were also obtained for each configuration. Nozzle pressure ratio was varied up to 10.0 for all configurations. Author

N89-21769*# Cornell Univ., Ithaca, NY. School of Mechanical and Aerospace Engineering.
AERODYNAMICS OF ENGINE-AIRFRAME INTERACTION Final Report, 1-30 Oct. 1988
DAVID A. CAUGHEY 17 Apr. 1989 25 p
(Contract NAG2-373)
(NASA-CR-184824; NAS 1.26:184824) Avail: NTIS HC A03/MF A01 CSCL 01A

The development of the variational approach for the solution of inviscid aerodynamic problems using solution adaptive grids is discussed. The formulation of a new, directional weighting, functional has been shown to have desirable properties. The scheme has been applied to compute the transonic flow past two-dimensional airfoils using the Euler equations of inviscid, compressible flow. Transonic flows in quasi-one-dimensional nozzles and over the two dimensional airfoils are solved on the various solution-adaptive-grids to demonstrate the applicability of the proposed directional-concentration functional and the grid adaptation process from the stand point of improving the solution accuracy and demonstrating the overall convergence. Author

N89-21770 Manchester Univ. (England).
FLOW PAST BLUFF BODIES Ph.D. Thesis
MICHAEL BENSON 1987 168 p
Avail: Univ. Microfilms Order No. BRD83908

Various areas of research are examined concerning the flow of fluid past bluff shaped bodies. The use of boundary integral techniques was investigated for solving two-dimensional potential flow problems. The rate of convergence of various methods is examined by numerical experiments performed on a circle and an ellipse. The results are supported by detailed mathematical analysis and many of the conclusions are expected to apply to arbitrarily shaped bodies without corners. In particular it is shown that improvements in the rate of convergence of the straight line/constant source panel method formulation are possible without resort to a higher order source density approximation. It is important to note that in the case of bluff bodies, potential flow models bear little resemblance to the physical flow. The construction of viscous models using vortex methods was then investigated. It is believed that a major deficiency of such models was the simulation of diffusive effects. An alternative to the common random walk technique is developed and used to simulate both symmetric and asymmetric laminar flow past a circular cylinder. The solutions compare well with existing finite difference solutions. On a slightly different note, towing tank experiments designed to investigate the movement of the separation point on a circular cylinder for Reynolds numbers below 550 were described. In contrast with numerical results no oscillations of this separation point are observed. It is suggested that further experimental investigations may clarify this discrepancy. Dissert. Abstr.

N89-21771 Princeton Univ., NJ.
ORGANIZED STRUCTURES IN A SUPERSONIC TURBULENT BOUNDARY LAYER Ph.D. Thesis
ERIC FRANCIS SPINA 1988 251 p
Avail: Univ. Microfilms Order No. DA8827776

A supersonic, zero-pressure-gradient, flat plate turbulent boundary layer (M approximately equals 2.9, Re sub theta approximately equals 80000) was experimentally investigated. The emphasis of this work was to investigate the nature of the organized structures in supersonic turbulent boundary layers. The data were obtained from arrays of high-frequency response hot wires and wall-pressure transducers with streamwise, vertical, and spanwise spacings. Correlation methods were used to determine the time-averaged structure of the boundary layer, and conditional sampling techniques were used to probe the time-dependent behavior of the organized motions. Many characteristics of the large-scale organized structures in supersonic flow are revealed, including: the largest structures span the entire boundary layer and are inclined at an average angle of 45 to 60 deg with a wide distribution of individual structure angles, the spanwise extent of the structures is slightly smaller than the vertical extent, and the convection velocity of the structures is uniform across the boundary layer and approximately equal to 0.9 U sub infinity. The upstream interface of the large-scale structures is associated with a sharp streamwise mass-flux gradient and this interface is in turn associated with dominant shear stress motions within and behind the structure. A comparison of the turbulence characteristics in supersonic and subsonic flow indicates that although there are broad similarities there are also fundamental differences in the form which the large-scale structures assume. Dissert. Abstr.

N89-21772*# Sandia National Labs., Livermore, CA. Combustion Research Facility.
FEASIBILITY OF FLIGHT EXPERIMENTS AND INSTRUMENTATION HARDWARE FOR IN-FLIGHT HYPERSONIC BOUNDARY-LAYER MEASUREMENTS
R. J. CATTOLICA, R. L. SCHMITT, and R. E. PALMER Feb. 1989 66 p
(Contract NASA ORDER L-96920-B; DE-AC04-76DR-00789)
(NASA-CR-184896; NAS 1.26:184896; DE89-007943; SAND-89-8204) Avail: NTIS HC A04/MF A01 CSCL 01A

We have examined the feasibility of implementing nonintrusive optical diagnostics to measure the properties of the boundary layer surrounding a hypersonic vehicle. Measurements of density, temperature, location of the shock front, and N2, O2, and NO concentrations are feasible using electron-beam fluorescence, for which instrumentation appropriate for flight experiments already exists. In particular, NO will be a key indicator of the chemistry occurring at the vehicle nose and leading edges. Measurements of velocity and O2 and NO concentrations will be feasible using laser-induced fluorescence when rugged and reliable miniature UV laser sources become available; such laser sources should be developed in the next few years. Optical and sensor instrumentation for spectrally resolving the fluorescence along a line emanating from the vehicle and passing radially through the shock front is presently available. Laboratory and wind tunnel experiments will be required to develop the technology base needed to apply these advanced diagnostics. Nevertheless, experimental data acquired from these diagnostic methods, both in flight experiments and in wind tunnel tests, will be invaluable for validating computational fluid dynamics computer codes and for designing next-generation high-performance hypersonic flight vehicles. DOE

N89-21773# Sandia National Labs., Albuquerque, NM.
WAKE RECONTACT: AN EXPERIMENTAL INVESTIGATION USING A RINGSLOT PARACHUTE
JAMES H. STRICKLAND and J. MICHAEL MACHA 13 Jan. 1989 45 p
(Contract DE-AC04-76DP-00789)
(DE89-008320; SAND-88-3058) Avail: NTIS HC A03/MF A01

A series of tests was conducted on a 10-ft diameter ringslot parachute with a geometric porosity of 20 percent to establish the conditions under which wake recontact occurs. The vertical helicopter drop tests covered a range of mass ratios from 0.5 to 3.0 and a range of Froude numbers from 70 to 400. Data consisted of velocity time histories obtained using a laser tracker and diameter time histories obtained from photometric data. A collapse parameter based on the ratio of the maximum parachute diameter to the subsequent minimum diameter was correlated with the mass ratio M sub R and the Froude number Fr. This pair of similarity parameters was subsequently replaced by the equivalent pair M sub R and V sub o V sub t in order to provide more intuitive results (V sub o V sub t is the initial to final velocity ratio). For large values of V sub o V sub t the collapse parameter R sub C appears to be a function of M sub R alone. Non-dimensional opening time and collapse time data were also correlated with M sub R and V sub o V sub t. In addition, opening load factors C sub X were calculated from the data and plotted as a function of V sub o V sub t. DOE

N89-21774# Calspan-Buffalo Univ. Research Center, NY. Dept. of Physical Sciences.
STUDIES OF THE STRUCTURE OF ATTACHED AND SEPARATED REGIONS OF VISCOUS/INVISCID INTERACTION AND THE EFFECTS OF COMBINED SURFACE ROUGHNESS AND BLOWING IN HIGH REYNOLDS NUMBER HYPERSONIC FLOWS Final Report, 1 Aug. 1985 - 1 Jun. 1988
MICHAEL S. HOLDEN, R. BERGMAN, J. HARVEY, G. DURYEA, and J. MOSELLE 2 Dec. 1988 141 p
(Contract F49620-85-C-0130)
(AD-A204364; CUBRC-88682; AFOSR-89-0033TR) Avail: NTIS HC A07/MF A01 CSCL 01/1

The first of these 2 studies examined the detailed structure of the hypersonic boundary layer over a large cone/flare configuration. Emphasis was on development and use of instrumentation with which to obtain flow field measurements of the mean and fluctuating properties of the attached and separated shear layers. Development and use of holographic interferometry and electron beam techniques in the high Mach number and Reynolds number environment developed in the shock tunnel are described. In the second study, detailed measurements of heat transfer, pressure and skin friction were made on a unique blowing and roughness model constructed to simulate the aerothermal phenomena associated with a rough ablating maneuverable reentry vehicle. In the 2nd study emphasis was placed on development and use of unique heat transfer and skin friction instrumentation to obtain measurements of the combined effects of blowing and roughness and to understand how such effects influence boundary layer separation in regions of shock wave/boundary layer interaction. Each focused around providing information with which to construct and evaluate the modeling required in time-averaged Navier-Stokes equations to predict the structure of compressible hypersonic boundary layers in regions of strong pressure gradient, shock wave/boundary layer interaction and flow separation over smooth, rough and ablating surfaces. GRA

N89-21775# Computational Mechanics Co., Austin, TX.
ANALYSIS OF FLOW-, THERMAL- AND STRUCTURAL-INTERACTION OF HYPERSONIC STRUCTURES SUBJECTED TO SEVERE AERODYNAMIC HEATING Annual Technical Report No. 1, 1 Nov. 1987 - 1 Nov. 1988
J. T. ODEN and E. A. THORNTON 30 Nov. 1988 56 p
(Contract F49620-88-C-0001)
(AD-A205077; TR-88-12; AFOSR-89-0089TR) Avail: NTIS HC A04/MF A01 CSCL 20/13

This first annual report presents progress in the modelling of hypersonic fluid-thermal-structural interaction. In this phase of the effort, the basic mechanisms of heat transfer and fluid-structure interaction were identified. Mathematical models for heat transfer, structural deformation and fluid flow analysis were formulated. New unified viscoplastic theories were adapted for the modelling of complex visco-elasto-plastic structural deformation, with temperature-dependent material properties. A general procedure for the analysis of fluid-thermal-structure interaction was formulated, and relevant finite element codes were developed. These problems were applied in the solution of representative examples of thermo-structural analysis of structures subject to aerodynamic heating. GRA

N89-21777# Max-Planck-Institut fuer Stroemungsforschung, Goettingen (Germany, F.R.).
THE EVALUATION AND REPRESENTATION OF INTERFEROGRAMS OF TRANSONIC FLOW FIELDS Thesis [ZUR AUSWERTUNG UND DARSTELLUNG VON INTERFEROGRAMMEN TRANSSONISCHER STROEMUNGSFELDER]
HANS-HERMANN BARTELS Dec. 1987 76 p In GERMAN
(MPIS-21/1987; ISSN-0436-1199; ETN-89-93808) Avail: NTIS HC A05/MF A01; Max-Planck Inst. fuer Stroemungsforschung, Boettinger Strasse 6-8, 3400 Goettingen, Fed. Republic of Germany, DM 20

A system for the evaluation of experimental interferograms was further developed, and the possibilities of quasi-three-dimensional representation of the obtained flow fields were investigated. The system allows a largely automatic evaluation of the interferograms and interactive control to guarantee an error-free evaluation. The calculated fields can be represented using quasi-3-D techniques. Proposals for the production of higher quality interferograms are given. ESA

N89-22571# Jiaotong Univ., Shanghai (China).
UNSTEADY AERODYNAMIC COMPUTATIONAL METHOD OF NON-COPLANAR WING-TAIL COMBINATIONS IN SUBSONIC FLOW
JIGUANG AN, WENBO ZHOU, MING YAN, KANGYAN CHEN, XIANCHAI SUN, ZHEN YAN, and CHUANREN QIU (Shanghai Aircraft Co., China) 1987 12 p Sponsored by Institute of Scientific and Technical Information of China, Beijing
(PB89-111470; ISTIC-TR-C-000196) Avail: NTIS HC A03/MF A01 CSCL 01/1

An unsteady aerodynamic computational method is presented for 3-D non-coplanar wing-tail combination (namely, an airplane with horizontal tail plane located higher or lower than wing) at subsonic speed. The velocity potential function of unsteady vortex ring is chosen as an elementary solution of governing equation of flow field. The whole computational method follows strictly the physical mechanism of unsteady aerodynamic phenomenon, so it can be widely used in predicting those unsteady aerodynamic data needed in aircraft design and performance evaluation. Author

N89-22572 Stanford Univ., CA.
A NUMERICAL STUDY OF VISCOUS VORTEX RINGS USING A

SPECTRAL METHOD Ph.D. Thesis
SHARON KAY STANAWAY 1988 199 p
Avail: Univ. Microfilms Order No. DA8826238

Viscous, axisymmetric vortex rings are investigated numerically by solving the incompressible Navier-Stokes equations using a spectral method designed for this type of flow. The results presented are axisymmetric, but the method is developed to be naturally extended to three dimensions. The spectral method relies on divergence-free basis functions. The basis functions are formed in spherical coordinates using Vector Spherical Harmonics in the angular directions, and Jacobi polynomials together with a mapping in the radial direction. Simulations are performed of a single ring over a wide range of Reynolds numbers (Re is identical with gamma nu), 0.001 is less than or equal to Re is less than or equal to 1000, and of two interacting rings. At large times, regardless of the early history of the vortex ring, it is observed that the flow approaches a Stokes solution that depends only on the total hydrodynamic impulse, which is conserved for all time. At small times, from an infinitely thin ring, the propagation speeds of vortex rings of varying Re are computed and comparisons are made with the asymptotic theory by Saffman. The results are in agreement with the theory; furthermore, the error is found to be smaller than Saffman's own estimate by a factor of the square root of (nu t/r squared) (at least for Re=0). The error also decreases with increasing Re at fixed core-to-ring radius ratio, and appears to be independent of Re as Re approaches infinity. Following a single ring, with Re = 500, the vorticity contours indicate shedding of vorticity into the wake and a settling of an initially circular core to a more elliptical shape, similar to Norbury's steady inviscid vortices. Finally, the case of leapfrogging vortex rings with Re = 1000 is considered. The results show severe straining of the inner vortex core in the first pass and merging of the two cores during the second pass. Dissert. Abstr.

N89-22574*# Institute for Computer Applications in Science and Engineering, Hampton, VA.
THE INVISCID AXISYMMETRIC STABILITY OF THE SUPERSONIC FLOW ALONG A CIRCULAR CYLINDER Final Report
PETER W. DUCK (Manchester Univ., England) Feb. 1989 74 p
(Contract NAS1-18605; NAS1-18107)
(NASA-CR-181816; NAS 1.26:181816; ICASE-89-19) Avail: NTIS HC A04/MF A01 CSCL 01/1

The supersonic flow past a thin straight circular cylinder is investigated. The associated boundary layer flow (i.e., the velocity and temperature field) is computed; the asymptotic, far downstream solution is obtained, and compared with the full numerical results. The inviscid, linear, axisymmetric (temporal) stability of this boundary layer is also studied. A so called doubly generalized inflexion condition is derived, which is a condition for the existence of so called subsonic neutral modes. The eigenvalue problem (for the complex wavespeed) is computed for two freestream Mach numbers (2.8 and 3.8), and this reveals that curvature has a profound effect on the stability of the flow. The first unstable inviscid mode is seen to rapidly disappear as curvature is introduced, while the second (and generally the most important) mode suffers a substantially reduced amplification rate. Author

N89-22575# National Aeronautical Establishment, Ottawa (Ontario).
COMPARISON OF BOUNDARY LAYER TRIPS OF DISK AND GRIT TYPES ON AIRFOIL PERFORMANCE AT TRANSONIC SPEEDS
Y. Y. CHAN Dec. 1988 40 p
(AD-A205206; NAE-AN-56; NRC-29908) Avail: NTIS HC A03/MF A01 CSCL 21/1

The effects on aerodynamic performance of a supercritical airfoil applying disk or grit tripping for boundary layer transition has been investigated for a typical supercritical airfoil at transonic speeds. It is observed that by allowing the laminar flow passing through the space between the disks, transition takes place a short distance downstream from the disk trip line. The boundary layer developed downstream from disk trip is therefore slightly thinner than that from a grit trip. The vortex generating mechanism of the disks may also enhance this development. This small difference has negligible effect on aerodynamics of the airfoil at low lift. However, at high lift, the difference in boundary layer developments is amplified by the strong shock wave and the severe adverse pressure gradient. The thinner and more energetic boundary layer induced by the disk trip will yield higher lift, lower drag and higher trailing edge pressure. GRA

N89-22576# Sandia National Labs., Albuquerque, NM. Parachute Systems Div.
A PRELIMINARY CHARACTERIZATION OF PARACHUTE WAKE RECONTACT
JAMES H. STRICKLAND and J. MICHAEL MACHA 1989 8 p
Presented at the 10th AIAA Aerodynamic Decelerator Systems Technical Conference, Cocoa Beach, FL, 18 Apr. 1989
(Contract DE-AC04-76DP-00789)
(DE89-006442; SAND-88-3058C; CONF-8904118-3) Avail: NTIS HC A02

A series of tests was conducted on a 10 ft diameter ringslot parachute with a geometric porosity of 20 percent to establish the conditions under which wake recontact occurs. The vertical helicopter drop tests covered a range of mass ratios from 0.5 to 3.0 and a range of Froude numbers from 70 to 400. Data consisted of velocity time histories obtained using a laser tracker and diameter time histories obtained from photometric data. A collapse parameter based on the ratio of the maximum parachute diameter to the subsequent minimum diameter was correlated with the mass ratio M sub R and the Froude number Fr or equivalently with the initial to final velocity ratio V sub o/V sub t. For large values of V sub o/V sub t the collapse parameter R sub c appears to be a function of M sub R alone. Non-dimensional opening time and collapse time data were also correlated with M sub R and V sub o/V sub t. DOE

N89-22577*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
RECTANGULAR NOZZLE PLUME VELOCITY MODELING FOR USE IN JET NOISE PREDICTION
U. H. VONGLAHN 1989 36 p Presented at the 25th Joint Propulsion Conference, Monterey, CA, 10-12 Jul. 1989; sponsored by AIAA, ASME, SAE and ASEE
(NASA-TM-102047; E-4739; NAS 1.15:102047; AIAA-89-2357)
Avail: NTIS HC A03/MF A01 CSCL 01/1

A modeling technique for predicting the axial and transverse velocity characteristics of rectangular nozzle plumes is developed. In this technique, modeling of the plume cross section is initiated at the nozzle exit plane. The technique is demonstrated for the plume issuing from a rectangular nozzle having an aspect ratio of 6.0 and discharging into quiescent air. Application of the present procedures to a nozzle discharging into a moving airstream (flight effect) are then demonstrated. The effects of plume shear layer structure modification on the velocity flowfield are discussed and modeling procedures are illustrated by example. Author

N89-22578# Aeronautical Research Inst. of Sweden, Stockholm. Aerodynamics Dept.
COMPRESSIBLE EULER SOLUTION AROUND A WING CANARD STING CONFIGURATION
TORSTEN BERGLIND 12 Feb. 1988 33 p
(Contract FMV-FLYGFL-82260-88-061-73-001)
(FFA-TN-1988-62; ETN-89-94316) Avail: NTIS HC A03/MF A01

A patched multiblock grid around a 65 deg canard attached to a sting is constructed by transfinite interpolation. The wing-sting is enveloped by a C-O type grid with a polar singularity at the apex. The grid emanates from the wing-sting surface via axisymmetric surfaces, the first contiguous to the trailing edge of the canard, the second contiguous to the leading edge of the canard, and finally the farfield boundary. The grid contains 310,000 grid points. A multiblock Euler solver with a high degree of vectorization (MESCI) was used for the flow computations. The canard is treated as a slit, whereby the grid has to be divided into two blocks, since MESCI does not allow slits in the interior domain. Each time step requires 7.6 CPU seconds on a CYBER-205. The flow field is computed at 10 and 20 deg angle of attack at a free stream Mach number of 0.85. The transonic flow cases are both of high complexity, containing local shock waves and the interaction of the canard tip vortex and the delta wing vortex. The flow solver in conjunction with the grid system is able to capture the dominant flow phenomena such as the canard and delta wing vortices. The C sub p-distributions on the upper side of the wing agree reasonably well with measurements. ESA

N89-22579# Centre d'Etudes Aerodynamiques et Thermiques, Poitiers (France).
INTERACTION BETWEEN AN ISOLATED VORTEX AND A WING PROFILE Final Report [INTERACTION ENTRE UN TOURBILLON ISOLE ET UN PROFIL D'AILE]
Mar. 1988 67 p In FRENCH
(Contract DRET-85-092)
(ETN-89-94364) Avail: NTIS HC A04/MF A01

Wind tunnel measurements were carried out in a two-dimensional configuration. A reproducible vortex with an axis parallel to the profile is created by mechanical means in the subsonic wind tunnel. The measurements include the velocity fields with and without profile, the wall pressures, and the lift. Smoke flow visualization was also used. The viscous vortex structure is disintegrated when passing over the profile, and three-dimensional effects appear. The modification of the wall pressure field is most important near the leading edge. ESA

N89-22580# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Goettingen (Germany, F.R.). Abteiling Hochgeschwindigkeitsstroemungen.
TRANSONIC AND SUPERSONIC FLOW PAST A 65 DEG DELTA WING WITH ROUNDED LEADING EDGES: ANALYSIS OF EXPERIMENTAL DATA
KRISHNASWAMI YEGNA NARAYAN and KLAUS HARTMANN Sep. 1988 67 p
(DFVLR-FB-88-44; ISSN-0171-1342; ETN-89-94378) Avail: NTIS HC A04/MF A01; DFVLR, VB-PL-DO, Postfach 90 60 58, 5000 Cologne, Fed. Republic of Germany, DM 20.50

Data on a sweptback cropped delta wing with rounded leading edges over a Mach number range of 0.4 to 4, and from tests at Mach 0.85 over a Reynolds number range of 2.4 to 13 million (based on root chord) are discussed. It is shown that the first occurrence of leading edge separation can be determined from one of three (related) criteria: a sudden drop in the peak suction pressure on the leeside, a rapid inboard movement of the location of the suction peak, and a rapid inboard movement of the foot of the pressure rise following the suction peak. Fully attached flow, mixed flow and leading edge separated flow types are identified. Flow attachment at the rounded leading edge occurs at a lower Mach number compared to a wing with sharp leading edge. Leading edge separation on a wing with a drooped leading edge occurs at an angle of attack higher than in the undrooped case by an angle equal to the droop. An increase in Reynolds number causes leading edge separation to occur at higher angles of attack. ESA

N89-22581# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Goettingen (Germany, F.R.). Abteilung Instabilitaeten und Abloesung.
FLOW OVER A LEADING EDGE WITH DISTRIBUTED ROUGHNESS
JERZY M. FLORYAN and UWE DALLMANN Sep. 1988 52 p
(DFVLR-FB-88-45; ISSN-0171-1342; ETN-89-94379) Avail: NTIS HC A04/MF A01; DFVLR, VB-PL-DO, Postfach 90 60 58, 5000 Cologne, Fed. Republic of Germany, DM 19

Flow over a leading edge with distributed roughness (assumed to have small amplitude, which permits linearization of the governing equations) was analyzed. Explicit solutions are obtained in the limits of large and small wave numbers. Results show that roughness can produce modifications of the flow far away from the solid surface, while modifications of the temperature field are confined to within the thermal boundary layer. Surface stresses tend to eliminate roughness if erosion or wall flexibility are admitted. It is noted that heat flow tends to concentrate at the tips of the roughness. ESA

N89-22582# Aeronautical Research Inst. of Sweden, Stockholm. Aerodynamics Dept.
WIND TUNNEL TESTS OF 16 PERCENT THICK AIRFOIL SECTION WITH SPOILERS AT DIFFERENT CHORDWISE POSITIONS
ANDERS BJORCK Dec. 1988 44 p Sponsored by the Swedish National Energy Administration
(FFA-TN-1987-39; ETN-89-94544) Avail: NTIS HC A03/MF A01

Wind tunnel tests were carried out at low speeds on a 16 percent thick, moderately cambered airfoil section equipped with spoilers at 7 different chordwise positions on the forward half part of the airfoil. Two spoiler positions were on the pressure side, two at the leading edge, and three on the suction side of the airfoil. The effect of spoiler height was examined. The spoiler height varied between 2.5 to 12.5 percent of the airfoil chord. The results indicate that a spoiler on the airfoil suction side positioned 5 percent of the chord from the leading edge is capable of eliminating the strong driving tangential force of the basic airfoil for the entire range of positive angles of attack tested. ESA

N89-22583# Aeronautical Research Inst. of Sweden, Stockholm. Aerodynamics Dept.
THE INFLUENCE OF THE LEADING EDGE GEOMETRY ON THE WAVE DRAG FOR A 65 DEGREE DELTA WING AT LOW SUPERSONIC SPEED AND SMALL ANGLES OF ATTACK
TORSTEN BERGLIND, GEORG DROUGGE, and PETER ELIASSON 25 Oct. 1988 15 p Sponsored by the Defence Material Administration of Sweden, Stockholm
(FFA-141; ISSN-0081-5640; ETN-89-94550) Avail: NTIS HC A03/MF A01; Almgvist and Wiksell Booksellers, Printers, Publishers, Stockholm, Sweden, 100 Finnish marks

High speed wind tunnel tests were performed to validate the Euler code WINGA2 at supersonic speeds. As test cases, three 65 deg wings (so-called Euler wings) were used at $M=1.2$. The influence of the body on the flow over the wing was computed with the Euler code MESCI. The agreement between computations and experiments is good. Wing design problems were considered. The results show that rather blunt leading edges, drooped or not, can result in good drag performance at low lift and moderate supersonic speeds. Such geometry could be beneficial for the subsonic maneuvering case. ESA

N89-22584# Centre d'Etudes et de Recherches, Toulouse (France). Dept. d'Etudes et de Recherches en Aerothermodynamique.
SIDEWALL BOUNDARY LAYER STUDY, WITH AND WITHOUT SUCTION, FOR THE 150 MM CHORD CAST 7 AIRFOIL AT THE T2 WIND TUNNEL
J. B. DOR, J. P. ARCHAMBAUD, and J. F. BREIL Dec. 1987 105 p In FRENCH
(Contract PHASE-3075-AN-225-D)
Avail: NTIS HC A06/MF A01

Tests to investigate sidewall effects realized at the T2 transonic wind tunnel equipped with top and bottom adaptive walls are described. The model was the 150 mm chord CAST 7 airfoil tested with fixed transition at 0.5 deg angle of attack. The flow field was studied near the solid sidewall, above the downstream part of the model upper side and in the wake, at Mach number 0.705 and 0.755, utilizing directional boundary layer probing, static pressure measurements, and wall visualizations. Suction rate (q suction / q test section) of about 4/1000 was achieved on sidewalls, on the downstream part of the model upperside and around the trailing edge. The velocity distribution on the airfoil, the lift coefficient and the modifications of the sidewall boundary layers (measurements, visualizations) allowed the suction effect to be analyzed. Author

N89-22585 Georgia Inst. of Tech., Atlanta.
CONVERGENCE OF DISCRETE-VORTEX INDUCED-FLOW CALCULATIONS BY OPTIMUM CHOICE OF MESH Ph.D. Thesis
YIHWAN DANNY CHIU 1988 239 p
Avail: Univ. Microfilms Order No. DA8904804

A brief review of numerical solutions for the lifting thin-airfoil theories for both fixed-wing and rotary-wing problems is presented. Errors are noted in numerical calculations by conventional VORTEX LATTICE METHODS (VLM) for two-dimensional thin-airfoil, Lifting-Line, and Lifting-Surface theories. Emphasis is made on the optimum choice of mesh and collocation points for VLM to ensure that numerical results will converge and that this convergence will be as rapid as possible. The Fourier Series Method of Lifting-Line theory for fixed-wing problems is extended for rotary-wings problems. An efficient and accurate numerical technique is offered to calculate the induced velocities due to trailing vortices. Applications of these new findings are made in order to develop a simple tip-loss formula for lightly-loaded rotors with rectangular planforms. Dissert. Abstr.

N89-22586 Georgia Inst. of Tech., Atlanta.
AERODYNAMICS OF NONRIGID BODIES UNDERGOING LARGE AMPLITUDE TIME-DEPENDENT MOTIONS Ph.D. Thesis
JATINDER SINGH 1988 191 p
Avail: Univ. Microfilms Order No. DA8904829

A simplified zonal approach is described to evaluate unsteady aerodynamic forces on nonrigid bodies undergoing large amplitude time-dependent motions or deformations. It analyzes unsteady flow in the limit of high Reynolds numbers. The kinematic aspect of the incompressible viscous flows in the form of an integral representation for the velocity vector is utilized to determine the surface vortex sheet strength representing the vorticity content of the boundary layers. Wake is modeled by the vortex filaments and knowing the surface vortex sheet strength and the strengths and locations of the wake vortices, a viscous theory of aerodynamics is then used to evaluate the resulting unsteady aerodynamic forces. The simplified zonal approach is cast into two alternate formulations, namely, the conformal transformation approach and the boundary element approach. The conformal transformation approach allows for the explicit evaluation of the unsteady aerodynamic forces, while the boundary element approach can solve flows about arbitrary bodies. Using the simplified zonal approach, a number of problems were solved for flows around rigid and nonrigid bodies undergoing a variety of prescribed motions. For the bodies undergoing high frequency oscillations or deformations, even for small amplitude motions, well formed vortex clusters dominate the near wake. The movement of these vortex clusters and the time-dependent changes in the strength of the vortex sheets gives rise to the unsteady aerodynamic forces. Results obtained for some problems are compared with the theoretical and experimental results of other researchers and good quantitative agreement is observed. Dissert. Abstr.

N89-22587 Georgia Inst. of Tech., Atlanta.
A STUDY OF UNSTEADY TURBULENT FLOW PAST AIRFOILS Ph.D. Thesis
JIUNN-CHI WU 1988 213 p
Avail: Univ. Microfilms Order No. DA8904832

When a helicopter is in forward flight, the aerodynamics of the rotor blade is very complex. The rotor blade may have transonic flow on the advancing side and may experience dynamic stall on the retreating side. In order to predict the characteristics of above complex flow, a solution procedure must be able to predict the large separated flow, unsteadiness, compressibility effects, and turbulence characteristics. For this purpose, an efficient solution procedure solving the two-dimensional and quasi three-dimensional, unsteady, compressible Navier-Stokes equations were developed and applied to rotor blade sections. Specifically, this work addresses the following areas: (1) reliable prediction of static airloads and dynamic stall hysteresis loops for arbitrary airfoils; (2) investigation of yaw effects on the airload characteristics; (3) transonic and/or stall flutter characteristics; (4) evaluation of algebraic, one-equation and two-equation turbulence models for strongly separated flows. Numerical results show that good prediction of static loads and dynamic stall hysteresis loops of rotor blade sections was feasible. Yaw effects on airloads were predicted to be less profound than observed in experiments. The present solution procedure was found to be capable of predicting transonic and stall flutter. In attached flows the three turbulence models considered gave good correlation with experimental data. For steady or unsteady separated flows, the three turbulence models only exhibit fair correlation with experimental data. No clear trend could be found favoring the use of higher order turbulence models in separated flows. Dissert. Abstr.

N89-22588 Purdue Univ., West Lafayette, IN.
AERODYNAMIC DETUNING OF A LOADED AIRFOIL CASCADE IN AN INCOMPRESSIBLE FLOW BY A LOCALLY ANALYTICAL METHOD Ph.D. Thesis
HSIAO-WEI DAVID CHIANG 1988 268 p
Avail: Univ. Microfilms Order No. DA8900647

A mathematical model is developed and utilized to demonstrate the enhanced aeroelastic stability and forced response behavior associated with aerodynamic detuning of a rotor operating in an incompressible flow field. The validity of the tuned cascade model and solution technique are demonstrated by considering the steady and unsteady aerodynamics of both theoretical and experimental cascade configurations. To verify the detuned cascade model and influence coefficient technique, predictions from this model are compared to the steady theoretical results and also the tuned cascade unsteady aerodynamic model predictions. The capabilities of this detuned cascade model are then demonstrated by predicting the flutter stability and forced response behavior of detuned rotor configurations. Nonuniform circumferential airfoil spacing and alternate blade structural detuning are both shown to enhance stability. The greatest stability enhancement resulted from a combination of aerodynamic and structural detuning. Also, the unstable baseline configuration can be stabilized by the introduction of splitter blades. For the forced response behavior, both the alternate circumferential spaced detuning and the alternate blade structural detuning can be beneficial on the response amplitude of the airfoils. By including aspect ratio effects, the alternate splitter blade detuning results in significantly reduced amplitudes of response for most cases considered. In conclusion, this detuning analysis has demonstrated that both the aeroelastic stability and forced responsive behavior can be greatly enhanced by aerodynamic detuning. Therefore, aerodynamic detuning appears to be a viable passive control mechanism for aeroelastic problems of an incompressible cascade. Dissert. Abstr.

N89-22589# Georgia Tech Research Inst., Atlanta.
SUPERSONIC PARTICLE PROBES: MEASUREMENT OF INTERNAL WALL LOSSES Final Report, 10 Jun. 1986 - 10 Jun. 1988
J. J. IVIE, L. J. FORNEY, and R. L. ROACH Mar. 1989 106 p
(Contract F40600-86-K-0004)
(AD-A205863; AEDC-TR-88-37) Avail: NTIS HC A06/MF A01 CSCL 20/4

The operating characteristics of supersonic particle probes were investigated. The characteristics such as internal wall deposition, pressure recovery, and ease of operation and construction were examined. Three basic probe designs were tested in a cold flow experiment designed to simulate the hot, hostile environment of rocket and jet engine plumes. The probe designs consisted of two internal shock probes (Dehne and Colket probes) and one external shock probe (McGregor probe). In the internal shock probes, the compression from supersonic to subsonic flow occurred either in a constant area throat (Dehne) or at a sudden expansion (Colket). In the external shock, or McGregor probe the shock was positioned slightly outside the entrance of the probe. From deposition studies performed on the probes, three factors were found to enhance deposition. These factors were: (1) shock-boundary layer interaction, (2) particle-boundary layer interaction, and (3) stagnation zones at sudden expansions. The probe with the lowest deposition was a McGregor probe with a 2.0-deg divergence angle. Using test particles with diameters of 1.0, 1.5, 2.0, and 2.5 micron, the average losses in the McGregor probe were 14 percent, whereas in the Colket and Dehne probes, the losses were 18 and 22 percent, respectively. A correlation was developed to predict the deposition (E) in the McGregor probe using Willeke's dimensionless parameter (Omega): E = 1011 Omega + 1.55. GRA

N89-22590# Naval Postgraduate School, Monterey, CA.
COMPUTATIONAL INVESTIGATION OF INCOMPRESSIBLE AIRFOIL FLOWS AT HIGH ANGLES OF ATTACK M.S. Thesis
JOHN M. MATHRE Dec. 1988 158 p
(AD-A205885) Avail: NTIS HC A08/MF A01 CSCL 01/1

Cebeci's viscous/inviscid interaction program was applied to the analysis of steady, two dimensional, incompressible flow past four airfoils, the NACA 66 sub 3-018, 0010 (Modified), 4412 and the Wortmann FX 63-137. Detailed comparisons with the available experimental results show that the essential features are correctly modelled, but that significant discrepancies are found in regions of flow separations. GRA

N89-22830*# Stanford Univ., CA.
TRANSITION TO TURBULENCE IN LAMINAR HYPERSONIC FLOW
JAAP VANDERVEGT *In its* Annual Research Briefs, 1988 p 115-119 Feb. 1989
Avail: NTIS HC A08/MF A01 CSCL 01/1

Progress in a recently started project aimed at the prediction of transition to turbulence in hypersonic flow is briefly discussed. The prediction of transition to turbulence is a very important issue in the design of space vessels. Two space vehicles currently under investigation, namely the aeroassisted transfer vehicle (AOTV) and the trans-atmospheric vehicle (TAV), suffer from strong aerodynamic heating. This heating is strongly influenced by the boundary layer structure. These aerospace vehicles fly in the upper atmospheric layer at a Mach number between 10 and 30 at very low atmospheric pressures. At very high altitudes the flow is laminar, but when the space vessel returns to a lower orbit, the flow becomes turbulent and the heating is dramatically increased. The prediction of this transition process is commonly done by means of experiments. The experimental facilities available nowadays cannot model the hypersonic flow field accurately enough by limitations in Mach and Reynolds number. These facilities also have a large free stream disturbance level which makes it very difficult to investigate transition accurately. An alternative approach is to study transition by theoretical means. Up to now numerical studies of hypersonic flow only discussed steady laminar or turbulent flow. This theoretical approach is extended to the study of transition in hypersonic flow by means of direct numerical simulations and additional theoretical investigations to explain the mechanisms leading to transition. A brief outline of how this research is to be performed is given. Author

03

AIR TRANSPORTATION AND SAFETY

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

A89-36069
HUMAN FACTORS IN CABIN SAFETY
HELEN C. MUIR and CLAIRE MARRISON (Cranfield Institute of Technology, England) Aerospace (UK) (ISSN 0305-0831), vol. 16, April 1989, p. 18-21.

Safety factors which influence the number of survivors in an aircraft emergency are examined. The configurational, procedural, environmental, and behavioral factors (Snow et al., 1970), which affect the evacuation of an aircraft are discussed. An experimental evacuation simulation program is described, in which incentive payments were given to the first half of the participants evacuating the plane in order to simulate the competition which occurs during many emergencies. Various widths between galley units, seat pitches, and seat vertical projections were tested. Data concerning the behavior of passengers evacuating the plane was obtained from video cameras and questionnaires. Preliminary results showing the usefulness of the method are presented. R.B.

A89-36117
SUDDEN INFLIGHT INCAPACITATION IN GENERAL AVIATION
C. F. BOOZE, JR. (FAA, Civil Aeromedical Institute, Oklahoma City, OK) Aviation, Space, and Environmental Medicine (ISSN 0095-6562), vol. 60, April 1989, p. 332-335. refs

This study considered NTSB data and postcrash medical data received by the Medical Statistical Section of the Civil Aeromedical Institute (CAMI), Oklahoma City, OK from 1975-82, and other related literature to estimate the probability of incapacitation in general aviation. Data for the years studied indicate that approximately 3 accidents per 1000 (15 per 1000 fatal accidents) are known to result from the incapacitation of the pilot for all causes. Results suggest that the likelihood of incapacitation increases with age. The occurrence of incapacitation for obvious medical reasons is less than would be expected based on general population morbidity/mortality data; however, the need for continued vigilance in certification, and education regarding flying with known or suspected medical problems, is emphasized. Author

A89-36122
EXPERIENCES OF ROCKET SEAT EJECTIONS IN THE SWEDISH AIR FORCE - 1967-1987
PER SANDSTEDT (Forsvarets Forskningsanstalt, Stockholm, Sweden) Aviation, Space, and Environmental Medicine (ISSN 0095-6562), vol. 60, April 1989, p. 367-373. refs

From 1967 to 1987, there were 83 successful and 9 fatal ejections with Saab rocket seats in the Swedish Air Force. Medical consequences and injury factors are reviewed. Thirty-nine survivors had nontrivial injuries; four were seriously injured. The risk for injury has been approximately 50 percent throughout the period. Two-thirds of the survivors resumed flying within a week, the remainder after up to 1 year, except for three pilots who terminated their flying status. Author

A89-38878
THE AVIATION WIRE STRIKE PROBLEM - THE DUTY TO WARN OF THIS AERIAL HAZARD
PETER ANDREW WARRICK Journal of Air Law and Commerce (ISSN 0021-8642), vol. 54, Spring 1989, p. 857-887. refs

Legal issues related to the aircraft safety hazard posed by wires such as transmission or power lines is examined. Federal regulations dealing with wire strike litigation are discussed, including the problem of determining whether or not the aircraft striking the wire was operating in navigable airspace and the question of whether or not aerial wires are sufficiently hazardous obstructions to warrant the costs of disclosure. Aviation wire strike cases against utility companies and the federal government are reviewed. Also, consideration is given to defenses used in such cases, such as the suggestion that a utility company has no duty to warn pilots about the presence of aerial wires and the argument that the primary responsibility to avoid obstructions rests with the pilot. Finally, proposals for resolving aviation wire strike conflicts are presented. R.B.

A89-39088
COMING TO TERMS WITH TCAS
JOHN BAILEY Flight International (ISSN 0015-3710), vol. 135, April 15, 1989, p. 40-42.

The certification of the U.S. Traffic Alert and Collision-Avoidance System, or 'TCAS', is expected to occur towards the end of 1989; by January 1, 1992, every large transport aircraft operating in U.S. airspace, foreign and domestic, will have to incorporate TCAS.

If the prospective collision-target aircraft has a mode S transponder with datalink capability, the TCAS computers aboard both aircraft will coordinate a complementary vertical-avoidance maneuver. Still under development is a further refinement of TCAS to yield mutual-avoidance maneuvers in the horizontal plane. Airlines with financial or cash-flow constraints may lose substantial revenue if they are unable to outfit their entire fleet with TCAS by 1992. O.C.

A89-39200#
CALCULATED AND EXPERIMENTAL STRESSES IN SOLID AND RING SLOT PARACHUTES
WILLIAM L. GARRARD and MICHAEL L. KONICKE (Minnesota, University, Minneapolis) Journal of Aircraft (ISSN 0021-8669), vol. 26, June 1989, p. 590-592. Research supported by Sandia National Laboratories. Previously cited in issue 03, p. 291, Accession no. A87-13815. refs

A89-39224
ACCIDENT INVESTIGATION AND THE PUBLIC INTEREST - A PILOT'S VIEW
RUSSELL F. KANE (International Federation of Air Line Pilots' Associations and Airline Pilots' Association of Japan, Accident Investigation Seminar, Tokyo, Oct. 6, 1988) Zeitschrift fuer Luft- und Weltraumrecht (ISSN 0340-8329), vol. 38, March 1989, p. 3-20.

New trends in the application of Paragraph 3.1 of Annex 13 (Aircraft Accident Investigation) to the Chicago Convention are discussed. The paragraph states that: 'The fundamental objective of the investigation of an accident or incident shall be the prevention of accidents and incidents. It is not the purpose of this activity to apportion blame or liability.' The historical background to this Annex is reviewed, and the problem of conflicting and sometimes simultaneous inquiries into the same accident is considered. The problems which arise in a world which appears increasingly prepared to involve pilots in the processes of the criminal and civil laws are addressed. C.D.

N89-21778 Purdue Univ., West Lafayette, IN.
DYNAMICS AND CONTROL OF TRUSS STRUCTURES WITH EXTENDING MEMBERS Ph.D. Thesis
RONG TYAI WANG 1988 137 p
Avail: Univ. Microfilms Order No. DA8900749

The effectiveness of using extendable truss members to tailor the vibrational characteristics of large truss structures is investigated. In contrast to the conventional control of structures using actuators mounted externally on the structure, the use of extendable truss members allows one to vary the control force internally, and, thus, achieve a change in natural frequencies and damping factors. If the actuator in the extendable member reacts to the member force instantaneously, then a negative gain will give rise to a stiffening effect and damping effect is also magnified. Explicit relations between the apparent structural stiffness and damping factor are derived in this study. If there is a delayed response in the actuator, then the gain must be chosen positive in order to achieve dynamic stability of the system. Further, the value of the gain must be less than unity. It is found that delay-time can be used most effectively to provide significant damping effect. Power transmission through a cell with extendable members is also studied. The power loss of a wave passing through this cell is found to depend highly on the modes of wave and on its wavelength. The potential use of the extendable members in the cells at the boundary of the structure is also investigated. For a wave with given frequency, it is possible to design the internal control force to completely absorb the energy of the incident wave. For large truss structures consisting of repeating identical cells, the dynamic characteristics can be found from the typical cell. A simple procedure is presented to derive natural frequencies of large structures from a single cell characteristics. Dissert. Abstr.

N89-21779# Aeronautical Systems Div., Wright-Patterson AFB, OH.
GROUND COLLISION WARNING SYSTEM PERFORMANCE CRITERIA FOR HIGH MANEUVERABILITY AIRCRAFT Final Report
DIANE S. SHAH 1 Dec. 1988 31 p
(AD-A204390; ASD-TR-88-5034) Avail: NTIS HC A03/MF A01 CSCL 01/4

Controlled flight into terrain (CFIT) constitutes a large category of Class A mishaps. CFIT occurs when the pilot's attention is diverted in a controllable aircraft resulting in impact with the ground. Warning systems which provide aural warning of impending CFIT have existed in commercial aircraft for some time. Because tactical aircraft operate at low altitudes and have high performance capabilities, systems for commercial aircraft have not proven suitable for tactical aircraft. Due to differences in missions, sensors, hardware configurations, performance capability, etc., each warning system developed for a tactical aircraft will be unique. This report presents performance criteria for use in developing a ground collision warning system for tactical aircraft. GRA

N89-21780# Simula, Inc., Phoenix, AZ.
THE NAVAL AIRCRAFT CRASH ENVIRONMENT: AIRCREW SURVIVABILITY AND AIRCRAFT STRUCTURAL RESPONSE Final Report, Sep. 1982 - May 1988
JOSEPH W. COLTMAN and STEPHEN M. ARNDT 9 Sep. 1988 100 p
(Contract N62269-82-C-0275; F41-400)
(AD-A204825; TR-88490; NADC-88106-60) Avail: NTIS HC A05/MF A01 CSCL 01/2

A study was conducted of U.S. Navy and Marine Corps flight mishaps occurring during the 10-year period of January 1972 to December 1981. One hundred eighty-four helicopter mishaps and 71 maritime aircraft (fixed-wing aircraft without ejection seats) mishaps were examined. Each flight mishap was reconstructed to determine orientation and velocity of the aircraft during the principal impact. Statistical distributions of impact parameters were tabulated for mishaps determined to be survivable. In addition, occupant injuries in each mishap were examined and a hazard which contributed to the injury was assigned. The cost of injuries associated with each hazard were identified and used as criteria for ranking the severity of the hazards. It was found that a significant number of major and fatal injuries occur in helicopter flight mishaps classified as survivable. The hazards which contribute to many of these injuries could be reduced in future helicopter designs through the incorporation of current crashworthiness design criteria (which was not imposed on the fleet examined in this study). A similar analysis of injuries and hazards in maritime aircraft flight mishaps indicates that selective use of crashworthy components would be beneficial; however, adoption of a crashworthiness specification to govern an entire aircraft design does not appear to be justifiable by the injury and cost statistics. GRA

N89-21781# Federal Aviation Administration, Atlantic City, NJ. Technical Center.
DESCRIPTION OF THE DERIVATION OF THE COLLISION RISK MODEL USED IN THE VERTICAL SEPARATION SIMULATION RISK MODEL
JOSEPH M. RICHIE Feb. 1989 20 p
(AD-A205109; DOT/FAA/CT-TN88/38) Avail: NTIS HC A03/MF A01 CSCL 17/7

This report presents a brief description of the derivation of the collision risk equations for the use on the vertical separation Midair Collision Simulation Risk Model. It also describes the estimation of the Collision Risk Model parameters for the current 2000-foot standard and the proposed 1000-foot planned vertical separation standard. The model itself consist of specialized computer programs and systematic procedures that realistically and economically simulate aircraft flight-planned movements in the National Airspace System (NAS). These aircraft movements are based on flight plans and tracking data transmitted to Central Flow Control Facility (CFCF) from all the 20 centers that make up the NAS. The task is to find the frequency, Na, with which a pair of aircraft flying at and above flight level (FL)290 would, by flight-planned intent, be proximate (near each other) in the NAS. The purpose of this mathematical model is to make a quantitative judgement about the safety of the proposed 1000-foot vertical separation, and provide an estimate of the risk of midair collision due to the loss of 1000-foot planned vertical separation. As the result of this first phase of the study, it is recommended that the model be enhanced to do the following: (1) step climbing, and (2) point-to-point navigation. GRA

N89-22591# Office of Technology Assessment, Washington, DC.

SAFE SKIES FOR TOMORROW: AVIATION SAFETY IN A COMPETITIVE ENVIRONMENT

Jul. 1988 194 p

(PB89-114318; OTA-SET-381; LC-88-600550) Avail: NTIS HC A09/MF A01; also available SOD HC $8.50 as 052-003-01126-3 CSCL 01/3

How well existing safety policies, regulations and technologies meet the government's responsibility for ensuring safety in commercial aviation are assessed and the role and capability of FAA to carry out its function are reviewed. Author

N89-22592# Sandia National Labs., Albuquerque, NM. Parachute Systems Div.

TESTING OF A NEW RECOVERY PARACHUTE SYSTEM FOR THE F111 AIRCRAFT CREW ESCAPE MODULE: AN UPDATE

DONALD W. JOHNSON 1989 7 p Presented at the 10th AIAA Aerodynamic Decelerator Systems Technical Conference, Cocoa Beach, FL, 18 Apr. 1989

(Contract DE-AC04-76DP-00789; AF PROJ. SM-MMK-87-10-324) (DE89-007139; SAND-89-0410C; CONF-8904118-4) Avail: NTIS HC A02/MF A01

A new recovery parachute system has been designed for the F111 crew escape module (CEM). The system includes a cluster of three 49 ft diameter ringslot-solid parachutes, a Kevlar deployment bag, and an explosively fired drogue gun to deploy the pilot parachute. Tests have been conducted that indicate the parachute system will meet the rate of descent requirement of 25 ft/sec at 5000 ft pressure altitude. To control the drag load developed by the parachutes, a new central reefing/disreefing system has been developed. Since the recovery parachute system is normally deployed crosswind from the CEM, line sail of the suspension lines during early tests was a problem but has been minimized by a dual pilot parachute system. DOE

N89-22593# National Transportation Safety Board, Washington, DC.

AIRCRAFT ACCIDENT REPORT: TRANS-COLORADO AIRLINES, INC., FLIGHT 2286, FAIRCHILD METRO 3, SA227 AC, N68TC BAYFIELD, COLORADO, JANUARY 19, 1988

4 Feb. 1989 91 p

(PB89-910401; NTSB/AAR-89/01) Avail: NTIS HC A05/MF A01 CSCL 01/3

About 1920 mountain standard time on January 19, 1988, N68TC, a Trans-Colorado Airlines Inc., Fairchild Metro 3, operating as a Continental Express flight 2286 from Stapleton International Airport, Denver, Colorado, with 2 flightcrew members and 15 passengers on board, crashed on approach to Durango, Colorado. The two flightcrew members and seven passengers were killed as a result of the accident. The National Transportation Safety Board determines that the probable cause of this accident was the first officer's flying and the captain's ineffective monitoring of an unstabilized approach which resulted in a descent below the published descent profile. Contributing to the accident was the degradation of the captain's performance resulting from his use of cocaine before the accident. The safety issues examined include the execution of a special approach by flightcrews and the effects of cocaine on human performance. Author

N89-22594# Wichita State Univ., KS. Inst. for Aviation Research.

ELECTRO-IMPULSE DE-ICING RESEARCH: FATIGUE AND ELECTROMAGNETIC INTERFERENCE TESTS Final Report

G. W. ZUMWALT, R. A. FRIEDBERG, and J. A. SCHWARTZ Mar. 1989 64 p

(DOT/FAA/CT-88/27) Avail: NTIS HC A04/MF A01

Electro-Impulse DeIcing (EIDI) was recently developed and tested with very encouraging results. Questions remain, however, regarding the fatigue life and electromagnetic compatibility of the system. Fatigue tests were conducted on two production aluminum wing leading edges and one composite material leading edge. These were done at realistic temperatures and impulse energies for an estimated aircraft lifetime of ice protection. Coil mounting brackets were the main casualties. Wing components did not fail. Tests were also conducted for metal and composite wings of electromagnetic radiation of EIDI over a wide frequency range. The aluminum wing was found to be an excellent shield. All wires external to the aluminum wing were shown to require careful shielding. The composite wing required all wiring and the metal doublers to be shielded and grounded. Author

04

AIRCRAFT COMMUNICATIONS AND NAVIGATION

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

A89-36592

AVSAT - THE FIRST DEDICATED AERONAUTICAL SATELLITE COMMUNICATIONS SYSTEM

D. K. DEMENT (Aeronautical Radio, Inc., Annapolis, MD) IN: International Conference on Satellite Systems for Mobile Communications and Navigation, 4th, London, England, Oct. 17-19, 1988, Proceedings. London, Institution of Electrical Engineers, 1988, p. 73-77.

ARINC has taken steps to establish a global aeronautical satellite communication system. Plans call for initiation of thin-route dataoperations in 1989, upgrading to establish voice communications via shared spot-beam transponders carried on other satellites, and deploying a worldwide network using dedicated satellites in the mid 1990's. Spectrum availability and system design considerations are assessed, and AvSat link budgets are examined. B.J.

A89-36594

TECHNICAL DESIGN AND PERFORMANCE ANALYSIS OF AERONAUTICAL SATELLITE COMMUNICATION SYSTEMS

Y. YASUDA, M. OHASHI, F. SUGAYA, and Y. HIRATA (Kokusai Denshin Denwa Co., Ltd., Tokyo, Japan) IN: International Conference on Satellite Systems for Mobile Communications and Navigation, 4th, London, England, Oct. 17-19, 1988, Proceedings. London, Institution of Electrical Engineers, 1988, p. 87-91. refs

The technical design aspects of aeronautical satellite communcation systems are highlighted, and the system performance is analyzed taking the Inmarsat system parameters into account. The bit interleaving size and the link budget are examined. In addition, the BER improvement by concatenated FEC coding using Reed-Solomon (RS) outer code is evaluated, and the parameters of RS codes, which can markedly reduce the BER without symbol interleaving at the Viterbi decoder output, are proposed. B.J.

A89-36595

FIELD TRIALS OF AERONAUTICAL SATELLITE COMMUNICATION SYSTEM

F. MAKITA, H. NAKAMURA, S. KASHIWABARA (Kokusai Denshin Denwa Co., Ltd., Tokyo, Japan), K. KOSAKA (Ministry of Posts and Telecommunications, Communication Research Laboratory, Koganei, Japan), K. MAEKITA (Japan Air Line, Co., Ltd. Tokyo) et al. IN: International Conference on Satellite Systems for Mobile Communications and Navigation, 4th, London, England, Oct. 17-19, 1988, Proceedings. London, Institution of Electrical Engineers, 1988, p. 92-96. refs

Several field trials and demonstrations of aeronautical satellite communications for aviation authority, airline, and passenger use, employing the Inmarsat space segment, have been conducted and planned in recent years. The experimental system used for the field trials consists of 9.6 kbit/s APC-MLQ, a rate 1/2 FEC codec using Viterbi decoding, and an interleaver. The field tests of the aeronautical satellite communication system were conducted in accordance with Inmarsat specifications, and the feasibility of the system was verified. B.J.

A89-36596
COLLABORATIVE EXPERIMENTS INVOLVING A SATELLITE BASED DATA LINK FOR AIR TRAFFIC SERVICES
G. A. COOKE (Civil Aviation Authority, London, England) and M. E. COX (EUROCONTROL, Brussels, Belgium) IN: International Conference on Satellite Systems for Mobile Communications and Navigation, 4th, London, England, Oct. 17-19, 1988, Proceedings. London, Institution of Electrical Engineers, 1988, p. 102-106.

The paper describes experiments devised by the UK Civil Aviation Authority (CAA) and Eurocontrol involving a satellite-based data link for air traffic services. The CAA's main interest is in satellite communications and surveillance to support air traffic services for aircraft flying over the North Atlantic region, while Eurocontrol's main interest is in the transition region between oceanic and continental airspace. B.J.

A89-36618
COMMUNICATION AND RANGING SYSTEMS FOR NAVIGATION EXPERIMENT USING ENGINEERING TEST SATELLITE V
A. ISHIDE (Ministry of Transport, Electronic Navigation Research Institute, Mitaka, Japan) IN: International Conference on Satellite Systems for Mobile Communications and Navigation, 4th, London, England, Oct. 17-19, 1988, Proceedings. London, Institution of Electrical Engineers, 1988, p. 222-226.

The communication and ranging systems for a navigation experiment using ETS-V are described. The system equipment was designed to give voice and data communication as well as ranging capabilities using small aircraft antennas. The expected characteristics were obtained in the laboratory test. K.K.

A89-38513
FUNDAMENTALS OF THE MAINTENANCE OF THE RADIO-ELECTRONIC EQUIPMENT OF AIRCRAFT [OSNOVY EKSPLUATATSII RADIOELEKTRONNOGO OBORUDOVANIIA LETATEL'NYKH APPARATOV]
KONSTANTIN I. PAVLENKO Moscow, Voennoe Izdatel'stvo, 1988, 168 p. In Russian. refs

The fundamental principles of the maintenance and repair of the radio-electronic equipment of aircraft are presented in a systematic manner. The discussion covers the concepts and characteristics of the reliability of radio-electronic equipment and factors affecting reliability; analysis of the technical condition of radio-electronic equipment; diagnostics and failure prevention; and technical aspects of flight reliability. Attention is also given to the organization and technical aspects of the maintenance and repair of the radio-electronic equipment of aircraft. V.L.

A89-39203
INTERFEROMETRY AGAINST DIFFERENTIAL DOPPLER - PERFORMANCE COMPARISON OF TWO EMITTER LOCATION AIRBORNE SYSTEMS
N. LEVANON (Tel Aviv University, Israel) IEE Proceedings, Part F: Radar and Signal Processing (ISSN 0143-7070), vol. 136, pt. F, no. 2, April 1989, p. 70-74.

A comparative random error analysis of two airborne systems that provide the location of a stationary emitter is presented. Both systems utilize only two airborne receivers. In the interferometric system, the separation between the receivers (baseline) is of the order of one wavelength, and the phase measurements yield bearing measurements. In the differential Doppler system, the baseline can extend to the full length of the aircraft, and phase measurements yield accumulated range difference. Both systems employ the Gauss-Newton iterative algorithm to obtain an unbiased least-squares estimate of the emitter location. Simple analytical expressions are obtained for the random error of both systems when the observation section is centered near the point of closest approach. Results of Monte Carlo computer simulations are also presented which confirm the theoretical error expressions. Author

A89-39500#
FORMULATION OF GAIN AND IMPEDANCE RELATIONS FOR CORNER REFLECTORS EMPLOYED IN CONJUNCTION WITH LOCALIZER ANTENNA ARRAYS
M. C. CHANDRA MOULY, P. S. K. SATYA PRASAD (VRS Engineering College, Vijayawada, India), and V. V. RAM PRASAD Institution of Engineers (India), Journal, Electronics and Telecommunication Engineering Division (ISSN 0251-1096), vol. 68, May 1988, p. 54-58. refs

Equations which can be used to compute the gain, and mutual and effective impedances of 90 and 60 deg conventional corner reflectors and a 60 deg truncated corner reflector are presented. Sine and cosine integrals were used. The values obtained for gain and impedance for 90 deg conventional corner reflectors agreed with published values. K.K.

A89-39827
AIRCRAFT AUTOMATIC LANDING SYSTEMS USING GPS
B. W. PARKINSON and K. T. FITZGIBBON (Stanford University, CA) Journal of Navigation (ISSN 0373-4633), vol. 42, Jan. 1989, p. 47-59. refs

An account is given of the design and simulation of an aircraft automatic landing system employing state-of-the-art carrier-tracking GPS receivers to measure aircraft position and velocity. The capability hypothesized has its basis in measurements taken on a five-channel receiver in an integrated Doppler-aiding mode. In some of the autopilot designs considered, either ground-based GPS transmitters or a radar altimeter was incorporated. The landing simulations encompassed wind shears and a gust model for the sake of realism; lateral and vertical displacement performance figures are presented with their 10 rms estimation errors during the glide-slope and flare phases. O.C.

A89-39829
AUTOMATIC CONFLICT DETECTION LOGIC FOR FUTURE AIR TRAFFIC CONTROL
S. RATCLIFFE Journal of Navigation (ISSN 0373-4633), vol. 42, Jan. 1989, p. 92-106. refs

The development of techniques for the construction of very reliable hardware, as well as of verifiable software, is underway for automatic ATC flight path conflict-resolution detection. A simple, brute-force computer-simulation exploration of trajectories has proven capable of revealing that the worst-case performance of the threat detector can be substantially poorer than would be expected from the values assigned to the logic parameters, or from an analysis that proceeds from the assumption that the threat aircraft is proceeding along a straight-line path. O.C.

A89-39830
BENEFITS OF 'AREA NAVIGATION' IN REGIONAL AVIATION
D. M. WALLACE (U.S. Institute of Navigation, Annual Meeting, Annapolis, MD, June 1988) Journal of Navigation (ISSN 0373-4633), vol. 42, Jan. 1989, p. 124-128.

The present evaluation of the development status of aircraft area-navigation systems, or 'RNAV', as encountered in 'hub and spoke' route operations, notes that such regional carriers as Air Ontario can simultaneously improve service and lower costs by employing RNAV. The bases for these performance improvements are improved cross-track and along-track navigation, less maneuvering in the departure and arrival phases of flights, the use of vertical navigation to optimize altitude, and the alternative use of either separate access or simultaneous converging approaches, as well as independent departure profiles. O.C.

N89-21782# National Aeronautical Establishment, Ottawa (Ontario).
AN INVESTIGATION OF LATERAL TRACKING TECHNIQUES, FLIGHT DIRECTORS AND AUTOMATIC CONTROL COUPLING ON DECELERATING IFR APPROACHES FOR ROTORCRAFT
S. BAILLIE, S. KERELIUK, and R. HOH Oct. 1988 63 p
(AD-A202910; NAE-AN-55; NRC-29604) Avail: NTIS HC A04/MF A01 CSCL 01/3

An in-flight simulation experiment was performed to investigate the impact on handling qualities and certification of various issues associated with low minima decelerating flight directed IFR approaches for rotorcraft. These issues were the use of crab versus sideslip techniques to maintain lateral tracking under crosswind conditions, the effects of various methods of vertical axis (glideslope) display, guidance and control, and the benefits of coupling flight director signals directly to the rotorcraft control actuators. The program was performed using the NAE Bell 205 Airborne Simulator and was partially funded by the United States Federal Aviation Administration. Experimental results demonstrated that crab technique approaches were satisfactory for all approach speeds and wind conditions investigated (up to 30-knot crosswinds). A factor not addressed in this study was the visual orientation of the landing pad at breakout to flight with visual references. Sideslipping approaches were also shown to be satisfactory until the steady state lateral acceleration exceeded approximately 0.07 G. While coupling of the collective actuator directly to the flight director provided the best glideslope tracking, evaluations showed that the configuration with A 2-cue (pitch and roll) flight director, using only a raw glideslope presentation, provided satisfactory handling qualities and was considered by FAA single DOT representative to be certifiable for IFR flight. GRA

N89-21783# Federal Aviation Administration, Atlantic City, NJ. Technical Center.
INSTRUMENT LANDING SYSTEM MATHEMATICAL MODELING STUDY FOR ORLANDO INTERNATIONAL AIRPORT RUNWAY 17R LOCALIZER, ORLANDO, FLORIDA, REVISED AIRSIDE DOCKING PLAN (SCHEME 3A)
JAMES D. RAMBONE and JOHN E. WALLS Nov. 1988 33 p
(AD-A204722; DOT/FAA/CT-TN89/1) Avail: NTIS HC A03/MF A01 CSCL 01/5

Upon the completion of a preliminary modeling effort described in Technical Note DOT/FAA/CT-TN88/35, ILS Mathematical Modeling Study for Orlando International Airport Runway 17R, ASO-430 provided a final version of an airside ramp utilization plan (Scheme 3A) for the Orlando Airport. This necessitated an additional modeling effort due to changes in aircraft docking arrangements, the addition of taxiing aircraft, and a Delta ramp operations control tower. Computed data are presented showing the effects of airside terminals with simulated docked and taxiing aircraft on the performance of an ILS localizer proposed for runway 17R at the Orlando International Airport. The Southern Region is concerned that reflections from two proposed airside terminals with docked and taxiing aircraft may degrade the localizer course beyond category 2/3 tolerances. Modeled course structure results indicate that marginal category 2/3 localizer performance should be obtained with the Wilcox Mark 3, 14-element, dual-frequency log periodic antenna and both airside terminals with docked and taxiing aircraft at the currently proposed locations, excluding aircraft taxiing parallel to the runway. Category 2/3 course structure results are not obtained when the parallel taxiing aircraft are included in the reflecting source configuration. Computed clearance orbit results indicate satisfactory linearity, course crossover, and signal clearance levels. GRA

N89-21784# Mitre Corp., McLean, VA.
A PROCEDURE FOR OPERATING DEPENDENT INSTRUMENT APPROACHES TO CONVERGING RUNWAYS
BERNARD LISKER Sep. 1988 67 p
(Contract DTFA01-84-C-0001)
(AD-A204723; MTR-88W125; DOT/FAA/DS-88/09) Avail: NTIS HC A04/MF A01 CSCL 17/7

This report introduces an air traffic control procedure that allows two staggered streams of aircraft, flying under Instrument Flight Rules (IFR), to approach and land on converging runways. The staggered arrivals provide adequate separation assurance between aircraft in the event of consecutive missed approaches. Unlike existing converging approach procedures, the new procedure allows Decision Heights (DHs) down to 200 feet, yielding arrival capacity improvements from 4 to 63 percent over single-runway operations. The report discusses currently approved converging approach procedures, their advantages and limitations, as well as the motivation for developing a new procedure. The new procedure is explained in detail and a 17-airport benefit analysis is included. That analysis concludes that the procedure introduced here can be implemented advantageously at several airports. GRA

N89-21785# Carnegie-Mellon Univ., Pittsburgh, PA. Software Engineering Inst.
FUNCTIONAL PERFORMANCE SPECIFICATION FOR AN INERTIAL NAVIGATION SYSTEM Final Report
B. C. MEYERS and NELSON H. WEIDERMAN Oct. 1988 48 p
(Contract F19628-85-C-0003)
(AD-A204850; CMU/SEI-88-TR-23; ESD-TR-88-024) Avail: NTIS HC A03/MF A01 CSCL 17/7

This document defines the functional and performance requirements for the inertial navigation system simulator that interfaces with the external computer system (ECS) simulator. Both the INS simulator and the ECS simulator are being developed in Ada by the Real-Time Embedded Systems Testbed Project. The INS simulator is similar to a real-world InS, but has reduced functionality. This document provides specifications for the major functions on the INS simulator. GRA

N89-22595# Civil Aeromedical Inst., Oklahoma City, OK.
STUDIES OF POSTSTRIKE AIR TRAFFIC CONTROL SPECIALIST TRAINEES. PART 2: SELECTION AND SCREENING PROGRAMS
CAROL A. MANNING, PAMELA S. KEGG, and WILLIAM E. COLLINS Jul. 1988 25 p
(AD-A199177; DOT/FAA/AM-88/3) Avail: NTIS HC A03/MF A01

Specific contributions of aviation psychologists to the selection and Academy training of FAA air traffic control specialists are presented in a historical context. Research results which formed the basis for the written aptitude selection tests, The Occupational Knowledge Test (for assessing prior experience), and the pass/fail screens for the Academy's nonradar and radar programs are noted. Results of continuing validation research on all aspects of these selection/screening programs are presented in detail as well as the means by which the results are used to: (1) predict training and performance outcomes; (2) model the impact of program changes; (3) allow the introduction of changes (improvements) without compromising the validity of the programs; and (4) assure compliance with the Uniform Guidelines on Employee Selection Procedures. The application of this line of research has produced considerable cost benefits to the agency. Author

N89-22596# Federal Aviation Administration, Washington, DC.
NATIONAL AIRSPACE SYSTEM PLAN: FACILITIES, EQUIPMENT, ASSOCIATED DEVELOPMENT AND OTHER CAPITAL NEEDS
Jun. 1988 364 p
(AD-A202615; AD-E900870) Avail: NTIS HC A16/MF A01 CSCL 01/4

This is the sixth annual update of the NAS Plan. The Plan addresses the compelling problems of how best to improve safety and efficiency, accommodate spiraling demands for aviation services, deal with the problems of aging or obsolete facilities, recognize and users desires for minimal restrictions on the use of the airspace, allow for a reduced Federal role, and create a foundation for continued evolution which exploits newer technologies and developments obtained through continuing research. The recurring theme throughout the Plan is that the solution lies in greater use of automation, consolidations of major facilities, and application of cost effective technological solutions. Topics of interest included in this update follow: Demand on the System; Air Traffic Control System - En Route, Terminal, and Flight Service and Weather; Ground-to-Air Systems; Interfacility Communications Systems; Maintenance and Operations Support Systems; Other Capital Needs; and Transition. GRA

N89-22598# Service Hydrographique et Oceanographique de la Marine, Paris (France). Section Geodesie-Geophysique.
GEODETIC POSITIONING SYSTEM FOR FLYING AIRCRAFT (MAY 1987) [POSITIONNEMENT GPS D'UN AVION EN VOL (MAI 1987)]
GILDAS COZIAN Nov. 1988 49 p In FRENCH
(REPT-013/88; ETN-89-94358) Avail: NTIS HC A03/MF A01

Flight tests were performed in on a Caravelle aircraft to evaluate a geodetic positioning system. A Strada laser trajectographic system furnished a precision submetric reference used to evaluate the real time geodetic position values and the same after differential data treatment. The tests show that the receiver allows in real time to determine the position of a flying aircraft with a three-dimensional precision better than 50 m. After differential treatment the precision is 5 m. ESA

05

AIRCRAFT DESIGN, TESTING AND PERFORMANCE

Includes aircraft simulation technology.

A89-36575
V-22 PREPARED FOR FURTHER EXPANSION OF FLIGHT ENVELOPE
CAROLE A. SHIFRIN Aviation Week and Space Technology (ISSN 0005-2175), vol. 130, April 10, 1989, p. 34-36, 40.

The initial test sequences of the V-22 'Osprey' tilt-rotor VTOL aircraft have been sucessfully performed in the helicopter-hover mode during nine separate flights totaling 2.3 hours. The flight envelope will now be expanded to a 60-kt airspeed and a ground taxi speed of 40 kt. The first three flights were limited to a speed of 20 kt at 30-ft altitude. The complete process of initial envelope expansion is expected to take 20-40 weeks, while incorporating modifications and revising test instrumentation. The next major step in the process will be the expansion of the 'airplane' operation envelope, with the nacelles pointed fully forward. O.C.

A89-36899* *National Aeronautics and Space Administration.* Ames Research Center, Moffett Field, CA.
HELICOPTERS AND VTOL. I
JOHN S. BURKS (NASA, Ames Research Center, Moffett Field, CA) Exxon Air World (ISSN 0014-5068), vol. 41, no. 1, 1989, p. 39-41.

Performance projections into the next half-century of VTOL aircraft design are presently made on the basis of recent design trends. Attention is given to the technology-development and commercial prospects for tilt-rotor, thrust-vectoring hover, lighter-than-air, and speculative electromagnetic-propulsion, remotely-beamed power systems. Highly automated air traffic control systems are envisioned which will incorporate AI, satellite positioning, synthetic vision, obstacle detection/avoidance and fiber-optic transmission to safely manage giant airborne mass-transit commuter systems. It is expected that tilt-rotor aircraft will become the dominant VTOL configuration as time passes. O.C.

A89-37019#
COMPUTER SIMULATION OF THE MOVEMENT OF LOADING DOOR RETRACTION MECHANISM WITH SLIDE TRACKS
DEKANG XIE and ZHENGPING WANG (Northwestern Polytechnical University, Xian, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 9, Dec. 1988, p. B645-B647. In Chinese, with abstract in English.

The movement of loading door retraction mechanism with slide track of an airplane is investigated. The mathematical model is established on the basis of selected geometrical parameters of the mechanism. The retracting movement of the loading door is simulated on a digital computer with the coordinates of the moving points computed step by step. The process of retraction is displayed on the screen for the examination of the fulfillment of design requirements. Adjustment of parameters can be made if necessary during the computation. Author

A89-37650#
GUST ANALYSIS OF AN AIRCRAFT WITH HIGHLY NON-LINEAR SYSTEMS INTERACTION
G. VINNICOMBE (Cambridge University, England), M. HOCKENHULL, and A. E. DUDMAN (British Aerospace, PLC, Civil Aircraft Div., Filton, England) AIAA, ASME, ASCE, AHS, ASC, Structures, Structural Dynamics and Materials Conference, 30th, Mobile, AL, Apr. 3-5, 1989. 8 p. refs
(AIAA PAPER 89-1377)

A new method of continuous turbulence Design Envelope Analysis is presented which is equivalent to existing techniques for a linear aircraft model but is also appropriate to nonlinear aircraft models. Rice's equation for level exceedence rates of a stationary, Gaussian, stochastic process is used to define a nonlinear aircraft design gust load and a procedure for estimating this load is developed. This method has recently been used for certification of the Airbus A320, which incorporates a nonlinear gust load alleviation system, and some resuls of this analysis are presented in order to illustrate the technique. Author

A89-37660
PASSENGER SEAT DESIGN COMMERCIAL TRANSPORT AIRCRAFT
SAE Aerospace Recommended Practice, SAE ARP 750, Nov. 19, 1987, 9 p. refs
(SAE ARP 750)

Design criteria beyond the minimum standards set down in FAR which are conducive to the formulation of seat structural designs furnishing the greatest safety margins for airliner passengers are discussed. Illustrative of these design practices is the requirement that seats equipped with integral food-tray tables will, during emergency landings, allow such a structure, in fully open position, to fail upon the exertion of a certain amount of loading in a way that does not expose occupants to any sharp points or edges. Underseat baggage restraint systems must prevent baggage from becoming loose articles prone to entering the aisles. O.C.

A89-38028
PREDICTION OF FATIGUE LIFE UNDER AIRCRAFT LOADING WITH AND WITHOUT USE OF MATERIAL MEMORY RULES
A. BUCH (Technion - Israel Institute of Technology, Haifa) International Journal of Fatigue (ISSN 0142-1123), vol. 11, March 1989, p. 97-105. refs

The use of correction factors in loading distributions to improve the accuracy of fatigue life predictions is described. Consideration is given to aircraft wing maneuver and gust loading programs as well as to the effect of reference stress, notch geometry, loading order, and loading spectrum modifications. It is found that application of conventional material memory rules in LSA1 (cycle-by-cycle calculation) does not reduce the scatter of N(pred)/N(exp) ratios in comparison to LSA2 (block-by-block counting). K.K.

A89-38498
OPTIMIZATION OF FLIGHT REGIMES ACCORDING TO ECONOMIC CRITERIA (2ND REVISED AND ENLARGED EDITION) [OPTIMIZATSIIA REZHIMOV POLETA PO EKONOMICHESKIM KRITERIIAM /2ND REVISED AND ENLARGED EDITION/]
STANISLAV IU. SKRIPNICHENKO Moscow, Izdatel'stvo Mashinostroenie, 1988, 153 p. In Russian. refs
The economic foundations of the optimization of flight regimes are presented, and cost criteria are described. The structure of operating costs for different flight regimes (cruising, ascending and descending, and maneuvers) is examined. Algorithms are presented for determining optimal regimes and the influence of various operating and economic factors, including aircraft weight, wind, air temperature, and fuel costs. Calculation examples are presented. B.J.

A89-38554* Princeton Univ., NJ.
EXPERIMENTAL STUDIES IN SYSTEM IDENTIFICATION OF HELICOPTER ROTOR DYNAMICS
ROBERT MCKILLIP, JR. (Princeton University, NJ) Vertica (ISSN 0360-5450), vol. 12, no. 4, 1988, p. 329-336. refs
(Contract NAG2-415)
Recent experiments investigating the system identification of helicopter rotor dynamics are described. The identification makes use of a two-pass procedure that estimates the rotor dynamic states prior to estimation of the dynamic equation parameters. Estimation of the rotor states is made possible through use of the predictive information contained in blade-mounted accelerometers combined with a specialized processing scheme utilizing these signals. Descriptions of the experimental hardware and the system identification technique are given, as well as implementation issues for using the procedure on other similarly instrumented rotor blades. Finally, comparisons with other identification techniques using the same data are presented. It is demonstrated that the approach is an attractive one for measurement of a helicopter rotor's dynamic behavior. Author

A89-38652
EXTENSION OF CLASSICAL TIP LOSS FORMULAS
DAVID A. PETERS and YIH-WAN CHIU (Georgia Institute of Technology, Atlanta) American Helicopter Society, Journal (ISSN 0002-8711), vol. 34, April 1989, p. 68-71. Research sponsored by the U.S. Army. refs
The differences between various tip loss formulas are examined and a new unified tip loss formula that is reasonable over the entire range of rotor parameters is presented. The assumptions of Prandtl's analytic solution are modified to obtain a more general tip loss formula that includes the effects of wake spacing and aspect ratio in a consistent manner for all values of the normalized wake spacing and normalized chord. The formula can be expressed in two equivalent ways. K.K.

A89-39086
COMPOSITES - HELICOPTERS LEADING THE WAY
JAMES H. BRAHNEY Aerospace Engineering (ISSN 0736-2536), vol. 9, May 1989, p. 19-26.
Helicopter manufacturers have aggressively developed composite structural components in order to capitalize on the ability to fabricate large, integral components requiring few fasteners, as well as to take advantage of the tailoring of material mechanical property characteristics that different reinforcement types and directions, in conjunction with a variety of matrices, can furnish. Important structural components now widely produced from polymer-matrix composites are primary rotor blades and bearingless hubs, driveshafts, tail rotors, and airframes. Illustrative examples of prepreg tape layup and large structure autoclaving processes are discussed. O.C.

A89-39193*# Wichita State Univ., KS.
ELECTROIMPULSE DEICING - ELECTRODYNAMIC SOLUTION BY DISCRETE ELEMENTS
W. D. BERNHART and R. L. SCHRAG (Wichita State University, KS) Journal of Aircraft (ISSN 0021-8669), vol. 26, June 1989, p. 547-553. Previously cited in issue 07, p. 945, Accession no. A88-22016. refs
(Contract NAG3-284)

A89-39194*# Toledo Univ., OH.
TWO-DIMENSIONAL SIMULATION OF ELECTROTHERMAL DEICING OF AIRCRAFT COMPONENTS
W. B. WRIGHT, T. G. KEITH, JR., and K. J. DE WITT (Toledo, University, OH) Journal of Aircraft (ISSN 0021-8669), vol. 26, June 1989, p. 554-562. Previously cited in issue 07, p. 946, Accession no. A88-22208. refs
(Contract NAG3-72)

A89-39198#
WING-STORE FLUTTER ANALYSIS OF AN AIRFOIL IN INCOMPRESSIBLE FLOW
ZHI-CHUN YANG and LING-CHENG ZHAO (Northwestern Polytechnic University, Xian, People's Republic of China) Journal of Aircraft (ISSN 0021-8669), vol. 26, June 1989, p. 583-587. refs
The flutter of two-dimensional airfoil with external store is analyzed to investigate the effects of pylon stiffness on flutter speed. Among the 40 configurations studied, five were tested in the wind tunnel to verify the analytical results. The variations of wing-store flutter speed with the pylon stiffness can basically be divided into three types. The curves of the normal and flutter frequencies vs pylon stiffness have the same pattern. They can be sketched approximately by the aid of the normal frequencies of the two degenerated two-degree-of-freedom systems, i.e., the freely hinged and rigidly connected store cases. A limiting flutter speed for very small pylon stiffness is deduced, which is useful to identify which type of flutter the configuration studied belongs to. Author

A89-39199#
FLUTTER ANALYSIS OF THE CF-18 AIRCRAFT AT SUPERSONIC SPEEDS
B. H. K. LEE (National Research Council of Canada, Ottawa) Journal of Aircraft (ISSN 0021-8669), vol. 26, June 1989, p. 588-590. Research supported by DND. refs
The 'harmonic gradient' and 'source distribution' methods for supersonic aircraft aerodynamic computation are presently compared for the cases of an F-18 wing surface pressure distributions and NASTRAN computation-based mode shape flutter behavior. For rigid-body modes, good agreement is obtained in pressure distributions except for high reduced frequencies near the wingtip. Agreement is also established between the two aerodynamic methods' flutter results. O.C.

A89-39226
GOOD PROSPECTS FOR LET'S 40-SEATER
BRIAN WANSTALL Interavia (ISSN 0020-5168), vol. 44, April 1989, p. 321-323.
The Czechoslovak commercial aircraft manufacturer LET is scheduled to begin delivering the L-610 twin-turboprop 40-seat commuter airliner in 1991; the 40 new aircraft on order from the Czechoslovak national airline, CSA, will take the place of the current fleet of less fuel-efficient Yak-40 airliners. The L-610 will incorporate air conditioning, cabin pressurization, an APU, and high-pressure hydraulics. The powerplant chosen for the L-610 is the three-spool, two-stage centrifugal compressor Motorlet M602 turboprop, producing 1360 kW. This engine's fuel consumption is 18 percent lower than that of the smaller (19-seat) L-410 airliner. O.C.

A89-39234
USAF/LOCKHEED F-117A HAS HIGH WING SWEEP BUT LOW WING LOADING
MICHAEL A. DORNHEIM Aviation Week and Space Technology (ISSN 0005-2175), vol. 130, May 1, 1989, p. 27.
The highly swept F-117A stealth fighter's wing has an aspect ratio of about 1.9 (based on its gross area), which probably penalizes its aerodynamic efficiency but may significantly reduce

radar cross-sections when viewed from some aspects. The extreme sweep angle may also allow the aircraft to be fitted into the C-5 airlifter for overseas deployment. Even though the F-117A is unlikely to have good high-lift performance, its large wing area yields a wing loading of 45 lb/sq ft, for a relatively benign stall speed. The aircraft uses two F404 engines without afterburner, and is estimated to have a thrust/weight ratio of 0.65, assuming a maximum weight of 34,000 lb. O.C.

A89-39259
SIMULATION OF OPTIMAL FLIGHT PATHS OF DYNAMICAL SOARING FLIGHT AND THE DESIGN OF A MODEL AIRCRAFT [SIMULATION OPTIMALER FLUGBAHNEN DES DYNAMISCHEN SEGELFLUGS UND AUSLEGUNG EINES MODELLFLUGZEUGS]
TH. NOTTEBAUM and O. GOEBEL (Aachen, Rheinisch-Westfaelische Technische Hochschule, Federal Republic of Germany) Zeitschrift fuer Flugwissenschaften und Weltraumforschung (ISSN 0342-068X), vol. 13, Jan.-Feb. 1989, p. 48-56. In German. refs

In order to assess the possibility of dynamic soaring with modern sailplanes, a computer program has been developed to simulate the flight maneuvers of any sailplane under measured wind shear conditions. The maneuver, an oval circuit inclined to the horizon, is adapted from the dynamic soaring of the albatros. Parameters like maximum load factor, maximum and minimum speed, and other performance data of the sailplane, together with the wind shear data, can be fed into the computer. In order to verify the calculated results, flight tests have been undertaken with a DFVLR sailplane equipped with a data acquisition system. Several examples show that dynamic soaring is theoretically possible with existing sailplanes. With the help of this simulation program, the flight path of a radiocontrolled model glider has been optimized for dynamic soaring in order to prepare for flight tests in boundary layer wind shears near the ground. Author

A89-39454#
MULTI-INPUT/MULTI-OUTPUT FREQUENCY DOMAIN MODAL IDENTIFICATION METHOD AND ITS APPLICATION IN GROUND VIBRATION TESTING
LINGMI ZHANG (Nanjing Aeronautical Institute, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 10, Jan. 1989, p. A21-A27. In Chinese, with abstract in English. refs

A frequency-domain MIMO modal identification method is presented. Its accuracy, reliability and capability of handling closely-spaced or repeated modes are proved by computer simulation and real structure testing. The application in an aircraft Ground Vibration Test (GVT) of a modern fighter is given. The results show that, compared to traditional multipoint sine-dwell GVT technique, the test operation is easier, the period is shorter, and the accuracy is higher. Therefore, the computation is reduced, and the necessity of distinguishing structural and 'noise' modes is avoided. Author

A89-39472#
F.E. SIMULATION OF CRASH FOR HELICOPTERS
SHOUMEI WANG (Beijing University of Aeronautics and Astronautics, People's Republic of China), XIAOFENG DONG, and MIAN PONG (Helicopter Design and Development Center of China, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 10, Feb. 1989, p. B27-B35. In Chinese, with abstract in English. refs

The paper summarizes the numerical simulation of crash for helicopters using nonlinear finite element technique. The structures considered include the pilot seat, shock absorber, floor, and skate. The problem is considered as dynamic response of the structure subjected to specified initial velocity or impulse load, with large deformation and plasticity. Special elements are designed to model the absorber and seat trail. Impact effects with ground are represented by gap elements. Author

A89-39509
PRELIMINARY RESULTS OF IN-FLIGHT EXPERIMENTS ON THE ACTIVE CONTROL OF PROPELLER-INDUCED CABIN NOISE
S. J. ELLIOTT, P. A. NELSON, I. M. STOTHERS, and C. C. BOUCHER (Southampton, University, England) Journal of Sound and Vibration (ISSN 0022-460X), vol. 128, Jan. 22, 1989, p. 355-357. Research supported by British Aerospace, PLC and Department of Trade and Industry.

The first results are presented of a series of experiments undertaken on the active control of the sound field in the passenger cabin of a 48-seat propeller-driven aircraft. The aircraft used is a BAe 748 twin turboprop which is flown under straight and level cruise conditions. The speed of the engines is nominally 14,200 rpm, producing a blade passage frequency of approximately 88 Hz, although, for some experiments, either one of the two engines is reduced in speed to 12,700 rpm (giving a blade passage frequency of 79 Hz) in order to discriminate between the contributions of the two propellers to the cabin sound field. The cabin sound field is controlled using a system of 16 loudspeakers to minimize the sum of the squared pressures sensed at 32 microphones in a plane at seated passenger head height. Results presented from one control system configuration demonstrate significant reductions in the sound pressure level. S.A.V.

A89-39510
A DEMONSTRATION OF ACTIVE NOISE REDUCTION IN AN AIRCRAFT CABIN
C. M. DORLING, G. P. EATWELL, S. M. HUTCHINS, C. F. ROSS, and S. G. C. SUTCLIFFE (Topexpress, Ltd., Cambridge, England) Journal of Sound and Vibration (ISSN 0022-460X), vol. 128, Jan. 22, 1989, p. 358-360. Research supported by British Aerospace, PLC.

Results are presented of an in-flight demonstration of active noise reduction in the cabin of a BAe 748 twin turboprop aircraft. The design of the noise control system is described. The performance of the system shows that active control of propeller noise in an aircraft cabin is feasible, and that substantial reductions in the sound levels can be achieved. The results also show that an active control system with a large number of interacting channels is practicable. The similarity between the predicted and actual reductions suggest that it is possible to make a reasonable assessment of the potential of an active control system by measuring the source and the acoustic environment separately. S.A.V.

N89-21786 Maryland Univ., College Park.
GROUND AND AIR RESONANCE OF BEARINGLESS ROTORS IN HOVER AND FORWARD FLIGHT Ph.D. Thesis
JINSEOK JANG 1988 221 p
Avail: Univ. Microfilms Order No. DA8827086

Ground and air resonances in hover and forward flight are examined for a bearingless rotor using a finite element formulation based on Hamilton's principle. Quasi-steady strip theory is used to evaluate aerodynamic forces, and unsteady aerodynamic effects are introduced approximately through a dynamic inflow mode. For the hover analysis, the nonlinear equations of motion are solved for steady blade deflections through an iterative procedure including the calculation of the pitch link displacement to obtain the desired pitch angle. The equations of motion for the rotor/fuselage dynamics are linearized about the vehicle trim state and the blade steady-state deflected position, and transformed to modal space using coupled vibration modes. These normalized equations consisting of the blade equations of motion, the fuselage equations of motion and the dynamic inflow equations, are then transformed into the nonrotating frame using the multiblade coordinate transformations. The complex eigenvalue analysis is done for the stability. For the analysis of forward flight, the periodic response is calculated using a finite element method in time after the nonlinear finite element equations in space are transformed to normal mode equations. The linearized period perturbation equations in the nonrotating frame are solved for the stability using Floquet transition matrix theory as well as constant coefficient approximation. Satisfactory correlation of predicted ground and air resonance results is carried out with data obtained from the measurements on 1/8th Froude-scaled dynamic model. Systematic parameteric studies are carried out to examine the effects of several design parameters on ground and air resonance stabilities. Lag frequencies has a substantial influence on ground resonance stability, whereas pitch-lag coupling (vertical location of cuff restraint), and pitch link stiffness have powerful effects on air resonance stability in hover and forward flight. Dissert. Abstr.

N89-21787# Ferranti Defense Systems, Inc., Binghamton, NY. Electro-optics Div.
AFTI (ADVANCED FIGHTER TECHNOLOGY INTEGRATION)/F-111 MISSION ADAPTIVE WING BRIEFING TO INDUSTRY Final Report, 18 Nov. 1986 - 22 Jul. 1988
Oct. 1988 427 p
(Contract F33615-78-C-3027)
(AD-A202467; AFWAL-TR-88-3082) Avail: NTIS HC A19/MF A01 CSCL 01/1

The AFTI/F-111 (Advanced Fighter Technology Integration/ F-111) Mission Adaptive Wing is a joint USAF and NASA program which is developing and flight demonstrating a smooth variable camber wing and flight control system capable of adjusting the wing's shape in response to flight condition and pilot input in order to maximize aerodynamic efficiency. The program objective is to produce flight substantiated design criteria for a practical wing system that maintains peak aerodynamic efficiency and versatility throughout the broad flight envelopes and diverse mission requirements of future military and civilian aircraft. This document contains illustrations presented at the second AFTI/F-111 Mission Adaptive Wing Briefing to Industry on 21 to 22 July 1988 in Dayton OH. The presentations covered the analysis, design, ground test, and flight test phases of the development of the automatic flight control system for the AFTI/F-111. Flight testing of the AFTI/F-111 Mission Adaptive Wing system was only partially complete at the time these illustrations were prepared for presentation. Data and findings should be considered preliminary. GRA

N89-21789# Air Force Systems Command, Wright-Patterson AFB, OH. Foreign Technology Div.
FLY, GREAT SEA EAGLE
SHANGFA XU, HONGJIN SUN, and JIWEN DUAN 13 Jan. 1989 9 p Transl. into ENGLISH from Jiefangjun Huabao (Peoples Republic of China), no. 8, 1987 p 18-19
(AD-A203979; FTD-ID(RS)T-0782-88) Avail: NTIS HC A02/MF A01 CSCL 01/3

China's own design and manufacture, the PS-5 seaplane bomber is a success. This achievement fills a gap in the history of the Chinese aviation industry and indicates that the Chinese aviation industry has advanced to a new level. The seaplane is an aircraft and a naval vessel blended into one. It has such features as good performance at low altitude, good concealment ability, good combat radius, and a long cruise duration. It can carry such weapons as air-to-ship missiles, deep-water bombs, torpedoes and mines. It is the ideal set-up for carrying out strikes against enemy naval vessels and submarines. At the same time, it is an effective tool for submarine hunting, anti-submarine, patrol, rescue and transport studies. GRA

N89-21790# Army Aviation Engineering Flight Activity, Edwards AFB, CA.
EVALUATION OF THE PRODUCTION CH-47D ADVERSE WEATHER COCKPIT (AWC) AERIAL REFUELING SYSTEM Final Report, 17 Jun. - 15 Jul. 1988
ROBERT D. ROBBINS, MARVIN L. HANKS, and MICHAEL K. HERBST Sep. 1988 79 p
(AD-A204030) Avail: NTIS HC A05/MF A01 CSCL 01/2

For this evaluation, eight flights were conducted for a total of 11.9 flight hours, 8.5 of which were productive, with 106 probe-to-drogue contacts and 18,160 pounds of fuel transferred. Level flight performance tests, aerial refueling tests and aerial refueling system tests were conducted by the contractor and were witnessed by Army Aviation Engineering Flight Activity (AEFA) personnel. No drag increment determination could be made from the inconclusive level flight test data. The contractor intends to analytically estimate the external drag of the aerial refueling system. The AEFA evaluation included day, night unaided vision and night aided vision aerial refueling operations using Aviator Night Vision Imaging System (ANVIS-6) night vision goggles with U.S.A.F. HC-130P tanker aircraft. Tests included a tanker proximity wake turbulence evaluation of the handling qualities in the refueling environment including off-center disconnects and non-responsive hose operations. One enhancing characteristic, one deficiency and three shortcomings, one of which was identified on a previous evaluation of the standard CH-47D, were noted. The aerial refueling lighting system is an enhancing characteristic. The requirement to have the battery switch ON in order to single-point refuel on the ground is a deficiency. The inability to select anything other than full bright on the refueling probe light and refueling searchlight during initial filament activation is a shortcoming. GRA

N89-21791# California Univ., Los Angeles. Dept. of Mechanical Aerospace and Nuclear Engineering.
CONTROL AUGMENTED STRUCTURAL OPTIMIZATION OF AEROELASTICALLY TAILORED FIBER COMPOSITE WINGS Annual Progress Report, 1 Nov. 1987 - 31 Oct. 1988
PERETZ FRIEDMANN and LUCIEN A. SCHMIT 30 Nov. 1988 54 p
(Contract F49620-87-K-0003)
(AD-A204534; AFOSR-89-0094TR) Avail: NTIS HC A04/MF A01 CSCL 20/4

A unique capability under development for structure/control synthesis of composite lifting surfaces in subsonic and supersonic flow regimes is described. The constituent modeling concepts for the lifting and control surface structure, the unsteady aerodynamics, and active control feedback laws are described. Sample problems are presented to demonstrate specific features of the capability. Current efforts to extend the capability to handle transonic aeroservoelasticity are described. GRA

N89-21792# Army Aviation Engineering Flight Activity, Edwards AFB, CA.
ARTIFICIAL AND NATURAL ICING TESTS OF THE EH-60A QUICK FIX HELICOPTER Final Report, 24 Feb. - 20 Mar. 1988
WILLIAM D. LEWIS, MARVIN L. HANKS, and CHRISTOPHER J. YOUNG Jun. 1988 86 p
(AD-A204589) Avail: NTIS HC A05/MF A01 CSCL 08/12

Artificial and natural icing flight tests were conducted on the EH-60A, Quick Fix helicopter (USA SN 84-24019) to establish a moderate icing flight envelope for the helicopter with the AN/ALQ-151(V)2 countermeasures system installed. The tests were conducted at Duluth, Minnesota from 24 February to 20 March 1988. A total of 11.8 flight hours were flown in the icing environment. After damage to an unprotected direction finding (DF) dipole antenna during an icing encounter, the project was terminated. During these tests, two deficiencies and eight shortcomings were noted. The two icing related deficiencies are: Excessive DF dipole antenna element oscillations induced by ice accumulation resulting in damage to the DF antenna element mounts and phenolic blocks, and the ice accretion and shedding characteristics of the EH-60A helicopter forward of the engine inlets resulting in a high probability of engine foreign object damage. The major shortcomings are: The excessive increase in power required with rotor system ice accumulation, the excessive Electronic Countermeasures (ECM) antenna oscillations induced by ice accumulation, the ice accretion and shedding characteristics of the outside air temperature probes, and the inability of the ECM antenna to fully retract following an icing flight. Four additional shortcomings were identified. The EH-60A Quick Fix helicopter, as configured for this test, was not suitable for flight into an icing environment. GRA

N89-21793# Naval Postgraduate School, Monterey, CA.
A STUDY OF THE EFFECT OF DESIGN PARAMETER VARIATION ON PREDICTED TILT-ROTOR AIRCRAFT PERFORMANCE M.S. Thesis
MARY COTTRELL DUNSTON Dec. 1988 103 p
(AD-A204856) Avail: NTIS HC A06/MF A01 CSCL 01/3

There is currently little data available for trend analyses of tilt-rotor aircraft performance. This study analyzed the sensitivity of predicted tilt-rotor performance to variations in six design parameters: disk loading, tip speed, solidity, download, wing loading, and wing thickness ratio. Two mission profiles were analyzed: A combat search-and-rescue mission and an antisubmarine warfare mission. A tilt-rotor preliminary design code was used to perform computer simulations; and data available from independent tests completed by NASA and the military were encoded in the input data decks. Results were presented as graphs of performance aspects plotted against the parameters varied. Because the study was a trend analysis, no specific conclusions were drawn but a summary was made of the more significant results. It is hoped that the results of this project can serve as a guide to preliminary selection of design parameters for tilt-rotor configurations that would be suitable for a broad range of military and civil applications. GRA

N89-21794# Army Aviation Engineering Flight Activity, Edwards AFB, CA.
ARTIFICIAL AND NATURAL ICING TESTS OF THE UH-60A HELICOPTER CONFIGURED WITH THE XM-139 MULTIPLE MINE DISPENSING SYSTEM (VOLCANO) Final Report, 10 Jan. - 22 Feb. 1988
DAVID A. DOWNEY, REGINALD C. MURRELL, and CHRISTOPHER J. YOUNG Mar. 1988 56 p
(AD-A205031; USAAEFA-85-15) Avail: NTIS HC A04/MF A01 CSCL 01/3

A limited evaluation of the UH-60A helicopter with XM-139 Multiple Delivery Mine Dispensing System (VOLCANO) was conducted to determine the capability to operate safely in a moderate environment. Artificial and natural icing tests were conducted at Duluth, Minnesota from 10 January through 22 February 1988. Testing was conducted by the U.S. Army Aviation Engineering Flight Activity and consisted of 16.4 productive flight hours. One deficiency related to inadequate procedures in the operator's and crewmember's checklist was identified. The checklist does not contain procedures to activate anti-icing systems. Two shortcomings were identified that involved the ice accretion characteristics of the VOLCANO. Ice accretion on the mounting hardware kit interferes with reinstalling the launcher rack jettison safety pins due to ice covering the safety pin holes. Ice accretion on the forward end of the launcher racks interferes with movement of the arming levers and locking levers to the safe and unlocked positions, respectively. The probability of damage to rotating components, due to impact with shed ice particles in descents is increased with the installation of the VOLCANO. The UH-60A helicopter with the VOLCANO system installed can safely operate in moderate icing conditions. GRA

N89-21795# Technische Univ., Berlin (Germany, F.R.). Inst. fuer Luft- und Raumfahrt.
INVESTIGATIONS OF THE PARAMETER REDUCTION IN THE OPTIMIZATION OF AIRCRAFT WING STRUCTURES [UNTERSUCHUNGEN ZUR PARAMETERREDUKTION BEI DER OPTIMIERUNG VON FLUGZEUG-TRAGFLUEGELSTRUCKTUREN]
BERND ZIEGLER 1988 111 p In GERMAN
(ILR-MITT-203; ETN-89-93786) Avail: NTIS HC A06/MF A01

The method of optimization parameter reduction in numerical optimization methods, using approach functions, is presented. The suitability of four types of interpolation functions (quadratic/cubic polynomials, splines, Bezier curves, B-splines) was investigated. It is shown that the group of spline interpolations is especially suited for approach functions; they are extremely handy and fast. However, the B-splines allow a better adaptation to the values of the variables which have to be interpolated. The separation of optimization method and structural analysis is very important. A preliminary optimization using the fully-stressed-design method is required. The correct choice of the penalty factor is essential for the interior penalty function optimization method. The effect of the interpolation time on the total calculation time is negligible. ESA

N89-21796 Princeton Univ., NJ.
A FLIGHT DYNAMIC STUDY OF THE HELICOPTER INCLUDING BLADE DYNAMICS Ph.D. Thesis
XIN ZHAO 1988 172 p
Avail: Univ. Microfilms Order No. DA8827762

A linearized model of rotorcraft dynamics was developed through the use of symbolic automatic equation generating techniques. The dynamic model was formulated in a unique way such that it can be used to analyze a variety of rotor/body coupling problems including a rotor mounted on a flexible shaft with a number of modes as well as free-flight stability and control characteristics. Direct comparison of the time response to longitudinal, lateral and directional control inputs at various trim conditions shows that the linear model yields good to very good correlation with flight test. In particular it is shown that a dynamic inflow model is essential to obtain good time response correlation, especially for the hover trim condition. It also is shown that the main rotor wake interaction with the tail rotor and fixed tail surfaces is a significant contributor to the response at translational flight trim conditions. A relatively simple model for the downwash and sidewash at the tail surfaces based on flat vortex wake theory is shown to produce good agreement. Then, the influence of rotor flap and lag dynamics on automatic control systems feedback gain limitations was investigated with the model. It is shown that the blade dynamics, especially lagging dynamics, can severely limit the useable values of the feedback gain for simple feed-back control and that multivariable optimal control theory is a powerful tool to design high gain augmentation control system. The frequency-shaped optimal control design can offer much better flight dynamic characteristics and a stable margin for the feedback system without need to model the lagging dynamics. Dissert. Abstr.

N89-22600# Messerschmitt-Boelkow-Blohm G.m.b.H., Bremen (Germany, F.R.). Unternehmensberetch Transport- und Verkehrsflugzeuge.
DEVELOPMENT AND TESTING OF CRITICAL COMPONENTS FOR TECHNOLOGICAL PREPARATION OF AN AIRBUS-CFRP-FUSELAGE, PHASE 2 Final Report, 1 May 1986 - 30 Jun. 1987
M. KOBLAX Nov. 1987 75 p In GERMAN; ENGLISH summary
(Contract BMFT-LKF-8652/7)
(MBB-UT-129/87; ETN-89-93769) Avail: NTIS HC A04/MF A01

Essential technological premises for the introduction of composite materials into the fuselage structure of future commercial aircraft were prepared. Selected critical as well as production-development components were manufactured, tested and evaluated. Tests were developed and prepared in order to continue post crash fire research. The possibilities to improve materials and processes were analyzed. The structural efficiency of the selected critical components was proved. The development risks are therefore sufficiently minimized. ESA

N89-22601# Aeronautical Research Inst. of Sweden, Stockholm. Aerodynamics Dept.
TRANSONIC AND SUPERSONIC WIND TUNNEL TESTS ON CONTROL EFFECTIVENESS ON SCHEMATIC MISSILE CONFIGURATIONS WITH CANARD CONTROLS
SVEN ERIK GUDMUNDSON and LARS TORNGREN Dec. 1987 76 p
(Contract FMV-FLYGFL-82223-78-170-21-001)
(FFA-TN-1988-11; ETN-89-94314) Avail: NTIS HC A05/MF A01

A wind tunnel investigation of pitch, yaw, and roll control effectiveness was performed at transonic and supersonic speeds for two body-canard-wing cruciform missile configurations. At zero roll angle position the setting angles were varied from 0 to 20 deg in steps of 5 or 10 deg for the two horizontal canard controls for pitch control tests, and for the two vertical canard controls for yaw control tests. At 45 deg roll angle position the setting angles were varied for all controls in both pitch and yaw control tests. At the roll control tests the setting angles were varied from 0 to 5 and 10 deg for all controls at both 0 and 45 deg roll angle position. Pitch control tests were done with the canard controls interdigitated 45 deg in relation to the wing planes. ESA

N89-22602# Aeronautical Research Inst. of Sweden, Stockholm. Aerodynamics Dept.

PREDICTION OF LOADS ON WING/BODY/EXTERNAL STORE/FINS PYLON-CONFIGURATIONS AT TRANSONIC SPEEDS

DIEQIAN WANG and SVEN G. HEDMAN 29 Aug. 1988 78 p
(Contract FMV-FLYGFL-82260-88-061-73-001)
(FFA-TN-1988-44; ETN-89-94547) Avail: NTIS HC A05/MF A01

A computational method for prediction of loads on configurations consisting of wing, body, external store, and pylon at transonic speeds is described. The geometric flexibility required for treatment of underwing pylon-mounted stores is achieved by the embedded grid technique. The store modeling capability permits a body of revolution with multiple aft fins in cruciform positions. The chosen formulation of the small perturbation equation and the selected mass flux boundary condition enhance the numerical stability and the accuracy of the computed store body flow field. Computed pressure distributions at zero angle of attack for two parabolic arc bodies of different thickness ratios were compared with experimental data, and an excellent agreement between calculation and experiment is obtained in a wide range of transonic speed, including Mach number 1 and a Mach number larger than 1. For a complete configuration it is observed that the method predicted the features of the flow. ESA

N89-22603 Georgia Inst. of Tech., Atlanta.

AN EFFICIENT INVERSE METHOD FOR THE DESIGN OF BLENDED WING-BODY CONFIGURATIONS Ph.D. Thesis

NEEP HAZARIKA 1988 180 p
Avail: Univ. Microfilms Order No. DA8904811

A numerical inverse design technique was developed for designing body-alone and wing-body configurations directly in the physical plane. Although numerous inverse design techniques exist, they are closely tied to the basic analyses, and can not be upgraded as improved analysis techniques become available. Moreover, many of these tools are configuration-specific, i.e., they are restricted to the design of specific configurations such as airfoils or wings. A general purpose analysis-and configuration-independent design scheme is developed. The present design technique is capable of incorporating a variety of analysis tools and is capable of designing body-alone and wing-body configurations with a minimum of modifications. The present method of designing directly in the physical plane derives its roots from panel methods and was applied to isolated aircraft components such as airfoils and nacelles in transonic flow. The present work avoids chordwise distortions when applied to blended wing-body configuration design, and trailing edge closure is ensured naturally within the solution scheme. The flow solver used to compute pressures over the initial, final and intermediate configurations is a full potential solver. The present work can be used to modify existing configurations to meet certain target requirements. The presence of shock waves and lifting surfaces does not seem to complicate or restrict the design process. Since the analysis is separate from the design, one can substitute Euler or Navier-Stokes solvers as they become more efficient and available. This technique thus provides a methodology for the inverse design of realistic configurations that are typical of high performance transonic aircraft. Dissert. Abstr.

06

AIRCRAFT INSTRUMENTATION

Includes cockpit and cabin display devices; and flight instruments.

A89-37537

TEST OF A CALIBRATION DEVICE FOR AIRBORNE LYMAN-ALPHA HYGROMETERS

EDWIN W. ELORANTA, ROLAND B. STULL, and ELIZABETH E. EBERT (Wisconsin, University, Madison) Journal of Atmospheric and Oceanic Technology (ISSN 0739-0572), vol. 6, Feb. 1989, p. 129-139. refs
(Contract NSF ATM-85-11196)

Results are presented from tests of a calibration device designed to fit over airborne Lyman-alpha probes to allow pure nitrogen, oxygen, and carbon dioxides gases into the probe's radiation path. The presence of these gases made it possible to calculate the path length, reference voltage, and oxygen absorption terms in the Lyman-alpha humidity equation. The tests of the calibration device show that it performs successfully. R.B.

A89-38949

COLOR DISPLAYS CAN REDUCE WORKLOAD

Aerospace Engineering (ISSN 0736-2536), vol. 9, April 1989, p. 10-14.

An account is given of the ways in which the A320 airliner's flight-management system (FMS) employs color displays in its Multipurpose Control and Display Unit (MCDU) to furnish perceptually effective flight-planning, navigation, guidance, and aircraft performance information. The FMS allows the flight crew to enter a complete flight plan, including departure and arrival procedures; it provides predictions of time, speed, altitude, fuel, and wind for every waypoint of the flight plan. Six colors are used for presenting data, and any MCDU character can be displayed in one of two available sizes. Illustrative examples of MCDU messages are presented. O.C.

A89-39227

HUD ON THE HEAD FOR COMBAT PILOTS

BRIAN WANSTALL Interavia (ISSN 0020-5168), vol. 44, April 1989, p. 334-338.

Helmet-mounted display (HMD) and helmet-mounted sight (HMS) systems fulfilling the role of HUDs are required for the European Fighter Aircraft, Rafale, the USAF's ATF, and the USN's ATA, as well as for retrofitting in some currently operational aircraft. The core component of an HMD or HMS is a helmet-positioning system which may employ electromagnetic, electrooptic, or acoustic sensors to furnish data for the helmet-tracking processor to extrapolate helmet position. Weight constraints motivate designers' current preoccupation with the question of whether a CRT should be mounted directly on the helmet, or whether a coherent fiber-optic cable should instead be used to bring images to the helmet. O.C.

A89-39587

NEAR-FIELD SCATTERING MEASUREMENTS FOR DETERMINING COMPLEX TARGET RCS

BARRY J. COWN and CHARLES E. RYAN, JR. (Georgia Institute of Technology, Atlanta) IEEE Transactions on Antennas and Propagation (ISSN 0018-926X), vol. 37, May 1989, p. 576-585. refs

The application of near-field scattering measurements for determining the near-zone and far-zone radar cross section (RCS) of complex targets that are both physically and electrically large is reviewed and examined in the light of recent advances in near-field measurement technology and data processing capabilities. I.E.

A89-39828

AIR NAVIGATION SYSTEMS. I - ASTRONOMICAL

NAVIGATION IN THE AIR 1919-1969. PART II - INSTRUMENTS
J. E. D. WILLIAMS Journal of Navigation (ISSN 0373-4633), vol. 42, Jan. 1989, p. 73-91. refs

A development history is presented for the optical instruments employed for aeronautical astronomical navigation, giving attention to both the design features of the optics employed and the comparative levels of navigational accuracy achieved. Prominent among the instruments employed from the inception of long-range aircraft navigation, circa 1919, to the achievement of dominance in the field by inertial navigation technologies circa 1969, have been the bubble sextant and the periscopic sextant, 'astrodome' bubbles, astrocompasses, and various clockwork mechanisms. O.C.

N89-22604# SLI Avionic Systems Corp., Grand Rapids, MI.
PRE AND POST MODIFICATION ELECTROMAGNETIC COMPATIBILITY TEST REPORT FOR THE C-130H SELF CONTAINED NAVIGATION SYSTEM WITH MLS A-KIT, REVISION
C. SNIDER 20 Jan. 1989 100 p
(Contract F09603-85-C-1224)
(AD-A205167; REPT-6216-055-REV) Avail: NTIS HC A05/MF A01 CSCL 20/14

The specific tests performed on the Self Contained Navigation System (SCNS) with MLS A-Kit, were a Pre-Modification Electromagnetic Interference (EMI) Signature of the aircraft equipment bays, flight deck and connecting wiring, followed by a Post-Modification EMI Signature and a functional compatibility test of the avionic systems with the SCNS system operating. The tests performed were an engineering evaluation of post-installation EMI and Electromagnetic Compatibility (EMC) with existing electronic and avionic systems in the C-130H Aircraft. The test objectives were to verify the proper EMI/EMC design, installation, and operation of the associated C-130H Aircraft subsystems prior to beginning flight test. This determines if the new installation, or the new or modified equipment would emit radiated or conducted EMI, and if emitted, whether the levels would create interference or degradation in existing equipment. GRA

07

AIRCRAFT PROPULSION AND POWER

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

A89-36215*# Lockheed Aeronautical Systems Co., Marietta, GA.
NEAR-FIELD ACOUSTIC CHARACTERISTICS OF A SINGLE-ROTOR PROPFAN
H. W. BARTEL and G. SWIFT (Lockheed Aeronautical Systems Co., Marietta, GA) AIAA, Aeroacoustics Conference, 12th, San Antonio, TX, Apr. 10-12, 1989. 13 p. refs
(Contract NAS3-24339)
(AIAA PAPER 89-1055)

The near-field noise characteristics of the SR-7L, an eight-blade, single-rotor, wing-mounted, tractor propfan have been determined. It is found that the noise is dominated by discrete tones, usually at the first order (and occasionally at the second or third order) of the blade-passage frequency. The highest noise levels were noted at conditions of high tip helical speeds and high dynamic pressures. R.R.

A89-36397* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
A REVIEW AND FORECAST OF ENGINE SYSTEM RESEARCH AT THE ARMY PROPULSION DIRECTORATE
GEORGE A. BOBULA (NASA, Lewis Research Center; U.S. Army, Propulsion Directorate, Cleveland, OH) Vertiflite (ISSN 0042-4455), vol. 35, Mar.-Apr. 1989, p. 12-19.

An account is given of the development status and achievements to date of the U.S. Army Propulsion Directorate's Small Turbine Engine Research (STER) programs, which are experimental investigations of the physics of entire engine systems from the viewpoints of component interactions and/or system dynamics. STER efforts are oriented toward the evaluation of complete turboshaft engine advanced concepts and are conducted at the ECRL-2 indoor, sea-level engine test facility. Attention is given to the results obtained by STER experiments concerned with IR-suppressing engine exhausts, a ceramic turbine-blade shroud, an active shaft-vibration control system, and a ceramic-matrix combustor liner. O.C.

A89-36399
T800/A129 FLIGHT PROGRAM
R. DAVID TOMS, JR. (General Motors Corp., Allison Gas Turbine Div., Indianapolis, IN) Vertiflite (ISSN 0042-4455), vol. 35, Mar.-Apr. 1989, p. 40-44.

The A129 helicopter has been chosen and used as the testbed aircraft for the state-of-the-art T800-LHT-800 turboshaft engine, since it approximates the primary mission roles for which the engine was developed. The twin-engine installation of the T800 in the A129 has furnished valuable information relative to control and functional interfaces. Systems testing was first conducted off the aircraft in order to reduce risks and provide early problem resolution. Testing of the electronic system was performed sequentially, progressively including additional system components as each test was completed. O.C.

A89-36400
T700 - GROWING TO MEET THE CHALLENGE
H. G. DONOHIE (General Electric Co., Aircraft Engine Business Group, Lynn, MA) Vertiflite (ISSN 0042-4455), vol. 35, Mar.-Apr. 1989, p. 48-52, 54, 55.

A development history is presented for the T700 turboshaft engine employed by U.S. Army helicopters, whose power output has been progressively enhanced in response to new performance requirements. Attention is given to the paths taken to (1) maximize 4000-ft altitude performance at 95 F ambient temperature, (2) minimize weight, and (3) improve levels of reliability and maintainability; this last involved extensive resort to component redundancy and modularity, as well as measures to protect the engine's inlet. A single-engine (one engine out) operational capability was also achieved for the T700 in the case of the AH-64A Apache helicopter. O.C.

A89-36473
AIRCRAFT GAS TURBINE BLADE AND VANE REPAIR
K. C. ANTONY and G. W. GOWARD (Turbine Components Corp., Branford, CT) IN: Superalloys 1988; Proceedings of the Sixth International Symposium, Champion, PA, Sept. 18-22, 1988. Warrendale, PA, Metallurgical Society, Inc., 1988, p. 745-754. refs

Some statistics on the needs for blade and vane repair or replacement, coating technology relevant to blade and vane repair, and the types of repair that commonly applied to turbine hardware are reviewed. Predictions are then made concerning the future of repair technology. It is noted that the future of blade and vane repair will be largely determined by replacement part pricing. Repair is expected to become less labor-intensive as automation becomes more feasible. V.L.

A89-36474
REJUVENATION OF SERVICE-EXPOSED IN 738 TURBINE BLADES
A. K. KOUL, J.-P. IMMARIGEON (National Aeronautical Establishment Ottawa, Canada), R. CASTILLO (Westinghouse Canada, Inc., Hamilton), P. LOWDEN, and J. LIBURDI (Liburdi Engineering, Burlington, Canada) IN: Superalloys 1988; Proceedings of the Sixth International Symposium, Champion, PA,

Sept. 18-22, 1988. Warrendale, PA, Metallurgical Society, Inc., 1988, p. 755-764. Research supported by DND. refs

A HIP rejuvenation study has been performed on an aluminide-coated internally-cooled IN 738 turbine blade from an aircraft engine. It is found that airfoils have a tendency to lengthen along their longitudinal axis during service, with the rate of lengthening increasing with increasing service life. The design of a HIP rejuvenation/heat treatment cycle to recover microstructures and creep properties is considered, and a rejuvenation cycle incorporating a diffusion treatment for recoating the blades is found to improve the time to rupture by a factor of 3 relative to new blades. R.R.

A89-36898

AIRCRAFT ENGINES. IV

PHILIP C. RUFFLES (Rolls-Royce PLC, London, England) Exxon Air World (ISSN 0014-5068), vol. 41, no. 1, 1989, p. 36-38.

Configurational design and thermodynamic performance gain trends are projected into the next 50 years, in view of the growing interest of aircraft manufacturers in both larger and more efficient high-bypass turbofan engines for subsonic flight and variable cycle engines for supersonic flight. Ceramic- and metal-matrix composites are envisioned as the key to achievement of turbine inlet temperatures 300 C higher than the 1400 C which is characteristic of the state-of-the-art, with the requisite high stiffness, strength, and low density. Such fiber-reinforced materials can be readily tailored to furnish greatest strength in a specific direction of loading. Large, low-density engines are critical elements of future 1000-seat aircraft. O.C.

A89-37651

LEADER - AN AUTOMATIC, REAL-TIME DIAGNOSTIC KNOWLEDGE SYSTEM

J. S. SHURTLEFF (Textron Lycoming, Stratford, CT) SAE, Aerospace Technology Conference and Exposition, Anaheim, CA, Oct. 3-6, 1988. 14 p.
(SAE PAPER 881443)

An expert system, LEADER, is implemented that supports acceptance testing of gas turbine engines in four independent test cells. The LEADER system expedites problem diagnosis by automatically analyzing engine parameters for fault identification. The system models the reasoning of an experienced engineer for a specific steady-state testing procedure with several hundred rules controlled by a diagnostic procedure. An overview of the system's objectives and benefits is given, along with its engine testing and diagnostics procedures. A summary of the system's implementation is presented, and the system's operation, user interface, and knowledge base implementation are discussed. The system's evaluation and testing considerations are outlined. S.A.V.

A89-37654

INTERRELATION OF ENGINE DESIGN AND BURNER CONFIGURATION WITH SELECTION AND PERFORMANCE OF ELECTRICAL IGNITION SYSTEMS FOR GAS TURBINE ENGINES

SAE Aerospace Information Report, SAE AIR 784, Oct. 2, 1988, 31 p.
(SAE AIR 784)

An attempt is presently made to furnish gas turbine engine designers with a working knowledge of the role of ignition systems in the achievement of performance objectives. A definitive sampling is accordingly presented of standard references, nomenclature, and descriptive terminology for gas turbine ignition system design. Attention is given to those aspects of combustion chamber structure and aerodynamics that influence the type-selection and performance of ignition systems. Areas for future research in the interest of determining potentially significant effects are noted. O.C.

A89-37661

LEADS, FLEXIBLE, SHIELDED, HIGH ENERGY IGNITION

SAE Aerospace Recommended Practice, SAE ARP 841, Jan. 18, 1988, 4 p.
(SAE ARP 841)

The requirements for shielded, flexible, high-energy ignition leads for use in gas turbine engines are presented. It is noted that the elastomeric materials employed must be resistant to oil, hydraulic fluid, fuel, aging, and weathering; the shielded leads must also furnish suitable EMI suppression levels. Attention is given to the character of the qualification test's resistance, continuity, and inspection requirements, as well as to the electrical test's joint-resistance, shielding-resistance, low voltage continuity, and high potential requirements. O.C.

A89-37752#

ON EVALUATION OF AIRCRAFT PROPULSION SYSTEM PERFORMANCE

ZENGYUAN TAO (Air Force Engineering Institute, People's Republic of China), QISHAN XU, and XIAOXIONG CHEN (Air Force PR China, Beijing, People's Republic of China) Journal of Aerospace Power (ISSN 1000-8055), vol. 4, Jan. 1989, p. 7-10, 87. In Chinese, with abstract in English. refs

In order to meet the requirements of performance evaluation for an aircraft propulsion system, the paper elaborates on how to implement the procedures, contents, and methods specified in National Military Standards. The paper can serve as a reference in designing, developing, and testing an aircraft or an engine and as one of the main arguments for checking and accepting the aircraft propulsion system performance in aircraft qualification flight tests. Author

A89-37753#

PERFORMANCE ANALYSIS OF A PROPULSION SYSTEM

ZHANG JING (Beijing University of Aeronautics and Astronautics, People's Republic of China) Journal of Aerospace Power (ISSN 1000-8055), vol. 4, Jan. 1989, p. 11-16, 86. In Chinese, with abstract in English. refs

Performance analysis programs of a propulsion system are established and recommended as tools for estimating installation penalties. The performance parameters, such as inlet capture area, inlet pressure recovery, inlet drag, nozzle gross thrust coefficient, nozzle/afterbody drag, installed thrust, and specific fuel consumption, can be obtained on condition that the uninstalled engine performance is matched with the inlet/nozzle internal and external performances. The influences of design parameters and operation conditions on the propulsion performance are also discussed. The numerical results obtained show that the installation penalties are 20 to 30 percent at the identical flight conditions and throttling settings. Author

A89-37754#

ADJUSTMENT OF RATIO OF ROTATION SPEED DIFFERENCE IN A TWIN-SPOOL TURBOJET ENGINE

ZIZHONG WU and SHANG YI (Nanjing Aeronautical Institute, People's Republic of China) Journal of Aerospace Power (ISSN 1000-8055), vol. 4, Jan. 1989, p. 17-20, 88. In Chinese, with abstract in English.

Analyzing the concept and the function of the ratio of rotation speed difference in a twin-spool turbojet engine indicates that the ratio has an effect on the surge margins of the high and low pressure compressors and on the match between the speed of high pressure compressor and the inlet gas temperature. A procedure for adjusting the ratio of rotation speed difference is proposed. The results of the adjustments are in good agreement with the trial run data. In addition, the effects of the ratio on the thrust, specific fuel consumption, speed of high pressure compressor, and turbine inlet gas temperature are considered. Author

A89-37757#

INVESTIGATION ON SIMULATION OF FOREIGN OBJECT IMPACT DAMAGE TO COMPRESSOR BLADE

ZHENDE SUN (Naval Aeronautical Engineering Institute, People's Republic of China) and QIXIN LU (Nanjing Aeronautical Institute, People's Republic of China) Journal of Aerospace Power (ISSN 1000-8055), vol. 4, Jan. 1989, p. 30-32, 92. In Chinese, with abstract in English.

An experimental method for the simulation of foreign object impact damage to a compressor blade is investigated. The impact damage mechanism is analyzed by means of a scanning electron microscope. A reasonable experimental method is proposed by comparing bullet damage with pendulum impact damage. Author

A89-37759#
A STUDY ON EXIT RADIAL TEMPERATURE PROFILE OF 2D EXPERIMENTAL COMBUSTOR
JIBAO LI (Chinese Gas Turbine Establishment, People's Republic of China) Journal of Aerospace Power (ISSN 1000-8055), vol. 4, Jan. 1989, p. 37-40, 90. In Chinese, with abstract in English. refs

The exit radial temperature profiles formed by four configurations of a dilution hole have been studied experimentally on a two-dimensional experimental combustor. The effect of different configurations of dilution hole design on the combustor exit radial temperature profile shows certain regularity. A semiempirical and semianalytical model has been developed for predicting the exit temperature profile of gas turbine combustor. The model can predict the effect of change in dilution zone design or combustion operating conditions on the variation of the combustor exit radial temperature profile based on exit temperatures measured before change. Author

A89-37769#
RESEARCH ON TEMPERATURE PROFILE FACTOR AT EXIT IN AN ANNULAR COMBUSTOR
BAOCHENG ZHANG (Shenyang Institute of Aeronautical Engineering, People's Republic of China) Journal of Aerospace Power (ISSN 1000-8055), vol. 4, Jan. 1989, p. 70-72, 94. In Chinese, with abstract in English.

The visualized statistics of the temperature profile factors (PF) at exits in an annular combustor and its sectors have been made. The results indicate that the number of heads in a sector has significant effect on PF. The empirical formulas for calculating all-ring combustor PF have been obtained from the fitting of statistical data. The relative errors between the calculations with these formulas and the measurements in tests are less than 0.045. Author

A89-37772#
COMPUTATION OF DYNAMIC PROCESS WITH LARGE DISTURBANCE FOR SPLIT-SHAFT GAS TURBINE
ZEHUA LU and BOSHENG YE (Tsinghua University, Beijing, People's Republic of China) Journal of Aerospace Power (ISSN 1000-8055), vol. 4, Jan. 1989, p. 79-81, 95. In Chinese, with abstract in English.

The computation of a dynamic process with large disturbance is examined for a split-shaft gas turbine. The Spey core engine used in a gas-stream combined cycle is used as an example. C.D.

A89-37773#
OPTIMIZING DESIGN FOR TURBOENGINE DIGITAL SPEED CONTROLLER
SHENGFA YANG (Northwestern Polytechnical University, Xian, People's Republic of China) Journal of Aerospace Power (ISSN 1000-8055), vol. 4, Jan. 1989, p. 82-84, 95. In Chinese, with abstract in English.

A method for optimizing the characteristics of a digital speed controller of a turboengine is presented. A dynamic model of this system has been developed. According to the chosen quadratic property criterion, six characteristic quantities of the digital controller are optimized by system simulation in a digital computer. Author

A89-37774#
STUDY ON EXCHANGE OPERATION BETWEEN TWO MICROCOMPUTERS IN AEROENGINE DIGITAL CONTROL
QIHUA XU and QIHUA WU (Northwestern Polytechnical University, Xian, People's Republic of China) Journal of Aerospace Power (ISSN 1000-8055), vol. 4, Jan. 1989, p. 85, 86, 95. In Chinese, with abstract in English.

Communication and trouble-self-detection of microcomputers in a dual-computer aeroengine digital control system are considered. Exchange operation between two microcomputers is discussed. Simulation tests of the exchange operation in the dual-computer engine speed control system are performed, and satisfactory results are reported. C.D.

A89-38502
NONSTATIONARY THERMAL DUTY OF THE STRUCTURAL ELEMENTS OF FLIGHT VEHICLES [NESTATSIONARNYI TEPLOVOI REZHIM ELEMENTOV KONSTRUKTSII DVIGATELEI LETATEL'NYKH APPARATOV]
MARSELII P. KUZ'MIN and IRINA M. LAGUN Moscow, Izdatel'stvo Mashinostroenie, 1988, 240 p. In Russian. refs

Numerical, analytical, and analog methods are presented for calculating the temperature fields, heat fluxes, and heat transfer during nonstationary processes associated with the service of the structural elements of flight vehicles. The discussion covers physical processes occurring in the engines of flight vehicles, classification of cooling devices, mathematical description of heat transfer processes, and thermal operating conditions of short-, medium-, and long-life engines. Attention is also given to the electrical modeling of nonstandard thermal processes in engines. V.L.

A89-38504
VIBRATIONS OF THE BLADES OF TURBOMACHINES [KOLEBANIIA LOPATOCHNOGO APPARATA TURBOMASHIN]
IURII S. VOROB'EV Kiev, Izdatel'stvo Naukova Dumka, 1988, 224 p. In Russian. refs

A refined mathematical model of turbine blading is proposed which treats the blades as a unified deformable system with allowance for flow effects. A variational method for calculating the vibrations of the system is developed; the finite element method is used for three-dimensional blade models. Vibration characteristics of blades, blade packets, bladed disks, and rotor-blade systems are discussed. Attention is also given to systems with blade imperfections. V.L.

A89-38510
VARIABLE-CYCLE TURBOJET ENGINES FOR MULTIPLE-REGIME AIRCRAFT [AVIATSIONNYE TURBOREAKTIVNYE DVIGATELI S IZMENIAEMYM RABOCHIM PROTSESSOM DLIA MNOGOREZHIMNYKH SAMOLETOV]
IULIAN N. NECHAEV, VIKTOR N. KOBEL'KOV, and ANATOLII S. POLEV Moscow, Izdatel'stvo Mashinostroenie, 1988, 176 p. In Russian. refs

The general design and operation of variable-cycle turbojet engines based on mixed-flow bypass engines are reviewed. The discussion covers current trends in the development of powerplants; characteristics of the adjustable elements of variable-cycle turbojet engines; the effective thrust of variable-cycle powerplants; and optimization of powerplants using variable-cycle engines. Control laws for the elements of variable-cycle engines are derived. V.L.

A89-38950
THE ALL-ELECTRIC (SECONDARY POWER) AIRPLANE
Aerospace Engineering (ISSN 0736-2536), vol. 9, April 1989, p. 17-19.

In all-electric airliner secondary power systems, all aircraft subsystems are directly or indirectly powered by a single, electrical power source and are driven or actuated by high energy density/efficiency low-volume inverters and induction motors. Developmental breakthroughs in power-management ICs, VLSI control electronics, and very compact motors have been the primary drivers in the evolution of all-electric secondary power systems. Novel 'switched-reluctance' motor designs are noted to be much simpler than permanent-magnet motors. The quadruple-redundant power distribution systems typically employed are designed to operate as a closed ring system, in which the generator can feed all bus-sections in the event of an emergency. O.C.

A89-39043#

APPLICATION OF A FUZZY CONTROLLER IN THE FUEL SYSTEM OF A TURBOJET ENGINE

CHI-HUA WU, YUN-HUA XU, and BEN-WEI LI (Northwestern Polytechnical University, Xian, People's Republic of China) (International Symposium on Air Breathing Engines, 8th, Cincinnati, OH, June 14-19, 1987, Proceedings, p. 459-464) Journal of Propulsion and Power (ISSN 0748-4658), vol. 5, May-June 1989, p. 373, 374. Previously cited in issue 20, p. 3161, Accession nc. A87-46227. refs

A89-39044#

J85 SURGE TRANSIENT SIMULATION

Y. SUGIYAMA (Japan Defense Agency, Technical Research and Development Institute, Tokyo), W. TABAKOFF, and A. HAMED (Cincinnati, University, OH) (International Symposium on Air Breathing Engines, 8th, Cincinnati, OH, June 14-19, 1987, Proceedings, p. 568-578) Journal of Propulsion and Power (ISSN 0748-4658), vol. 5, May-June 1989, p. 375-381. Previously cited in issue 20, p. 3161, Accession no. A87-46240. refs

A89-39284

ELECTROMAGNETIC BACKSCATTER FROM OPEN-ENDED CIRCULAR CYLINDER WITH COMPLEX TERMINATION

J. J. BOONZAAIER and J. A. G. MALHERBE (Pretoria, University, Republic of South Africa) Electronics Letters (ISSN 0013-5194), vol. 25, Feb. 2, 1989, p. 218-220. refs

In this paper, a jet aircraft engine model is proposed that uses a radial blade configuration and a coaxial center rod to describe respectively the engine blades and the axle of the engine. The termination is described using three different waveguides. A circular waveguide describes the intake, a coaxial waveguide the center rod or axle of the engine, and coaxial-sector waveguides describe the engine blades. Comparison of the theory with previous results and with measurement shows that the model has improved realism in approximating the physical construction of a jet engine. C.D.

A89-39480#

A RESEARCH EXPERIMENT OF DISCRETE FUEL INJECTION IN AERO-ENGINE COMBUSTION CHAMBER

BAOSEN ZHI (Northwestern Polytechnical University, Xian, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 10, Feb. 1989, p. B85-B88. In Chinese, with abstract in English.

The importance of research experiments on discrete fuel injection in aero-engine combustion chambers is briefly discussed. The experiment shows that good atomizing quality at different flight conditions and increased combustion efficiency can be maintained by changing fuel supply frequency. At the same time, problems concerning the discrete fuel injection test on the combustion chamber test bed, including the choice of nozzles, the discrete injection quality test, and the test installations, are discussed. Author

N89-21797 Stanford Univ., CA.

THE EFFECT OF EXHAUST PLUME/AFTERBODY ON INSTALLED SCRAMJET PERFORMANCE Ph.D. Thesis

THOMAS ALAN EDWARDS 1988 130 p

Avail: Univ. Microfilms Order No. DA8826134

First-generation sustained hypersonic flight vehicles will be driven by air-breathing scramjet (supersonic combustion ramjet) engines. Due to engine size limitations, the exhaust gas leaving the nozzle will be highly underexpanded. Consequently, a significant amount of thrust and lift can be extracted by allowing the exhaust gases to expand along the underbody of the vehicle. Predicting how these forces influence overall vehicle thrust, lift, and moment is essential to a successful design. An upwind, implicit Navier-Stokes (UWIN) computer program, is applied to hypersonic exhaust plume/afterbody flow fields. The capability to solve entire vehicle geometries at hypersonic speeds, including an interacting exhaust plume, is demonstrated. Comparison of the numerical results with available experimental data shows good agreement in all cases investigated. For moderately underexpanded jets, afterbody forces were found to vary linearly with the nozzle exit pressure, and increasing the exit pressure produced additional nose-down pitching moment. Coupling a species continuity equation to the UWIN code enabled calculations indicating that exhaust gases with low isentropic exponents (gamma) contribute larger afterbody forces than high-gamma exhaust gases. Moderately underexpanded jets, which remain attached to unswept afterbodies, underwent streamwise separation on upswept afterbodies. Highly underexpanded jets produced altogether different flow patterns, however. The highly underexpanded jet creates a strong plume shock, and the interaction of this shock with the afterbody was found to produce complicated patterns of crossflow separation. Finally, the effect of thrust vectoring on vehicle balance has been shown to alter dramatically the vehicle pitching moment.

Dissert. Abstr.

N89-21798*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

A PERSPECTIVE ON FUTURE DIRECTIONS IN AEROSPACE PROPULSION SYSTEM SIMULATION

BRENT A. MILLER, JOHN R. SZUCH, RAYMOND E. GAUGLER, and JERRY R. WOOD 1989 9 p Presented at the 4th International Conference, Santa Clara, CA, 30 Apr. - 5 May 1989; sponsored by the International Supercomputing Inst.

(NASA-TM-102038; E-4608; NAS 1.15:102038) Avail: NTIS HC A02/MF A01 CSCL 21/5

The design and development of aircraft engines is a lengthy and costly process using today's methodology. This is due, in large measure, to the fact that present methods rely heavily on experimental testing to verify the operability, performance, and structural integrity of components and systems. The potential exists for achieving significant speedups in the propulsion development process through increased use of computational techniques for simulation, analysis, and optimization. This paper outlines the concept and technology requirements for a Numerical Propulsion Simulation System (NPSS) that would provide capabilities to do interactive, multidisciplinary simulations of complete propulsion systems. By combining high performance computing hardware and software with state-of-the-art propulsion system models, the NPSS will permit the rapid calculation, assessment, and optimization of subcomponent, component, and system performance, durability, reliability and weight-before committing to building hardware.

Author

N89-21799*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

AN EXPLICIT RUNGE-KUTTA METHOD FOR TURBULENT REACTING FLOW CALCULATIONS

A. A. BORETTI (Florence Univ., Italy) Apr. 1989 17 p

(NASA-TM-101945; E-4635; NAS 1.15:101945) Avail: NTIS HC A03/MF A01 CSCL 21/5

The paper presents a numerical method for the solution of the conservation equations governing steady, reacting, turbulent viscous flow in two-dimensional geometries, in both Cartesian and axisymmetric coordinates. These equations are written in Favre-averaged form and closed with a first order model. A two-equation K-epsilon model, where low Reynolds number and compressibility effects are included, and a modified eddy-break up model are used to simulate fluid mechanics turbulence, chemistry and turbulence-combustion interaction. The solution is obtained by using a pseudo-unsteady method with improved perturbation propagation properties. The equations are discretized in space by using a finite volume formulation. An explicit multi-stage dissipative Runge-Kutta algorithm is then used to advance the flow equations in the pseudo-time. The method is applied to the computation of both diffusion and premixed turbulent reacting flows. The computed temperature distributions compare favorably with experimental data. Author

N89-21800 Oxford Univ. (England).
UNSTEADY AERODYNAMICS AND HEAT TRANSFER IN A TRANSONIC TURBINE STAGE Ph.D. Thesis
D. A. ASHWORTH 1987 277 p
Avail: Univ. Microfilms Order No. BRD83740

Prediction methods for gas turbine flow for both the calculation of surface pressures and heat transfer rates are not available. Such features include the prediction of three-dimensional viscous flowfields, the accurate location and strengths of the secondary flow regimes in a turbine passage, and allowance for time-dependent variations. The time-varying phenomena is studied. Such phenomena occur due to the periodic interaction between stages in a turbine, either that of a nozzle guide vane on a rotor downstream or vice-versa. In most contemporary designs of turbines the effects are due primarily to the wakes from the trailing-edge of the upstream airfoil, and to any associated shock structures resulting from transonic exit flow Mach numbers. These wake and shock interactions were investigated using a simulation method. Measurements of heat transfer rates and pressures for two examples of high-pressure turbine rotor blades are presented and supported by flow visualization methods such as surface oil-dots and schlieren photography. The majority of analysis deals with the first of these (a highly-loaded transonic profile) while the second blade (designed for use in a large civil engine) is included for investigation of the effects of flow unsteadiness on the film cooling process. The transition process is examined in detail by use of wide band-width heat transfer measurements, and a method derived for modelling this process. It was possible to observe the effect of the enhanced turbulence in the simulated nozzle guide vane wake and effects due to a shock-boundary layer interaction. The reaction of the blade boundary layers to these disturbances is identified, and trajectories of disturbed events tracked along the blade surfaces. The measurements which have been taken allow for some aspects of wake and shock interactions to be included in the design process for turbine blading.
Dissert. Abstr.

N89-21801# Purdue Univ., West Lafayette, IN. Thermal Sciences and Propulsion Center.
RESEARCH AS PART OF THE AIR FORCE RESEARCH IN AERO PROPULSION TECHNOLOGY (AFRAPT) PROGRAM Final Technical Report, Aug. 1987 - Aug. 1988
SANFORD FLEETER Aug. 1988 5 p
(Contract AF-AFOSR-0305-86; AF PROJ. 2308)
(AD-A204968; AFOSR-89-0199TR) Avail: NTIS HC A02/MF A01 CSCL 21/5

Eleven students participated in the Air Force Research in Aero Propulsion Technology (AFRAPT) program during the 1987 to 1988 academic year. During this year: One new Ph.D. candidate completed two qualifying exams and initiated his thesis research; One new Ph.D. candidate withdrew from the program and is now permanently employed at a participating company; four M.S.M.E. candidates completed their thesis and are now permanently employed at a participating company; five M.S.M.E. candidates completed their course work, and are working on their thesis projects. GRA

N89-22605*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
ACTIVE VIBRATION CONTROL FOR FLEXIBLE ROTOR BY OPTIMAL DIRECT-OUTPUT FEEDBACK CONTROL
KENZOU NONAMI, ELISEO DIRUSSO, and DAVID P. FLEMING 1989 9 p Proposed for presentation at the 12th Biennial Conference on Mechanical Vibration and Noise, Montreal, Quebec, 17-20 Sep. 1989; sponsored by ASME
(NASA-TM-101972; E-4672; NAS 1.15:101972) Avail: NTIS HC A02/MF A01 CSCL 21/5

Experimental research tests were performed to actively control the rotor vibrations of a flexible rotor mounted on flexible bearing supports. The active control method used in the tests is called optimal direct-output feedback control. This method uses four electrodynamic actuators to apply control forces directly to the bearing housings in order to achieve effective vibration control of the rotor. The force actuators are controlled by an analog controller that accepts rotor displacement as input. The controller is programmed with experimentally determined feedback coefficients; the output is a control signal to the force actuators. The tests showed that this active control method reduced the rotor resonance peaks due to unbalance from approximately 250 micrometers down to approximately 25 micrometers (essentially runout level). The tests were conducted over a speed range from 0 to 10,000 rpm; the rotor system had nine critical speeds within this speed range. The method was effective in significantly reducing the rotor vibration for all of the vibration modes and critical speeds. Author

N89-22606*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
INVESTIGATION OF LOW NOX STAGED COMBUSTOR CONCEPT IN HIGH-SPEED CIVIL TRANSPORT ENGINES
HUNG LEE NGUYEN, DAVID A. BITTKER, and RICHARD W. NIEDZWIECKI 1989 23 p Presented at the 25th Joint Propulsion Conference, Monterey, CA, 10-12 Jul. 1989; cosponsored by the AIAA, ASME, SAE, and ASEE
(NASA-TM-101977; E-4071; NAS 1.15:101977; AIAA-89-2942)
Avail: NTIS HC A03/MF A01 CSCL 21/5

Levels of exhaust emissions due to high temperatures in the main combustor of high-speed civil transport (HSCT) engines during supersonic cruise are predicted. These predictions are based on a new combustor design approach: a rich burn/quick quench/lean burn combustor. A two-stage stirred reactor model is used to calculate the combustion efficiency and exhaust emissions of this novel combustor. A propane-air chemical kinetics model is used to simulate the fuel-rich combustion of jet fuel. Predicted engine exhaust emissions are compared with available experimental test data. The effect of HSCT engine operating conditions on the levels of exhaust emissions is also presented. The work described in this paper is a part of the NASA Lewis Research Center High-Speed Civil Transport Low NO(x) Combustor program. Author

N89-22607*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
TRANSONIC VISCOUS FLOW CALCULATIONS FOR A TURBINE CASCADE WITH A TWO EQUATION TURBULENCE MODEL
A. A. BORETTI (Florence Univ., Italy) Apr. 1989 16 p
(NASA-TM-101944; E-4634; NAS 1.15:101944) Avail: NTIS HC A03/MF A01 CSCL 21/5

A numerical method for the study of steady, transonic, turbulent viscous flow through plane turbine cascades is presented. The governing equations are written in Favre-averaged form and closed with a first order model. The turbulent quantities are expressed according to a two-equation kappa-epsilon model where low Reynolds number and compressibility effects are included. The solution is obtained by using a pseudo-unsteady method with improved perturbation propagation properties. The equations are discretized in space by using a finite volume formulation. An explicit multistage dissipative Runge-Kutta algorithm is then used to advance the flow equations in the pseudo-time. First results of calculations compare fairly well with experimental data. Author

N89-22608 Motoren- und Turbinen-Union Muenchen G.m.b.H. (Germany, F.R.).
PROPULSION SYSTEMS WITH IMPROVED EFFICIENCY FOR FUTURE PASSENGER AIRCRAFT. MAIN TASK A: CONCEPTUAL INVESTIGATIONS OF FUTURE PROPULSION SYSTEMS WITH ENHANCED PROPULSIVE EFFICIENCY [ANTRIEBE MIT VERBESSERTER WIRTSCHAFTLICHKEIT FUER ZUKUENFTIGE VERKEHRSFLUGZEUGE. HAUPTAUFGABE A: KONZEPTIONELLE UNTERSUCHUNGEN VON ZUKUENFTIGEN ANTRIEBEN MIT ERHOEHTEM VORTRIEBSWIRKUNGSGRAD]
SCHILL, GUMUCIO, WILDNER, GEIDEL, and TRACKSDORF 30 Jun. 1987 186 p In GERMAN
(Contract BMFT-LFT-8510/4)
(MTU-TB-87/010; ETN-89-93765) Avail:

Fachinformationszentrum Karlsruhe, 7514
Eggenstein-Leopoldshafen 2, Fed. Republic of Germany

Open counter-rotating propfan propulsion systems as pusher with and without transmission were investigated. The variant with transmission is shown to be the most advantageous concept with respect to specific fuel consumption, weight and noise. The main advantages of the pusher without transmission are (besides the omission of the transmission) the smaller length and the smaller propeller diameter. The concept CRISP (Counter-Rotating Integrated Shrouded Propfan) was selected for further studies. Questions concerning CRISP, such as electrical auxiliary apparatus in samarium-cobalt technology and alternative transmission variants, are discussed. A nuclear propulsion system with single-rotor gas generator and innovative component technology was designed. ESA

N89-22609 Cincinnati Univ., OH.
LDV MEASUREMENTS AND INVESTIGATION OF FLOW FIELD THROUGH RADIAL TURBINE GUIDE VANES Ph.D. Thesis
HASAN EROGLU 1988 216 p
Avail: Univ. Microfilms Order No. DA8903591

The results of laser Doppler velocimeter (LDV) measurements and investigation of detailed flow field through radial inflow turbine guide vanes are presented. A three-component LDV system was used for the velocity measurements. The results are presented as contour plots of mean velocities, flow angles and turbulent stresses. Significant end wall cross flows were observed inside the blade passages close to the trailing edges. However, these cross flows are different from the ones in axial turbines because of the counter effects of the radial pressure gradient, the blade shape, and the high negative incidence angle. The flow field through the blade passages was found to be strongly influenced by the scroll geometry. The lack of periodicity between flow channels and asymmetry with respect to the two end walls were attributed to this upstream influence. The rapid mixing of the free stream flow with the wakes occurred downstream of the trailing edges. The average flow angle at downstream measuring station was found to be lower than the exit blade angle showing flow overturning at this radial location. The turbulence intensity increased in the downstream direction. The turbulent stresses also generally increased in the flow direction, but at different rates. The cross plane contour plots of turbulent stress components indicated that the turbulence is anisotropic. The mass flow rate increase did not change the inlet flow angle, but it decreased the passage averaged exit flow angle. The turbulence intensity and stresses decreased with the increase of the mass flow rate. In addition to the experimental investigation, an analytical study of the flow field through the guide vanes of the experimental radial turbine was performed. The flow field was computed using an inviscid, panel method computer code on the blade-to-blade surface of revolution at midspan position. Dissert. Abstr.

N89-22659# Ministry of Defence, London (England).
FUTURE ADVANCED AERO-ENGINES: THE MATERIALS CHALLENGE
D. R. HIGHTON and W. J. CHRISPIN *In* AGARD, Application of Advanced Material for Turbomachinery and Rocket Propulsion 10 p Mar. 1989
Avail: NTIS HC A13/MF A01

A balanced program of aero-engine advanced engineering is pursued in the UK, and an important and growing element of this program is that devoted to materials and processing technology. The quest for more capable materials is an essential element of that program. The powerplant continues to be a critical factor in improving vehicle capability in all military and civil applications. A position has been reached where further improvements in propulsion depend not only on maintaining current effort in aerothermodynamic technology, but also making substantial investments in new high risk materials technology. E.R.

08

AIRCRAFT STABILITY AND CONTROL

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

A89-36927*# Kansas Univ., Lawrence.
SENSITIVITY ANALYSIS OF DIGITAL FLIGHT CONTROL SYSTEMS USING SINGULAR-VALUE CONCEPTS
JAMES D. PADUANO and DAVID R. DOWNING (Kansas, University, Lawrence) (Guidance, Navigation and Control Conference, Williamsburg, VA, Aug. 18-20, 1986, Technical Papers, p. 338-345) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 12, May-June 1989, p. 297-303. Previously cited in issue 23, p. 3409, Accession no. A86-47437. refs
(Contract NCC2-293)

A89-36928*# Virginia Polytechnic Inst. and State Univ., Blacksburg.
SINGULAR TRAJECTORIES IN AIRPLANE CRUISE-DASH OPTIMIZATION
KARL D. BILIMORIA and EUGENE M. CLIFF (Virginia Polytechnic Institute and State University, Blacksburg) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 12, May-June 1989, p. 304-310. Research supported by DARPA. Previously cited in issue 22, p. 3540, Accession no. A87-50488. refs
(Contract F49620-87-C-0116; NAG1-203)

A89-36929#
TRAJECTORY OPTIMIZATION WITH RISK MINIMIZATION FOR MILITARY AIRCRAFT
JOHN L. VIAN and JOHN R. MOORE (Boeing Military Airplane Co., Wichita, KS) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 12, May-June 1989, p. 311-317. Previously cited in issue 22, p. 3542, Accession no. A87-50526. refs

A89-36930*# City Coll. of the City Univ. of New York, NY.
EIGENSTRUCTURE ASSIGNMENT FOR THE CONTROL OF HIGHLY AUGMENTED AIRCRAFT
KENNETH M. SOBEL (City College, New York) and FREDERICK J. LALLMAN (NASA, Langley Research Center, Hampton, VA) (1988 American Control Conference, 7th, Atlanta, GA, June 15-17, 1988, Proceedings. Volume 2, p. 1267-1276) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 12, May-June 1989, p. 318-324. Previously cited in issue 24, p. 3909, Accession no. A88-54549. refs

A89-36931*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
APPLICATION OF PRECOMPUTED CONTROL LAWS IN A RECONFIGURABLE AIRCRAFT FLIGHT CONTROL SYSTEM
DANIEL D. MOERDER (NASA, Langley Research Center; Information and Control Systems, Inc., Hampton, VA), NESIM HALYO (Information and Control Systems, Inc., Hampton, VA), JOHN R. BROUSSARD (Texas Instruments, Inc., Lewisville), and ALPER K. CAGLAYAN (Charles River Analytics, Inc., Cambridge, MA) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 12, May-June 1989, p. 325-333. refs
(Contract F33615-84-C-3608)

A self-repairing flight control system concept in which the control law is reconfigured after actuator and/or control surface damage to preserve stability and pilot command tracking is described. A key feature of the controller is reconfigurable multivariable feedback. The feedback gains are designed off-line and scheduled as a function of the aircraft control impairment status so that reconfiguration is performed simply by updating the gain schedule after detection of an impairment. A novel aspect of the gain schedule design procedure is that the schedule is calculated using a linear quadratic optimization-based simultaneous stabilization algorithm in which the scheduled gain is constrained to stabilize a collection of plant models representing the aircraft in various control failure modes. A description and numerical evaluation of a controller design for a model of a statically unstable high-performance aircraft are given. Author

A89-36932*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
SIMULATION EVALUATION OF AN ADVANCED CONTROL CONCEPT FOR A V/STOL AIRCRAFT
E. MORALEZ, V. K. MERRICK, and J. A. SCHROEDER (NASA, Ames Research Center, Moffett Field, CA) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 12, May-June 1989, p. 334-341. Previously cited in issue 22, p. 3542, Accession no. A87-50536. refs

A89-36934#
FLIGHT CONTROL SYSTEM DESIGN FOR AN IN-FLIGHT SIMULATOR
F. HENSCHEL (DFVLR, Brunswick, Federal Republic of Germany) and S. CHETTY (National Aeronautical Laboratory, Bangalore, India) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 12, May-June 1989, p. 351-356. Previously cited in issue 22, p. 3541, Accession no. A87-50497. refs

A89-36998#
EQUIVALENT SYSTEMS METHOD TO EVALUATE THE FLIGHT QUALITIES
FENG LIANG, LINCHANG ZHANG, and CHUNJIN LI (Beijing University of Aeronautics and Astronautics, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 9, Nov. 1988, p. A581-A585. In Chinese, with abstract in English.

The determination of equivalent systems both in time domain and frequency domain is discussed. Various matching forms of equivalent systems are studied. In the frequency domain, the nonlinear optimization is used to find the equivalent parameters. In the time domain, the adaptive filtering algorithms with UD decomposition are employed as an identification algorithm to estimate the parameters. Author

A89-37461
FLUTTER OF A WING WITH AN AILERON IN TRANSONIC FLOW [O FLATTERE KRYLA S ELERONOM V OKOLOZVUKOVOM POTOKE]
IU. P. NUSHTAEV Zhurnal Vychislitel'noi Matematiki i Matematicheskoi Fiziki (ISSN 0044-4669), vol. 29, April 1989, p. 598-603. In Russian. refs

The problem of the flutter of an infinite-span wing with an aileron in transonic flow of an ideal gas is solved numerically by linearizing the aerodynamic characteristics, with allowance made for compression shock fluctuations. The nonstationary aerodynamic characteristics are calculated using an implicit finite difference scheme. The effect of inertial and aerodynamic constraints on vibration stability is investigated, and a comparison is made with a solution for systems with a single degree of freedom. V.L.

A89-37524
VALIDATION OF NONSTATIONARY AERODYNAMICS MODELS FOR LONGITUDINAL AEROPLANE MOTION ON THE BASIS OF FLIGHT MEASUREMENTS
VILEM KOCKA Zprava VZLU, no. Z-56, 1988, p. 1-14. refs

The longitudinal motion of a light transport aircraft is considered as being excited by a pulse deflection of the elevator control surface during slow steady horizontal flight. On the basis of physical analysis, basic and simplified models of nondimensional aerodynamic frequency transfers and related nondimensional aerodynamic step admittances are derived. They comprise separated quasistationary and nonstationary parts. The analysis is useful for didactic purposes in flight mechanics and aerodynamics. An objective means of verifying the validity of aerodynamic models, which is based on flight measurements of an actual airplane, is suggested for use during airplane design. S.A.V.

A89-39258
INTEGRAL RUDDER SYSTEM FOR AIRCRAFT STEERING [INTEGRALES RUDERSYSTEM ZUR STEUERUNG VON FLUGZEUGEN]
W. HEINRICH Zeitschrift fuer Flugwissenschaften und Weltraumforschung (ISSN 0342-068X), vol. 13, Jan.-Feb. 1989, p. 42-47. In German.

A control surface system is being developed to reduce maximum wing loads and improve aircraft low-speed maneuverabilty while still permitting structural amplification relative to conventional systems. The system's greatest advantages pertain to canard or swept-back wing aircraft. The effects of the system on slow-flight characteristics, flight performance, longitudinal stability, curved flight, yawing moment, lateral control, and lateral stability as experimentally verified on a flight model are discussed. The influence of the integral rudder system on the flight structure, including the bending moment, torsion moment, and structural weight, is briefly addressed. C.D.

A89-39458#
ROBUST CONTROL OF AN ACTIVE VIBRATION ISOLATION SYSTEM FOR HELICOPTERS
QITAI GU (Tsinghua University, Beijing, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 10, Jan. 1989, p. A48-A54. In Chinese, with abstract in English.

The rejection of so-called blade harmonic disturbances generated by the main rotor of helicopters and atmospheric turbulence is an important problem which should be considered in the design of future helicopters. In this paper, robust control theory was applied to the design of an active vibration-isolation system which effectively restricts the influence of blade harmonics on the fuselage at the first and second harmonic frequencies, as well as eliminates the static relative displacement between the main rotor and fuselage under ascent or descent acceleration. Author

A89-39459#
THE ANALYSIS AND PREDICTION OF THE SPIN EQUILIBRIUM POINT OF MODERN AIRCRAFTS
SHUNDA XIAO and YIN CHENG (Northwestern Polytechnical University, Xian, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 10, Jan. 1989, p. A55-A59. In Chinese, with abstract in English.

Two approximate methods for predicting the equilibrium point of steady-state spin are presented. First, approximate values of state variables during steady-state spin are determined analytically by neglecting certain parameters which have trivial influence on the spin. In the second method, the state variables of the equilibrium point are calculated by a digital computer by using the Davidson-Fletcher-Powell optimization method. In this way, the computing time for digital simulation of spin motions is shortened. Author

N89-21802*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
LATERAL STABILITY ANALYSIS FOR X-29A DROP MODEL USING SYSTEM IDENTIFICATION METHODOLOGY
DAVID L. RANEY and JAMES G. BATTERSON Jun. 1989 27 p
(NASA-TM-4108; L-16471; NAS 1.15:4108) Avail: NTIS HC A03/MF A01 CSCL 01/3

A 22-percent dynamically scaled replica of the X-29A forward-swept-wing airplane has been flown in radio-controlled drop tests at the NASA Langley Research Center. A system identification study of the recorded data was undertaken to examine the stability and control derivatives that influence the lateral behavior of this vehicle with particular emphasis on an observed wing rock phenomenon. All major lateral stability derivatives and the damping-in-roll derivative were identified for angles of attack from 5 to 80 degrees by using a data-partitioning methodology and a modified stepwise regression algorithm. Author

N89-21803# Air Force Inst. of Tech., Wright-Patterson AFB, OH. School of Engineering.
MULTIVARIABLE CONTROL LAW DESIGN FOR THE CONTROL RECONFIGURABLE COMBAT AIRCRAFT (CRCA) M.S. Thesis
DARYL HAMMOND Dec. 1988 422 p
(AD-A202697; AFIT/GE/ENG/88D-14) Avail: NTIS HC A18/MF A01 CSCL 01/4

Typically, control law analysis and design for an aircraft include separating the longitudinal and lateral equations of motion and designing control laws for each separate motion. The simplifying assumptions are often valid and do not adversely affect the analysis and design when aerodynamic cross-coupling is minimal. The Control Reconfigurable Combat Aircraft (CRCA) design includes an all-flying canard with 30 degrees of dihedral angle which prevents the normal separation of lateral and longitudinal equations because of high aerodynamic cross-coupling. The multivariable control law design used in this thesis incorporates the high gain error actuated Proportional plus Integral (PI) controller developed by Professor Brian Porter of the University of Salford, England. Control law development and simulation are preformed using the computer aided design program called mat. Two successful fixed gain controller design methods and an adaptive controller design are demonstrated. The three control surfaces on each wing are operated together, so they are treated in this thesis as one control effector. Thus, the five CRCA control inputs for this design consist of two canards, left trailing edge flaperon, right trailing edge flaperon, and rudder. An adaptive controller design, using a recursive least squares (RLS) parameter estimation algorithm, is developed for a self-tuning control system. GRA

N89-21804# Massachusetts Inst. of Tech., Cambridge. Lab. for Advanced Composites.
STALL FLUTTER OF GRAPHITE/EPOXY WINGS WITH BENDING-TORSION COUPLING Annual Technical Report, 1 Jul. 1987 - 30 Jun. 1988
PETER DUNN and JOHN DUGUNDJI 25 Oct. 1988 25 p
(Contract F49620-86-C-0066)
(AD-A203077; TELAC-88-11; AFOSR-88-1289TR) Avail: NTIS HC A03/MF A01 CSCL 01/3

An analytical and experimental investigation is made of the non-linear, large amplitude, high angle of attack, stall flutter behavior of cantilevered graphite/epoxy wings. Ten six-ply graphite/epoxy wings with a wide range of bending-torsion characteristics were constructed and styrofoam fairings epoxied to these to form NACA-0012 airfoil shapes. Wind tunnel tests on these cantilevered wings revealed torsional and bending stall flutter limit cycles, depending on the layup. Reasonable agreement with steady, non-linear theory and with unsteady, linear theory was found. Fourier analysis applied to the ONERA 2-D non-linear, unsteady, aerodynamic model shows reasonable agreement with 2-D experiments on aerodynamic force and moment coefficients. GRA

N89-21806 Alabama Univ., University.
ENERGY CONCEPTS APPLIED TO CONTROL OF AIRPLANE FLIGHT IN WIND SHEAR Ph.D. Thesis
KALMANJE KRISHNAKUMAR 1988 282 p
Avail: Univ. Microfilms Order No. DA8826950

The principle of inertial energy distribution control for optimal wind shear penetration is developed theoretically, and a controller based on this principle is experimentally tested using a non-linear Boeing 727 math model. A Monte Carlo simulation for take-off, landing, and go-around flight conditions in the presence of microburst wind shear environment, is used to demonstrate the controller's universal application capabilities. The results of the experimental study show excellent height minimization characteristics of the controller based on the inertial energy distribution error performance index. Control of airplane flight in microburst wind shear environments is investigated from the point of view of optimally managing the available airplane energy. An energy analysis was conducted to identify viable energy-related performance indices for optimal control system design. Several energy related performance indices were evaluated for their relative microburst wind shear penetration characteristics, via an emergy-based feedback control system design. The concept and importance of feeding back inertial energy parameters for airplane guidance was introduced . The energy-based controller was tested for its robustness in a realistic microburst environment, using a Monte Carlo simulation of landing, take-off, and go-around flight conditions. Statistical models for the microburst strength, size, and location were used for the Monte Carlo simulation. Results are presented in terms of the probability of hitting an obstacle and in terms of the statistics of maximum deviations of airplane variables of interest. A number of recommendations, based both on the energy analysis and on the results obtained, are included. Dissert. Abstr.

N89-21807# Sparta, Inc., Lexington, MA.
STABILITY AND CONTROL OF HYPERVELOCITY VEHICLES Final Report, Apr. 1986 - Dec. 1987
RUDRAPATNA V. RAMNATH Feb. 1989 155 p
(Contract F33615-86-C-3616)
(AD-A205160; AFWAL-TR-89-3019) Avail: NTIS HC A08/MF A01 CSCL 01/3

This report investigates the general class of problems associated with the flight dynamics of hypervelocity vehicles and their control. After an examination of typical vehicles, flight environment, operating conditions and trajectories, a general analytical theory is developed to solve the significant problems. Based on typical flight scenarios, the dynamics are appropriately formulated to fit the situation in question. Thus the flight dynamics are investigated on a variety of trajectories, including re-entry and flight on constant-latitude minor circles at constant altitude. Re-entry dynamics are analyzed along steep, shallow, and arbitrary trajectories. Asymptotic analytical solutions are developed by the Generalized Multiple Scales method, in which the clock functions are necessarily nonlinear and complex quantities in order to solve the nonlinear and time varying dynamics. GRA

N89-22610 Purdue Univ., West Lafayette, IN.
MODEL-BASED ANALYSIS AND COOPERATIVE SYNTHESIS OF CONTROL AND DISPLAY AUGMENTATION FOR PILOTED FLIGHT VEHICLES Ph.D. Thesis
SANJAY GARG 1988 281 p
Avail: Univ. Microfilms Order No. DA8825537

The thrust of this research is to develop and validate a systematic technique for pilot-optimal control/display synthesis in complex, closed-loop manual control tasks. The suggested methodology makes extensive use of an Optimal Control Model of human behavior, both for synthesis as well as analysis. The use of the Optimal Control Modeling approach to adequately predict the effects of control/display interaction on human performance and workload, is first validated by performing a detailed model-based study of a set of configurations previously evaluated in an in-flight experimental study. The mathematical formulation of the Cooperative Control Synthesis technique is then extended to allow for simultaneously augmenting the display dynamics as well as plant or controlled element dynamics. The first order necessary conditions for the optimality of the control/display augmentation control laws are derived and a numerical solution algorithm is developed to solve for these control laws. The methodology is exercised to synthesize control and display augmentation in a compensatory tracking task with a generic controlled element. Analytical evaluations of the designs indicate the applicability of the methodology to meet pilot-centered requirements and to provide a task specific, systematic trade-off between control and display augmentation. An extensive real-time man-in-the-loop simulation study is performed to validate the results from the methodology. Finally, the utility of the methodology is demonstrated by synthesizing control-display designs in the longitudinal approach and landing task for a modern, statically unstable fighter-type aircraft. Dissert. Abstr.

N89-22611# Aeronautical Research Labs., Melbourne (Australia).
SINGLE CHANNEL TEST CONTROLLERS Aircraft Structures Technical Memo.
I. POWLESLAND and E. S. MOODY Jun. 1988 55 p
(AD-A204088; ARL-STRUC-TM-488; DODA-AR-005-525) Avail: NTIS HC A04/MF A01 CSCL 14/2

The stand-alone controllers in single and coupled-channel forms are described. Details of hardware and software are given, and notes on the associated data acquisition system and test boxes are included. A number of appendices provide data for preparation and reading of floppy disks, for cycling and communication rate adjustments and detailed information on other aspects of these units. GRA

09

RESEARCH AND SUPPORT FACILITIES (AIR)

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

A89-37783#
INVESTIGATION FOR VENTING TEST TECHNOLOGY WITH LARGE-SIZED MODEL IN A LARGE WIND TUNNEL
ZHANAO DONG (Luoyang Dynamics Institute, People's Republic of China) Acta Aerodynamica Sinica (ISSN 0258-1825), vol. 7, March 1989, p. 75-80. In Chinese, with abstract in English.

This paper describes briefly the investigation of venting test technology with a large-sized model in a 1.2m x 1.2m wind tunnel. Four main problems are solved as follows: the contradiction between balance rod and venting pipeline simultaneous measurements for both 34 point pressures and six-component balance forces variations in flow and in base pressure. The test results were compared with those obtained in 0.6m x 0.6m wind tunnel. It is shown that the venting test technology applied in both model and wind tunnel with large or small size are quite satisfied. Author

A89-37786#
THE APPLICATION OF WALL PRESSURE METHOD IN LOW SPEED RETURN WIND TUNNEL WITH CLOSED JET
MINGYAN CHEN (Nanjing Aeronautical Institute, People's Republic of China) Acta Aerodynamica Sinica (ISSN 0258-1825), vol. 7, March 1989, p. 94-101. In Chinese, with abstract in English.

A wall pressure signature method presented by Hackett has been introduced in order to estimate the wind tunnel corrections at high angles of attack. The tests of four flat plate wing and wing-body models of similar geometry with various sizes have been completed in NH-2 wind tunnel of Nanjing Aeronautical Institute. The results of test and calculation showed that the present method is convenient to use and the results corrected are accurate and reliable. But it is necessary to point out that the satisfactory results can be obtained only if the static pressure obtained from measurement at the surface of wall be corrected properly for closed jet and return wind tunnel with the breather slot aft the jet. Author

A89-38582
AIRPORT TECHNOLOGY INTERNATIONAL 1988
MAURICE G. HUDSON, ED. London, Sterling Publications, Ltd., 1988, 252 p. No individual items are abstracted in this volume.

The current status of airport technology is surveyed in reviews and reports by industry experts. Topics addressed include airport policy and management; the planning, design, and construction of airports; passenger handling and commercial operations; cargo handling; and ramp operations and handling. Consideration is given to problems of maintenance, airfield operations, ATC and navigation, training, and security. Extensive diagrams, drawings, graphs, and photographs are provided. T.K.

A89-39008
ACOUSTIC EMISSION TESTING THE F-111
J. M. CARLYLE (Physical Acoustics Corp., Princeton, NJ) NDT International (ISSN 0308-9126), vol. 22, April 1989, p. 67-73. refs

An acoustic emission (AE) test chamber is described for locating sources of failure in the F-111 fighter/bomber D6AC steel structures. The chamber periodically chills the F-111 aircraft to -40 C and stresses them up to +7.3 g and down to -3.0 g. The cold proof test station AE monitoring system includes a color CRT displaying the exact location of AE events in real time on simultaneous overhead and side views of the F-111. The events are colored green, yellow, and red according to their severity, as calculated from their amplitude and energy. A monochromatic CRT is used concurrently with the color CRT to display severity information on AE events which only arrive at one sensor. Audio alarms also alert the operator to crucial events, using two tones to distinguish the degree of severity. S.A.V.

A89-39469#
DEVELOPMENT OF A SECOND GENERATION INJECTOR DRIVEN TRANSONIC WIND TUNNEL AT BUAA
YUNPEI LING, HUA ZHANG, and JIAN LIU (Beijing University of Aeronautics and Astronautics, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 10, Feb. 1989, p. B9-B14. In Chinese, with abstract in English. refs

The development of an injector-driven transonic pilot wind tunnel in BUAA is reported. Improvements are made in dynamic flow quality and mass efficiency. The pressure fluctuation level in the test section meets the advanced world standard and specifically satisfies or approaches Lowson's formula and Mabey's criterion. The mass ratio and free-stream turbulence attain a reasonably good level. Experimental results indicate good prospects for utilizing the injector-driven technique in advanced transonic wind tunnels. C.D.

A89-39477#
ON THE ACCELERATING AIRFLOW PROBLEM IN THE TEST SECTION OF A TRANSONIC WIND TUNNEL
GUOFENG ZHENG (Nanjing Aeronautical Institute, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 10, Feb. 1989, p. B73-B75. In Chinese, with abstract in English.

The accelerating airflow problem in the transonic test section with perforated wall is investigated from three aspects: (1) the axial distribution of porosity, (2) the determination of design parameters in the front of accelerating section, and (3) the investigation of the region of influence. Assuming that the axial pressure drop and the cross-flow velocity in a mass-flow nozzle is equal to those in the solid wall nozzle, a formula for calculating the open-area ratio of the mass-flow nozzle can be deduced. It is found that the predicted values of the open-area are consistent with the measured ones. Hence, the formula can be utilized to design the open-area ratio distribution of the mass-flow nozzle. Author

N89-21808# Aeronautical Research Labs., Melbourne (Australia).
DESCRIPTION OF A SIMPLE ROTOR TEST RIG AND PRELIMINARY WAKE STUDIES Aerodynamics Technical Memo.
M. J. WILLIAMS and K. R. REDDY May 1988 23 p
(AD-A204089; ARL-AERO-TM-397; DODA-AR-005-527) Avail: NTIS HC A03/MF A01 CSCL 01/3

A simple test rig has been constructed, to obtain detailed rotor wake geometry data. The rotor head and blades have been taken from a radio-controlled model and attached to a 1HP 3-phase motor. The rotor and drive system were mounted on a rigid tripod-supported stand, and the rig used to obtain smoke flow visualization photographs of tip vortices within the rotor wake.

These photographs provide vortex trajectories from which axial and radial coordinates of the vortex can be determined. The resulting data can be used to construct prescribed wake models for use in helicopter aerodynamics codes. GRA

N89-21809# University of Southern Illinois, Carbondale. Materials Technology Center.

A PROPOSAL FOR FUNDING TO PURCHASE A HIGH-TEMPERATURE FURNACE TO ENABLE DETERMINATION OF THE HIGH TEMPERATURE MECHANICAL PROPERTIES OF STRUCTURAL CARBON MATERIALS Final Report, 15 Aug. 1987 - 15 Aug. 1988

MAURICE A. WRIGHT 13 Oct. 1988 5 p
(Contract AF-AFOSR-0397-87; AF PROJ. 2306)
(AD-A204103; AFOSR-88-1315TR) Avail: NTIS HC A02/MF A01 CSCL 14/2

This report documents the purchase of a controlled environment furnace, designed for attachment to the MTS and Instron tensile testing machines used by the researchers of the Materials Technology Center at Southern Illinois University at Carbondale. After investigating proper sources for the equipment, a purchase requisition was processed on December 7, 1987 through university procedures and Board of Trustees approval. GRA

N89-21810# General Electric Co., Burlington, VT. Armament Systems Dept.

AEROBALLISTIC RESEARCH FACILITY DATA ANALYSIS SYSTEM (ARFDAS) Final Technical Report, Oct. 1986 - Sep. 1987

MARK FISCHER and WAYNE HATHAWAY Sep. 1988 144 p
(Contract F08635-87-C-0005)
(AD-A204308; AD-E801786; AFATL-TR-88-48) Avail: NTIS HC A07/MF A01 CSCL 19/10

This report documents the computerized analysis programs used to examine free-flight, ballistic trajectory data (spatial position, angular orientation, and time) obtained at the United States Air Force Aeroballistic Research Facility (ARF). The Aeroballistic Research Facility Data Analysis System (ARFDAS) is a set of FORTRAN programs used to extract aerodynamic coefficients from experimental spark range data. This report, essentially a User's Manual, concentrates on how to utilize ARFDAS to conduct the desired analysis. The theory behind derivation of the six degree of freedom equations of motion is fully explained by the references. The purpose of the report is to enable a person, who possesses a good knowledge of aerodynamics, to utilize the ARFDAS computer codes to analyze experimental data to final coefficient form. GRA

N89-21811# Army Engineer Waterways Experiment Station, Vicksburg, MS. Structures Lab.

EVALUATION OF BARRIER CABLE IMPACT PAD MATERIALS Final Report, Sep. 1983 - Sep. 1984

TONY B. HUSBANDS and DENNIS L. BEAN Mar. 1988 94 p
(Contract MIPR-N-90-29; MIPR-F-83-73; AF PROJ. 2104)
(AD-A204356; AFESC/ESL-TR-87-33) Avail: NTIS HC A05/MF A01 CSCL 01/5

The U.S. Air Force uses an aircraft arresting system on many of their runways for emergency stopping of aircraft. It consists of a 1- or 1-1/4-inch steel cable stretched across the runway connected to a braking mechanism. When aircraft tires impact the cable, considerable damage occurs to concrete and other materials placed underneath the cable. Materials previously used were not performing satisfactorily for various reasons. A survey was made in 1980 for the Air Force Engineering and Services Center (AFESC) to locate materials for evaluation. Five of these were selected for detailed testing. The materials were tested for gel times, peak exotherms, bond strength, abrasion resistivity, ultraviolet degradation, resiliency, hardness, abrasion-impact resistance, effect of curing temperature, and proportioning errors. GRA

N89-21812# Federal Aviation Administration, Washington, DC. Office of Airport Planning and Programming.

ELIGIBILITY OF NOISE ABATEMENT PROPOSALS FOR GRANTS-IN-AID UNDER THE AIRPORT IMPROVEMENT PROGRAM

ELLIS OHNSTAD Jan. 1989 26 p
(AD-A204724; DOT/FAA/PP-89/2) Avail: NTIS HC A03/MF A01 CSCL 14/2

This report summarizes the provisions of existing Federal laws, regulations, administrative policies and grant program procedures which relate to funding of noise abatement projects. The report also presents historical data on Federally assisted noise compatibility projects and funding levels in fiscal years 1982 to 1987. A literature search was conducted and parties involved with airport noise compatibility planning and project implementation were consulted to identify proposals which are currently not eligible for grant assistance and the reasons for their ineligibility. The report concludes with recommendations to make eligibility criteria more flexible and to provide clearer guidance to parties involved with noise compatibility project formulation, evaluation and implementation. GRA

N89-21813# Carnegie-Mellon Univ., Pittsburgh, PA. Dept. of Software Engineering.

AN OOD (OBJECT-ORIENTED DESIGN) PARADIGM FOR FLIGHT SIMULATORS, 2ND EDITION Final Report

KENNETH J. LEE, MICHAEL S. RISSMAN, RICHARD DIPPOLITO, CHARLES PLINTA, and ROGER VANSCOY Sep. 1988 120 p
(Contract F19628-85-C-0003)
(AD-A204849; CMU/SEI-88-TR-30; ESD-TR-88-031) Avail: NTIS HC A06/MF A01 CSCL 12/5

This report presents a paradigm for object-oriented implementations of flight simulators. It is a result of work on the Ada Simulator Validation Program (ASVP) carried out by members of the technical staff at the Software Engineering Institute (SEI). Object-oriented design (OOD) predominates discussions about Ada-based software engineering. The identification of objects and the implementation of objects are two separate issues. This paradigm is a model for implementing systems of objects. The objects are described in a form of specification called an object diagram. The paradigm is not about how to create the specification. Although much has been written on object-oriented design, SEI project members could find no examples of object-oriented implementations relevant to flight simulators. Examples were required for two reasons. First, object-orientation was new to both of the contractors on the ASVP. A methodology which leads to a specification of objects is useful only if developers know how to implement what is specified. Second, managers were skeptical about the benefits of object-oriented design. Examples were needed to determine whether benefits outweigh costs. GRA

N89-22614*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

HARDWARE AND OPERATING FEATURES OF THE ADAPTIVE WALL TEST SECTION FOR THE 0.3-METER TRANSONIC CRYOGENIC TUNNEL

RAYMOND E. MINECK Jun. 1989 41 p
(NASA-TM-4114; L-16548; NAS 1.15:4114) Avail: NTIS HC A03/MF A01 CSCL 14/2

A 13- by 13-inch adaptive wall test section was installed in the Langley 0.3-Meter Transonic Cryogenic Tunnel circuit. This test section has four solid walls and is configured for two-dimensional airfoil testing. The top and bottom walls are flexible and movable, whereas the sidwalls are rigid and fixed. The test section has a turntable to support airfoil models, a survey mechanism to probe the model wake, and provisions for a sidewall boundary-layer-control system. Details of the adaptive wall test section , the tunnel circuit modifications, the supporting instrumentation, the monitoring and control hardware, and the wall adaptation strategy are discussed. Sample results of shakedown tests with the test section empty and with an airfoil installed are also included. Author

N89-22615# Air Force Systems Command, Wright-Patterson AFB, OH. Foreign Technology Div.
VISTING CHINA'S AERODYNAMICS RESEARCH AND DEVELOPMENT CENTER
YONGDAI HU and YAPING LI 5 Jan. 1989 12 p Transl. into ENGLISH from Sichuan Huabao (People's Republic of China), no. 5, Iss. 53, Sep. 1987 p 7-9
(AD-A203980; FTD-ID(RS)T-0639-88) Avail: NTIS HC A03/MF A01 CSCL 14/2

A visit ot the reseach and development facility is detailed. The facility was developed to meet the needs of China's aviation and space industry and it's peoples' economic development. One highlight of the visit was the wind tunnel. Photographs are presented. E.R.

N89-22616*# Vigyan Research Associates, Inc., Hampton, VA.
MICROCOMPUTER BASED CONTROLLER FOR THE LANGLEY 0.3-METER TRANSONIC CRYOGENIC TUNNEL
S. BALAKRISHNA and W. ALLEN KILGORE Mar. 1989 149 p
(Contract NAS1-17919)
(NASA-CR-181808; NAS 1.26:181808) Avail: NTIS HC A07/MF A01 CSCL 14/2

Flow control of the Langley 0.3-meter Transonic Cryogenic Tunnel (TCT) is a multivariable nonlinear control problem. Globally stable control laws were generated to hold tunnel conditions in the presence of geometrical disturbances in the test section and precisely control the tunnel states for small and large set point changes. The control laws are mechanized as four inner control loops for tunnel pressure, temperature, fan speed, and liquid nitrogen supply pressure, and two outer loops for Mach number and Reynolds number. These integrated control laws have been mechanized on a 16-bit microcomputer working on DOS. This document details the model of the 0.3-m TCT, control laws, microcomputer realization, and its performance. The tunnel closed loop responses to small and large set point changes were presented. The controller incorporates safe thermal management of the tunnel cooldown based on thermal restrictions. The controller was shown to provide control of temperature to + or - 0.2K, pressure to + or - 0.07 psia, and Mach number to + or - 0.002 of a given set point during aerodynamic data acquisition in the presence of intrusive geometrical changes like flexwall movement, angle-of-attack changes, and drag rake traverse. The controller also provides a new feature of Reynolds number control. The controller provides a safe, reliable, and economical control of the 0.3-m TCT. Author

N89-22617*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
NEW HYPERSONIC FACILITY CAPABILITY AT NASA LEWIS RESEARCH CENTER
JEFFREY E. HAAS, ROGER CHAMBERLIN, and JOHN H. DICUS 1989 16 p Presented at the 25th Joint Propulsion Conference, Monterey, CA, 10-12 Jul. 1989; sponsored by AIAA, ASME, SAE and ASEE
(NASA-TM-102028; E-4760; NAS 1.15:102028; AIAA-89-2534) Avail: NTIS HC A03/MF A01 CSCL 14/2

Four facility activities are underway at NASA Lewis Research Center to develop new hypersonic propulsion test capability. Two of these efforts consist of upgrades to existing operational facilities. The other two activities will reactivate facilities that have been in a standby condition for over 15 years. These four activities are discussed and the new test facilities NASA Lewis will have in place to support evolving high speed research programs are described. Author

N89-22619# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick (Germany, F.R.). Hauptabteilung Windkanaele.
THE LOW-SPEED WIND TUNNEL AT DVFLR IN BRUNSWICK (FED. REPUBLIC OF GERMANY) Status Report, 1988
GERHARD KAUSCHE, HORST OTTO, DIETMAR CHRIST, and RUEDIGER SIEBERT Sep. 1988 96 p In GERMAN; ENGLISH summary Original contains color illustrations
(DFVLR-MITT-88-25; ISSN-0176-7739; ETN-89-94371) Avail: NTIS HC A05/MF A01; DFVLR, VB-PL-DO, Postfach 90 60 58, 5000 Cologne, Fed. Republic of Germany, DM 43

Information for users of the low-speed wind tunnel Braunschweig (NWB) of DFVLR is presented. The wind tunnel has a closed return circuit comprising an open and a closed test section, the cross-section being 3.25 m x 2.80 m. A maximum velocity of 90 m/sec in the closed test section and of 75 m/sec in the open one can be achieved. The information required for the preliminary planning of test programs and for the preliminary layout of models for intended tests is given. ESA

N89-22620 Council for National Academic Awards (England).
INVESTIGATION OF THE EFFECTS OF INCREASED SOPHISTICATION OF SIMULATION OF THE ATMOSPHERIC WIND IN WIND TUNNELS Ph.D. Thesis
ALLAN HODGSON CUSICK 1988 413 p
Avail: Univ. Microfilms Order No. BRD-84076

The influence of the sophistication of the simulation of the natural wind in wind tunnels was investigated upon the correlation of model and full scale ground wind speeds and directions. A model of a section of the Manchester University campus, centered about the Mathematics Tower, was made at a scale of 1:250. It extended, at this scale, for a distance of one meter in all directions. This model was tested in three wind tunnels. Two are of high, one of low, sophistication of simulation of the natural wind. It was found that results in all three wind tunnels were significantly affected by model limitations such as the artificial ending of wind dominant building formations at the edge of the model, and potentially, by mis-positioning of ground wind probes at measuring stations in areas of high horizontal velocity gradient. The least sophisticated simulation produced local defects which were markedly worse than corresponding defects in the other two simulations in one particular wind direction. However, the measurements at points in the least sophisticated simulation, which were free of effects directly related to the limited size of the wind tunnel relative to the model, exhibited a similar level of correlation with full scale results to that in the sophisticated simulations. Following the normal custom in pre-construction environmental wind tunnel testing of large buildings in an urban area, only the buildings and major features were included in the model. In these circumstances the effect of the ground-cover on the completed site is expected to give an extra safety factor over the model ground wind predictions made using the smooth base board. The results in all three wind tunnels indicated conformity with these expectations. Dissert. Abstr.

N89-22621 Colorado Univ., Boulder.
NUMERICAL STUDY OF A MULTIPURPOSE TRANSONIC WIND TUNNEL WITH AN ADAPTABLE INJECTION-SUCTION SYSTEM Ph.D. Thesis
SHING-CHUNG ONN 1988 117 p
Avail: Univ. Microfilms Order No. DA8902928

For the simplicity in installation and operation, an adaptable injection-suction (AIS) system was implemented to see if it can be used to replace the conventional convergent-divergent nozzle in a multipurpose transonic wind tunnel. Results for three different AIS systems indicate that such an idea is feasible. Without viscous effects, an isentropic small-disturbance velocity potential formulation is used to solve this transonic flow problem. Based on the examined cases, it can be found that: (1) before choking, with increasing M sub infinity, the normal shock can be gradually moved down the channel and the supersonic bubble grows like the flow in a conventional convergent-divergent nozzle, (2) after choking, both the location and shape of the sonic line are invariant with respect to decreased exit pressure, (3) in a subcritical flow, the pressure distribution at the AIS system is approiximately symmetric with respect to the center of the AIS system, and the pressure distribution is no longer symmetric in a supercritical flow, (4) the supersonic bubble in a supercritical flow may disappear by reducing the strength of the AIS system, (5) after choking, by lowering the choked exit pressure, the shock can be moved further downstream to become a lambda shock near the exit of the channel, (6) for the case by using an AIS system with injection only, a sonic flow at the exit section can be obtained by locating the trailing edge of this injection system at the wall exit and specifying the exit Mach number to be unity, and (7) an originally choked flow may not be choked if the AIS system is shifted to a different location. From the first three findings, it can be concluded that the present numerical calculations of this transonic flow problem are fairly reliable. Dissert. Abstr.

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ASTRONAUTICS

Includes astronautics (general); astrodynamics; ground support systems and facilities (space); launch vehicles and space vehicles; space transportation; spacecraft communications, command and tracking; spacecraft design, testing and performance; spacecraft instrumentation; and spacecraft propulsion and power.

A89-36543*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
IMPACT CRATERING IN LOW-GRAVITY ENVIRONMENTS - RESULTS OF RECONNAISSANCE EXPERIMENTATION ON THE NASA KC-135A REDUCED-GRAVITY AIRCRAFT
M. J. CINTALA, F. HORZ (NASA, Johnson Space Center, Houston, TX), and T. H. SEE (Lockheed Engineering and Sciences Co., Houston, TX) IN: Lunar and Planetary Science Conference, 19th, Houston, TX, Mar. 14-18, 1988, Proceedings. Cambridge/Houston, TX, Cambridge University Press/Lunar and Planetary Institute, 1989, p. 627-639. refs

A program of flight experimentation was performed on the NASA KC-135A reduced-gravity aircraft to evaluate the potential for conducting impact experiments in reduced-gravity environments and to collect impact-cratering data at gravity levels below 1 g. Lead pellets were launched into coarse-grained sand at velocities of about 65-130 m/sec while the gravitational acceleration was maintained at 0.59-0.05 g. A total of 64 craters were studied and, after allowance is made for the atmospheric pressure over the target (0.83 atm), their diameters are found to have been consistent with scaling predictions made on the basis of ground-based experimentation. Formation times were also obtained for 33 of these craters and constitute a distribution that is somewhat different from that described by the ground-based data. Nevertheless, the KC-135 data set as a whole falls on the trend formed by the ground-based results. The overall agreement between the two data sets attests to the stability of the aircraft as a platform for impact experimentation. Author

A89-36611
COMBINING THE USE OF GEOSTATIONARY AND INCLINED ORBIT SATELLITES FOR INTEGRATED COMMUNICATIONS AND NAVIGATION APPLICATIONS
G. KINAL and K. HUNGERFORD (International Maritime Satellite Organization, London, England) IN: International Conference on Satellite Systems for Mobile Communications and Navigation, 4th, London, England, Oct. 17-19, 1988, Proceedings. London, Institution of Electrical Engineers, 1988, p. 186-189.

The diversity of requirements for mobile communications and position determination suggests a liberal interpretation of 'integration' of communications and navigation. A combination of Inmarsat geostationary and GPS inclined-orbit satellites could be employed in a hybrid mode so as to obtain most of the advantages of both passive navigation and active radiolocation (surveillance). The application of this concept to oceanic air traffic control is used to illustrate how such integration enhances both the communications and navigation functions. Author

A89-37004#
COUPLING FACTOR METHOD FOR STUDYING ELASTIC MOTION OF FLIGHT VEHICLES
JIANPING YUAN and SHILU CHEN (Northwestern Polytechnical University, Xian, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 9, Dec. 1988, p. B555-B560. In Chinese, with abstract in English.

By coupling of elastic motion is meant a process in which the forces resulting from elastic vibration act on the same vehicle, and lead to new elastic motions. It is the coupling that maintains vibration. When the equations of motion are rewritten in matrix, the coupling factor is a bilinear form in modal functions or their derivatives determined at the impelling point and impelled point, respectively, with T-1 M as the coefficient of the form. Aerodynamic force is the most essential and it may give rise to coupling between the distinct vibrations. When the engine is installed on a flexible body, the propulsive force also results in vibration. In the feedback control system, control force will produce vibration that is related to the points of measurement and control. But if an open loop control is used, no coupling exists. At the end, coupling factors are applied to optimizing the positions of engine sensor and actuator. Practical examples are given. Author

A89-37646
VOICE OF AUTHORITY
PETER DONALDSON Space (ISSN 0267-954X), vol. 5, Mar.-Apr. 1989, p. 13, 14.

The development of voice control systems for use on space vehicles is discussed. French testing of a voice control system on the Mirage III aircraft is examined. Possible applications of the system include the Hermes, EVA on the Space Shuttle, and construction and maintenance on the Space Station. The ways in which voice control technology may be used to reduce astronaut workload are summarized. Issues related to the development of voice control systems are considered, including voice dependency, changes in voice patterns, speed, accuracy, and verifying commands. R.B.

A89-37659
GRAVITY REFUELING NOZZLES AND PORTS INTERFACE STANDARDS FOR CIVIL AIRCRAFT
SAE Aerospace Standard, SAE AS 1852, Feb. 1988, 4 p. (SAE AS 1852)

The critical interface dimensions for airframe refueling ports and ground refueling nozzles pertinent to gravity fuel-feed civil aircraft servicing are presented. It is the intention of such standardized interface limits to prevent the misfueling of reciprocating-engine aircraft requiring aviation gasoline with turbine fuel. Both English and metric nozzle tip dimensions are given. O.C.

A89-38234
FUNDAMENTAL ASPECTS OF AN AEROSPACEPLANE
RYOJIRO AKIBA (Institute of Space and Astronautical Science, Sagamihara, Japan) IN: International Symposium on Space Technology and Science, 16th, Sapporo, Japan, May 22-27, 1988, Proceedings. Volume 2. Tokyo, AGNE Publishing, Inc., 1988, p. 1521-1526.

The aerospaceplane defined in this paper is a single-stage vehicle reaching an orbital speed through an atmospheric flight. General characteristics are clarified for the air breathing engine operating in a wide range of flight velocity on the basis of one dimensional conservation laws. It is pointed out that utilization of the energy carried by the intake air is important as well as utilization of the oxygen. The trajectory analysis shows that the gravity loss is negligible along a constant heating rate trajectory in the range of Mach number from 5 to 25 in which SCRAM operates. Further simplified analyses reveal several features of propulsion utilizing the energy of heat produced by the aerodynamic drag. Author

A89-39028#
INVESTIGATION OF A SMALL SOLID FUEL RAMJET COMBUSTOR
YESHAYAHOU LEVY, ALON GANY (Technion - Israel Institute of Technology, Haifa), and RONI ZVULONI Journal of Propulsion and Power (ISSN 0748-4658), vol. 5, May-June 1989, p. 269-275. refs

Experimental and analytical investigations of a small solid-fuel ramjet (SFRJ) combustor were conducted. A static test system with a 25-kW electrical air heater simulated the air temperature and pressure encountered in flight at a Mach number of 3 at sea level. The transparent polymethylmethacrylate fuel used in the tests permitted continuous video photography, revealing the local fuel-regression-rate behavior and the instantaneous ignition and combustion phenomena. The results demonstrated high combustion efficiency and indicated peculiar local and average fuel-regression-rate correlations. The analysis indicated that the specific conditions resulting from the low Reynolds number range in small SFRJ motors, in contrast to large combustors, enhance the effect of the sudden-expansion heat-transfer regime relative to the boundary-layer regime. Author

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CHEMISTRY AND MATERIALS

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

A89-36335
POLYMERS FOR ADVANCED STRUCTURES - AN OVERVIEW
DAVID TANNER, JOHN R. SCHAEFGEN (Du Pont de Nemours and Co., Wilmington, DE), and VLODEK GABARA (Du Pont de Nemours and Co., Richmond, VA) IN: IUPAC International Symposium on Polymers for Advanced Technologies, Jerusalem, Israel, Aug. 16-21, 1987, Proceedings. New York, VCH Publishers, Inc., 1988, p. 384-418. refs

This paper reviews advances in polymer science that have enabled development of high-performance materials, describes the systems approach to applications, and previews future trends. The emphasis is on important applications; e.g., in aircraft, aerospace, marine, automobiles, and ballistics where lightweight, energy-efficient structures provide the impetus for radically new designs and performance. Author

A89-36405
METALLURGICAL STABILITY OF INCONEL ALLOY 718
J. W. BROOKS and P. J. BRIDGES (Inco Engineered Products, Ltd., Birmingham, England) IN: Superalloys 1988; Proceedings of the Sixth International Symposium, Champion, PA, Sept. 18-22, 1988. Warrendale, PA, Metallurgical Society, Inc., 1988, p. 33-42. refs

Extensive heat treatment and forging trials have been carried out on Inconel alloy 718 produced by vacuum melting in order to clarify the time-temperature transformation characteristics of the material. The effect of forging practice on microstructure and mechanical properties has also been determined, together with the long term stability of the alloy. The gamma-star precipitation behavior has been defined for annealing times up to 10,000 hours, and the transformation kinetics have been compared and contrasted with those of conventional gamma-prime-strengthened superalloys. An explanation for the relationship between grain-boundary delta precipitation and creep ductility is presented. Author

A89-36406
ON DEVELOPING A MICROSTRUCTURALLY AND THERMALLY STABLE IRON-NICKEL BASE SUPERALLOY
J. P. COLLIER, A. O. SELIUS, and J. K. TIEN (Columbia University, New York) IN: Superalloys 1988; Proceedings of the Sixth International Symposium, Champion, PA, Sept. 18-22, 1988. Warrendale, PA, Metallurgical Society, Inc., 1988, p. 43-52. refs

In order to obtain a turbine engine hot-section alloy possessing the excellent fabricability and heat resistance of IN718, but with a temperature ceiling higher than that imposed in that alloy by microstructural instabilities occurring at elevated temperatures, seven novel Fe-Ni-base superalloy compositions have been formulated. Tests have been conducted to ascertain the effect of systematically changing the Al, Ti, and Nb contents on the microstructural stability and long-term elevated temperature mechanical properties. Increasing the Al+Nb content and the Al/Ti ratio in the alloy was found to yield more of the stable gamma-prime phase and less of the brittle delta phase, while enhancing the mechanical properties of the alloy. O.C.

A89-36410
CAUSES AND EFFECTS OF CENTER SEGREGATION IN ELECTRO-SLAG REMELTED ALLOY 718 FOR CRITICAL ROTATING PART APPLICATIONS
M. D. EVANS and G. E. KRUZYNSKI (Cytemp, Specialty Steel Div., Titusville, PA) IN: Superalloys 1988; Proceedings of the Sixth International Symposium, Champion, PA, Sept. 18-22, 1988. Warrendale, PA, Metallurgical Society, Inc., 1988, p. 91-100. refs

The causes of center segregation in electroslag remelted (ESR) 718 superalloy are investigated in the interest of defining processing parameters yielding consistently segregation-free ESR 718 ingots suitable for gas turbine turbomechanical element applications. Remelt tests gave attention to the effects of melt rate, slag chemistry and volume, and electrode immersion depth; billet-conversion practices were investigated, and macrostructural, microstructural, and associated mechanical properties were characterized. While the greater susceptibility to macrosegregation in ESR than in vacuum-arc remelted material of this composition is confirmed, positive effects on center segregation are indicated. O.C.

A89-36411
DEVELOPMENT OF GATORIZED MERL 76 FOR GAS TURBINE DISK APPLICATIONS
R. H. CALESS and D. F. PAULONIS (United Technologies Corp., Pratt and Whitney Group, East Hartford, CT) IN: Superalloys 1988; Proceedings of the Sixth International Symposium, Champion, PA, Sept. 18-22, 1988. Warrendale, PA, Metallurgical Society, Inc., 1988, p. 101-110.

The MERL 76 alloy was developed to produce components by hot isostatic pressing (HIP). To provide for enhanced shaping capability, improved material utilization, and to explore potential property benefits, a development program was undertaken to qualify Gatorized MERL 76. The MERL 76 composition was fixed, and billets were consolidated by HIP, followed by Gatorizing into the required component shape. Detailed studies were conducted to define both metal processing (e.g., HIP and forging) and heat treatment parameters. Comprehensive monotonic and fatigue testing of full-size components has demonstrated that Gatorized MERL 76 met all program goals. This material has been used in commercial service since 1983, with excellent experience. Author

A89-36414
DEVELOPMENT OF INCONEL ALLOY MA 6000 TURBINE BLADES FOR ADVANCED GAS TURBINE ENGINE DESIGNS
B. A. EWING and S. K. JAIN (General Motors Corp., Allison Gas Turbine Div., Indianapolis, IN) IN: Superalloys 1988; Proceedings of the Sixth International Symposium, Champion, PA, Sept. 18-22, 1988. Warrendale, PA, Metallurgical Society, Inc., 1988, p. 131-140.

An account is given of development efforts involving the MA 6000 superalloy's near-net-shape forging and thermal protection coating techniques for uncooled turbine blade applications. Attention is given to turbine blade forging accomplishments to date with an oxide dispersion-strengthened MA 6000 alloy version. The stress rupture results obtained are noted to be competitive with single crystal superalloy blades in the high temperature/low stress regime. Oxidation tests have indicated that the new, duplex coating system used is superior to commercially available types. O.C.

A89-36418

BEYOND SUPERALLOYS - THE GOALS, THE MATERIALS AND SOME REALITY

CHESTER T. SIMS (Rensselaer Polytechnic Institute, Troy, NY) IN: Superalloys 1988; Proceedings of the Sixth International Symposium, Champion, PA, Sept. 18-22, 1988. Warrendale, PA, Metallurgical Society, Inc., 1988, p. 173-182.

Next-generation gas turbine-related applications for superalloys have been envisioned which require a doubling of operating temperature and a reduction of strength/weight to about 5 g/cu cm for highly refractory superalloys in the near future; these requirements are to be satisfied irrespective of turbine blade, vane, and disk operation in atmospheres that may be oxidizing, neutral, or reducing. Turbine-inlet temperatures of the order of 2200 C may thereby be reached, using comparatively little active cooling. 'Oxide/oxide' ceramic fiber-reinforced ceramic matrix composites are recommended as the best development goal in the longer term. O.C.

A89-36424

SECOND-GENERATION NICKEL-BASE SINGLE CRYSTAL SUPERALLOY

A. D. CETEL and D. N. DUHL (United Technologies Corp., Pratt and Whitney Group, East Hartford, CT) IN: Superalloys 1988; Proceedings of the Sixth International Symposium, Champion, PA, Sept. 18-22, 1988. Warrendale, PA, Metallurgical Society, Inc., 1988, p. 235-244. refs

Significant increases in high temperature strength capability have been achieved in a second-generation nickel-base single crystal alloy designed for advanced military and commercial turbine airfoil applications. This new alloy, designated PWA 1484, offers a 50 F improvement in metal temperature capability (creep-rupture strength, thermal fatigue resistance, and oxidation resistance) over PWA 1480, the first nickel-base single crystal turbine alloy to enter production. PWA 1484 represents the first use of rhenium in a production single crystal superalloy. The alloy properties have been fully characterized and demonstrate an outstanding combination of high-temperature creep and fatigue strength as well as excellent oxidation resistance. Production processing of single crystal PWA 1484 castings has shown that the alloy has good castability and a wide solution heat treatment range. The superior properties of PWA 1484 have been confirmed through extensive engine testing. Author

A89-36425

ENHANCED RUPTURE PROPERTIES IN ADVANCED SINGLE CRYSTAL ALLOYS

S. M. FOSTER, T. A. NIELSEN, and P. NAGY (Williams International, Walled Lake, MI) IN: Superalloys 1988; Proceedings of the Sixth International Symposium, Champion, PA, Sept. 18-22, 1988. Warrendale, PA, Metallurgical Society, Inc., 1988, p. 245-254. refs

Extended thermal processing has been employed to improve the rupture lives of the single-crystal superalloys CMSX-2 and -4G, whose compositions are similar except for the addition of Re in the latter in the interest of high-temperature stability. The high-temperature aging cycles yielded gamma-prime platelet formation as well as varying degrees of gamma-prime coarsening, whose effect on rupture and tensile properties was then studied. It is found that overaging the gamma-prime in CMSX-2 occurs more easily than in CMSX-4G; mechanical property tests have also demonstrated that extended thermal cycles yield increased rupture lives due to gamma-prime platelet formation and coarsening, with only minor decrease in tensile strength. O.C.

A89-36435

A HAFNIUM-FREE DIRECTIONALLY SOLIDIFIED NICKEL-BASE SUPERALLOY

DONGLIANG LIN, SONGHUI HUANG (Jiaotong University, People's Republic of China), and CHUANQI SUN (Institute of Aeronautic Materials, Beijing, People's Republic of China) IN: Superalloys 1988; Proceedings of the Sixth International Symposium, Champion, PA, Sept. 18-22, 1988. Warrendale, PA, Metallurgical Society, Inc., 1988, p. 345-354. refs

This paper provides a review of current efforts on design of a hafnium-free directionally solidified nickel-base superalloy with good castability, post-casting transverse ductility and improved creep strength. Emphasis is being placed on the effect of alloy modifications on castability and the improvement of creep strength by increasing solid solution temperature. Author

A89-36440

ELECTRON BEAM COLD HEARTH REFINEMENT PROCESSING OF INCONEL ALLOY 718 AND NIMONIC ALLOY PK50

S. PATEL, I. C. ELLIOTT (Inco Alloys International, Ltd., Hereford, England), H. RANKE, and H. STUMPP (Leybold AG, Hanau, Federal Republic of Germany) IN: Superalloys 1988; Proceedings of the Sixth International Symposium, Champion, PA, Sept. 18-22, 1988. Warrendale, PA, Metallurgical Society, Inc., 1988, p. 397-406.

This paper describes the electron beam (EB) refining of Inconel alloy 718 and Nimonic alloy PK50 in a 250 kW furnace. The EB furnace design is shown and described. The EB melting process performance and the resulting metallurgical structures, chemistry, forgeability, cleanness levels, and mechanical behavior are reported and discussed. C.D.

A89-36452

PROPERTY OPTIMIZATION IN SUPERALLOYS THROUGH THE USE OF HEAT TREAT PROCESS MODELLING

R. A. WALLIS and P. R. BHOWAL (Cameron Forge Co., Houston, TX) IN: Superalloys 1988; Proceedings of the Sixth International Symposium, Champion, PA, Sept. 18-22, 1988. Warrendale, PA, Metallurgical Society, Inc., 1988, p. 525-534.

One important variable in maximizing tensile, creep, stress rupture and toughness properties in superalloys is the cooling rate from the alloy solutioning temperature. Correlations between properties and cooling rates may be conveniently developed using small blanks of material. Implementation of the data in complex geometries such as aircraft engine disks, however, is most effectively done through finite element modelling of the heat treatment process. The application of heat treat process modelling to predict the property levels at various locations in parts having relatively complex shapes are discussed. An example of the use of models to obtain the required properties while reducing residual stress levels in the part is given together with an example where the properties are maximized against the tendency of the part to crack during quenching. Author

A89-36480

DEGRADATION OF ALUMINIDE COATED DIRECTIONALLY SOLIDIFIED SUPERALLOY TURBINE BLADES IN AN AERO GAS TURBINE ENGINE

P. C. PATNAIK, J. E. ELDER, and R. THAMBURAJ (Hawker Siddeley Canada, Inc., Toronto) IN: Superalloys 1988; Proceedings of the Sixth International Symposium, Champion, PA, Sept. 18-22, 1988. Warrendale, PA, Metallurgical Society, Inc., 1988, p. 815-824. Research supported by the National Aeronautical Establishment Ottawa and DND. refs

An experimental study is made of service induced degradation, such as oxidation, thermal fatigue, and interdiffusion, in a directionally solidified Ni-based superalloy, Rene 80H, with a diffusion aluminide coating that is currently used in the high-pressure turbine of an advanced aircraft engine. It is found that the aluminide coating behaves poorly under thermal fatigue. Thermal fatigue cracks initiate in the coating and propagate into the substrate, leading to a catastrophic oxidation of the substrate alloy. The cracks often turn from the radial to the axial direction, which can cause the failure of the entire blade. Interdiffusion of alloying elements between the coating and the substrate leads to the formation of a deleterious sigma phase at the interface, which can cause embrittlement, particularly in thin sections of the blade. V.L.

A89-36484
INFLUENCE OF THERMAL FATIGUE ON HOT CORROSION OF AN INTERMETALLIC NI-ALUMINIDE COATING
JOHN W. HOLMES and FRANK A. MCCLINTOCK (MIT, Cambridge, MA) IN: Superalloys 1988; Proceedings of the Sixth International Symposium, Champion, PA, Sept. 18-22, 1988. Warrendale, PA, Metallurgical Society, Inc., 1988, p. 855-864. refs
(Contract NSF DMR-84-18718)

The hot corrosion of Ni-aluminide coatings, applied by pack aluminization to stepped-disk fatigue specimens machined from a monocrystalline Ni-base alloy (Rene 14), was investigated experimentally in relation to the fatigue strain history of the specimens. After 6000 cycles between peak strains of -0.26 percent at 925 C and 0.03 percent at 650 C, extensive hot corrosion attack occurred, whereas only minor oxidation of the coating was observed after 6000 cycles between lower peak strains of -0.16 percent at 925 C and 0.01 percent at 650 C. The strain history dependence of hot corrosion is attributed to the cracking of the protective surface oxide, resulting in direct interaction between the coating and molten Na_2SO_4, which was applied to the specimens during the tests. V.L.

A89-36721#
TAMING CERAMIC FIBER
ALAN S. BROWN Aerospace America (ISSN 0740-722X), vol. 27, May 1989, p. 14-17, 20-22.

An evaluation is made of the development status and comparative performance of ceramic fibers applicable to metal-matrix and ceramic-matrix components for gas turbine engine and hypersonic airframe primary structures. Difficulties in fiber producibility, which increase price/lb, and strength-degrading reactions that can occur at fiber/matrix interfaces at the high temperatures encountered during both fiber/matrix consolidation and high-temperature service, remain major obstacles to further implementation. Much research has concentrated on intermetallic Ti and Al matrices, in order to reduce their brittleness. O.C.

A89-36722#
MATERIALS FOR THE NASP
NED D. NEWMAN and RICHARD E. PINCKERT (McDonnell Douglas Corp., Saint Louis, MO) Aerospace America (ISSN 0740-722X), vol. 27, May 1989, p. 24-26, 31.

An evaluation is made of experimental results obtained to date concerning the identification of high structural performance/high service temperature/low density materials for use by the National Aerospace Plane's X-30 technology-demonstrator airframe. Refractory composite development encompasses carbon/carbon and ceramic-matrix composites. Metal-matrix composites under intensive study are exemplified by SiC fiber-reinforced Ti alloy matrices; these materials retain high strength to 1800 F; attention has been given to fiber/matrix reaction zone behavior during simulated hypersonic flight conditions. The X-30 will incorporate active cooling of leading edges combustion chamber walls, etc. O.C.

A89-37658
AIRCRAFT TURBINE FUEL CONTAMINATION HISTORY AND ENDURANCE TEST REQUIREMENTS
SAE Aerospace Information Report, SAE AIR 4023, March 1, 1988, 26 p.
(SAE AIR 4023)

Standard tests have evolved which subject fuel system components to a controlled, severe, contaminated-fuel environment, in order to ascertain a given fuel system design's filtration and contamination-resistant component features. It has been suggested that a slug-type contamination test be used in order to expose fuel-system components to typical fuel tank debris; contaminants such as sealant globs, lockwire, aluminum chips, o-ring slices, reticulated foam, and cotton linters should be used. The more intensive use of composite materials in airframes could results in novel kinds of contaminants. O.C.

A89-37756#
A STUDY ON GH169 CRACK PROPAGATION UNDER CREEP-FATIGUE INTERACTION
YAN LI, WENGLONG JIANG, and HONGFAN ZHOU (Beijing Institute of Aeronautical Materials, People's Republic of China) Journal of Aerospace Power (ISSN 1000-8055), vol. 4, Jan. 1989, p. 25-29, 89. In Chinese, with abstract in English.

As a new technique of crack detection at high temperatures, the reversing dc electric potential method is used to study the crack propagation behaviors of an aero-engine turbine disk material, GH169, under creep-fatigue interaction at 650 C and at different hold times. The experimental results indicate that the life prediction model based on the hyperbolic sine function is superior to the life prediction model based on the Paris formulation. Moreover, the former model is more convenient in application. Author

A89-38021
EFFECT OF CRACK SIZE ON THE TENSILE STRENGTH OF CERAMICS IN A HIGH-TEMPERATURE CORROSIVE ENVIRONMENT
YOSHIYUKI MUNAKATA and TETSUYA SENDA (Ministry of Transport, Ship Research Institute, Mitaka, Japan) JSME International Journal, Series I (ISSN 0914-8809), vol. 32, April 1989, p. 287-291.

Ceramics with considerable defects in corrosive ash were tested at temperatures of 650 C for PSZ and 900 C for SiC. Corrosive ash containing vanadium pentoxide and sodium sulphate was applied to an artificial flaw produced by a Vickers indentation on the specimen. The surface damage of PSZ in a high-temperature corrosive environment does not significantly influence the tensile strength. The corrosive ash on SiC ceramics with surface flaws contributes little to the strength as compared to that on PSZ ceramics. K.K.

A89-38153
ANODIZED ALUMINUM AND ALUMINUM ALLOY COATINGS FOR THERMAL CONTROL
SONG LIN CONG (Chinese Academy of Sciences, Shanghai Institute of Ceramics, People's Republic of China) IN: International Symposium on Space Technology and Science, 16th, Sapporo, Japan, May 22-27, 1988, Proceedings. Volume 1. Tokyo, AGNE Publishing, Inc., 1988, p. 951-955. refs

The characteristics of four types of anodized aluminum and aluminum alloy coatings for thermal control on spacecraft are described. The coatings include the bright anodized aluminum coating, the bright anodized aluminum foil, the anodized alluminum alloy coating, and the black anodized aluminum and aluminum alloy coating. Both of the bright coatings are characterized by low solar absorptance and a wide range of the solar absorptance to emittance ratio. The bright anodized aluminum foil may be adhered to nonaluminum materials. The black coating has high solar absorptance and emittance and is stable to UV-vacuum irradiation. R.B.

A89-38387
SCRAMJET COMBUSTION WITH AN AID OF SILANE
KENJI SUGIMOTO IN: International Symposium on Space Technology and Science, 16th, Sapporo, Japan, May 22-27, 1988, Proceedings. Volume 2. Tokyo, AGNE Publishing, Inc., 1988, p. 2595-2600. refs

The effect of substituting 25-percent silane for hydrogen on the combustion of a stoichiometric H_2-O_2 mixture at 823-1617 K is investigated in shock-tube experiments simulating conditions in a scramjet engine. The ignition delay time is determined on the basis of monochromator/PMT detection of OH emission, and the results are presented in extensive graphs. Silane is found to improve the H_2 combustion, significantly at temperatures up to about 1200 K but only slightly at higher temperatures. The accuracy of theoretical combustion models is shown to be good at low temperatures but only fair at high temperatures. T.K.

N89-21851# Naval Postgraduate School, Monterey, CA.
COMPOSITE FAILURE CRITERION: PROBABILISTIC FORMULATION AND GEOMETRIC INTERPRETATION M.S. Thesis
JONG C. LIM Dec. 1988 96 p
(AD-A205275) Avail: NTIS HC A05/MF A01 CSCL 12/3

The objective of this thesis is to derive the reliability and the associated probabilistic failure criterion for composite materials under combined stress. In the analytical deviation, the concept of joint probability was used and applied to the Weibull distribution function. In applications, given the experimental measurements of the necessary statistical parameters for the specific composite, the probabilistic criterion of the composite failure and the reliability of the specific structure can be predicted. Graphical representations for the joint reliability and joint failure contours were made in two and three dimensional space for the several different sets of statistical strength parameters to illustrate the effect of parameters on reliability. Such understanding will enhance selection of fiber and matrix (which have their own statistical strength parameters) and can lead to improvement in reliability of some composite components in an aircraft structure. These reliability and failure concepts can also be used in repair problems by selecting the proper composite material with the appropriate statistical parameters. GRA

N89-21873# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). Structures and Materials Panel.
THE FATIGUE IN AIRCRAFT CORROSION TESTING (FACT) PROGRAMME
R. J. H. WANHILL, J. J. DELUCCIA, and M. T. RUSSO (Naval Air Development Center, Warminster, PA.) Feb. 1989 214 p
(AGARD-R-713; ISBN-92-835-0495-X) Avail: NTIS HC A10/MF A01

In the 1970s the Structures and Materials Panel decided to embark on collaborative research activities in the area of fatigue. One of the first activities was the Corrosion Fatigue Cooperative Testing Programme (CFCTP), the precursor to the Fatigue in Aircraft Corrosion Testing (FACT) program. Both programs are described. Failure by fatigue and degradation by corrosion continue to be major considerations in aircraft design. Environmental effects influence both inititation and propagation of fatigue cracks, and dynamic loading may cause more rapid deterioration of corrosion protection systems. Therefore the conjoint action of dynamic loading and environmental attack, i.e., corrosion fatigue, requires special attention. Many corrosion fatigue tests were done on aluminum alloys. However, few included critical structural details like joints, under realistic cyclic load histories and in service-like environments. Ever fewer used practical corrosion protection systems. These aspects are specifically addressed by the CFCTP and FACT programs. The results provide a significant contribution to the understanding of aircraft corrosion fatigue and should encourage further investigation. Author

N89-21926# Central Research Inst. of Electric Power Industry, Tokyo (Japan).
SIMULATION ANALYSIS ON CERAMIC GAS TURBINE
TOSHIO MIMAKI, TOSHIO ABE, TORU HISAMATSU, TERUHIDE HAMAMATSU, HIROSHI ISHIKAWA, and KATSUO WADA Aug. 1987 67 p In JAPANESE; ENGLISH summary
(DE88-756469; CRIE-W-87002) Avail: NTIS (US Sales Only) HC A04/MF A01

In the application of ceramics to gas turbine materials, the analysis and estimation of thermal stress and careful strength verification were required at the trip on a gas turbine subjected to sudden thermal shock, therefore by the simulation on 20 MW class gas turbine for coal gasification, the quantity change of state of gas in a gas turbine inlet at the trip was studied, and an effective operation method to reduce the thermal shock was investigated. Since the smoothing of temperature gradient and the sudden reduction of high temperature gas flow were considered to be most effective for the thermal stress reduction of ceramic materials, the operation methods of a fuel stop valvel, blow-off valvle at a compressor outlet and compressor inlet guide vane were investigated. As a result of the simulation, the method to rapidly reduce working gas flow by simultaneous control of the compressor inlet guide vane and blow-off valve was recommended as the most suitable method at present. DOE

N89-21943# Geo-Centers, Inc., Newton, MA.
JET FUEL DEOXYGENATION Interim Report, Mar. 1987 - Jul. 1988
SHIRLEY DARRAH Oct. 1988 29 p
(Contract F33615-84-C-2412)
(AD-A205006; GC-TR-88-1416-013; AFWAL-TR-88-2081) Avail: NTIS HC A03/MF A01 CSCL 07/3

This program was initiated to identify and characterize methods of deoxygenating quantities of jet fuel to improve fuel thermal stability. Three methods, chemical getters, molecular sieves and nitrogen sparging, were evaluated in our laboratory. In the case of nitrogen sparging, additional results were obtained by comparing laboratory experimental results with the output from ULLAGE, a computer based mathematical model. Each method was shown to reduce the oxygen content of jet fuel. Economic and system considerations favor nitrogen sparging for large quantities of fuel. GRA

N89-21983 Centre d'Essais Aeronautique Toulouse (France).
MATERIALS TESTS: MEANS AND TECHNIQUES [EXPERTISE MATERIAUX - MOYENS ET TECHNIQUES]
I.-A. PATRICK ARMANDO *In* CNES, Quality, Components and Technological Analysis p 1159-1225 Aug. 1988 In FRENCH
Avail: CEPADUES-Editions, 111 Rue Nicolas-Vauquelin, 31100 Toulouse, France

The techniques used to characterize the materials employed in aeronautical construction are reviewed, as well as the desirable properties and specification procedures. Materials discussed include metals, composites, ceramics, sintered powders, refractory materials, and metallic matrix composites. ESA

N89-22654# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). Propulsion and Energetics Panel.
APPLICATION OF ADVANCED MATERIAL FOR TURBOMACHINERY AND ROCKET PROPULSION
Mar. 1989 282 p In ENGLISH and FRENCH Meeting held in Bath, England, 3-5 Oct. 1988
(AGARD-CP-449; ISBN-92-835-0498-4) Avail: NTIS HC A13/MF A01

The proceedings of the conference are presented. The specialists' meetings were arranged in the following sessions: Overview and Combined Applications; Gas Turbine Applications; Rocket Applications; and Special Applications. A Technical Evaluation report is included at the beginning of the proceedings. The aim of the specialists' meetings was to review the advances made in the field of materials applicable in the hot parts of aerospace propulsion system during the last few years. The meetings offered a forum for the users of new materials in the fields of turbomachines and rockets to report on recent achievements and to discuss the various applications.

N89-22655# Air Force Materials Lab., Wright-Patterson AFB, OH. Metals and Ceramics Div.
TECHNICAL EVALUATION REPORT
NORMAN M. TALLAN *In* AGARD, Application of Advanced Material for Turbomachinery and Rocket Propulsion 11 p Mar. 1989
Avail: NTIS HC A13/MF A01

A technical evaluation is presented of the materials presented at the 72nd Propulsion and Energetics Panel Specialists' Meeting. The objective of the meeting was to bring together the designers, developers and users of aerospace propulsion systems and the developers and producers of aerospace materials to provide a forum in which the material requirements of both current and future propulsion systems and the ability of emerging new materials to meet those requirements could be reviewed. The scope included the properties and potential applications of superalloys, refractory metals, advanced intermetallic alloys, and metal matrix composites based on them; carbon-carbon and ceramic matrix composites; coatings and the processes used to prepare them; bearing and insulation materials; braze and weld repair methods; innovative design approaches to the use of these new materials; and the damage tolerance and life prediction of these materials and their implications with regard to damage tolerant design and applications to real propulsion systems. E.R.

N89-22656# Pratt and Whitney Aircraft, West Palm Beach, FL. Materials Engineering.
APPLICATION OF ADVANCED MATERIALS FOR TURBOMACHINERY AND ROCKET PROPULSION
JOSEPH B. MOORE *In* AGARD, Application of Advanced Material for Turbomachinery and Rocket Propulsion 5 p Mar. 1989
Avail: NTIS HC A13/MF A01

Gas turbine engines of the 1980's and 1990's will require improved nickel and titanium alloys as well as certain intermetallic compounds and low temperature composites. Engines of the 2000's with significantly higher thrust to weight ratios will require lighter weight, higher temperature non-conventional materials including aluminum alloys, titanium metal matrix composites, intermetallic compounds, and ceramic matrix composites. Major concerns once these materials are developed will be the design, manufacture, inspection, and repair of required components at affordable cost. Current or near-term liquid rocket engines having technology levels equivalent to those being studied for the space transportation and advanced launch systems can benefit from improved materials for turbomachinery, high heat flux throat regions of the thrust chamber, high strength, hydrogen resistant materials for cases and ducts, and refractory materials for uncooled or partially cooled nozzle extensions. To meet the far term goals for advanced rocket engines required for single-stage-to-orbit (SSTO) vehicles materials requirements are not unlike those described above for 21st century gas turbine engines. Author

N89-22657# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Stuttgart (Germany, F.R.). Inst. for Structures and Design.
MONOLITHIC AND FIBER CERAMIC COMPONENTS FOR TURBOENGINES AND ROCKETS
R. KOCHENDOERFER *In* AGARD, Application of Advanced Material for Turbomachinery and Rocket Propulsion 10 p Mar. 1989
Avail: NTIS HC A13/MF A01

From the design point of view, whether or not the existing experience gained during the automotive ceramic turbine development can be transferred to aero jet engines is reviewed. It is well known that design considerations strongly influence the failure tolerance of ceramic structures. Following material adequate design concepts will increase component reliability. Focussing these topics, the future application of ceramics for thermally and/or mechanically high-loaded structures within the propulsion system are discussed. Actual available data of emerging materials as C/C, C/SiC, SiC/Sic are presented. The material's behavior, their potential for structural applications as well as design consequences are evaluated. Author

N89-22658# Royal Aircraft Establishment, Farnborough (England). Space Dept.
CVD AND DIFFUSION COATINGS FOR HIGH TEMPERATURE APPLICATIONS IN TURBOMACHINERY AND ROCKET MOTORS
S. P. FIELD, J. E. RESTALL, C. D. CHALK, and C. HAYMAN (Fulmer Research Inst. Ltd., Stoke Poges, England) *In* AGARD, Application of Advanced Material for Turbomachinery and Rocket Propulsion 12 p Mar. 1989
Avail: NTIS HC A13/MF A01

A brief but critical review is presented of recent developments in Chemical Vapor Deposition (CVD) metal and ceramic coatings for aerospace applications, covering in addition to standard CVD, activated CVD, diffusion CVD, pressure pulsed CVD and the more recently explored chemical vapor infiltration (CVI) processing. Fused slurry diffusion coatings are also covered. Important applications of such coatings and free-standing shapes are outlined and illustrated, particularly CVD diffusion aluminizing, chromizing and siliconizing of turbine blades, refractory metal coatings and free-standing components of rocket motors. Future trends in materials technology are also discussed with particular reference to the CVD coating of fibers, including modified carbon-carbon and other ceramic composites for high temperature operation in oxidizing environments. Author

N89-22660# Rolls-Royce Ltd., Derby (England). Materials Research.
NEW METALLIC MATERIALS FOR GAS TURBINES
M. A. HICKS *In* AGARD, Application of Advanced Material for Turbomachinery and Rocket Propulsion 13 p Mar. 1989
Avail: NTIS HC A13/MF A01

The mix of properties required for high performance components in the gas turbine will continue to necessitate the use of metallic materials for the forseeable future. Examples are shown which indicate how a detailed understanding of material/component behavior and a better understanding and control of the manufacturing process are becoming increasingly important in meeting the anticipated design targets. Author

N89-22661# Pratt and Whitney Aircraft, West Palm Beach, FL.
DAMAGE TOLERANCE CONCEPTS FOR ADVANCED MATERIALS AND ENGINES
T. E. FARMER and M. C. VANWANDERHAM *In* AGARD, Application of Advanced Material for Turbomachinery and Rocket Propulsion 7 p Mar. 1989
Avail: NTIS HC A13/MF A01

Planned increases in thrust to weight for future gas turbine engines require dramatically higher operating temperatures and rotor speeds. This necessitates simpler design, improved materials and sophisticated fabrication techniques. Damage Tolerance Design (DTD) has been established as the basis for gas turbine engine design and maintenance in the U.S. Consideration of damage tolerance has significant influence on configurations and materials. The advanced configurations, bonded structures, composites, anisotropic alloys and less ductile materials required to meet the advanced engine goals challenge the current DTD philosophy. Fortunately, interim plans for incremental increases in performance and engine configuration to meet long-term goals afford the opportunities for developing transition technologies to meet these objectives. Author

N89-22662# Rolls-Royce Ltd., Derby (England).
MATERIAL/MANUFACTURING PROCESS INTERACTION IN ADVANCED MATERIAL TECHNOLOGIES
G. W. MEETHAM *In* AGARD, Application of Advanced Material for Turbomachinery and Rocket Propulsion 7 p Mar. 1989
Avail: NTIS HC A13/MF A01

Since the first flight of a gas turbine powered aircraft some forty years ago, tremendous advances in engine performance have been made in terms of thrust, thrust-weight ratio and specific fuel consumption. The performance and efficiency of gas turbine engines is a direct function of the maximum cycle temperature and, throughout the forty years in which the aero gas turbine has existed, this has provided the motivation for the continuous development of materials which are capable of operating at higher temperatures in the turbine section of the engine. Turbine entry temperatures have risen from around 700 C in the Whittle W1 engine in 1941 to around 1350 C in current advanced engines. Author

N89-22663# Fiat Aviazione S.p.A., Turin (Italy). Stress Dept.
DEVELOPMENT OF STRESS AND LIFING CRITERIA FOR SINGLE CRYSTAL TURBINE BLADES
S. SALVANO, M. STANISCI, and E. CAMPO *In* AGARD, Application of Advanced Material for Turbomachinery and Rocket Propulsion 9 p Mar. 1989
Avail: NTIS HC A13/MF A01

The stress and lifing criteria applied to turbine blades are discussed, by focusing the relevant features which make single crystal materials different from conventional alloys. The discussion basis is provided by the material data and blade finite element analyses, collected for the application of single crystal alloys to advanced aircraft engines. Author

N89-22665# Garrett Turbine Engine Co., Phoenix, AZ.
THE DEMONSTRATION OF MONOLITHIC AND COMPOSITE CERAMICS IN AIRCRAFT GAS TURBINE COMBUSTORS
FRANK G. DAVIS and DALE A. HUDSON *In* AGARD, Application of Advanced Material for Turbomachinery and Rocket Propulsion 10 p Mar. 1989
Avail: NTIS HC A13/MF A01

Since the mid seventies, the Air Force Wright Aeronautical Laboratories Aero Propulsion Laboratory has been on a course to evaluate and demonstrate the application of advanced non-metallic materials in experimental gas turbine engines. Potential increases of several hundred degrees or more in operating temperature represents a quantum leap in engine capability. Since the seventies, combustion rig tests have been successfully performed at near-stoichiometric conditions on two ceramic combustor configurations. These combustors were annular, through-flow designs similar to the metallic burners used in present-day military propulsion gas turbines. The first configuration used monolithic ceramic segments as a portion of the inner and outer combustor liners. The segments were supported by an external metal structure. These segments were fabricated from silicon carbide material. In the most recent program ceramic composite rings were used to form the inner and outer liners. The rings were composed of silicon carbide fibers and a silicon carbide matrix. The ceramic composite rings required no external support structure. Testing consisted of both steady-state and transient operations. During transient testing, the combustors were subjected to rapid thermal cycling. Testing of silicon carbide and silicon nitride ceramic materials has just begun. Author

N89-22688# Naval Air Development Center, Warminster, PA. Aircraft and Crew Systems Technology Directorate.
THE EFFECTS OF PLASTIC MEDIA BLASTING PAINT REMOVAL ON THE MICROSTRUCTURE OF GRAPHITE/EPOXY COMPOSITE MATERIALS Final Report, Oct. 1986 - Oct. 1987
JOSEPH KOZOL, STEVEN THOMAN, and KENNETH CLARK 7 Oct. 1988 45 p
(AD-A204801; NADC-88109-60) Avail: NTIS HC A03/MF A01 CSCL 11/4

Plastic media blasting (PMB) was assessed as a paint removal method for AS4/3501-6 and IM6/3501-6 graphite epoxy (Gr/Ep) composite materials. Microstructural effects on these composite materials were evaluated after repeated paint/blast cycles. Polyester (type 1) and urea formaldehyde (type 2) plastic media materials were used in a variety of blast conditions. Ultrasonic inspection, optical microscopy and scanning electron microscopy were used to assess the damage induced during paint removal. After one paint/blast cycle, most of the blast conditions caused little or no visual damage to the composite substrates. After four paint/blast cycles, several of the conditions caused minimal visual damage. Paint removal by sanding caused more visual damage after one paint removal cycle than any of the repeat blast conditions that were evaluated. GRA

N89-22702# Aerospatiale, Suresnes (France). Direction Centrale de la Qualite.
TESTS OF NEW MATERIALS WITH SECOND GENERATION CARBON FIBERS, TEST REPORT [ESSAIS CSPC 319-20 SONDAGE SUR NOUVEAUX MATERIAUX AVEC FIBRES DE CARBONE DE DEUXIEME GENERATION. PROCES-VERBAL 47-188F]
J. ODORICO, G. PELLAN, and R. PERRIER 23 Jan. 1987 51 p In FRENCH
(Contract STPA-83-96-003)
(REPT-47-188/F; ETN-89-94355) Avail: NTIS HC A04/MF A01

Material to implement the mainframe structure of future aircraft were tested. The results presented refer to five carbon-epoxy systems. The tests include tensile tests, interlayer shearing, flexion on unidirectional specimens, tensile on crossed ply specimens, delamination sensitivity, and influence of holes on the mechanical behavior. Improvements of up to 50 pct of the mechanical characteristics are found. ESA

N89-22703# Aerospatiale, Suresnes (France). Direction Centrale de la Qualite.
CSPC TEST 319.30: STUDY ON IMPACT TOLERANCE OF PREIMPREGNATED CARBON-EPOXY SYSTEMS [ESSAI CSPC 319.30: ETUDE DE LA TOLERANCE AUX CHOCS DES PREIMPREGNES CARBONE-EPOXY. PROCES-VERBAL 47-323/F]
B. SOULEZELLE and J. ODORICO 21 Dec. 1988 57 p In FRENCH
(REPT-47-323/F; ETN-89-94356) Avail: NTIS HC A04/MF A01

Standard tests aiming to evaluate the impact behavior of carbon epoxy structural aircraft components are described. After impact testing, the specimens are tested in compression or static traction. The method allows to determine the loss of mechanical characteristics due to impact. The designer must then use a maximum admissible stress corresponding to maximum invisible impact damage. ESA

N89-22707# Aeronautical Research Inst. of Sweden, Stockholm. Structures Dept.
A SURVEY OF POLY-ETHER-ETHER-KETONE AND ITS ADVANCED COMPOSITES
SOREN NILSSON Dec. 1988 55 p
(Contract FMV-FFL-82250-86-169-25-001)
(FFA-TN-1988-37; ETN-89-94545) Avail: NTIS HC A04/MF A01

The suitability of PEEK for aircraft structures was reviewed. Its major advantages compared to present epoxy matrix systems are: increased toughness; better impact resistance; greater ease of repair; less hygroscopic; infinite shelf-life; some metal forming operations are transferable to thermoplastic forming; and quality of material may be better in terms of less batch-to-batch variation. However, in processing thermoplastics one can encounter; higher pressures and temperatures; and difficulties with fiber-wet-out at the higher molecular weights and consequently higher void contents. ESA

N89-22718# Universal Energy Systems, Inc., Dayton, OH.
COMBUSTOR FLOW VISUALIZATION USING INNOVATIVE INFRARED THERMOGRAPHICS TECHNIQUES Final Report, 1 Jul. 1986 - 2 Jan. 1987
GARY D. STREBY Mar. 1989 227 p
(Contract F33615-86-C-2670)
(AD-A205905; WRDC-TR-89-2015) Avail: NTIS HC A11/MF A01 CSCL 21/2

Innovative computational analysis methods and image processing techniques were combined with a commercially available infrared (IR) thermal imaging video system to produce complete surface thermographic data of a ramjet combustor configuration. The components of the data analysis system, the data-reduction procedures, and typical test data are presented. Data precision and the limitations of the infrared system are discussed. Unique capabilities of the system included continuous infrared color or gray-scale video monitoring of a heated test article, full-frame video digitizing and image enhancement of infrared thermal images, and computer processing to produce complete surface 3-dimensional thermal topographic data plots of a heated combustor under actual operating conditions. GRA

N89-22768# Army Materials Technology Lab., Watertown, MA. Polymer Research Branch.
ENVIRONMENTALLY INDUCED DISCONTINUITIES IN TRANSPARENT POLYMERS Final Report
JANICE J. VANSELOW, ALEX J. HSIEH, and JENNIE H. BROWN Feb. 1989 13 p Presented at the US Army CRDEC Conference,

Chemical Defense Research, Nov. 1988
(AD-A205483; MTL-TR-89-11) Avail: NTIS HC A03/MF A01
CSCL 07/6

Several grades of poly(methyl methacrylate) (PMMA) used in the aircraft industry have been selected for evaluation of their resistance to chemically-induced stress crazing and cracking. Solvents include simulants for CW agents, the decontaminant, DS2, and another surface active agent, o-xylene. Craze initiation due to solvents applied to the surface of these materials is determined, and the improved stress crazing resistance due to biaxial stretching of PMMA is demonstrated. Fracture toughness is determined for all formulations. Crack propagation is measured in the isotropic samples via a static dead-weight loading apparatus while the solvent, o-xylene, is applied. Results demonstrate varying comparative resistances based on the different test methods. GRA

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ENGINEERING

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

A89-36304

CONSIDERATION OF ENVIRONMENTAL CONDITIONS FOR THE FATIGUE EVALUATION OF COMPOSITE AIRFRAME STRUCTURE

MATTHIAS BERG, JOHANN J. GERHARZ (Fraunhofer-Institut fuer Betriebsfestigkeit, Darmstadt, Federal Republic of Germany), and OGUZ GOKGOL (Messerschmitt-Boelkow-Blohm GmbH, Hamburg, Federal Republic of Germany) IN: Composite materials: Fatigue and fracture; Proceedings of the Second Symposium, Cincinnati, OH, Apr. 27, 28, 1987. Volume 2. Philadelphia, PA, American Society for Testing and Materials, 1989, p. 29-44. refs

This paper demonstrates the 'compensation factor' approach in fatigue evaluation of large composite airframe structures, which uses the compensation factors to take into account the effects of environmental history (temperature and humidity) expected in service and missing during the testing of large structures. Compensation factors were experimentally derived, using small preconditioned coupon specimens made from carbon/epoxy prepregs; the specimens were subjected to accelerated quasi-realistic mechanical and environmental flight-by-flight loading. In parallel, other specimens were loaded exactly like the composite airframe structure (i.e., with less stimulated environment). It was found that, only at load levels higher than presently necessary for the applied carbon/epoxy systems, fatigue loading with simultaneous quasi-realistic environmental loading did reduce the life to fracture, as compared to samples without simulated environment. I.S.

A89-36319

FRACTURE OF PRESSURIZED COMPOSITE CYLINDERS WITH A HIGH STRAIN-TO-FAILURE MATRIX SYSTEM

KEVIN J. SAEGER and PAUL A. LAGACE (MIT, Cambridge, MA) IN: Composite materials: Fatigue and fracture; Proceedings of the Second Symposium, Cincinnati, OH, Apr. 27, 28, 1987. Volume 2. Philadelphia, PA, American Society for Testing and Materials, 1989, p. 326-337. refs

An experimental and analytical investigation was conducted to examine the fracture behavior of pressurized graphite/epoxy cylinders and coupons that utilize a high strain-to-failure matrix system. The material system is a five-harness satin-weave cloth made of AS4 fiber impregnated with Cycom 907 epoxy. Tests were performed on standard tensile coupons to determine the elastic constants of the material and the notched and unnotched fracture characteristics of a quasi-isotropic (0, 45)s laminate of this material system. Two notch types, holes and slits, were examined, and existing failure criteria were explored as means to extrapolate these coupon data to the prediction of the failure of axially slit cylinders, which were also tested. The fracture characteristics of this composite system were compared to a baseline system with 3501-6 epoxy. In the laminates using the 'tough' matrix system, delamination was not a significant damage mode. Previous work had shown localized delamination in the 3501-6 laminates. However, both the coupon tests and the cylinder tests indicate that this high strain-to-failure matrix system is more notch-sensitive than the baseline epoxy system with the relatively brittle 3501-6 matrix. Author

A89-36398

THE TRANSMISSION DEVELOPMENT PROCESS AT LUCAS WESTERN

ROBERT B. BOSSLER, JR. (Lucas Western, Inc., City of Industry, CA) Vertiflite (ISSN 0042-4455), vol. 35, Mar.-Apr. 1989, p. 20-25.

An account is given of the technology development efforts undertaken by a helicopter transmission manufacturer in order to produce hardware to more exacting performance requirements than had been previously considered. The first of the illustrative examples considered is a 5,400 hp propeller drive for a high-speed marine hydrofoil employing a supercavitating rotor. Additional examples are drawn from efforts to develop mechanical drives for hoists deployable aboard helicopters. The technology developments required concerned gear systems, joints, dynamics, component design, and lubrication systems. O.C.

A89-36436

THE PROCESSING AND TESTING OF A HOLLOW DS EUTECTIC HIGH PRESSURE TURBINE BLADE

R. G. MENZIES, C. A. BRUCH, J. A. SMITH, R. C. HAUBERT (General Electric Co., Evendale, OH), and M. F. GIGLIOTTI (General Electric Co., Schenectady, NY) IN: Superalloys 1988; Proceedings of the Sixth International Symposium, Champion, PA, Sept. 18-22, 1988. Warrendale, PA, Metallurgical Society, Inc., 1988, p. 355-364. refs
(Contract F33615-77-C-5200)

A program designed to evaluate the feasibility of directionally solidified eutectic high pressure turbine blades is described. The program's objectives are to define the materials, design, and fabrication technology required for the application of eutectic composites in HPT blade components, and to demonstrate their applicability in advance aircraft gas turbine engines. The Rene 150 blade design was successfully modified to incorporate the excellent mechanical properties of NiTaC-14B. The alloy has an an approximately 225 deg F superiority over conventionally cast Rene 80. K.K.

A89-36455

LASER DRILLING OF A SUPERALLOY COATED WITH CERAMIC

P. FORGET, M. JEANDIN (Paris, Ecole Nationale Superieure des Mines, Evry, France), P. LECHERVY, and D. VARELA (SNECMA, Moissy-Cramayel, France) IN: Superalloys 1988; Proceedings of the Sixth International Symposium, Champion, PA, Sept. 18-22, 1988. Warrendale, PA, Metallurgical Society, Inc., 1988, p. 553-562. refs

An Nd:YAG rod laser was used to drill small holes in conventional Hastelloy X sheets coated with yttria-stabilized zirconia plasma sprayed onto an MCrAlY bond coat, also deposited by conventional air plasma spraying. The effects of the principal laser parameters, such as pulse length, pulse rate, and power density are determined, and thermal models are developed. Coupled with the energy-matter balance, the models can be used to optimize the laser drilling parameters. V.L.

A89-36576
INTERNATIONAL CONFERENCE ON SATELLITE SYSTEMS FOR MOBILE COMMUNICATIONS AND NAVIGATION, 4TH, LONDON, ENGLAND, OCT. 17-19, 1988, PROCEEDINGS
Conference organized by IEE. London, Institution of Electrical Engineers, 1988, 283 p. For individual items see A89-36577 to A89-36625.

Attention is given to the following topics: antennas and propagation, systems for communication, systems for land mobile communications, systems for aeronautical communications, and system economics, operation, and traffic. Particular papers are presented on tracking receiver design for the electronic beam squint tracking system in the maritime mobile environment, network signalling system design considerations in a multiservice mobile satellite communication systems, Inmarsat's aeronautical satellite communication system, and proposed systems configurations for a satellite-based ISDN. B.J.

A89-36585
NTT'S PROGRAM OF EXPERIMENTAL MOBILE SATELLITE SYSTEM (EMSS) USING ETS-V AND PRELIMINARY RESULTS
T. SAKAI, H. MISHIMA, E. HAGIWARA, and K. SATOH (Nippon Telegraph and Telephone Public Corp., Radio Communication Systems Laboratories, Tokyo, Japan) IN: International Conference on Satellite Systems for Mobile Communications and Navigation, 4th, London, England, Oct. 17-19, 1988, Proceedings. London, Institution of Electrical Engineers, 1988, p. 38-42. refs

The system configuration of NTT's EMSS program is described. Preliminary results from this program are presented, including data on ship earth station antenna switching, channel performance monitoring, and bit error rate characteristics. B.J.

A89-36593
INMARSAT'S AERONAUTICAL SATELLITE COMMUNICATION SYSTEM
P. WOOD (International Maritime Satellite Organization, London, England) IN: International Conference on Satellite Systems for Mobile Communications and Navigation, 4th, London, England, Oct. 17-19, 1988, Proceedings. London, Institution of Electrical Engineers, 1988, p. 78-82. refs

The service requirements, system elements, and system design of Inmarsat's aeronatutical satellite communication system are discussed. The system design is summarized in terms of modulation and coding, transmission format, data applications, and transmission channel characteristics. B.J.

A89-36655
GENERALIZED CRITERIA FOR MICROWAVE BREAKDOWN IN AIR-FILLED WAVEGUIDES
D. ANDERSON, M. LISAK (Chalmers Tekniska Hogskola, Goteborg, Sweden), and T. LEWIN (Ericsson Radio Systems AB, Molndal, Sweden) Journal of Applied Physics (ISSN 0021-8979), vol. 65, April 15, 1989, p. 2935-2945. refs

Generalized threshold conditions were formulated for microwave breakdown in air-filled waveguides, which take into account the temperature-dependent processes that affect the breakdown process. Emphasis is placed on the parameter range characterized by pressures larger than 100 torr and microwave frequencies between 1 and 40 GHz, relevant to the airborne radar application. The analysis showed a significant reduction in the electric field strength required to produce breakdown in hot air, as compared to the breakdown in fields for lower temperature, providing a theoretical explanation of the fact that the breakdown thresholds of microwave devices are observed to be much lower than those predicted by the conventional cold-air theory. I.S.

A89-36723#
STRUCTURES FOR HYPERVELOCITY FLIGHT
PETER K. SHIH, ALLEN D. ZWAN, MICHAEL N. KELLEY, and JACK PRUNTY (General Dynamics Corp., Convair Div., San Diego, CA) Aerospace America (ISSN 0740-722X), vol. 27, May 1989, p. 28-31.

Manned transatmospheric hypervelocity vehicles such as that studied under the aegis of the USAF Wright Aeronautical Laboratories will require the integration of cryogenic tankage, highly aerothermodynamically loaded structures, crew systems, and propulsion; thermophysical analyses have accordingly become essential to the effort of design with the requisite advanced materials. A hybrid outer structure design has been formulated in which slip-joined carbon-carbon cover panels lie over an encapsulated fibrous insulation blanket that in turn protects the underlying metallic primary structure. Cryogenic tankage of lightweight Al-Li alloy is also employed. O.C.

A89-36909#
MEASUREMENTS IN SEPARATING BOUNDARY LAYERS
M. DIANAT and I. P. CASTRO (Surrey, University, Guildford, England) (ICAS, Congress, 15th, London, England, Sept. 7-12, 1986, Proceedings. Volume 2, p. 905-910) AIAA Journal (ISSN 0001-1452), vol. 27, June 1989, p. 719-724. Research supported by the Ministry of Defence Procurement Executive and SERC. Previously cited in issue 24, p. 3592, Accession no. A86-49073. refs

A89-36916*# United Technologies Research Center, East Hartford, CT.
CALCULATION OF UNSTEADY FLOWS IN TURBOMACHINERY USING THE LINEARIZED EULER EQUATIONS
KENNETH C. HALL (United Technologies Research Center, East Hartford, CT) and EDWARD F. CRAWLEY (MIT, Cambridge, MA) AIAA Journal (ISSN 0001-1452), vol. 27, June 1989, p. 777-787. Research supported by the General Electric Co., General Motors Corp., and Fannie and John Hertz Foundation. Previously announced in STAR as N87-22948. refs
(Contract NSG-3079)

A method for calculating unsteady flows in cascades is presented. The model, which is based on the linearized unsteady Euler equations, accounts for blade loading shock motion, wake motion, and blade geometry. The mean flow through the cascade is determined by solving the full nonlinear Euler equations. Assuming the unsteadiness in the flow is small, then the Euler equations are linearized about the mean flow to obtain a set of linear variable coefficient equations which describe the small amplitude, harmonic motion of the flow. These equations are discretized on a computational grid via a finite volume operator and solved directly subject to an appropriate set of linearized boundary conditions. The steady flow, which is calculated prior to the unsteady flow, is found via a Newton iteration procedure. An important feature of the analysis is the use of shock fitting to model steady and unsteady shocks. Use of the Euler equations with the unsteady Rankine-Hugoniot shock jump conditions correctly models the generation of steady and unsteady entropy and vorticity at shocks. In particular, the low frequency shock displacement is correctly predicted. Results of this method are presented for a variety of test cases. Predicted unsteady transonic flows in channels are compared to full nonlinear Euler solutions obtained using time-accurate, time-marching methods. The agreement between the two methods is excellent for small to moderate levels of flow unsteadiness. The method is also used to predict unsteady flows in cascades due to blade motion (flutter problem) and incoming disturbances (gust response problem). Author

A89-36917*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
INTEGRATED APPROACH FOR ACTIVE COUPLING OF STRUCTURES AND FLUIDS
GURU P. GURUSWAMY (NASA, Ames Research Center, Moffett Field, CA) AIAA Journal (ISSN 0001-1452), vol. 27, June 1989, p. 788-793. Research supported by USAF. refs

Strong coupling of structure and fluids is common in many engineering environments, particularly when the flow is nonlinear and very sensitive to structural motions. Such coupling can give rise to physically important phenomena, such as a dip in the transonic flutter boundary of a wing. The coupled phenomenon can be analyzed in closed form for simple cases that are defined

by linear structural and fluid equations of motion. However, complex cases defined by nonlinear equations pose a more difficult task for solution. It is important to understand these nonlinear coupled problems, since they may lead to physically important new phenomena. Flow discontinuities, such as a shock wave, and structural discontinuities, such as a hinge line of a control surface of a wing, can magnify the coupled effects and give rise to new phenomena. To study such a strongly coupled phenomenon, an integrated approach is presented in this paper. The aerodynamic and structural equations of motion are simultaneously integrated by a time-accurate numerical scheme. The theoretical simulation is done using the time-accurate unsteady transonic aerodynamic equations coupled with modal structural equations of motion. As an example, the coupled effect of shock waves and hinge-line discontinuities are studied for aeroelastically flexible wings with active control surfaces. The simulation in this study is modeled in the time domain and can be extended to simulate accurately other systems where fluids and structures are strongly coupled.
Author

A89-36919#
VARIATIONS OF UNDAMPED ROTOR BLADE FREQUENCIES SUBJECTED TO TRANSIENT HEAT FLUX
ANAND M. SHARAN (Newfoundland, Memorial University, Saint John's, Canada) and RAJEEVE BAHREE AIAA Journal (ISSN 0001-1452), vol. 27, June 1989, p. 802-808. refs
(Contract NSERC-A-5549)

In the present work, the variation of rotor blade natural frequencies due to the radiative heat flux has been studied. The dynamic equations of motion have been obtained using curved, 20 node, solid, isoparametric finite elements. The effect of the variation of the pretwist angle on the natural frequencies also has been studied. Author

A89-36966
THE OPTICAL BIDIRECTIONAL ACCELEROMETER
O. DUPONT and J. C. LEGROS (Bruxelles, Universite Libre, Brussels, Belgium) (COSPAR, ESA, and International Union of Crystallography, Plenary Meeting, 27th, Topical Meeting on Microgravity, Espoo, Finland, July 18-29, 1988) Advances in Space Research (ISSN 0273-1177), vol. 8, no. 12, 1988, p. 147-154.

A new optical bidirectional accelerometer is described with particular reference to applications in a microgravity environment during a parabolic flight experiment. The capability of the instrument to detect the gravity level is demonstrated experimentally. The g resistance of the instrument is at least 5.5 g; the sensitivity of the accelerometer can be adjusted by modifying the mass fixed at the end of the optic guide, the length of the guide, or the diameter of the thin end of the guide. V.L.

A89-37006#
EXPERIMENTAL INVESTIGATION ON BUCKLING OF AIRCRAFT SHELL BY THE CURVED GRATING SHADOW MOIRE METHOD
ZHIQIANG TAO, WENKUAN BIAN, and DAZHEN YUN (Dalian Institute of Technology, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 9, Dec. 1988, p. B568-B573. In Chinese, with abstract in English.

On the basis of the shadow moire method with curved grating, the buckling parameters such as the smallest critical load, ultimate buckling load, and the buckling mode of two kinds of models of aircraft shell under the action of axial compression or uniform internal pressure are given in this paper. The two kinds of models included circular cylindrical and pillow cylindrical shells. There are twenty-eight specimens with different thickness and rib styles.
Author

A89-37011#
A WAY FOR UPGRADING THE ACCURACY OF FORCE MEASUREMENT
GUANGZHI YU (Beijing University, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 9, Dec. 1988, p. B609-B613. In Chinese, with abstract in English.

This paper presents a description for studying the balance signals with a dynamic method. The optimum active filter has been developed for the measurement system of the wind tunnel at Beijing University on the basis of simulation using digital filters. The results of the investigation have shown that the accuracy of force measurements can be improved without increasing the running time of the wind tunnel. Author

A89-37421
DYNAMICAL CALCULATIONS OF ENGINE COMPONENTS BASED ON ELASTICITY EQUATIONS [O POSTROENII DINAMICHESKIKH RASCHETOV DETALEI DVIGATELEI NA OSNOVE URAVNENII TEORII UPRUGOSTI]
N. D. KUZNETSOV, L. I. FRIDMAN, A. I. ERMAKOV, and V. N. UKHOV Problemy Prochnosti (ISSN 0556-171X), March 1989, p. 3-8. In Russian. refs

An elasticity approach to the vibration analysis of gas turbine engine components of complex configurations is proposed which makes it possible to determine the natural frequencies and modes of structures with a higher accuracy than that obtainable with methods based on kinematic hypotheses. The method consists of the approximation of geometrically complex components by canonic bodies, conjugation of these bodies, and derivation of a frequency equation for the whole system. V.L.

A89-37525
CONTRIBUTION TO CENTRIFUGAL IMPELLER DESIGN
VACLAV VANEK Zprava VZLU, no. Z-57, 1989, p. 1-9. refs

A portion of a centrifugal compressor impeller pre-development research program is described. Results of an investigation on a set of radially-bladed impellers, the ARTI 305, are discussed. The impellers are designed for identical initial boundary conditions. The space shapes of the impeller blades are different, and the blading geometry is defined by two deceleration coefficients. An experimental investigation is carried out to verify the impeller design and manufacturing methods and the influence of the space shape of the impeller blading on its performance map. S.A.V.

A89-37627
INFRARED THERMOGRAPHY - A QUANTITATIVE TOOL FOR HEAT STUDY [LA THERMOGRAPHIE INFRAROUGE - UN OUTIL QUANTITATIF A LA DISPOSITION DU THERMICIEN]
D. BALAGEAS, D. BOSCHER, A. DEOM, J. FOURNIER, and R. HENRY (ONERA, Chatillon-sous-Bagneux, France) (Revue Generale Thermique, Oct. 1988, p. 501-510) ONERA, TP no. 1989-3, 1989, 11 p. In French. Research supported by DRET and Service Technique des Programmes Aeronautiques. refs
(ONERA, TP NO. 1989-3)

Three applications of infrared thermography for temperature determination are discussed: (1) the detection, localization, and thermal characterization of delamination in carbon-epoxy composite structures; (2) the determination of the heat transfer coefficients for wind tunnel models; and (3) the measurement of temperature in a helicopter blade section during icing/deicing tests performed in an icing wind tunnel. R.R.

A89-37631#
VIBRATIONS IN AEROSPACE STRUCTURES - PREDICTION, PREVENTION AND CONTROL
R. DAT (ONERA, Chatillon-sous-Bagneux, France) (Israel Annual Conference on Aviation and Astronautics, Tel Aviv, Israel, Feb. 2-15, 1989) ONERA, TP no. 1989-9, 1989, 13 p. refs
(ONERA, TP NO. 1989-9)

The effects of aerospace vibrations on safety, the crew and passenger comfort, and the stability of structural elements are discussed, together with the ways by which vibrations can be reduced and controlled. Special attention is given to the problem of vibration as part of the structural design. It is shown that the structural modeling techniques differ according to the frequency range and structure size, the configuration of the structure, and the mechanism of vibration generation. It is emphasized that experiments are important not only to validate calculation codes, but also to provide data for model adjustment, to identify the characteristics of comosite materials well as the characteristics of a whole structure, and to provide an evaluation of the excitation loads. I.S.

A89-37640#

NEW POSSIBILITIES OF VISCOUS-INVISCID NUMERICAL TECHNIQUES FOR SOLVING VISCOUS FLOW EQUATIONS WITH MASSIVE SEPARATION

J. C. LE BALLEUR (ONERA, Chatillon-sous-Bagneux, France) (Symposium on Numerical and Physical Aspects of Aerodynamic Flows, Long Beach, CA, Jan. 16-19, 1989) ONERA, TP no. 1989-24, 1989, 21 p. refs

(ONERA, TP NO. 1989-24)

A viscous-inviscid formulation and numerical coupling algorithms for computations in high Reynolds number aerodynamics are presented. The defect formulation Le Balleur (1986) is extended to study thin-layer massive separation with turbulent three-dimensional velocity profiles. Also, two generalizations of Le Balleur's (1985) semiinverse coupling method are presented for massive separations and for coupling with Euler solvers. Numerical results are given for two-dimensional steady separated flows. Also, a computation method is proposed for massively separated steady flows over airfoils at deep stall conditions. R.B.

A89-37642#

APPLICATION OF INFRARED THERMOGRAPHY TO THE INTERPRETATION OF TESTS IN AN ICING WIND TUNNEL [APPLICATION DE LA THERMOGRAPHIE INFRAROUGE A L'INTERPRETATION D'ESSAIS DANS UNE SOUFFLERIE GIVRANTE]

R. HENRY and D. GUFFOND (ONERA, Chatillon-sous-Bagneux, France) (Societe Francaise des Thermiciens, Journee d'Etude, Paris, France, Jan. 18, 1989) ONERA, TP no. 1989-28, 1989, 11 p. In French. refs

(ONERA, TP NO. 1989-28)

Wall temperature measurements were obtained in an icing wind tunnel using infrared thermography in order to validate models for the simulation of electrothermal deicers intended for helicopter blades. The measurement procedure involves adjusting the camera for the temperature range considered, determining the directional emissivity of the profile surface and of the ice, and using Mie theory to determine the atmospheric transmission factor. The present results demonstrate the importance of taking the phase change of the ice into account in deicer modeling. R.R.

A89-37766#

VARIATION OF CRITICAL SPEED OF A ROTOR-BEARING SYSTEM WITH SLIGHT RELOCATION OF BEARING

YAN LI and ZEYONG YIN (Nanhua Power Plant Research Institute, People's Republic of China) Journal of Aerospace Power (ISSN 1000-8055), vol. 4, Jan. 1989, p. 63, 64, 93. In Chinese, with abstract in English.

A formula has been derived for calculating the variation of critical speeds of a rotor-bearing system with slight change of bearing position. The formula can determine which bearing should change position and in which direction it should move so that the desired critical speeds of the system could be reached. The formula has been applied to rearranging the bearings of a certain aeroengine so successfully that its critical speeds are farther away from the working speed range than before. Author

A89-37768#

EXPERIMENTAL INVESTIGATION OF SUDDEN IMBALANCE RESPONSE ON A FLEXIBLE ROTOR SYSTEM WITH SQUEEZE-FILM DAMPER

CAIGAO FU and XIFAN LI (Chinese Gas Turbine Establishment, People's Republic of China) Journal of Aerospace Power (ISSN 1000-8055), vol. 4, Jan. 1989, p. 67-69, 93. In Chinese, with abstract in English.

An experimental method is used to investigate suddenly applied imbalance response of a flexible rotor with an uncentralized squeeze-film damper. The results show that the unstable transient process in this system is very short, and only after a few cycles the system recovers to steady state on new vibration level. The squeeze-film damper system has a limited capability of sudden subjection to the imbalance load. The limits depend mainly on the oil-film clearances of the damper. This work will be helpful for selecting squeeze-film parameters and experimental method of suddenly applied imbalance. Author

A89-37847

ACTIVE VIBRATION CONTROL OF FLEXIBLE ROTORS - AN EXPERIMENTAL AND THEORETICAL STUDY

C. R. BURROWS (Bath, University, England), M. N. SAHINKAYA, and S. CLEMENTS (Strathclyde, University, Glasgow, Scotland) Royal Society (London), Proceedings, Series A - Mathematical and Physical Sciences (ISSN 0080-4630), vol. 422, no. 1862, March 8, 1989, p. 123-146. Research supported by SERC. refs

The Burrows and Sahinkaya (1983) algorithm for the control of flexible-rotor synchronous vibration is presently extended to the case in which a single magnetic actuator can be used to estimate multimode rotor-bearing system characteristics and apply the optimum control force required for minimization of synchronous vibration. The rotor in question is supported by oil-film bearings; the algorithm used determines the optimum control force without prior knowledge of the bearing or rotor characteristics of the distribution of out-of-balance forces. This theoretical work's application is illustrated by the case of a rig. Excellent control was obtained by measuring midspan rotor stations. O.C.

A89-37878

AERODYNAMIC DEVICE FOR GENERATING MONO-DISPERSE FUEL DROPLETS

G. J. GREEN, D. E. WALSH (Mobil Research and Development Corp., Princeton, NJ), F. TAKAHASHI, and F. L. DRYER (Princeton University, NJ) Review of Scientific Instruments (ISSN 0034-6748), vol. 60, April 1989, p. 646-652. refs

A device has been developed for generating well-defined, one-dimensional streams of small monosized droplets of a variety of fuels. The droplets produced are well separated, making this technique well suited to experimental combustion studies of unsupported, isolated droplets. This method has been used successfully to generate droplets of light and middistillate petroleum fuels, heavy oils, boron/JP-10 slurries, and coke/oil slurries, for a range of combustion studies. The principle of operation of the device is the aerodynamic stripping of incompletely formed droplets emerging from the tip of a capillary/fine wire which resides in the throat of a venturi or convergent nozzle. Author

A89-38189

CONFIGURATION OF TUNED DRY GYRO REDUNDANT SYSTEM

HIROKIMI SHINGU (National Aerospace Laboratory, Chofu, Japan) IN: International Symposium on Space Technology and Science, 16th, Sapporo, Japan, May 22-27, 1988, Proceedings. Volume 1. Tokyo, AGNE Publishing, Inc., 1988, p. 1211-1216. refs

The configuration of a redundant attitude reference system using three tuned dry gyros is presented. The system increases the reliability of a strapdown inertial navigator and the failure detection procedure required for system operation. The sensor orientation in the system is modeled and the relationships between navigation reference data and outputs of the tuned dry gyros are obtained. It is shown that sensor failure may be detected using various combinations of gyro outputs. The failure detection procedure is simulated and the speed of failure detection is evaluated. R.B.

A89-38499

HYDRODYNAMICS AND HEAT TRANSFER IN THE POROUS ELEMENTS OF FLIGHT VEHICLE STRUCTURES [GIDRODINAMIKA I TEPLOOBMEN V PORISTYKH ELEMENTAKH KONSTRUKTSII LETATEL'NYKH APPARATOV]

VLADIMIR M. POLIAEV, VITALII A. MAIOROV, and LEONARD L. VASIL'EV Moscow, Izdatel'stvo Mashinostroenie, 1988, 168 p. In Russian. refs

The physical processes underlying the operation of high-efficiency porous heat transfer elements used in flight vehicles are examined in the light of current theoretical concepts. In particular, attention is given to the classification, structure and applications of porous heat transfer elements; resistance and heat transfer during the motion of a single-phase coolant in porous matrices; principal problems in transpiration cooling; and intensification of heat transfer in channels with a porous filler. The discussion also covers the liquid evaporative cooling of the porous walls of flight vehicle structures and porous fuel elements. V.L.

A89-38500

CALCULATION OF THE PRINCIPAL PARAMETERS OF THE ACTUATING MECHANISMS OF AIRCRAFT SLAVE DRIVES [RASCHET OSNOVNYKH PARAMETROV ISPOLNITEL'NYKH MEKHANIZMOV SLEDIASHCHIKH PRIVODOV LETATEL'NYKH APPARATOV]

VITALII A. POLKOVNIKOV and ANDREI V. SERGEEV Moscow, Izdatel'stvo Mashinostroenie, 1988, 192 p. In Russian. refs

Problems associated with the synthesis of the principal parameters of slave drive actuators are examined in the context of the theory of dynamic capability limits. The synthesis methods discussed here are based on the use of a computer and take into account the nonlinear properties of the actuating mechanisms, characteristics of the load resistance moments, the laws of drive motion, and the structure of the drive power unit (one-dimensional or multidimensional). Procedures for calculating the principal parameters of the actuating mechanisms are illustrated by examples. V.L.

A89-38615

THREE COMPONENT LASER DOPPLER ANEMOMETRY IN LARGE WIND TUNNELS

KARL-ALOYS BUETEFISCH (DFVLR, Institut fuer experimentelle Stroemungsmechanik, Goettingen, Federal Republic of Germany) Progress in Aerospace Sciences (ISSN 0376-0421), vol. 26, no. 1, 1989, p. 79-113. refs

Starting with the physical background of laser Doppler anemometry (LDA), the important parameters influencing the proper operation of such an instrument in large wind tunnels to obtain the flow velocity are discussed. Aspects for designing a three component LDA system to get the time dependent velocity vector are treated. A compact three-component system operated in backscatter and off-axis mode is described. Three component velocity and turbulence results which have been obtained in the 3 sq m subsonic and 1 sq m transonic wind tunnels of the DFVLR are presented. Author

A89-38632

XRD TECHNIQUES IN AERO ENGINE DEVELOPMENT

M. PLANT Metals and Materials (ISSN 0266-7185), vol. 5, April 1989, p. 205-209.

State-of-the-art computer-aided data collection and interpretation have been enlisted to extend the role of XRD in novel areas of aircraft engine high-temperature structural material and component characterization. XRD has proved to be an ideal tool for the evaluation of such alternative advanced surface-treatment processes as glass-bead and shot-peening; XRD in these cases establishes the magnitude and direction of residual stresses at different depths from the surface. XRD has also been used to generate data on the interaction between mold material and cast alloys, and to monitor variations in the type are relative quantity of secondary metallic phases in alloys. O.C.

A89-38764

VISUALIZATION OF AERODYNAMIC FLOW FIELDS USING PHOTOREFRACTIVE CRYSTALS

A. HAFIZ, R. MAGNUSSON, J. S. BAGBY, D. R. WILSON, and T. D. BLACK (Texas, University, Arlington) Applied Optics (ISSN 0003-6935), vol. 28, April 15, 1989, p. 1521-1524. refs

(Contract DAAL03-86-K-0149)

Interferometry based on double exposure Fourier transform holography in photorefractive crystals is applied for visualization of aerodynamic flow fields. The interferograms obtained are of similar quality as those produced using holographic film but with greatly simplified procedures. The results presented are obtained using a high-power cw argon laser and iron doped lithium niobate crystals. The angular characteristics of the Fourier transform data holograms are studied. Author

A89-38874

A TWO-SPARK SCHLIEREN SYSTEM FOR VERY-HIGH VELOCITY MEASUREMENT

D. PAPAMOSCHOU (California Institute of Technology, Pasadena) Experiments in Fluids (ISSN 0723-4864), vol. 7, no. 5, April 1989, p. 354-356. Research supported by the Rockwell International Foundation Trust.

(Contract N00014-85-K-0646)

A simple and relatively inexpensive optical method to record the evolution of very rapid events in high-speed flow is described. The method is a two-spark variant of the schlieren system. For each shot, two distinct frames are produced on the same piece of film, each of very short exposure. The timing between the two frames is adjustable and can range anywhere upwards of 1 microsec. The system requires very few additions to an existing schlieren setup and contains no movable parts. It has been successfully applied to a supersonic shear-layer experiment where velocities of turbulent-flow structures were accurately determined. C.D.

A89-38951

APPLICATION OF NONDESTRUCTIVE INSPECTION METHODS TO COMPOSITES

THOMAS S. JONES and HAROLD BERGER (Industrial Quality, Inc., Gaithersburg, MD) Materials Evaluation (ISSN 0025-5327), vol. 47, April 1989, p. 390, 391, 393-398, 400. refs

The capabilities and limitations of some typical NDI as applied to composites are examined. The methods considered include: visual inspection, tap test, ultrasonic through-transmission testing, ultrasonic pause-echo testing, ultrasonic polar backscatter, ultrasonic resonance, ultrasonic correlation, X-radiography, X-ray backscatter imaging, neutron radiography, laser holography, thermal infrared inspection, acoustic emission, acoustic ultrasonics, and eddy current testing. An initial sorting approach is given which can be used for the selection of inspection methods for particular composite discontinuities. C.D.

A89-38954

NONDESTRUCTIVE VOLUMETRIC CT-SCAN EVALUATION OF MONOLITHIC CERAMIC TURBINE COMPONENTS

M. W. VANNIER, C. J. OFFUTT (Washington University, Medical Center, Saint Louis, MO), and W. A. ELLINGSON (Argonne National Laboratory, IL) Materials Evaluation (ISSN 0025-5327), vol. 47, April 1989, p. 454-459, 465. refs

Contiguous transaxial high-resolution computed tomographic (CT) scans of two green-ceramic turbine rotors were obtained using a medical CT scanner. The CT-scan examinations revealed internal defects in the bladed portion of one of the rotors. The serial section data were reconstructed in a three-dimensional (3D) form with surface and transparent volumetric computer graphics processing techniques. Real-time sequences showing the presence of internal defects and details of the objects were produced and recorded on video tape. Digital radiographs of the rotors were obtained for comparison to the CT reconstructions, using photostimulable phosphor imaging plates as a replacement for film. This study demonstrates the feasibility of 3D volumetric visualization for nondestructive evaluation of advanced ceramic turbine components. Author

A89-39037#

SWIRLING FLOWS IN AN ANNULAR-TO-RECTANGULAR TRANSITION SECTION

THOMAS H. SOBOTA and FRANK E. MARBLE (California Institute of Technology, Pasadena) Journal of Propulsion and Power (ISSN 0748-4658), vol. 5, May-June 1989, p. 334-340. Previously cited in issue 21, p. 3401, Accession no. A87-48576. refs

A89-39050
STRESS TENSOR MEASUREMENTS WITHIN THE VANELESS DIFFUSER OF A CENTRIFUGAL COMPRESSOR
T. M. A. MAKSOUD and M. W. JOHNSON (Liverpool, University, England) Institution of Mechanical Engineers, Proceedings, Part C - Journal of Mechanical Engineering Science (ISSN 0954-4062), vol. 203, no. C1, 1989, p. 51-59. Research supported by SERC. refs

Distributions of normal and shear (Reynolds) stresses inside the vaneless diffuser of a low-speed centrifugal compressor are presented. The measurements were made using a triple hot-wire system and a phase lock loop sampling technique. Results were obtained on cross-sectional planes at eight radial stations between the impeller outlet and the diffuser exit at three different flowrates. The turbulence was highly anisotropic and became more so as the flowrate was increased. The tangential component of turbulent intensity was found to be significantly smaller than either the radial or axial component. The blade wake observed at the diffuser inlet decays very rapidly due to the strong tangential Reynolds stresses generated by the opposed secondaray flows on either side of the wake. The passage wake decays very much more slowly and is still identifiable at the diffuser discharge. Author

A89-39076#
MODERN JOINING METHODS FOR FUTURE AIRCRAFT STRUCTURES
GUENTER BRODEN Dornier Post (ISSN 0012-5563), no. 1, 1989, p. 10-12.

The results of recent developmental tests of next-generation aircraft metallic structure joining technologies are presented. Superplastic forming/diffusion bonding (SPF/DB) has been employed in the case of a Ti-alloy fin leading edge, which has been realized with two 'skin' and two 'rib' panels; the SPF tool for the leading edge is of symmetrical design, so that two parts may be manufactured in the right-hand and left-hand tool sections in a single SPF/DB cycle. For Al alloys, whose oxide surface film precludes DB, liquid-phase diffusion bonding is illustrated. Temperature, contact pressure, and retention-time parameters have been carefully optimized to minimize structural changes in the superplastic 7475 alloy. O.C.

A89-39186#
COLOR HELIUM BUBBLE FLOW-VISUALIZATION TECHNIQUE
DONG ZHAO, ZHONGQI WANG, XIAODI ZHANG, JIALIN QIN, and XIANZHONG LANG (Harbin Aerodynamic Research Institute, People's Republic of China) (ICAS, Congress, 15th, London, England, Sept. 7-12, 1986, Proceedings. Volume 2, p. 900-904) Journal of Aircraft (ISSN 0021-8669), vol. 26, June 1989, p. 499-502. Previously cited in issue 24, p. 3599, Accession no. A86-49072.

A89-39519
EIGENSOLUTION OF PERIODIC ASSEMBLIES OF MULTI-MODE COMPONENT SYSTEMS
P. D. CHA and C. PIERRE (Michigan, University, Ann Arbor) Journal of Sound and Vibration (ISSN 0022-460X), vol. 129, Feb. 22, 1989, p. 168-174. refs
(Contract NSF MSM-87-00820)

The free vibration of a periodic structure made up of identically connected identical components is investigated. An analytical solution for the eigenvalue problem is obtained which, although not completely closed-form, provides information on the sinusoidal variation of the mode shapes in space and the effects of system parameters on mode shapes and natural frequencies. Results for an assembly of three clamped-free Euler-Bernoulli beams are presented and shown to reduce to the closed-form eigensolution of Chen (1971). T.K.

A89-39823
APPLICATION OF THE THEORY OF FUZZY SETS TO THE TWO-CRITERION STOCHASTIC OPTIMIZATION OF RIBBED SHELLS [PRIMENENIE TEORII NECHETKIKH MNOZHESTV K DVUKHKRITERIAL'NOI STOKHASTICHESKOI OPTIMIZATSII REBRISTYKH OBOLOCHEK]
IU. M. POCHTMAN and M. M. FRIDMAN Akademiia Nauk SSSR, Izvestiia, Mekhanika Tverdogo Tela (ISSN 0572-3299), Mar.-Apr. 1989, p. 161-164. In Russian. refs

The paper is concerned with the optimization of hinged closed cylindrical shells cross-reinforced by a system of ribs stochastically loaded by uniform pressure of the white noise type. The treatment allows for the discrete nature of the reinforcement in accordance with the shell model. The analysis presented here is relevant to the loading of aircraft skin panels in an acoustic pressure field. V.L.

N89-21984 Centre d'Essais Aeronautique Toulouse (France).
FAILURE ANALYSIS: ANALYSIS OF LANDING GEAR FATIGUE TEST RESULTS FOR MECHANICAL AND METALLURGICAL CONSIDERATIONS IN ORDER TO DETERMINE THE AUTHORIZED RUN TIME [ANALYSE DES RESULTATS D'UN ESSAI DE FATIGUE D'ATTERRISSEUR, A PARTIR DE CONSIDERATIONS MECANIQUES ET METALLURGIQUES, POUR DETERMINER UNE DUREE AUTORISEE D'EXPLOITATION]
CLAUDE BLEUZEN *In* CNES, Quality, Components and Technological Analysis p 1229-1246 Aug. 1988 In FRENCH
Avail: CEPADUES-Editions, 111 Rue Nicolas-Vauquelin, 31100 Toulouse, France

Landing gear fatigue tests carried out over 200,000 cycles detected to find cracks which make safe service life inferior to specifications. The analysis of the case is presented, detailing the reasoning steps and decisions. A reasoning schema and decision tree are presented. Materials science is used to support the analysis. The corrective action taken is described. ESA

N89-21987# Engineering Management Concepts, Camarillo, CA.
PLASTIC MEDIA BLASTING RECYCLING EQUIPMENT STUDY Final Report, Jun. 1987 - Sep. 1988
Oct. 1988 81 p
(Contract N00123-85-D-0901)
(AD-A202463; NCEL-CR-89.001) Avail: NTIS HC A05/MF A01 CSCL 13/8

Plastic Media Blasting (PMB) is a new technology introduced as a candidate to replace wet chemical paint stripping of airframes and component parts. This report documents the physical testing, observations, and laboratory analyses used to evaluate the effectiveness of plastic media recycling equipment at three PMB sites. Different systems for recycling plastic media were evaluated for operational performance, losses, efficiency, and metal removal. An optimum recycling system was selected which included a cyclone for gross air/media separation, a vibrating screen to remove extra large and extra small particles, and a self-cleaning magnetic separator for ferrous particle removal. GRA

N89-22014# Selenia S.p.A., Naples (Italy).
DESIGN, IMPLEMENTATION AND COMPUTER AIDED TESTS OF A SHAPED REFLECTOR FOR AN AIR TRAFFIC CONTROL SYSTEM [PROGETTAZIONE, REALIZZAZIONE E TEST ASSISTITI DA CALCOLATORE DI UN RIFLETTORE SHAPED PER UN SISTEMA DI CONTROLLO DEL TRAFICO AEREO]
G. ASCIONE and U. F. DELIA 1988 5 p In ITALIAN; ENGLISH summary Presented at the 7th Riunione Nazionale di Elettromagnetismo Applicato, Frascati, Italy, 5-8 Sep. 1988
(ETN-89-94229) Avail: NTIS HC A02/MF A01

The use of computer aided methods to perform and optimize a reflector is described. The reflector is to be used in a mobile sheltered system. The description includes characterization of the illuminator, surface synthesis, profile definition, computer aided manufacturing, and measuring techniques. The use of a workstation dedicated to electromagnetic design is allowed to manufacture the reflector without a reduced scale physical model step. ESA

N89-22016# China Aeronautical Establishment, Beijing.
STUDY OF THE REAL EMULATION OF THE ELECTRONIC INTEGRATED SYSTEM
ZUNXIAO LIU and JINGCHUN WANG 1988 23 p
(PB89-116271; HJB-850281) Avail: NTIS HC A03/MF A01
CSCL 09/1

Real time simulation of flight environment for an aeronautical electronic integrated system is discussed. Seven simulation items with two closed-loop modes are included. The navigation-fire control function block for intercept phase has been selected as a typical case. The simulation process is carried out through a series of procedures including the establishment of mathematical model, erecting simulation model, realizing digital simulation and updating mathematical model. The emphasis is laid on the analysis of the pilot's transfer function and the noise model of sensors, and comparison is made to the closed-loop with pilot intervention and the ideal sensor model individually. A satisfactory result is obtained. Author

N89-22052# Air Force Inst. of Tech., Wright-Patterson AFB, OH. School of Engineering.
THE EFFECTS OF INCIDENCE ANGLE AND FREE STREAM TURBULENCE ON THE PERFORMANCE OF A VARIABLE GEOMETRY TWO-DIMENSIONAL COMPRESSOR CASCADE AT HIGH REYNOLDS NUMBERS M.S. Thesis
EDWARD M. PONIATOWSKI Dec. 1988 321 p
(AD-A202650; AD-E900870; AFIT/GAE/AA/88D-31) Avail: NTIS HC A14/MF A01 CSCL 20/4

For this investigation, a seven-blade cascade of NACA 65-A506 airfoils with two inch chord, aspect ration of one, and solidity of 1.5 was used. This cascade used porous side wall suction to establish two-dimensional flow conditions. Flow Unit Reynolds numbers exceeding 2.5 million foot, and average free stream turbulence levels of 1 pct and 7 pct were used. Cascade geometry was varied in a manner similar to that used in current variable stator designs: maintaining axial direction and blade spacing constant, while varying incidence angle, stagger angle, and angle of attack. Incidence angles of -3, 0, and +3 deg were investigated. Total pressure loss coefficient decreases through the cascade and may increase in the wake as incidence angle or free stream turbulence increase. The change in loss coefficient with increasing incidence was determined to be insignificant when compared with the change as a result of increased free stream turbulence. Blade suction surface pressure coefficients decrease sharply along the first 30 pct chord as incidence increases. The suction surface pressure coefficients show a uniform increase across the blade center span with additional free stream turbulence. Increases in incidence and free stream turbulence result in thicker boundary layers and suggest both earlier transition and intermittent separation on the forward half of the blade. Evidence also suggests that the location of the minimum loss incidence angle may change with additional free stream turbulence. GRA

N89-22066# Sverdrup Technology, Inc., Arnold Air Force Station, TN.
PARC CODE VALIDATION FOR PROPULSION FLOWS Final Report, 1 Oct. 1987 - 30 Sep. 1988
G. K. COOPER, G. D. GARRARD, and W. J. PHARES Jan. 1989 116 p Prepared in cooperation with Arnold Engineering Development Center, Arnold AFS, TN
(AD-A204293; AEDC-TR-88-32) Avail: NTIS HC A06/MF A01
CSCL 21/5

Validation/calibration of the PARC Navier-Stokes computer program for flows typical of turbine engine and rocket motor testing at the Arnold Engineering Development Center has been performed for a number of fundamental test cases. Laminar and turbulent flow simulations for a flat plate with zero pressure gradient have been compared with solutions of the boundary-layer equations with good-to-excellent results. These test cases examined effects of grid spacing in both the streamwise and cross-stream directions, compressibility, and heat transfer. The laminar flow simulations with a new artificial viscosity model were in excellent agreement with the boundary-layer code results; the turbulent simulations with a Baldwin- and Lomax-style turbulence model compared less favorably with some cases showing a 10-percent error in skin friction. The near wake of turbulent supersonic jet was also simulated and compared very well with experimental data. GRA

N89-22070# Rutgers - The State Univ., New Brunswick, NJ. Dept. of Mechanical and Aerospace Engineering.
THEORETICAL INVESTIGATION OF 3-D SHOCK WAVE-TURBULENT BOUNDARY LAYER INTERACTIONS, PART 7 Annual Report, 1 Oct. 1987 - 30 Sep. 1988
DOYLE KNIGHT 15 Nov. 1988 76 p
(Contract AF-AFOSR-0266-86; AF PROJ. 2307)
(AD-A204482; RU-TR-172-MAE-F-PT-7; AFOSR-89-0139TR)
Avail: NTIS HC A05/MF A01 CSCL 20/4

This research describes continuing efforts in the analysis of 3-D shock wave turbulent boundary layer interactions. A significant research activity in 3-D hypersonic shock turbulent interactions is initiated to further develop and validate the theoretical model. The quasiconical free interaction principle is examined by simulation of two geometries -17.5 deg sharp fin and (30,60) swept compression corner (Mach 3) - selected to obtain similar shock strengths. The comparison with experimental data is good. It is confirmed that the differences caused by the particular geometry of the model appear only behind the inviscid shock wave. Continuing research on 3-D turbulent interaction control is focused on the effect of bleed and the simulation of flows past the double-fin configuration. The effect of suction is examined on a strong (fin angle = 20 deg, Mach 3) and a weak interaction (8 deg, Mach 3). The overall effect of bleed is remarkably modest. Two double-fin configurations (4 x 4 and 8 x 8, Mach 3) are simulated. A study of the computed flowfield indicates that the first is a weak interaction. In contrast, the 8 x 8 configuration displays an interesting separated flowfield. An analysis of viscous and inviscid effects in a sharp fin and a swept corner flow indicates that the physics of both geometries are governed primarily by inviscid (pressure) effects. Viscous effects are of lower magnitude but are not restricted to the sublayer region. GRA

N89-22078# Washington Univ., Seattle. Dept. of Applied Mathematics.
DEVELOPMENT OF A STREAMLINE METHOD Final Report, 1 Jun. 1987 - 31 Aug. 1988
CARL E. PEARSON Nov. 1988 3 p
(Contract AF-AFOSR-0111-84; AF PROJ. 2307)
(AD-A205146; AFOSR-89-0133TR) Avail: NTIS HC A02/MF A01
CSCL 20/4

The research investigated and developed a novel streamline method for the computation of steady state compressible flows in ducts and axial compressors. The method is based on the description of a streamline in terms of axial position and two parameters. A coupled pair of second order differential equation are developed and solved by a relaxing process in the subsonic case, and by downstream marching in the supersonic case. GRA

N89-22807# China Aeronautical Establishment, Beijing.
ACCELERATION TEST FOR AIRCRAFT LOW-PASS FILTER
ZHUFENG ZHANG 1988 17 p
(PB89-116263; HJB-860367) Avail: NTIS HC A03/MF A01
CSCL 09/3

A constant intensive acceleration endurance test method is introduced. Forty paper-capacitor low-pass filters were selected at random sampling for the reliability endurance test at four intensive levels on the increased temperature. According to the measured data during reliability test and using the graphic method, the normal intensive endurance distribution curve can be obtained by extension of the points on the accelerating endurance curve, preliminary judging the filter testing with the distribution tendency, and evaluating the product reliable life-time and the characteristic life-time, the accelerating factor can be calculated. It is to get the theoretical basis to conduct the accelerating endurance test at the increased temperature. Author

N89-22835# Naval Postgraduate School, Monterey, CA.
CONTROL OF EMBEDDED VORTICES USING WALL JETS M.S. Thesis
GEOFFREY E. SCHWARTZ Sep. 1988 291 p
(AD-A202606; AD-E900870) Avail: NTIS HC A13/MF A01
CSCL 20/11

A wall jet inclined at 30 deg to horizontal was used to alter the structural characteristics of streamwise vortices embedded in a turbulent boundary layer developing in a zero pressure gradient. The vortices were created using a half delta wing attached to the floor of a wind tunnel. With the jet opposing the vortex downwash and blowing ratio increasing from 0 to 4.8, streamwise vorticity decreased from approx. 750 to approx. 150/s while circulation decreased from approx. 0.15 sq m/s. The average vortex core radius increased from approx. 0.9 to approx. 2.4 cm, while the vortex moved approx. 3 cm spanwise toward the jet. With the jet at the vortex upwash and blowing ratio increasing from 0 to 6.7, streamwise vorticity decreased from approx. 860 to approx. 570/s while circulation decreased from approx. 0.17 to approx. 0.15 sq m/s. GRA

N89-22838*# Virginia Polytechnic Inst. and State Univ., Blacksburg. Dept. of Aerospace and Ocean Engineering.
COMPUTATIONAL FLUID DYNAMICS RESEARCH IN THREE-DIMENSIONAL ZONAL TECHNIQUES Final Technical Report
ROBERT W. WALTERS Apr. 1989 16 p
(Contract NAG1-866)
(NASA-CR-181406; NAS 1.26:181406) Avail: NTIS HC A03/MF A01 CSCL 20/4

Patched-grid algorithms for the analysis of complex configurations with an implicit, upwind-biased Navier-Stokes solver were investigated. Conservative and non-conservative approaches for performing zonal interpolations were implemented. The latter approach yields the most flexible technique in that it can handle both patched and overlaid grids. Results for a two-dimensional blunt body problem show that either approach yield accurate steady-state shock locations and jump conditions. In addition, calculations of the turbulent flow through a hypersonic inlet on a three-zone grid show that the numerical prediction is in good agreement with the experimental results. Through the use of a generalized coordinate transformation at the zonal interface between two or more blocks, the algorithm can be applied to highly stretched viscous grids and to arbitrarily-shaped zonal boundaries. Applications were made to the F-18 aircraft at subsonic, high-alpha conditions, in support of the NASA High-Alpha Research Program. The calculations were compared to ground-based and flight test experiments and were used as a guide to understanding the ground-based tests, which are laminar and transitional, and their relationship to flight. Calculations about a complete reconnaissance aircraft were also performed in order to further demonstrate the capability of the patched-grid algorithm. Author

N89-22845# Sandia National Labs., Albuquerque, NM. Parachute Systems Div.
A VORTEX PANEL ANALYSIS OF CIRCULAR-ARC BLUFF-BODIES IN UNSTEADY FLOW
JAMES H. STRICKLAND 1989 28 p Presented at the 10th AIAA Aerodynamic Decelerator Systems Technical Conference, Cocoa Beach, FL, 18 Apr. 1989
(Contract DE-AC04-76DP-00789)
(DE89-007141; SAND-89-0366C; CONF-8904118-2; AIAA-89-0930) Avail: NTIS HC A03/MF A01

A method which is capable of calculating the unsteady flow field around circular-arc bluff bodies of zero thickness is presented. This method utilizes linear vortex panels to model the body surface and a portion of the wake surfaces. Discrete vortices are used to model the remainder of the wake surfaces. Separation is assumed to occur at the sharp edges of the bodies. Numerical results for circular-arc bodies with included angles of less than 180 degrees are compared with experimental data and found to be in good agreement. DOE

N89-22866# Princeton Univ., NJ. Dept. of Mechanical and Aerospace Engineering.
THE STRUCTURE AND CONTROL OF THREE-DIMENSIONAL SHOCK WAVE TURBULENT BOUNDARY LAYER INTERACTIONS Final Report, 15 Jul. 1986 - 30 Sep. 1988
SEYMOUR M. BOGDONOFF 14 Feb. 1989 39 p
(Contract F49620-86-C-0094)
(AD-A205923; MAE-1851; AFOSR-89-0285TR) Avail: NTIS HC A03/MF A01 CSCL 20/4

The present report briefly reviews the work accomplished on the study of three-dimensional shock wave turbulent boundary layer interactions at a Mach 3. The work consisted of two major thrusts: (1) Modeling of the complex interaction and detailed experiments coordinated with extensive computations; and (2) Exploratory studies of control concepts for a 20 deg fin and crossing shock configurations. The completed works have been reported and are briefly reviewed. A brief resume is presented of incompleted results on complex interactions, new heat transfer techniques, initial spanwise boundary layer effects, and studies in a new Low Turbulence Variable Geometry facility. GRA

N89-22868*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
SURFACE TEMPERATURE MEASUREMENTS USING A THIN FILM THERMAL ARRAY
L. A. DILLON-TOWNES, P. B. JOHNSON, R. L. ASH (Old Dominion Univ., Norfolk, VA.), K. DARYABEIGI, and J. C. WHIPPLE Mar. 1989 22 p
(Contract NAS1-17993)
(NASA-TM-101549; NAS 1.15:101549) Avail: NTIS HC A03/MF A01 CSCL 14/2

A thin film device was designed and fabricated to measure surface temperatures. An array of eight integrated thermal sensors are mounted on a 0.002 inch (0.05 mm) Kapton film and multiplexed to obtain an area thermal measurement. The device was tested on a flat plate airfoil and demonstrated a temperature variation of 0.55 C maximum and 0.05 C minimum compared to embedded thermocouples. Future improvements are also discussed. Author

N89-22879# Centre d'Etudes et de Recherches, Toulouse (France). Dept. d'Etudes et de Recherches en Aerothermodynamique.
IMPLEMENTATION OF A TWO-COMPONENT LASER ANEMOMETER AT THE T2 WIND TUNNEL
J. L. BONNET, A. SERAUDIE, J. P. ARCHAMBAUD, and A. MIGNOSI Jul. 1987 123 p In FRENCH Original contains color illustrations
(A-501-H; T-114-A) Avail: NTIS HC A06/MF A01

A series of tests for perfecting the velocity measurement with a two-component laser anemometer was carried out on a 180 mm chord RA16SC1 airfoil at the T2 wind tunnel, in September 1986. Measurements were performed on boundary layers, wake, and shock probing on the upper side of the model, mainly for two Mach number values (M = 0.6 and 0.725) at 2 deg angle of attack, corresponding respectively to a steady shock and to a buffeting configuration. The anemometer system was tested to determine its limitations and practical problems of its use: theoretical limitations due to the filter, to the wall approach, to the density gradients etc. In conclusion, good velocity measurements are reliable with this laser anemometer at the T2 wind tunnel, with respect to the use limitations. Author

N89-22891*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
ROTORDYNAMIC INSTABILITY PROBLEMS IN HIGH-PERFORMANCE TURBOMACHINERY, 1988
Washington, DC Feb. 1989 454 p Workshop held in College Station, TX, 16-18 May 1988; sponsored by NASA, Lewis Research Center, Cleveland, OH, Texas A and M Univ., College Station, ARO, Durham, NC, and Aeropropulsion Lab., Wright-Patterson AFB, OH
(NASA-CP-3026; E-4227; NAS 1.55:3026) Avail: NTIS HC A20/MF A01 CSCL 13/9

The continuing trend toward a unified view is supported with several developments in the design and manufacture of turbomachines with enhanced stability characteristics along with data and associated numerical/theoretical results. The intent is to provide a continuing impetus for an understanding and resolution of these problems. Topics addressed include: field experience, dampers, seals, impeller forces, bearings, and compressor and rotor modeling.

N89-22892*# Zhejiang Univ. (China).
SOME FIELD EXPERIENCE WITH SUBSYNCHRONOUS VIBRATION OF CENTRIFUGAL COMPRESSORS
XI-XUAN WANG, JIN-CHU GU, QIN-GEN SHEN, YONG-LI HUA, LAN-SHENG ZHU, and YUN-TIAN DU (Zhengzhou Polytechnic Inst., Henan, China) *In* NASA, Lewis Research Center, Rotordynamic Instability Problems in High-Performance Turbomachinery, 1988 p 1-18 Feb. 1989
Avail: NTIS HC A20/MF A01 CSCL 13/9

A lot of large chemical fertilizer plants producing 1000 ton NH3/day and 1700 ton urea/day were constructed in the 1970's in China. During operation, subsynchronous vibration takes place occasionally in some of the large turbine-compressor sets and has resulted in heavy economic losses. Two cases of subsynchronous vibration are described: Self-excited vibration of the low-pressure (LP) cylinder of one kind of N2-H2 multistage compressor; and Forced subsynchronous vibration of the high-pressure (HP) cylinder of the CO2 compressor. Author

N89-22894*# CESI, Milan (Italy).
SOME IN-FIELD EXPERIENCES OF NON-SYNCHRONOUS VIBRATIONS IN LARGE ROTATING MACHINERY
GIUSEPPE COLNAGO, CLAUDIO FRIGERI, ANDREA VALLINI, and GIAN ANTONIO ZANETTA (Ente Nazionale per l'Energia Elettrica, Rome, Italy) *In* NASA, Lewis Research Center, Rotordynamic Instability Problems in High-Performance Turbomachinery, 1988 p 41-59 Feb. 1989
Avail: NTIS HC A20/MF A01 CSCL 13/9

Some problems associated with non-synchronous vibrations are analyzed by describing three cases experienced with fairly large rotating machines in operating conditions. In each case, a brief description is first given of the machine and of the instrumentation used. The experimental results are then presented, with reference to time or frequency domain recordings. The lines followed in diagnosis are then discussed and, lastly, the corrective action undertaken is presented. Author

N89-22895*# Southampton Univ. (England). Dept. of Mechanical Engineering.
THE SPECTRAL ANALYSIS OF AN AERO-ENGINE ASSEMBLY INCORPORATING A SQUEEZE-FILM DAMPER
R. HOLMES and M. M. DEDE *In* NASA, Lewis Research Center, Rotordynamic Instability Problems in High-Performance Turbomachinery, 1988 p 61-86 Feb. 1989
Avail: NTIS HC A20/MF A01 CSCL 13/9

Aero-engine structures have very low inherent damping and so artificial damping is often introduced by pumping oil into annular gaps between the casings and the outer races of some or all of the rolling-element bearings supporting the rotors. The thin oil films so formed are called squeeze film dampers and they can be beneficial in reducing rotor vibration due to unbalance and keeping to reasonable limits the forces transmitted to the engine casing. However, squeeze-film dampers are notoriously non-linear and as a result can introduce into the assembly such phenomena as subharmonic oscillations, jumps and combination frequencies. The purpose of the research is to investigate such phenomena both theoretically and experimentally on a test facility reproducing the essential features of a medium-size aero engine. The forerunner of this work was published. It was concerned with the examination of a squeeze-film damper in series with housing flexibility when supporting a rotor. The structure represented to a limited extent the essentials of the projected Rolls Royce RB401 engine. That research demonstrated the ability to calculate the oil-film forces arising from the squeeze film from known motions of the bearing components and showed that the dynamics of a shaft fitted with a squeeze film bearing can be predicted reasonably accurately. An aero-engine will normally have at least two shafts and so in addition to the excitation forces which are synchronous with the rotation of one shaft, there will also be forces at other frequencies from other shafts operating on the squeeze-film damper. Theoretical and experimental work to consider severe loading of squeeze-film dampers and to include these additional effects are examined. Author

N89-22897*# Texas A&M Univ., College Station. Dept. of Mechanical Engineering.
CAVITATION EFFECTS ON THE PRESSURE DISTRIBUTION OF A SQUEEZE FILM DAMPER BEARING
FOUAD Y. ZEIDAN and JOHN M. VANCE *In* NASA, Lewis Research Center, Rotordynamic Instability Problems in High-Performance Turbomachinery, 1988 p 111-132 Feb. 1989
Sponsored in part by General Electric Co., Aircraft Engine Business Group
Avail: NTIS HC A20/MF A01 CSCL 13/9

High speed motion pictures have revealed several operating regimes in a squeeze film damper. Pressure measurements corresponding to these distinct regimes were made to examine their effect on the performance of such dampers. Visual observation also revealed the means by which the pressure in the feed groove showed higher amplitudes than the theory predicts. Comparison between vapor and gaseous cavitation are made based on their characteristic pressure wave, and the effect this has on the total force and its phase. Author

N89-22898*# Texas A&M Univ., College Station. Dept. of Mechanical Engineering.
AN ELECTROVISCOUS DAMPER
JORGEN L. NIKOLAJSEN and M. S. HOQUE *In* NASA, Lewis Research Center, Rotordynamic Instability Problems in High-Performance Turbomachinery, 1988 p 133-141 Feb. 1989
Sponsored in part by TAMU Turbomachinery Research Consortium
Avail: NTIS HC A20/MF A01 CSCL 13/9

A new type of vibration damper for rotor systems was developed and tested. The damper contains electroviscous fluid which solidifies and provides Coulomb damping when an electric voltage is imposed across the fluid. The damping capacity is controlled by the voltage. The damper was incorporated in a flexible rotor system and found to be able to damp out high levels of unbalanced excitation. Other proven advantages include controllability, simplicity, and no requirement for oil supply. Still unconfirmed are the capabilities to eliminate critical speeds and to suppress rotor instabilities. Author

N89-22899*# Texas A&M Univ., College Station.
ANNULAR HONEYCOMB SEALS: TEST RESULTS FOR LEAKAGE AND ROTORDYNAMIC COEFFICIENTS; COMPARISONS TO LABYRINTH AND SMOOTH CONFIGURATIONS
DARA W. CHILDS, DAVID ELROD, and KEITH HALE *In* NASA, Lewis Research Center, Rotordynamic Instability Problems in High-Performance Turbomachinery, 1988 p 143-159 Feb. 1989
Previously announced in X89-10207
(Contract NAG3-181; F49620-82-K-0033)
Avail: NTIS HC A20/MF A01 CSCL 11/1

Test results are presented for leakage and rotordynamic coefficients for seven honeycomb seals. All seals have the same radius, length, and clearance; however, the cell depths and diameters are varied. Rotordynamic data, which are presented, consist of the direct and cross-coupled stiffness coefficients and the direct damping coefficients. The rotordynamic-coefficient data show a considerable sensitivity to changes in cell dimensions; however, no clear trends are identifiable. Comparisons of test data for the honeycomb seals with labyrinth and smooth annular seals show the honeycomb seal had the best sealing (minimum leakage) performance, followed in order by the labyrinth and smooth seals. For prerotated fluid entering the seal, in the direction of shaft rotation, the honeycomb seal has the best rotordynamic stability followed in order by the labyrinth and smooth. For no prerotation, or fluid prerotation against shaft rotation, the labyrinth seal has the best rotordynamic stability followed in order by the smooth and honeycomb seals. Author

N89-22900*# Kaiserslautern Univ. (Germany, F.R.). Dept. of Mechanical Engineering.
ROTORDYNAMIC COEFFICIENTS FOR LABYRINTH SEALS CALCULATED BY MEANS OF A FINITE DIFFERENCE TECHNIQUE
R. NORDMANN and P. WEISER *In* NASA, Lewis Research Center, Rotordynamic Instability Problems in High-Performance Turbomachinery, 1988 p 161-175 Feb. 1989
Avail: NTIS HC A20/MF A01 CSCL 11/1

The compressible, turbulent, time dependent and three dimensional flow in a labyrinth seal can be described by the Navier-Stokes equations in conjunction with a turbulence model. Additionally, equations for mass and energy conservation and an equation of state are required. To solve these equations, a perturbation analysis is performed yielding zeroth order equations for centric shaft position and first order equations describing the flow field for small motions around the seal center. For numerical solution a finite difference method is applied to the zeroth and first order equations resulting in leakage and dynamic seal coefficients respectively. Author

N89-22901*# Rockwell International Corp., Canoga Park, CA. Rocketdyne Div.
ROTORDYNAMIC COEFFICIENTS FOR STEPPED LABYRINTH GAS SEALS
JOSEPH K. SCHARRER *In* NASA, Lewis Research Center, Rotordynamic Instability Problems in High-Performance Turbomachinery, 1988 p 177-195 Feb. 1989
Avail: NTIS HC A20/MF A01 CSCL 11/1

The basic equations are derived for compressible flow in a stepped labyrinth gas seal. The flow is assumed to be completely turbulent in the circumferential direction where the friction factor is determined by the Blasius relation. Linearized zeroth and first-order perturbation equations are developed for small motion about a centered position by an expansion in the eccentricity ratio. The zeroth-order pressure distribution is found by satisfying the leakage equation while the circumferential velocity distribution is determined by satisfying the momentum equations. The first order equations are solved by a separation of variables solution. Integration of the resultant pressure distribution along and around the seal defines the reaction force developed by the seal and the corresponding dynamic coefficients. The results of this analysis are presented in the form of a parametric study, since there are no known experimental data for the rotordynamic coefficients of stepped labyrinth gas seals. The parametric study investigates the relative rotordynamic stability of convergent, straight and divergent stepped labyrinth gas seals. The results show that, generally, the divergent seal is more stable, rotordynamically, than the straight or convergent seals. The results also show that the teeth-on-stator seals are not always more stable, rotordynamically, then the teeth-on-rotor seals as was shown by experiment by Childs and Scharrer (1986b) for a 15 tooth seal. Author

N89-22905*# Case Western Reserve Univ., Cleveland, OH.
A SEAL TEST FACILITY FOR THE MEASUREMENT OF ISOTROPIC AND ANISOTROPIC LINEAR ROTORDYNAMIC CHARACTERISTICS
M. L. ADAMS, T. YANG, and S. E. PACE (Electric Power Research Inst., Palo Alto, CA.) *In* NASA, Lewis Research Center, Rotordynamic Instability Problems in High-Performance Turbomachinery, 1988 p 253-267 Feb. 1989
Avail: NTIS HC A20/MF A01 CSCL 11/1

A new seal test facility for measuring high-pressure seal rotor-dynamic characteristics has recently been made operational at Case Western Reserve University (CWRU). This work is being sponsored by the Electric Power Research Institute (EPRI). The fundamental concept embodied in this test apparatus is a double-spool-shaft spindle which permits independent control over the spin speed and the frequency of an adjustable circular vibration orbit for both forward and backward whirl. Also, the static eccentricity between the rotating and non-rotating test seal parts is easily adjustable to desired values. By accurately measuring both dynamic radial displacement and dynamic radial force signals, over a wide range of circular orbit frequency, one is able to solve for the full linear-anisotropic model's 12 coefficients rather than the 6 coefficients of the more restrictive isotropic linear model. Of course, one may also impose the isotropic assumption in reducing test data, thereby providing a valid qualification of which seal configurations are well represented by the isotropic model and which are not. In fact, as argued in reference (1), the requirement for maintaining a symmetric total system mass matrix means that the resulting isotropic model needs 5 coefficients and the anisotropic model needs 11 coefficients. Author

N89-22906*# Kaiserslautern Univ. (Germany, F.R.). Dept. of Mechanical Engineering.
FINITE DIFFERENCE ANALYSIS OF ROTORDYNAMIC SEAL COEFFICIENTS FOR AN ECCENTRIC SHAFT POSITION
R. NORDMANN and F. J. DIETZEN *In* NASA, Lewis Research Center, Rotordynamic Instability Problems in High-Performance Turbomachinery, 1988 p 269-284 Feb. 1989
Avail: NTIS HC A20/MF A01 CSCL 11/1

The dynamic coefficients of seals are calculated for shaft movements around an eccentric position. The turbulent flow is described by the Navier-Stokes equations in connection with a turbulence model. The equations are solved by a finite-difference procedure. Author

N89-22909*# Textron Bell Helicopter, Fort Worth, TX.
INFLUENCE OF IMPELLER SHROUD FORCES ON TURBOPUMP ROTOR DYNAMICS
JIM P. WILLIAMS and DARA W. CHILDS (Texas A&M Univ., College Station.) *In* NASA, Lewis Research Center, Rotordynamic Instability Problems in High-Performance Turbomachinery, 1988 p 323-339 Feb. 1989 Previously announced as X89-10213
Avail: NTIS HC A20/MF A01 CSCL 13/9

The shrouded-impeller leakage path forces calculated by Childs (1987) have been analyzed to answer two questions. First, because of certain characteristics of the results of Childs, the forces could not be modeled with traditional approaches. Therefore, an approach has been devised to include the forces in conventional rotordynamic analyses. The forces were approximated by traditional stiffness, damping and inertia coefficients with the addition of whirl-frequency-dependent direct and cross-coupled stiffness terms. The forces were found to be well-modeled with this approach. Finally, the effect these forces had on a simple rotor-bearing system was analyzed, and, therefore, they, in addition to seal forces, were applied to a Jeffcott rotor. The traditional methods of dynamic system analysis were modified to incorporate the impeller forces and yielded results for the eigenproblem, frequency response, critical speed, transient response and an iterative technique for finding the frequency of free vibration as well as system stability. All results lead to the conclusion that the forces have little influence on natural frequency but can have appreciable effects on system stability. Specifically, at higher values of fluid swirl at the leakage path entrance, relative stability is reduced. The only unexpected response characteristics that occurred are attributed to the nonlinearity of the model. Author

N89-22910*# Mechanical Technology, Inc., Latham, NY.
MAGNETIC BEARING STIFFNESS CONTROL USING FREQUENCY BAND FILTERING
H. MING CHEN *In* NASA, Lewis Research Center, Rotordynamic Instability Problems in High-Performance Turbomachinery, 1988 p 341-352 Feb. 1989
Avail: NTIS HC A20/MF A01 CSCL 13/9

Active magnetic bearings can be implemented with frequency band-reject filtering that decreases the bearing stiffness and damping at a small bandwidth around a chosen frequency. The control scheme was used for reducing a rotor dynamic force, such as an imbalance force, transmitted to the bearing stator. The scheme creates additional system vibration modes at the same frequency. It also shows that the amount of force reduction is limited by the stability requirement of these modes. Author

N89-22911*# Rotor Bearing Dynamics, Inc., Wellsville, NY.
A MAGNETIC DAMPER FOR FIRST MODE VIBRATION REDUCTION IN MULTIMASS FLEXIBLE ROTORS
M. E. F. KASARDA, P. E. ALLAIRE, R. R. HUMPHRIS, and L. E. BARRETT (Virginia Univ., Charlottesville.) *In* NASA, Lewis Research Center, Rotordynamic Instability Problems in High-Performance Turbomachinery, 1988 p 353-372 Feb. 1989
Avail: NTIS HC A20/MF A01 CSCL 13/9

Many rotating machines such as compressors, turbines and pumps have long thin shafts with resulting vibration problems, and would benefit from additional damping near the center of the shaft. Magnetic dampers have the potential to be employed in these machines because they can operate in the working fluid environment unlike conventional bearings. An experimental test rig is described which was set up with a long thin shaft and several masses to represent a flexible shaft machine. An active magnetic damper was placed in three locations: near the midspan, near one end disk, and close to the bearing. With typical control parameter settings, the midspan location reduced the first mode vibration 82 percent, the disk location reduced it 75 percent and the bearing location attained a 74 percent reduction. Magnetic damper stiffness and damping values used to obtain these reductions were only a few percent of the bearing stiffness and damping values. A theoretical model of both the rotor and the damper was developed and compared to the measured results. The agreement was good. Author

N89-22912*# Aerojet TechSystems Co., Sacramento, CA.
INCORPORATING GENERAL RACE AND HOUSING FLEXIBILITY AND DEADBAND IN ROLLING ELEMENT BEARING ANALYSIS
R. R. DAVIS and C. S. VALLANCE *In* NASA, Lewis Research Center, Rotordynamic Instability Problems in High-Performance Turbomachinery, 1988 p 373-387 Feb. 1989
Avail: NTIS HC A20/MF A01 CSCL 13/9

Methods for including the effects of general race and housing compliance and outer race-to-housing deadband (clearance) in rolling element bearing mechanics analysis is presented. It is shown that these effects can cause significant changes in bearing stiffness characteristics, which are of major importance in rotordynamic response of turbomachinery and other rotating systems. Preloading analysis is demonstrated with the finite element/contact mechanics hybrid method applied to a 45 mm angular contact ball bearing. Author

N89-22913*# Texas A&M Univ., College Station. Dept. of Mechanical Engineering.
EXPERIMENTAL VERIFICATION OF AN EDDY-CURRENT BEARING
JORGEN L. NIKOLAJSEN *In* NASA, Lewis Research Center, Rotordynamic Instability Problems in High-Performance Turbomachinery, 1988 p 389-394 Feb. 1989 Sponsored in part by TAMU Turbomachinery Research Consortium
Avail: NTIS HC A20/MF A01 CSCL 13/9

A new type of electromagnetic bearing was built and tested. It consists of fixed AC-electromagnets in a star formation surrounding a conducting rotor. The bearing works by repulsion due to eddy-currents induced in the rotor. A single bearing is able to fully support a short rotor. The rotor support is inherently stable in all five degrees of freedom. No feedback control is needed. The bearing is also able to accelerate the rotor up to speed and decelerate the rotor back to standstill. The bearing design and the experimentation to verify its capabilities are described. Author

N89-22914*# Sulzer-Escher Wyss Ltd., Zurich (Switzerland).
ROTORDYNAMIC STABILITY PROBLEMS AND SOLUTIONS IN HIGH PRESSURE TURBOCOMPRESSORS
J. SCHMIED *In* NASA, Lewis Research Center, Rotordynamic Instability Problems in High-Performance Turbomachinery, 1988 p 395-413 Feb. 1989
Avail: NTIS HC A20/MF A01 CSCL 13/9

The stability of a high pressure compressor is investigated with special regard to the self-exciting effects in oil seals and labyrinths. It is shown how to stabilize a rotor in spite of these effects and even increase its stability with increasing pressure. Author

N89-22915*# Bently Rotor Dynamics Research Corp., Minden, NV.
ROLE OF CIRCUMFERENTIAL FLOW IN THE STABILITY OF FLUID-HANDLING MACHINE ROTORS
D. E. BENTLY and A. MUSZYNSKA *In* NASA, Lewis Research Center, Rotordynamic Instability Problems in High-Performance Turbomachinery, 1988 p 415-430 Feb. 1989
Avail: NTIS HC A20/MF A01 CSCL 13/9

The recent studies of the dynamic stiffness properties of fluid lubricated bearing and seals by the authors have yielded most of the generalized characteristics discussed and used in this paper. They include bearing and seal nonlinear fluid film properties associated with stiffness, damping, and fluid average circumferential velocity ratio. Analytical relationships yield the rotor system's dynamic stiffness characteristics. This paper shows the combination of these data to provide the fluid-induced rotor stability equations. Author

N89-22916*# Aerojet TechSystems Co., Sacramento, CA.
ENHANCED ROTOR MODELING TAILORED FOR RUB DYNAMIC STABILITY ANALYSIS AND SIMULATION
R. R. DAVIS *In* NASA, Lewis Research Center, Rotordynamic Instability Problems in High-Performance Turbomachinery, 1988 p 431-444 Feb. 1989
Avail: NTIS HC A20/MF A01 CSCL 13/9

New methods are presented that allow straightforward application of complex nonlinearities to finite element based rotor dynamic analyses. The key features are: (1) the methods can be implemented with existing finite element or dynamic simulation programs, (2) formulation is general for simple application to a wide range of problems, and (3) implementation is simplified because nonlinear aspects are separated from the linear part of the model. The new techniques are illustrated with examples of inertial nonlinearity and torquewhirl which can be important in rubbing turbomachinery. The sample analyses provide new understanding of these nonlinearities which are discussed. Author

N89-22917*# Mitsubishi Heavy-Industries Ltd., Takasago (Japan).
HIGH STABILITY DESIGN FOR NEW CENTRIFUGAL COMPRESSOR
H. KANKI, K. KATAYAMA, S. MORII, Y. MOURI, S. UMEMURA, U. OZAWA, and T. ODA *In* NASA, Lewis Research Center, Rotordynamic Instability Problems in High-Performance Turbomachinery, 1988 p 445-459 Feb. 1989
Avail: NTIS HC A20/MF A01 CSCL 13/9

It is essential that high-performance centrifugal compressors be free of subsynchronous vibrations. A new high-performance centrifugal compressor has been developed by applying the latest rotordynamics knowledge and design techniques: (1) To improve the system damping, a specially designed oil film seal was developed. This seal attained a damping ratio three times that of the conventional design. The oil film seal contains a special damper ring in the seal cartridge. (2) To reduce the destabilizing effect of the labyrinth seal, a special swirl canceler (anti-swirl nozzle) was applied to the balance piston seal. (3) To confirm the system damping margin, the dynamic simulation rotor model test and the full load test applied the vibration exciting test in actual load conditions. Author

N89-22925*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
TRANSMISSION OVERHAUL AND REPLACEMENT PREDICTIONS USING WEIBULL AND RENEWEL THEORY
M. SAVAGE and D. G. LEWICKI (Army Aviation Systems Command, Cleveland, OH.) 1989 12 p Presented at the 25th Joint Propulsion Conference, Monterey, CA, 10-12 Jul. 1989; cosponsored by the AIAA, ASME, SAE and ASEE
(Contract DA PROJ. 1L1-62209-A-47-A)
(NASA-TM-102022; E-4756; NAS 1.15:102022; AVSCOM-TR-89-C-007; AIAA-89-2919) Avail: NTIS HC A03/MF A01 CSCL 13/9

A method to estimate the frequency of transmission overhauls is presented. This method is based on the two-parameter Weibull statistical distribution for component life. A second method is presented to estimate the number of replacement components needed to support the transmission overhaul pattern. The second method is based on renewal theory. Confidence statistics are applied with both methods to improve the statistical estimate of sample behavior. A transmission example is also presented to illustrate the use of the methods. Transmission overhaul frequency and component replacement calculations are included in the example. Author

N89-22939*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
STRUCTURAL DYNAMICS BRANCH RESEARCH AND ACCOMPLISHMENTS FOR FY 1988
Apr. 1989 48 p
(NASA-TM-101406; E-4498; NAS 1.15:101406) Avail: NTIS HC A03/MF A01 CSCL 20/11

Fiscal year 1988 research highlights from the Structural Dynamics Branch at NASA Lewis Research Center are described. Highlights from the branch's major work areas -- aeroelasticity, vibration control, dynamic systems, and computational structural methods -- are included as well as a complete listing of the FY 88 branch publications. Author

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GEOSCIENCES

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

A89-39647* San Jose State Univ., CA.
THE USE OF DFDR INFORMATION IN THE ANALYSIS OF A TURBULENCE INCIDENT OVER GREENLAND
PETER F. LESTER, ORHAN SEN (San Jose State University, CA), and R. E. BACH, JR. (NASA, Ames Research Center, Moffett Field, CA) Monthly Weather Review (ISSN 0027-0644), vol. 117, May 1989, p. 1103-1107. refs
(Contract NCC2-315)

Digital flight data recorder (DFDR) tapes from commercial aircraft can provide useful information about the mesoscale environment of severe turbulence incidents. Air motion computations from these data and their errors are briefly described. An example of mesoscale meteorological information available from DFDR tapes is presented for a case of turbulence in mountain waves over the Greenland icecap. Author

N89-22287 Texas Univ., Arlington.
MICROBURST SIMULATION VIA VORTEX-RING AND TURBULENT JET MODELS Ph.D. Thesis
TUNG WAN 1988 123 p
Avail: Univ. Microfilms Order No. DA8901077

Microbursts, suggested as primary causes of many aircraft fatal crashes, are studied. A microburst, or low-level intense wind shear, is generated by a thunderstorm or a small rain cloud, and presents hazardous conditions for aircraft during takeoff and landing maneuvers. Recently released data show that a microburst resembles a transient vortex ring. Three microburst models were constructed. First, the turbulent jet model encompasses a free jet at high altitude and a wall jet near the ground surface. Second, the vortex ring model is a combination of a primary and an image vortex ring, with an inviscid-viscous interaction at the central axial and surface regions. An unsteady version of this model is also provided by solving the trajectory equation with the Direct Formal Integration (DFI) method or with the Runge-Kutta method. Third and finally, the complete unsteady microburst model equations (conservation of mass, momentum, and energy), or what has been referred to as the Navier-Stokes model formulation, are solved by the successive over relaxation method. Results show that the microburst can be simulated accurately by impulsive turbulent jet at high altitude and a transient vortex ring in mid-air and near the ground surface. In addition to improved understanding of the physical nature of microbursts, the models presented can also be used for flight simulation and the pilot training purposes.
Dissert. Abstr.

N89-23048*# National Oceanic and Atmospheric Administration, Boulder, CO. Wave Propulsion Lab.
HAZARD INDEX CALCULATION FOR 31 MAY 1984 MICROBURST AT ERIE, COLORADO Final Report
R. A. KROPFLI Oct. 1988 54 p Sponsored by NASA, Langley Research Center, Hampton, VA
(NASA-CR-184968; NAS 1.26:184968; PB89-127831; NOAA-TM-ERL-WPL-155) Avail: NTIS HC A04/MF A01 CSCL 04/2

Two x-band Doppler radars, operated by NOAA, were used to collect high resolution data within a small, benign looking microburst during the PHOENIX II boundary layer experiment. The lowest 2.5 km of the microbursts was observed throughout its development and dissipation over a 15 minute period. These observations presented an excellent opportunity to compute a quantitative threat to a hypothetical aircraft whose flight track would carry it through the microburst. The hazard index is based on the kinetic energy loss to the aircraft that would be produced by the microburst; it is a function of the vertical air motion, horizontal spatial derivatives of the wind field, and the assumed aircraft air speed and direction. Indices were computed and plotted for all 8 volume scans and peak values were observed to be sufficiently high to present a significant hazard to an aircraft. 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.

A89-36351#
SOME MATHEMATICAL CONSIDERATIONS ON VIEWS OF THE GROUND SURFACE IN FLIGHT
YOSHINORI TAKEUCHI Japan Air Self Defense Force, Aeromedical Laboratory, Reports (ISSN 0023-2858), vol. 29, June 1988, p. 61-69. In Japanese, with abstract in English. refs

A mathematical study of the view of the ground surface from an aircraft is presented. A three-dimensional coordinate system is given and definitions are developed for the perspective projection coordinates of a texture element on the ground, the visual angle of a ground element, the angular velocity of a ground element, and the horizontal distance of a ground element from the aircraft. Examples are provided using the definitions to study aircraft takeoff and landing and helicopter flight. Also, consideration is given to the use of motion parallax and optical flowing for altitude and speed estimates. R.B.

A89-36943#
MEASURES OF MODAL CONTROLLABILITY AND OBSERVABILITY FOR FIRST- AND SECOND-ORDER LINEAR SYSTEMS
A. M. A. HAMDAN and A. H. NAYFEH (Virginia Polytechnic Institute and State University, Blacksburg) (Dynamics and control of large structures; Proceedings of the Sixth VPI&SU/AIAA Symposium, Blacksburg, VA, June 29-July 1, 1987, p. 453-475) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 12, May-June 1989, p. 421-428. Previously cited in issue 02, p. 203, Accession no. A89-11680. refs
(Contract F49620-87-C-0088)

A89-36990#
SELECTION OF WEIGHTING MATRICES FOR LINEAR OPTIMAL REGULATOR
JIANHUA ZHAO and ZICAI WANG (Harbin Institute of Technology, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 9, Nov. 1988, p. A534-A539. In Chinese, with abstract in English. refs
A new method is presented for selecting weighting matrices of a linear quadratic regulator. By using the new method, the linear regulator has short setting time, small overshoot, and good robustness; the presented recurrence algorithm is simple. The method is successfully applied to the design of an aircraft control system. Examples show the advantages of the method. Author

A89-37014#
GDPP - A PRACTICAL CAD SOFTWARE PACKAGE
XIAORONG CHEN, XIAOMU YE, and YUN HUANG (Chendu Aviation Co., People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 9, Dec. 1988, p. B621-B624. In Chinese, with abstract in English. refs
Rapid and optimum design of aircraft configuration models is examined, and two software packages for engineering analysis of configuration models are introduced. The GDPP software package has been running for two years and good results have been obtained using it in practical design. Together with its common data base, GDPP has become a practical CAD software package shared by many specialist groups. C.D.

A89-37234* Notre Dame Univ., IN.
NEURAL COMPUTING FOR NUMERIC-TO-SYMBOLIC CONVERSION IN CONTROL SYSTEMS
KEVIN M. PASSINO, MICHAEL A. SARTORI, and PANOS J. ANTSAKLIS (Notre Dame, University, IN) IEEE Control Systems Magazine (ISSN 0272-1708), vol. 9, April 1989, p. 44-52. refs
(Contract JPL-957856; DAAL03-88-K-0144)
A type of neural network, the multilayer perceptron, is used to classify numeric data and assign appropriate symbols to various classes. This numeric-to-symbolic conversion results in a type of information extraction, which is similar to what is called data reduction in pattern recognition. The use of the neural network as a numeric-to-symbolic converter is introduced, its application in autonomous control is discussed, and several applications are studied. The perceptron is used as a numeric-to-symbolic converter for a discrete-event system controller supervising a continuous variable dynamic system. It is also shown how the perceptron can implement fault trees, which provide useful information (alarms) in a biological system and information for failure diagnosis and control purposes in an aircraft example. I.E.

A89-38511
ADAPTIVE AUTOMATIC CONTROL SYSTEMS FOR FLIGHT VEHICLES [ADAPTIVNYE SISTEMY AVTOMATICHESKOGO UPRAVLENIIA LETATEL'NYMI APPARATAMI]
NIKOLAI I. SOKOLOV, VLADISLAV IU. RUTKOVSKII, and NIKITA B. SUDZILOVSKII Moscow, Izdatel'stvo Mashinostroenie, 1988, 208 p. In Russian. refs
The main principles of the architectural design and performance analysis of fast-response search-free adaptive control systems for flight vehicles are presented. Various methods for the identification of the variables of the controlled process within a nonstationary system are discussed. Attention is also given to the principles of the design of search-free adaptive systems for the control of systems with slowly variable parameters. V.L.

A89-38512
SYNTHESIS OF SYSTEMS FOR THE MOTION CONTROL OF NONSTATIONARY OBJECTS [SINTEZ SISTEM UPRAVLENIIA DVIZHENIEM NESTATSIONARNYKH OB'EKTOV]
GENNADII I. VANIURIKHIN and VIKTOR M. IVANOV Moscow, Izdatel'stvo Mashinostroenie, 1988, 168 p. In Russian. refs
The works presents methods for the synthesis and analysis of optimal control systems for flight vehicles which are characterized by substantial nonstationarity and random scatter of parameters. Attention is given to continuous and discrete models for linear and nonlinear problems of optimal control, including those with adaptation and learning elements. Examples, algorithms, and programs are presented which make it possible to assess the applicability of the proposed methods to the control of nonstationary and unstable objects. B.J.

A89-39777
INPUT SIGNAL SELECTION IN THE IDENTIFICATION OF LINEAR CONTINUOUS DYNAMIC SYSTEMS FROM DISCRETE OBSERVATIONS [VYBOR VKHODNYKH SIGNALOV PRI IDENTIFIKATSII LINEINYKH NEPRERYVNYKH DINAMICHESKIKH SISTEM PO DISKRETNYM NABLIUDENIIAM]
V. N. OVCHARENKO Avtomatika i Telemekhanika (ISSN 0005-2310), Feb. 1989, p. 87-95. In Russian. refs
The problem of estimating the parameters of linear continuous dynamic systems from discrete observations is treated simultaneously with the problem of selecting the input signal. The method of selecting the input signal proposed here makes it possible to obtain a control law that ensures the specified level of identification of the unknown parameters. The method is illustrated by a numerical example from aircraft flight dynamics. V.L.

N89-22366# General Electric Co., Cincinnati, OH. Aircraft Engines.
INTERFACE 2: ADVANCED DIAGNOSTIC SOFTWARE Final Report, Jul. 1985 - Jul. 1988
LEE R. LAPIERRE, PETER A. COSTEN, DAVID L. DOEL, and RASIK P. SHAH 14 Dec. 1988 168 p
(Contract F33657-85-C-2131)
(AD-A204527; AFWAL-TR-88-2096) Avail: NTIS HC A08/MF A01 CSCL 01/3
JET-X is an expert system for the diagnosis and maintenance of the TF34-100 jet engine as installed on the USAF A-10A aircraft. JET-X uses input supplied by the TEMS (turbine engine monitoring system) installed on the airplane and, in addition, uses data retrieved from the CEMS (comprehensive engine management system) data base that is part of the ground computer support system. Both of these monitoring systems generate alarms which are the starting points for JET-X analyses. As part of an earlier contract, diagnostic troubleshooting procedures had been established for resolving each of these alarms. These diagnostic procedures have been embedded into the JET-X system, generally in a much expanded form. In addition, a number of help facilities have been developed for JET-X to assist the novice diagnostician. JET-X has been designed to be both a flight-line diagnostic tool and a training aid. Although the system is not complete at this point, a first good prototype has been developed, and some field experience has been gained in order to evaluate the system and to guide future enhancements. This report describes the development of the JET-X system, its features and limitations, results of the field trial, and gives conclusions and recommendations for future work. GRA

N89-23213# Swedish Defence Research Establishment, Linkoeping. Dept. of Information Technology.
FUSION OF MULTISENSOR DATA: A SUMMARY OF THE JASMIN PROJECT

NILS OLANDER and BENGT ROSEN Jun. 1988 23 p In SWEDEN; ENGLISH summary
(FOA-C-30498-3.3; ISSN-0347-3708; ETN-89-94126) Avail: NTIS HC A03/MF A01; Swedish Defence Research Establishment, P.O. Box 1165, S-581 11 Linkoeping, Sweden, 50 Swedish crowns

The Jasmin project studied how knowledge based techniques could be used to combine symbolic data from different sensors. The application in mind concerned reconnaissance data from an aircraft. The system can also deal with geographical items. To keep the effectiveness of the sensors, various types of automation shall be necessary to interpret the data. ESA

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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.

A89-36216*# Lockheed Aeronautical Systems Co., Marietta, GA.

INSTALLED PROPFAN (SR-7L) FAR-FIELD NOISE CHARACTERISTICS

N. N. REDDY, H. W. BARTEL, and M. SALIKUDDIN (Lockheed Aeronautical Systems Co., Marietta, GA) AIAA, Aeroacoustics Conference, 12th, San Antonio, TX, Apr. 10-12, 1989. 7 p.
(Contract NAS3-24339)
(AIAA PAPER 89-1056)

Far-field noise characteristics of the SR-7L single-rotor propfan were obtained from the Propfan Test Assessment (PTA) aircraft flight tests. The aircraft was flown at low altitudes (about 310m) above the ground at a constant speed of about 92 m/sec. The acoustic data were acquired with an array of ground-flush microphones positioned on both sides of the flight path. Propfan-generated noise levels were extracted from the total aircraft noise, and these data were then used to study the far-field noise characteristics. The directivities at the polar and azimuthal planes, and the variations of the blade-order tone levels with propfan power and blade tip Mach number were derived. The effect of inflow angle was studied by changing the nacelle tilt angle. The levels and the directivity were very sensitive to the nacelle tilt angle (i.e., inflow angle). The noise levels in the aft quadrant were found to be higher than in the forward quadrant. Also, the noise levels on the starboard side of the aircraft were found to be higher than on the port side. The noise levels increase with propfan power and rotational speed. Author

A89-36217*# Lockheed Aeronautical Systems Co., Marietta, GA.

LATERAL NOISE ATTENUATION OF THE ADVANCED PROPELLER OF THE PROPFAN TEST ASSESSMENT AIRCRAFT

F. W. CHAMBERS, N. N. REDDY, and H. W. BARTEL (Lockheed Aeronautical Systems Co., Marietta, GA) AIAA, Aeroacoustics Conference, 12th, San Antonio, TX, Apr. 10-12, 1989. 9 p. refs
(Contract NAS3-24339)
(AIAA PAPER 89-1057)

Lateral noise attenuation characteristics of the advanced propeller are determined using the flight test results of the testbed aircraft, Propfan Test Assessment (PTA), with a single, large-scale propfan. The acoustic data were obtained with an array of ground-mounted microphones positioned at distances up to 2.47 km (8100 feet) to the side of the flight path. The aircraft was flown at a Mach number of 0.31 for a variety of operating conditions. The lateral noise attenuation in a frequency range containing the blade passage frequency of the propeller was found to have positive magnitudes on the propfan side and negative magnitudes on the opposite side. The measured attenuation exhibits a strong dependence upon the elevation angle. The results also display a clear dependence upon the angle at which the propeller and nacelle are mounted on the wing (inflow angle). Author

A89-36218*# Lockheed Aeronautical Systems Co., Marietta, GA.

FLUCTUATING PRESSURES ON WING SURFACES IN THE SLIPSTREAM OF A SINGLE-ROTOR PROPFAN

G. SWIFT and H. W. BARTEL (Lockheed Aeronautical Systems Co., Marietta, GA) AIAA, Aeroacoustics Conference, 12th, San Antonio, TX, Apr. 10-12, 1989. 12 p.
(Contract NAS3-24339)
(AIAA PAPER 89-1058)

Measurements of the fluctuating pressure levels (FPLs) induced on a Propfan Test Assessment wing by the SR-7L propfan slipstream within the airplane flight envelope were obtained as a function of propfan operating conditions. It is shown that FPLS were high over most of the flight envelope, and that the spectra were dominated by the propfan first-order blade passage frequency tone. The highest FPLs were found at the lowest aircraft test altitudes and Mach numbers and for propfan conditions of lowest rotational tip speed and highest power. R.R.

A89-36219#

REVIEW OF SONIC BOOM THEORY

KENNETH J. PLOTKIN (Wyle Laboratories, Arlington, VA) AIAA, Aeroacoustics Conference, 12th, San Antonio, TX, Apr. 10-12, 1989. 38 p. refs
(AIAA PAPER 89-1105)

A review is presented of sonic boom theory, covering three viewpoints: historical perspective, an exposition of established boom theory and special phenomena, and the theoretical needs of current sonic boom problems. The review is intended to serve as a tutorial for the nonspecialist as well as a review of the current state-of-the-art and open issues. The greatest interest in sonic boom was associated with SST projects of the 1960s, and much of sonic boom theory has been shaped by that influence. Major elements of sonic boom analysis have been well established into what may be called standard theory. Current sonic boom problems require elements beyond standard theory, including the influence of hypersonic speeds, better integration of sonic boom analysis into the aircraft design process, and a more complete understanding of focal zones. Author

A89-36220*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

A PREDICTION OF HIGH-SPEED ROTOR NOISE

TIMOTHY W. PURCELL (NASA, Ames Research Center; U.S. Army, Aeroflightdynamics Directorate, Moffett Field, CA) AIAA, Aeroacoustics Conference, 12th, San Antonio, TX, Apr. 10-12, 1989. 12 p. refs
(AIAA PAPER 89-1132)

A combined computational (CFD) and integral approach solves the acoustic pressure fields of two high-speed helicopter rotors. A CFD code supplies boundary data to a non-linear type of Kirchhoff integral formulation to find the far-field pressures. Direct calculations of pressures are given by the CFD code up to the sonic cylinder where the Kirchhoff method takes over. This paper shows predictions and measurements of High-Speed Impulsive (HSI) noise in hover for two different rotor geometries. One rotor has a conventional rectangular planform, while the other rotor is highly swept and tapered. The swept rotor analysis forms the majority of this paper. Test data from both rotors are shown and compared with predictions for a range of tip Mach numbers from .85 to .95 (including delocalization). The correlation with the near-field pressures from the straight bladed experiment is excellent and good to excellent correlation is seen for the far-field pressures from both experiments. Author

A89-36221#

PREDICTION OF COUNTER-ROTATION PROPELLER NOISE

A. B. PARRY (Strathclyde, University, Glasgow, Scotland) and D. G. CRIGHTON (Cambridge University, England) AIAA,

Aeroacoustics Conference, 12th, San Antonio, TX, Apr. 10-12, 1989. 27 p. refs
(AIAA PAPER 89-1141)

Using asymptotic techniques the complex expressions for the sound radiated from a counter-rotation propeller are reduced to provide simple results which do not involve numerical integration or the evaluation of Bessel functions but retain the main parametric dependences. The unsteady loadings on the blades, needed as input to the radiation formulas, are also evaluated asymptotically. Here consideration is given to the effects of both viscous wakes and bound potential fields, the latter resulting in unsteady loads on both blade rows. Comparisons are made with measurements taken from fly-over tests on the Fairey Gannet aircraft. Excellent agreement is obtained between the asymptotic theory and the data in terms of both absolute level and directivity. In addition, for some interaction tones, it is shown that the potential field interactions are much stronger than the viscous wake interactions. Author

A89-37652#

ASYMPTOTIC ANALYSIS OF THE TRANSONIC REGION OF A HIGH-SPEED PROPELLER

INGEMAR A. A. LINDBLAD (Flygtekniska Forsoksanstalten, Bromma, Sweden) AIAA, Aeroacoustics Conference, 12th, San Antonio, TX, Apr. 10-12, 1989. 15 p. refs
(AIAA PAPER 89-1077)

A model problem with a moderately swept symmetric rotor blade is considered. It is shown that, for realistic parameter values, the general features of the transonic region of a high-speed propeller can be described by a linear equation of the lowest order. The rotating transonic problem is singular in character; this permits the existence of regions of high disturbance levels in the interior of the flow where nonlinear terms are important. K.K.

A89-39195*# Sverdrup Technology, Inc., Cleveland, OH.

HIGH-SPEED PROPELLER PERFORMANCE AND NOISE PREDICTIONS AT TAKEOFF/LANDING CONDITIONS

M. NALLASAMY (Sverdrup Technology, Inc., Cleveland, OH), R. P. WOODWARD, and J. F. GROENEWEG (NASA, Lewis Research Center, Cleveland, OH) Journal of Aircraft (ISSN 0021-8669), vol. 26, June 1989, p. 563-569. Previously cited in issue 07, p. 1088, Accession no. A88-22193. refs

A89-39506

A NOTE ON SOUND FROM THE INTERRUPTION OF A CYLINDRICAL FLOW BY A SEMI-INFINITE AEROFOIL OF SUBSONIC SPEED

Y. P. GUO (Cambridge, University, England) Journal of Sound and Vibration (ISSN 0022-460X), vol. 128, Jan. 22, 1989, p. 275-286. refs

An analysis is presented of the sound radiated from the interruption of a steady cylindrical flow by a semiinfinite aerofoil that moves subsonically in the plane perpendicular to the flow. The scattered sound energy is found explicitly as a function of the aerofoil Mach number, which is different from the case of supersonic aerofoils where the scattered energy is independent of the speed at which the aerofoil moves. It is shown that the radiated acoustic energy increases from zero to the value for supersonic aerofoils as the aerofoil Mach number increases from zero to unity. The reduction of sound energy at low Mach numbers is shown to be the result of the existence of a second-order suction force at the sharp leading edge which, in the case of subsonic aerofoils, does negative work during the interruption process, and hence causes an energy flow into the leading edge. The energy absorbed by the leading edge is shown to exactly balance the difference between the loss of the kinetic energy of the steady flow and the acoustic energy radiated to infinity. Author

A89-39514

ON SOUND GENERATED WHEN A VORTEX IS CHOPPED BY A CIRCULAR AIRFOIL

M. S. HOWE (BBN Laboratories, Inc., Cambridge, MA) Journal of Sound and Vibration (ISSN 0022-460X), vol. 128, Feb. 8, 1989, p. 487-503. Research supported by the U.S. Navy. refs

An analysis is made of the sound produced when a rectilinear vortex is cut by a circular airfoil translating at zero angle of attack. The flow Mach number is sufficiently small that the airfoil is acoustically compact, and detailed predictions are given for a vortex whose axis is nearly normal to the plane of the airfoil. The two principal components of the radiation are associated with axial and azimuthal distributions of vorticity, the latter being non-zero when there exists a finite axial velocity defect in the core of the vortex. Comparison is made with similar predictions for a two-dimensional airfoil of infinite span, and the general effects of arbitrary, finite span are briefly discussed. Author

A89-39515

AN APPROXIMATE METHOD FOR SONIC FATIGUE ANALYSIS OF PLATES AND SHELLS

R. D. BLEVINS (Rohr Industries, Inc., San Diego, CA) Journal of Sound and Vibration (ISSN 0022-460X), vol. 129, Feb. 22, 1989, p. 51-71. refs

Approximate analytical methods are developed for determining the response of plate and shell structures to coherent sound fields. The methods are based on separating the spatial and temporal aspects of the problem and then developing approximations for both. Direct comparison is made with experimental data. Author

A89-39588

SCATTERING FROM THREE-DIMENSIONAL CRACKS

ALLEN K. DOMINEK, HARRY T. SHAMANSKY, and NAN WANG (Ohio State University, Columbus) IEEE Transactions on Antennas and Propagation (ISSN 0018-926X), vol. 37, May 1989, p. 586-591. Research supported by Rockwell International Corp. refs

Scattering from three-dimensional cracks is analyzed and measured. The crack geometry is modeled as a rectangular groove in a perfectly conducting surface. The grove forming the crack may be terminated with an open aperture creating a slit in the conducting surface or with an impedance boundary creating a trough. The scattered fields from a crack are analyzed with two types of scattering mechanisms: a component directly related to the scattered fields from a two-dimensional crack, and a traveling-wave component. I.E.

A89-39816

MOTION OF A THREE-DEGREES-OF-FREEDOM GYROSCOPE WITH A DYNAMICALLY UNBALANCED ROTOR IN THE CASE OF CONTACT BETWEEN THE INTERNAL FRAME AND AN ELASTIC LIMITER [DVIZHENIE TREKHSTEPENNOGO GIROSKOPA S DINAMICHESKI NESBALANSIROVANNYM ROTOROM PRI KONTAKTE VNUTRENNEI RAMKI S UPRUGIM OGRANICHITELEM]

A. D. VAL'KO, V. A. GARANKIN, V. A. ISAEV, and S. E. KUKHTEVICH Akademiia Nauk SSSR, Izvestiia, Mekhanika Tverdogo Tela (ISSN 0572-3299), Mar.-Apr. 1989, p. 25-29. In Russian.

A89-39819

A METHOD FOR DETERMINING THE INERTIA TENSOR OF A CRAFT IN FLIGHT [OB ODNOM SPOSOBE OPREDELENIIA TENZORA INERTSII APPARATA V POLETE]

K. B. ALEKSEEV and N. V. NIKOLAEV Akademiia Nauk SSSR, Izvestiia, Mekhanika Tverdogo Tela (ISSN 0572-3299), Mar.-Apr. 1989, p. 60, 61. In Russian. refs

Knowledge of the inertia tensor is essential for controlling the turning maneuvers of flight vehicles. Here, an analytical-experimental method for determining the inertia tensor is proposed which is based on measuring the angular velocity of the vehicle and the counteraction of the jet engines. In contrast to other methods, the approach proposed here does not require that the initial kinetic moment of the flight vehicle equal zero. V.L.

N89-22445# Max-Planck-Institut fuer Stroemungsforschung, Goettingen (Germany, F.R.).
THE AEROACOUSTICS OF THE INTERACTION BETWEEN VORTICES AND BODIES IN A TRANSONIC FLOW Thesis [ZUR AEROAKUSTIK DER WECHSELWIRKUNG VON WIRBELN MIT TRANSSONISCH UMSTROEMTEN KOERPERN]
KARSTEN LOEHR Feb. 1988 66 p In GERMAN
(MPIS-3/1988; ISSN-0436-1199; ETN-89-93811) Avail: NTIS HC A04/MF A01; Max-Planck Inst. fuer Stroemungsforschung, Boettinger Strasse 6-8, 3400 Goettingen, Fed. Republic of Germany, DM 21

Vortex production in the wake of rectangular cylinders, as well as the interaction between vortices and aerodynamic profiles in transonic channel flow were investigated. The vortices are improved if the vortex separation is resonant with the transversal fundamental, acoustic mode of the channel. Using the superimposed acoustic field the vortex separation was synchronized and the separation process stimulated. The synchronization improves the two-dimensionality of the observed flow and provides a good reproducibility of the phenomena. During the interaction with profiles the following accumulating waves were observed the formation of a high-pressure region from the stagnation point upstream of the sound wave, and the formation of shocks in the high-speed region between vortex and fixed surface which leave the profile upstream as shock waves. ESA

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SOCIAL SCIENCES

Includes social sciences (general); administration and management; documentation and information science; economics and cost analysis; law and political science; and urban technology and transportation.

A89-38876
THE CHICAGO CONVENTION - ARTICLE 33 AND THE SFAR 40 EPISODE
STEPHEN D. MCCREARY Journal of Air Law and Commerce (ISSN 0021-8642), vol. 54, Spring 1989, p. 721-755. refs

Two court cases concerning Special Federal Aviation Regulation (SFAR) No. 40 (1979), which prevented the operation of foreign registered DC-10s in the U.S., are examined. The reciprocal recognition rule of Article 33 of the 1944 Chicago Convention and the minimum airworthiness standards defined in Annex 8 of the Chicago Convention are analyzed. The events leading up to SFAR No. 40, and the cases British Calendonian Airways Ltd. v. Bond and Balair Ltd. v. the United States are discussed. Consideration is given to policy issues that arise regarding the mutual recognition rule when the U.S. is in fundamental disagreement over a safety issue. R.B.

A89-38877
PRIVATIZATION OF THE AIR TRAFFIC CONTROL SYSTEM - ITS RATIONALE, IMPLEMENTATION AND IMPLICATIONS
DAVID DUNCAN Journal of Air Law and Commerce (ISSN 0021-8642), vol. 54, Spring 1989, p. 795-824. refs

The possible privatization of the air traffic control system in the U.S. is examined. A review of attempts to privatize federal government activities during the 1980s is presented. Organized constituencies opposed to privatization and strategies of privatization proponents are discussed. Arguments are given for and against privatization of the air traffic control system and previous efforts to privatize the system are considered, including the original private system, the proposal of Poole (1982) and the recommendations of the President's Commission on Privatization (1988) regarding the air traffic control system. R.B.

N89-23361# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
CALENDAR OF SELECTED AERONAUTICAL AND SPACE MEETINGS
Jun. 1988 144 p In ENGLISH and FRENCH
(AGARD-CAL-88/2; ISBN-92-835-0470-4) Avail: NTIS HC A07/MF A01

A schedule is presented of some aeronautical and space meetings and workshops which are of interest to the aforementioned community. This calendar is published every six months, in June and December of each year. Details concerning the meetings listed in this particular issue of the calendar were obtained form National and International Organizations which sponsor aeronautical and space meetings and from other sources such as journals and periodicals. E.R.

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GENERAL

N89-23403# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
AGARD HIGHLIGHTS 88/2
Sep. 1988 39 p
Avail: NTIS HC A03/MF A01

Topics addressed include: a review of fluid dynamics; military pilot ergonomics; and future air operations. The award of the von Karman Medal for 1988 is presented. B.G.

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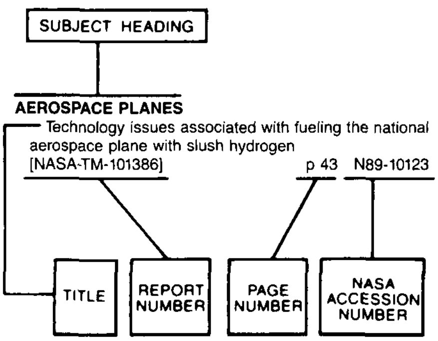

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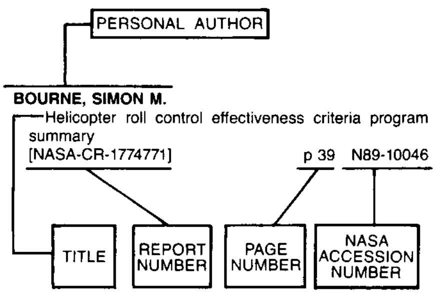

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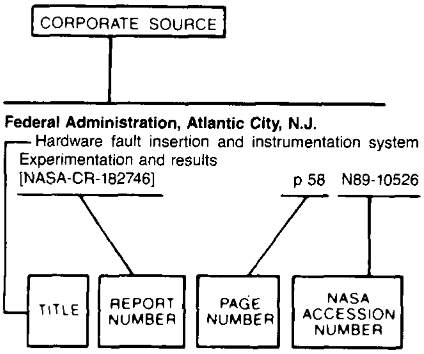

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FOREIGN TECHNOLOGY INDEX

AERONAUTICAL ENGINEERING / *A Continuing Bibliography (Supplement 243)* September 1989

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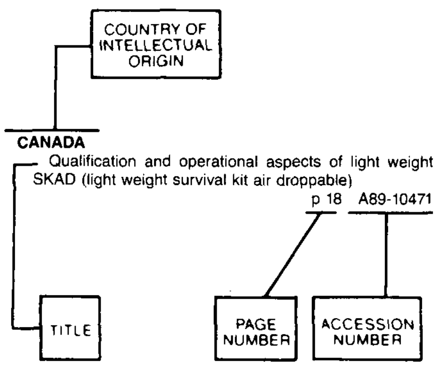

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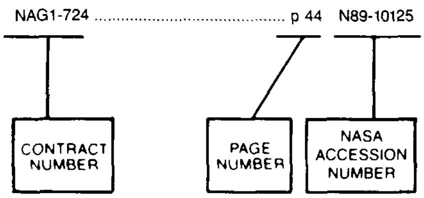

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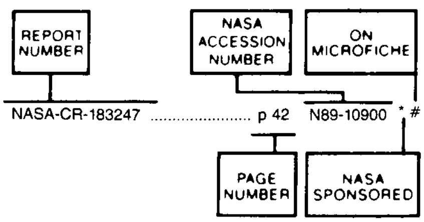

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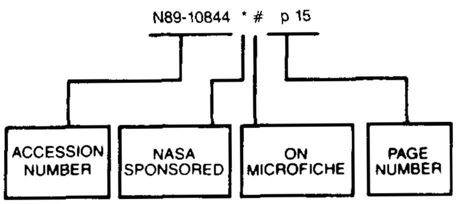

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