NASA

Aeronautical Engineering
A Continuing Bibliography with Indexes

NASA SP-7037(237)
March 1989

National Aeronautics and Space Administration

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NASA SP-7037(237)

AERONAUTICAL ENGINEERING

A CONTINUING BIBLIOGRAPHY WITH INDEXES

(Supplement 237)

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 February 1989 in

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

National Aeronautics and Space Administration
Office of Management
Scientific and Technical Information Division
Washington, DC 1989

INTRODUCTION

This issue of *Aeronautical Engineering -- A Continuing Bibliography* (NASA SP-7037) lists 572 reports, journal articles and other documents originally announced in February 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	
CONTRACT NUMBER →	(Contract NCC1-22)	PUBLICATION DATE
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), vol. 25, Aug. 1988, p. 747-751. refs	← JOURNAL TITLE

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

AERONAUTICAL ENGINEERING

A Continuing Bibliography (Suppl. 237)

MARCH 1989

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AERONAUTICS (GENERAL)

A89-12951
MANUFACTURING - THE CUTTING EDGE
ALAN POSTLETHWAITE Flight International (ISSN 0015-3710), vol. 134, Sept. 17, 1988, p. 36-40.

An account is given of the features and productivity improvements demonstrated to date by several major U.S. civilian and military aircraft manufacturers with state-of-the-art manufacturing facilities dedicated to advanced materials. The materials encompass both fiber-reinforced composites and metallics; CIM processes are typically employed to accomplish highly controlled prepreg tape-laying for complex composite structural component geometries, or material storage and retrieval operations for a large-scale machining apparatus that employs robotic vision for work-fixture tooling and control. AI is employed to solve the complex scheduling problems created by such fabrication systems. O.C.

A89-12952
THE LONG-LIFE STRUCTURE
J. M. RAMSDEN Flight International (ISSN 0015-3710), vol. 134, Sept. 17, 1988, p. 56-59.

The massive structural fatigue-related failure of a B737 airliner pressurized cabin in flight on April 28, 1988, after its accumulation of 89,000 flights, has led to FAA Airworthiness Directives requiring special inspections. An FAA Notice of Proposed Rulemaking dated May 31, 1988 prescibes further inspections for high-flight-time B737s, as well as eddy-current probes of every lap joint along the full length of the fuselage, and feeler-gage probing of tear-strap ('waffle-doubler') bond status. These proposals entail the complete removal of cabin panelling and insulation, as well as external paint-stripping; these operations are estimated to require some 2000 man-hours/aircraft. O.C.

A89-12954#
ANOTHER CHANCE FOR CANARDS
RICHARD DEMEIS Aerospace America (ISSN 0740-722X), vol. 26, Oct. 1988, p. 24-26.

The design and performance of the OMAC Laser 300, a business aircraft currently being developed on the basis of a canard configuration and conventional materials, are briefly characterized. Consideration is given to the unsuccessful flight tests of the original version, ongoing flight tests of an improved model, the fail-safe design of the main wing attachments, and fundamental design considerations (including the implications of recent wind-tunnel experiments at NASA Langley). Photographs are provided. T.K.

A89-13671#
RELIABILITY AND MAINTAINABILITY IN MODERN AVIONICS EQUIPMENT - A USER'S POINT OF VIEW
FRANS J. KENNIS IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 1677-1682.

The point of view of the user (i.e. Belgian Air Force) concerning the reliability and maintainability of modern avionics equipment in tactical fighter aircrafts is presented. Past experiences by the Belgian Air Force on aircrafts such as the F-84F, F-104G and Mirage III are highlighted. Maintainability problems related to the F-16 are analyzed, causes of lack of maintainability are indicated, and recommendations are made for improving maintainability. A special analysis addresses the F-16 reliability improvement warranty (RIW). A new approach is presented for a RIW contract which more evenly distributes the burdens and risks between the contractor and the government. Author

A89-15035
MBB'S FIVE-PLANT FACTORY - AN ECONOMIC INTERACTION OF FORCES
New-Tech News, no. 3, 1988, p. 30-35.

MBB has integrated the activities of its Varel, Einswarden, Bremen, Stade, and Hamburg plants, which are respectively responsible for NC milling of structural components, fuselage-shell construction, CAM pressure-forming of sheet metal structures, advanced composite structures, and aircraft fuselage assembly, into a highly efficient system for Airbus airliner production by a workforce of nearly 13,000 personnel. Super Guppy aircraft are used to transport these outsize airframe components to the Toulouse final assembly plant. O.C.

A89-15420
FUELING OUR TRANSPORTATION ENGINES AFTER THE PETROLEUM IS GONE
R. LACALLI and H. OMAN (Boeing Aerospace Co., Seattle, WA) IN: 1988 IECEC; Proceedings of the Twenty-third Intersociety Energy Conversion Engineering Conference, Denver, CO, July 31-Aug. 5, 1988. Volume 4. New York, American Society of Mechanical Engineers, 1988, p. 369-372. refs

As fossil fuel reserves dwindle to depletion in the next 25 years, the use of alternative fuels may come to be constrained by the amount of CO2 generated by their combustion. In the extreme case, requiring total preclusion of CO2 emissions, only fuels processed by 500 new nuclear power plants will be admissible. Attention is given to the feasibility of ammonia for subsonic flight and hydrogen for supersonic flight. O.C.

A89-16079
SUPPORTABILITY OF COMPOSITE AIRFRAMES - AN INTEGRATED LOGISTIC VIEWPOINT
W. GEIER and J. VILSMEIER (Messerschmitt-Boelkow-Blohm GmbH, Munich, Federal Republic of Germany) (Paisley College of Technology and USAF, Workshop on Supportability of Composite Airframe Structures, Glasgow, Scotland, Aug. 3, 4, 1987) Composite Structures (ISSN 0263-8223), vol. 10, no. 1, 1988, p. 17-36.

The supportability of composite airframe structures is examined from an integrated logistic support standpoint whereby availability and life cycle costs are key parameters in assessing the supportability of a system. Close relation between engineering and logistic disciplines is shown to be essential in achieving good supportability. Attention is also given to repairability requirements. V.L.

A89-16084
SUPPORTABILITY OF COMPOSITE AIRFRAMES - THE LAVI FIGHTER AIRCRAFT
A. SEGAL (Israel Aircraft Industries, Ltd., Lod) (Paisley College of Technology and USAF, Workshop on Supportability of Composite Airframe Structures, Glasgow, Scotland, Aug. 3, 4, 1987) Composite Structures (ISSN 0263-8223), vol. 10, no. 1, 1988, p. 105-108.

The Astra executive aircraft, the Lavi fighter, and the Pioneer mini-RPV all contain composite materials. The experience gained to date from the use of composite materials has been quite good, despite some problems during the development stages. Some of the problems encountered during the development of the Lavi are discussed. Author

A89-16085
SUPPORTABILITY OF ADVANCED COMPOSITE STRUCTURES
THOMAS H. BENNETT (General Dynamics Corp., Fort Worth, TX) (Paisley College of Technology and USAF, Workshop on Supportability of Composite Airframe Structures, Glasgow, Scotland, Aug. 3, 4, 1987) Composite Structures (ISSN 0263-8223), vol. 10, no. 1, 1988, p. 109-115.

Advanced composite airframe structures are entering service at an ever increasing rate. Early applications to secondary and stiffness-critical primary structures have been successful and have provided a wealth of operational support experience. This paper offers an operator's definition of supportability as applied to advanced composite structures. Author

A89-16201
RADIO TECHNICAL COMMISSION FOR AERONAUTICS, ANNUAL ASSEMBLY MEETING AND TECHNICAL SYMPOSIUM, WASHINGTON, DC, NOV. 17-19, 1987, PROCEEDINGS
JOANN C. JAGO, ED. (Radio Technical Commission for Aeronautics, Washington, DC) Washington, DC, Radio Technical Commission for Aeronautics, 1987, 119 p. For individual items see A89-16202 to A89-16205.

The present conference discusses international considerations concerning novel aircraft communications and navigation technologies' applications, human factors-related issues in new aircraft cockpit technology, the process of transition to novel cockpit technologies, and the role of military organizations in providing and using emerging technologies. Also discussed are modernization plans in the U.S., modernization planning in the Western Pacific, and a European perspective on the process of evolution towards new technology systems. O.C.

A89-16203#
TRANSITIONING TO NEW TECHNOLOGIES FOR NEXT GENERATION AIRCRAFT
JOHN D. MCDONNELL (Douglas Aircraft Co., Long Beach, CA) IN: Radio Technical Commission for Aeronautics, Annual Assembly Meeting and Technical Symposium, Washington, DC, Nov. 17-19, 1987, Proceedings. Washington, DC, Radio Technical Commission for Aeronautics, 1987, p. 47-55.

It is noted that the length of periods for development and implementation of novel avionics is increasing, in conjunction with increases in the complexity of their implementation and their greater expense. Successful implementation will require greater emphasis on cost/benefit analyses, as well as increased coordination among builders, users, and planners. These system-centered technologies include the Microwave Landing System, Mode S surveillance radar, and Satcom and Satnav. O.C.

N89-11690# Boeing Commercial Airplane Co., Seattle, WA.
WORLD JET AIRPLANE INVENTORY AT YEAR-END 1987
Mar. 1988 83 p
(PB88-191168) Avail: NTIS HC A05/MF A01 CSCL 01B

Data in this edition of the World Jet Airplane Inventory reflect, as accurately as possible, the status of the world's commercial jet airplane fleets (including some military derivatives) at the end of the year 1987. The World Jet Airplane Inventory is composed of a selected number of computer printouts from JETTRACK, a computer-based jet airplane inventory system kept by the Market Research Department of Boeing Commercial Airplane Company. Fleet data in this system are obtained from many different sources, including airframe manufacturers, airplane owners and operators, governments, and trade publications. The document provides details for announced orders, deliveries, and inventories for all commercial jet airplanes built in the United States and Western Europe with a capacity of 60 seats and up. In addition, the year-end 1987 inventory data in Sections 4 and 6 include non-Russian operators of the Tupolev-134 and larger passenger airplanes build in the USSR. Announced jet airplane orders are summarized in Section 1. Orders that were placed and later cancelled are treated as if they never occurred. The tabulations include all airplanes that were never sold but are (or were) used exclusively for the manufacturers' private purposes, such as flight testing, route proving, and short-term leasing. GRA

N89-11691# Federal Aviation Administration, Washington, DC. Office of Management Systems.
CENSUS OF US CIVIL AIRCRAFT: CALENDAR YEAR 1987 Annual Report
31 Dec. 1987 346 p
(AD-A196626; FAA-AMS-420) Avail: NTIS HC A15/MF A01 CSCL 01C

This report presents information about the U.S. civil aircraft fleet. It includes detailed tables of air carrier aircraft and an inventory of registered aircraft by manufacturer and model, and general aviation aircraft by state and county of the owner. GRA

N89-11693# Air Force Systems Command, Wright-Patterson AFB, OH. Foreign Technology Div.
AVIATION AND SPACE NEWS
24 Jun. 1988 11 p Transl. into ENGLISH from Hangkong Zhishi (Peoples Republic of China), no. 12, Dec. 1986 p 607
(AD-A197702; FTD-ID(RS)T-0286-88) Avail: NTIS HC A03/MF A01 CSCL 01C

The initiation of development of MD-11 and MD-90 passenger airplane is discussed, along with the upgrade plan for extended-range TriStar passenger airplane. Other topics of articles are: CAT sets new record, Rolls-Royce and Pratt-Whitney joint venture supersonic VTOL engine, A Sudan civilian airplane crashed, no survivers, A Honduras Air Force C-130 crashed, Solid Rocket Propellant Conference held in Jiujiang, China aviation photos exhibited in Changchun, A memorable get-together-The first Aviation Summer Camp for the Youths of Jilin Province, First Aviation Summer Camp for Youths held in Hubei Province, International Defense Technology Exhibition in Beijing. GRA

N89-11694*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
FLOW-FIELD SURVEY OF AN EMPENNAGE WAKE INTERACTING WITH A PUSHER PROPELLER
W. CLIFTON HORNE and PAUL T. SODERMAN Oct. 1988 54 p
(NASA-TM-101003; A-88185; NAS 1.15:101003) Avail: NTIS HC A04/MF A01 CSCL 01B

The flow field between a model empennage and a 591-mm-diameter pusher propeller was studied in the Ames 7- by 10-Foot Wind Tunnel with directional pressure probes and hot-wire anemometers. The region probed was bounded by the empennage trailing edge and downstream propeller. The wake properties, including effects of propeller operation on the empennage wake, were investigated for two empennage geometries: one, a vertical tail fin, the other, a Y-tail with a 34 deg dihedral. Results showed that the effect of the propeller on the empennage wake upstream of the propeller was not strong. The flow upstream of the propeller was accelerated in the streamwise direction by the propeller, but the empennage wake width and velocity defect were relatively unaffected by the presence of the propeller. The peak turbulence in the wake near the propeller tip station, 0.66 diameter behind the vertical tail fin, was approximately 3 percent of the free-stream velocity. The velocity field data can be used in predictions of the acoustic field due to propeller-wake interaction. Author

N89-12535# Northrop Corp., Hawthorne, CA.
AUTOMATED AIRFRAME ASSEMBLY PROGRAM (AAAP) SURVEY OF CIM STATUS IN THE AIRCRAFT INDUSTRY Final Report, 30 Nov. 1986 - 30 Oct. 1987
Apr. 1988 42 p
(Contract F33615-87-C-5217)
(AD-A197368; AFWAL-TR-88-4051) Avail: NTIS HC A03/MF A01 CSCL 13H

The purpose of this survey was to evaluate different airframe manufacturing environments. Price Waterhouse and Northrop Aircraft Division (NAD) personnel developed the survey questions jointly to evaluate the Needs and Requirements definition for the Automated Airframe Assembly Program (AAAP). AAAP focused on major and minor subassembly operations and related areas. The survey breaks these down into two timeframes: the next 1 to 5 years (today) and the future (5 to 10 years). The Survey consisted of seven major functional sections including an integration section. The Survey sections were completed by those individuals most familiar with the issues being addressed. The results respondents to this survey are being kept strictly confidential. Price Waterhouse gathered combined and evaluated survey results. NAD personnel do not have access to an individual company's responses. GRA

N89-12537# National Transportation Safety Board, Washington, DC. Bureau of Safety Programs.
ANNUAL REVIEW OF AIRCRAFT ACCIDENT DATA, US GENERAL AVIATION, CALENDAR YEAR 1985
13 Oct. 1987 238 p
(PB88-115787; NTSB-ARG-87-03) Avail: NTIS HC A11/MF A01 CSCL 01C

A statistical compilation and review of general aviation accidents which occurred in 1985 in the United States, its territories and possessions, and in international waters are presented. The accidents reported are all those involving U.S. registered aircraft not conducting operations under 14 CFR 121, 14 CFR 125, 14 CFR 127, or 14 CFR 135. The report is divided into sections, each of which presents a review of a subset of all general aviation accidents. Each subset represents aircraft of similar types or aircraft being operated for particular purposes. Several tables present accident parameters for 1985 only, and each section includes tabulations which present comparative statistics for 1985 and for the five-year period 1980 through 1984. GRA

N89-12538*# Georgia Inst. of Tech., Atlanta. School of Aerospace Engineering.
TRAJECTORY OPTIMIZATION AND GUIDANCE LAW DEVELOPMENT FOR NATIONAL AEROSPACE PLANE APPLICATIONS Final Report, 1 Jul. 1987 - 30 Nov. 1988
A. J. CALISE, G. A. FLANDRO, and J. E. CORBAN Dec. 1988 130 p Prepared for General Dynamics Corp., St. Louis, Mo.
(Contract NAG1-784)
(NASA-CR-182994; NAS 1.26:182994) Avail: NTIS HC A07/MF A01 CSCL 01B

The work completed to date is comprised of the following: a simple vehicle model representative of the aerospace plane concept in the hypersonic flight regime, fuel-optimal climb profiles for the unconstrained and dynamic pressure constrained cases generated using a reduced order dynamic model, an analytic switching condition for transition to rocket powered flight as orbital velocity is approached, simple feedback guidance laws for both the unconstrained and dynamic pressure constrained cases derived via singular perturbation theory and a nonlinear transformation technique, and numerical simulation results for ascent to orbit in the dynamic pressure constrained case. Author

N89-12539*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
AIRCRAFT TECHNOLOGY OPPORTUNITIES FOR THE 21ST CENTURY
JAMES A. ALBERS and JOHN ZUK Nov. 1988 49 p Presented at the Conference on New Technology and the Aviation System, Los Angeles, Calif., 16-18 Nov. 1988
(NASA-TM-101060; A-89009; NAS 1.15:101060) Avail: NTIS HC A03/MF A01 CSCL 01B

New aircraft technologies are presented that have the potential to expand the air transportation system and reduce congestion through new operating capabilities, and at the same time provide greater levels of safety and environmental compatibility. Both current and planned civil aeronautics technology at the NASA Ames, Lewis, and Langley Research Centers are addressed. The complete spectrum of current aircraft and new vehicle concepts is considered including rotorcraft (helicopters and tiltrotors), vertical and short takeoff and landing (V/STOL) and short takeoff and landing (STOL) aircraft, subsonic transports, high speed transports, and hypersonic/transatmospheric vehicles. New technologies for current aircraft will improve efficiency, affordability, safety, and environmental compatibility. Research and technology promises to enable development of new vehicles that will revolutionize or greatly change the transportation system. These vehicles will provide new capabilities which will lead to enormous market opportunities and economic growth, as well as improve the competitive position of the U.S. aerospace industry. Author

02

AERODYNAMICS

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

A89-12877
SHOCK TUBE STUDIES OF VORTEX STRUCTURE AND BEHAVIOR
D. BERSHADER (Stanford University, CA) IN: Shock tubes and waves; Proceedings of the Sixteenth International Symposium, Aachen, Federal Republic of Germany, July 26-31, 1987. Weinheim, Federal Republic of Germany, VCH Verlagsgesellschaft mbH, 1988, p. 5-18. refs
(Contract DAAG29-83-K-0146)

This study deals with a detailed measurement and analysis of the structure and time history of a free vortex undergoing convection in a quasi-uniform, shock-generated compressible flow. Densities were obtained by a sequence of pulsed holographic interferograms, supplemented by independent pressure studies. Insertion of these data into relevant equations provided information on distribution of velocity components, temperature and other physical variables within the vortex; some time-dependent features were determined as well. Evaluation of the results showed several distinctive characteristics; they included the expected strong vacuum at the vortex center, the existence of a velocity or vorticity core, and an inward radial mass flow. Several of the results, e.g., the functional form of the density distribution, have yet to be fully understood. Author

A89-12884
THE RAM ACCELERATOR AND ITS APPLICATIONS - A NEW APPROACH FOR REACHING ULTRAHIGH VELOCITIES
A. HERTZBERG, A. P. BRUCKNER, D. W. BOGDANOFF, and C. KNOWLEN (Washington, University, Seattle) IN: Shock tubes and waves; Proceedings of the Sixteenth International Symposium, Aachen, Federal Republic of Germany, July 26-31, 1987. Weinheim, Federal Republic of Germany, VCH Verlagsgesellschaft mbH, 1988, p. 117-128. refs
(Contract F08635-84-K-0143)

In the 'ram accelerator' concept, controlled release of chemical energy is used to accelerate projectiles to velocities from 0.7 to 12 km/sec. Several different modes of ram accelerator propulsion are described, which have overlapping limits of operation that span this velocity range. The theoretical performance and the operational velocity limits of the subsonic-combustion-driven modes are discussed. The experimental facility developed to investigate the ram acelerator concept is described, and the results of experiments performed over the velocity range of 700-1900 m/sec, using methane-based propellant mixtures, are presented. These results were found to be in good agreement with theoretical predictions. I.S.

A89-12887

HEAT TRANSFER AND INTERFEROMETRIC STUDY OF THE FLOW OVER A REARWARD FACING STEP IN HYPERSONIC HIGH ENTHALPY STREAM

S. L. GAI, N. T. REYNOLDS, and J. P. BAIRD (Australian Defence Force Academy, University College, Campbell, Australia) IN: Shock tubes and waves; Proceedings of the Sixteenth International Symposium, Aachen, Federal Republic of Germany, July 26-31, 1987. Weinheim, Federal Republic of Germany, VCH Verlagsgesellschaft mbH, 1988, p. 153-159. Research supported by the Australian Research Grants Scheme. refs

Measurements of heat transfer behind a rearward facing step in hypersonic high enthalpy stream, using the Australian National University free-piston driven Shock Tunnel T3, are described. The range of enthalpies considered was much greater than those reported previously in the literature. High response surface thermocouples were used to measure the heat transfer rates. Interferograms, with an M-Z interferometer, were obtained and improved visualization was further facilitated by digitizing the interferograms and using Fourier analysis to determine fringe positions. This then provided a phase map of the flow region in which the phase was color coded to emphasize flow characteristics. Author

A89-12888

UNSTEADY SHOCK BOUNDARY LAYER INTERACTION AHEAD OF A FORWARD FACING STEP

N. SAIDA, R. TANAKA, and Y. HASHIBA (Aoyama Gakuin University, Tokyo, Japan) IN: Shock tubes and waves; Proceedings of the Sixteenth International Symposium, Aachen, Federal Republic of Germany, July 26-31, 1987. Weinheim, Federal Republic of Germany, VCH Verlagsgesellschaft mbH, 1988, p. 169-175. refs

The processes of formation of shock wave and boundary layers interaction ahead of a forward facing step placed on a flat plate was studied in a shock tube. Two step models of different height were examined. The initial pressure ratio was set to 200 and shock wave shapes and flow field density distributions were measured using optical techniques. Also a second-order explicit method of MacCormack was used to calculate the flow field. It was shown that after the reflection two high density regions were formed near the flat plate ahead of the step. The former is beneath the front leg of bifurcated shock and the latter is close to the step front. Author

A89-12890

MULTIPLE SHOCK WAVE AND TURBULENT BOUNDARY LAYER INTERACTION IN A RECTANGULAR DUCT

H. SUGIYAMA, J. ZHANG, F. ABE (Muroran Institute of Technology, Japan), and H. TAKEDA (Toyota Motor Co., Ltd., Tokyo, Japan) IN: Shock tubes and waves; Proceedings of the Sixteenth International Symposium, Aachen, Federal Republic of Germany, July 26-31, 1987. Weinheim, Federal Republic of Germany, VCH Verlagsgesellschaft mbH, 1988, p. 185-191. refs

The effects of the locations of pseudoshock waves in straight square ducts in which the flows are choked at the duct exits on the structure and oscillation phenomena of pseudoshock waves were investigated. The experiments were conducted at the duct-entrance Mach-infinity numbers between 1.72 and 1.88, and the duct length to width ratios (L/D) between 20.6 and 23.6. It was found that the location of a pseudoshock wave moves in a downstream direction with decreasing L/D ratios and increasing Mach-infinity values. As the location of pseudoshock waves moves, the shape of the pseudoshock waves changed from the lambda-type pseudoshock wave, which oscillates with an amplitude of about 0.2 D and low frequencies below 40 Hz, to the X-type wave, which oscillates more regularly with an amplitude of 0.3 D, low frequencies less than 70 Hz, and high frequencies of about 150 to 250 Hz. I.S.

A89-12894

NUMERICAL SIMULATION OF SUPERSONIC TWO-PHASE GAS-PARTICLE FLOWS

MARTIN SOMMERFELD (Erlangen-Nuernberg, Universitaet, Erlangen, Federal Republic of Germany) IN: Shock tubes and waves; Proceedings of the Sixteenth International Symposium, Aachen, Federal Republic of Germany, July 26-31, 1987. Weinheim, Federal Republic of Germany, VCH Verlagsgesellschaft mbH, 1988, p. 235-241. refs

The free jet expansion of a gas-particle mixture is numerically simulated by the piecewise linear method for the gas phase and a so-called Lagrangian discrete particle method to calculate the particle motion throughout the flow field. Here the particle phase is represented by parcels consisting of a number of particles having the same properties. In the numerical results the effect of the particle size, the particle loading and the ambient pressure on the jet shape and structure, namely the shock wave configuration and the jet boundary is discussed. In the case of larger particles, where the particle relaxation length is larger than the flow field the shape and structure of the barrel shock and Mach disk are almost unaffected by the particles. For smaller particles, which are close to equilibrium with the gas phase the barrel shock becomes more and more dispersed by increasing the loading ratio and the Mach disk is shifted downstream, whereby its strength is reduced. Eventually the Mach disk disappears and the barrel shock intersets with the jet axis. Author

A89-12895

NUMERICAL SIMULATION OF SHOCK LAYER STRUCTURE IN A SUPERSONIC DUSTY GAS FLOW PAST A BLUNTED BODY

M. S. RAMM and A. A. SCHMIDT (AN SSSR, Fiziko-Tekhnicheskii Institut, Leningrad, USSR) IN: Shock tubes and waves; Proceedings of the Sixteenth International Symposium, Aachen, Federal Republic of Germany, July 26-31, 1987. Weinheim, Federal Republic of Germany, VCH Verlagsgesellschaft mbH, 1988, p. 251-259. refs

A simulation of a supersonic dusty flow past a sphere is presented. It is shown that high-speed particle-body surface interaction is accompanied by the particle disintegration, which affects the density profiles across the shock layer. The model presented makes it possible to determine the major features of the flow and account for processes occurring in the particulate phase-flow boundary interaction. I.S.

A89-12906

THE THREE-SHOCK THEORY WITH VISCOUS EFFECTS

GABI BEN-DOR (Negev, University, Beersheba, Israel) IN: Shock tubes and waves; Proceedings of the Sixteenth International Symposium, Aachen, Federal Republic of Germany, July 26-31, 1987. Weinheim, Federal Republic of Germany, VCH Verlagsgesellschaft mbH, 1988, p. 527-534. refs

When the actual angles between the four discontinuities of a triple point, i.e., the incident shock, the reflected shock, the Mach stem and the slipstream, are compared to those predicted by the well known inviscid perfect-gas three-shock theory of von Neumann, a discrepancy too large to be attributed to experimental inaccuracies is evident. In order to improve the analytical predictions of the three-shock theory, the boundary layers developing on both sides of the slipstream were integrated into von Neumann's three-shock theory. Using these boundary layers, the displacement thickness as a function of the distance from the triple point along the slipstream was calculated. The displacement thickness was then used to obtain an imaginary displaced slipstream. It was then found that if the angular displacement of the imaginary slipstream at a distance equivalent to the thickness of the incident shock wave is imposed as a boundary condition for the flow directions in both of its sides, then the calculations result in an excellent agreement with the experimental data. Author

A89-12907

MACH REFLECTION OF A MOVING, PLANE SHOCK WAVE UNDER RAREFIED FLOW CONDITIONS

Z. A. WALENTA (Polska Akademia Nauk, Instytut Podstawowych Problemow Techniki, Warsaw, Poland) IN: Shock tubes and waves; Proceedings of the Sixteenth International Symposium, Aachen, Federal Republic of Germany, July 26-31, 1987. Weinheim, Federal Republic of Germany, VCH Verlagsgesellschaft mbH, 1988, p. 535-541. refs

The process of formation of the Mach reflection of a moving, plane shock wave at a wedge is described on the basis of the available information, obtained from low-density shock tube experiments. The reflected shock is generated with a certain delay with respect to the appearance of the incident shock at the wedge tip. Having been generated, the reflected shock has a circularly cylindrical shape and meets the incident shock at the wedge surface, producing an apparently regular reflection. After a sufficiently long time, the Mach stem appears; however, at this initial stage, the geometry of the reflection is different from predictions of the generally accepted von Neumann's theory. The mechanism of further evolution of the phenomenon is then discussed in detail. Author

A89-12915

A STUDY ON UPSTREAM MOVING PRESSURE WAVES INDUCED BY VORTEX SEPARATION

J. SRULIJES and F. SEILER (Saint Louis, Institut Franco-Allemand de Recherches, France) IN: Shock tubes and waves; Proceedings of the Sixteenth International Symposium, Aachen, Federal Republic of Germany, July 26-31, 1987. Weinheim, Federal Republic of Germany, VCH Verlagsgesellschaft mbH, 1988, p. 621-628. refs

Shock tube experiments were performed in order to study subsonic flows around flat plates, cylinders, and wing profiles with blunt trailing edges. The results show that each vortex separation is related to the formation of pressure waves which move upstream at a velocity slightly higher than the difference between the speed of sound and the flow velocity. The relative density variation across the pressure waves is found to be of order 0.01, increasing slightly with increasing flow Mach number. A local supersonic region with a recompression shock formation is noted at the upper side of the wing. R.R.

A89-12923

TRANSONIC SHOCK TUBE FLOW OVER A NACA 0012 AEROFOIL AND ELLIPTICAL CYLINDERS

KATSUHIRO ITOH and KAZUYOSHI TAKAYAMA (Tohoku University, Sendai, Japan) IN: Shock tubes and waves; Proceedings of the Sixteenth International Symposium, Aachen, Federal Republic of Germany, July 26-31, 1987. Weinheim, Federal Republic of Germany, VCH Verlagsgesellschaft mbH, 1988, p. 693-699. refs

The unsteady transonic flow induced behind a shock wave is of importance to study unsteady shock wave loading over bodies. The present paper reports a computational and experimental investigation of unsteady transonic flow over an elliptical cylinder and a NACA 0012 aerofoil in a shock tube. The experiment was conducted in a 60 mm x 150 mm shock tube equipped with double exposure holographic interferometry. To simulate the unsteady transonic shock tube flow, a Total Variation Diminishing (TVD) finite difference scheme is applied to the Navier-Stokes equations. The complicated unsteady transonic flow accompanied by shock waves was successfully simulated with a high resolution. The computational isopycnics are consistent with those of the experimental interferograms. Author

A89-12928

NUMERICAL SIMULATION OF PRESSURE WAVE BOUNDARY LAYER INTERACTION

H. REISTER (DFVLR, Institut fuer theoretische Stroemungsmechanik, Goettingen, Federal Republic of Germany) IN: Shock tubes and waves; Proceedings of the Sixteenth International Symposium, Aachen, Federal Republic of Germany, July 26-31, 1987. Weinheim, Federal Republic of Germany, VCH Verlagsgesellschaft mbH, 1988, p. 733-739. refs

Shock tube experiments show vortex shedding behind a flat plate and pressure waves propagating upstream. Of particular interest is the interaction of these waves with the turbulent boundary layer. A fourth-order Runge-Kutta finite volume method was developed, solving the compressible Navier-Stokes equations. For the numerical simulation of the pressure wave boundary layer interaction, the steady turbulent flat plate boundary layer solution is taken as an initial distribution. The most important result of the viscous interaction with the turbulent boundary layer is that the separation phenomena are not observed as is the case for the corresponding interaction in laminar boundary layers. Author

A89-13102

INTEGRAL EQUATION METHOD FOR CALCULATING THE NONSTATIONARY AERODYNAMIC CHARACTERISTICS OF A ROTATING ANNULAR BLADE ROW [METOD INTEGRAL'NYKH URAVNENII DLIA RASCHETA NESTATSIONARNYKH AERODINAMICHESKIKH KHARAKTERISTIK VRASHCHAIUSHCHEGOSIA KOL'TSEVOGO LOPATOCHNOGO VENTSA]

A. A. OSIPOV and K. S. REENT Zhurnal Vychislitel'noi Matematiki i Matematicheskoi Fiziki (ISSN 0044-4669), vol. 28, Sept. 1988, p. 1367-1378. In Russian. refs

A method is developed for solving a singular integral equation describing nonstationary flow around a rotating annular row of thin weakly loaded blades. The method proposed here is applicable to subsonic and supersonic flows and also to mixed regimes with subsonic flow at the blade root and supersonic flow at the blade rim. The method is based on a specially developed procedure for regularizing the integral equation kernel which makes it possible to allow for the local properties of the kernel in subsonic and supersonic flows. V.L.

A89-13158

NUMERICAL STUDY OF AXISYMMETRIC FLOWS IN THE WAKE OF BLUNT BODIES IN THE PATH OF SUPERSONIC FLOW OF A VISCOUS GAS [CHISLENNOE ISSLEDOVANIE OSESIMMETRICHNYKH TECHENII V SLEDE ZA ZATUPLENNYMI TELAMI, OBTEKAEMYMI SVERKHZVUKOVYM POTOKOM VIAZKOGO GAZA]

O. N. BELOVA, N. S. KOKOSHINSKAIA, and V. M. PASKONOV Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza (ISSN 0568-5281), July-Aug. 1988, p. 42-47. In Russian. refs

Axisymmetric flow in the near wake of spherically blunted cones in the path of a supersonic flow of a viscous perfectly heat-conducting gas is investigated numerically using full Navier-Stokes equations. Flow structure in the near wake is described in detail, and the effect of the Mach (2, 3, and 4) and Reynolds numbers on the base pressure, full body resistance, and geometric characteristics of the wake is analyzed. The results obtained are compared against experimental data. V.L.

A89-13160

A STUDY OF SUPERSONIC ISOBARIC SUBMERGED TURBULENT JETS [ISSLEDOVANIE SVERKHZVUKOVYKH IZOBARICHESKIKH ZATOPLENNYKH TURBULENTNYKH STRUI]

V. S. KRASOTKIN, A. I. MYSHANOV, S. P. SHALAEV, N. N. SHIROKOV, and M. IA. IUDELOVICH Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza (ISSN 0568-5281), July-Aug. 1988, p. 56-62. In Russian. refs

Supersonic submerged turbulent air jets are investigated experimentally in the Mach range 1.5-3.4, with the ratio of the full enthalpy of the ambient medium to that of the jet varying from 0.01 to 1. A study is also made of oxygen-hydrogen jets issuing from a nozzle at Mach 1 and 2.4 and oxidizer excess ratios of 0.3-5. It is proposed that the jet be divided into two sections: the initial one and the main one. It is shown that, in the main section of the jet, the dimensionless velocity and temperature at the jet axis vary in inverse proportion to distance and are independent of the flow characteristics determining the length of the initial section. V.L.

A89-13163
ANALYSIS OF OPTIMAL NONSYMMETRIC PLANE NOZZLES WITH ALLOWANCE FOR MOMENT CHARACTERISTICS [K ANALIZU OPTIMAL'NYKH NESIMMETRICHNYKH PLOSKIKH SOPEL S UCHETOM MOMENTNYKH KHARAKTERISTIK]
A. I. RYLOV Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza (ISSN 0568-5281), July-Aug. 1988, p. 103-108. In Russian. refs

The characteristics of flow in nonsymmetric plane nozzles in which maximum moment is achieved with respect to a specified point are examined. The conditions for maximum moment are derived from an analysis of the second variation. A numerical analysis is carried out for nozzles with a relatively short lower wall, which are considered for possible application in advanced powerplants. V.L.

A89-13165
EFFECT OF THE DIFFUSIVE SEPARATION OF CHEMICAL ELEMENTS ON A CATALYTIC SURFACE [EFFEKT DIFFUZIONNOGO RAZDELENIIA KHIMICHESKIKH ELEMENTOV NA KATALITICHESKOI POVERKHNOSTI]
V. L. KOVALEV and O. N. SUSLOV Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza (ISSN 0568-5281), July-Aug. 1988, p. 115-121. In Russian. refs

Asymptotic expansion, at large Schmidt numbers, of a solution to a system of equations of a chemically nonequilibrium multicomponent boundary layer near the catalytic surface of a blunt body is used to obtain formulas for the diffusion flows of reaction products, chemical elements, and heat fluxes. It is shown that, in the case of supersonic flow of air past a body, the extent of the diffusive separation of oxygen is largely determined by the concentration of atoms at the outside edge of the boundary layer and characteristics of the homogeneous and heterogeneous catalytic reactions. V.L.

A89-13166
SUPERSONIC FLOW OF AN INHOMOGENEOUS VISCOUS GAS PAST A BLUNT BODY UNDER CONDITIONS OF SURFACE INJECTION [SVERKHZVUKOVOE OBTEKANIE ZATUPLENNOGO TELA NERAVNOMERNYM POTOKOM VIAZKOGO GAZA PRI PODACHE GAZA S POVERKHNOSTI]
I. G. EREMEITSEV, N. N. PILIUGIN, and S. A. IUNITSKII Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza (ISSN 0568-5281), July-Aug. 1988, p. 122-129. In Russian. refs

Axisymmetric flow of an inhomogeneous viscous gas flow past smooth blunt bodies at large Mach numbers is investigated for the case of nonseparated flow. Equations of a thin viscous shock layer with generalized Rankine-Hugoniot conditions on the shock wave and boundary conditions on the body, allowing for surface gas injection, are solved numerically. The effect of surface gas injection on the conditions of nonseparated flow are analyzed as a function of the Reynolds number; critical values of the inhomogeneity parameter are obtained. V.L.

A89-13173
SELF-SIMILAR REVERSED FLOWS IN THE SEPARATION REGION OF A TURBULENT BOUNDARY LAYER [AVTOMODEL'NYE VOZVRATNYE TECHENIIA V OBLASTI OTRYVA TURBULENTNOGO POGRANICHNOGO SLOIA]
L. V. GOGISH Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza (ISSN 0568-5281), July-Aug. 1988, p. 173-177. In Russian. refs

A self-similar reversed flow of an incompressible fluid is modeled by using Karman pulse equations and simple concepts of the self-similarity of turbulent tangential stress profiles. Depending on the values of empirical constants, the flow may be realized either beyond the separation point of the turbulent boundary layer or before the point of its reattachment. The empirical constants are determined on the basis of several independent experimental studies of subsonic and supersonic separated turbulent flows of liquids and gases. V.L.

A89-13174
NUMERICAL SOLUTION OF THE PROBLEM OF GAS FLOW OUT OF A VESSEL WITH FLAT WALLS [CHISLENNOE RESHENIE ZADACHI OB ISTECHENII GAZA IZ SOSUDA S PLOSKIMI STENKAMI]
IU. S. KOSOLAPOV Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza (ISSN 0568-5281), July-Aug. 1988, p. 177-181. In Russian. refs

The paper is concerned with the classical problem of stationary flow of an ideal gas out of an infinite plane vessel with a rectilinear wall generatrix forming an angle with the plane of symmetry of the flow. The problem is stated in a hodograph plane and solved numerically for supersonic flow and different flow angles using the method proposed by Fenain et al. (1974). The results obtained are compared with data in the literature. V.L.

A89-13233
DISCRETE NATURE OF VORTEX FORMATION WITH THE ONSET OF CIRCULATION FLOW ABOUT A WING [O DISKRETNOM KHARAKTERE VIKHREOBRAZOVANIIA PRI VOZNIKNOVENII TSIRKULIATSIONNOGO OBTEKANIIA KRYLA]
V. S. SADOVSKII and G. I. TAGANOV PMTF - Zhurnal Prikladnoi Mekhaniki i Tekhnicheskoi Fiziki (ISSN 0044-4626), July-Aug. 1988, p. 44-48. In Russian.

A dipole model is proposed for describing the nonlinear process of the onset of circulation flow about a wing that starts moving at a constant velocity, from the position of rest, in a nonviscous incompressible fluid. The circulation and dimensions of the first vortex region of the discrete wake behind a plate are estimated for angle of attack 90 deg. The behavior of the model solution beyond the dipole bifurcation point is analyzed. V.L.

A89-13335
FORMATION OF SUPERSONIC-JET STRUCTURE [FORMIROVANIE STRUKTURY SVERKHZVUKOVOI STRUI]
E. A. UGRIUMOV and A. I. TSVETKOV IN: The dynamics of homogeneous and inhomogeneous media. Leningrad, Izdatel'stvo Leningradskogo Universiteta, 1987, p. 55-61. In Russian. refs

Experimental results are presented on the qualitative flow pattern of unsteady supersonic jets for different prechamber-starting conditions. It is shown that the jet-formation process depends on the geometrical dimensions of the nozzle and prechamber, as well as on the rate of pressure increase in the prechamber. B.J.

A89-13337
CHARACTERISTICS OF A BOUNDARY LAYER ON A SPHERICALLY BLUNT CONICAL BODY AT LOW ALTITUDES WITH ALLOWANCE FOR THE HEATING AND ABLATION OF THE BODY [KHARAKTERISTIKI POGRANICHNOGO SLOIA SFERICHESKI ZATUPLENNOGO KONICHESKOGO TELA NA NIZKIKH VYSOTAKH S UCHETOM NAGREVA TELA I UNOSA MASSY S EGO POVERKHNOSTI]
L. A. ARKHANGEL'SKAIA IN: The dynamics of homogeneous and inhomogeneous media. Leningrad, Izdatel'stvo Leningradskogo Universiteta, 1987, p. 66-73. In Russian. refs

Calculation results are presented on the characteristics of a turbulent boundary layer along the lateral surface of a blunt cone in hypersonic gas flow, with allowance for chemical reactions and outer-flow inhomogeneity. The effect of the heating and ablation of the body on these characteristics is evaluated. B.J.

A89-13341
FEATURES OF THE USE OF SCHEMES OF FIRST AND SECOND ORDER OF ACCURACY TO CALCULATE THE MIXING OF OFF-DESIGN SUPERSONIC JETS [OSOBENNOSTI ISPOL'ZOVANIIA SKHEM PERVOGO I VTOROGO PORIADKA TOCHNOSTI PRI RASCHETE SMESHENIIA NERASCHETNYKH SVERKHZVUKOVYKH STRUI]

A. V. LAVROV IN: The dynamics of homogeneous and inhomogeneous media. Leningrad, Izdatel'stvo Leningradskogo Universiteta, 1987, p. 93-98. In Russian. refs

The use of first and second order schemes with respect to the transverse coordinate to calculate the mixing of off-design supersonic jets on the basis of simplified Navier-Stokes equations is examined. It is shown that, for regimes with moderate values of the Reynolds numbers and low values of the off-design parameter, exact solutions can be obtained using second-order schemes for a small number of points of the difference grid. B.J.

A89-13347

FLOW IN THE REGION OF THE INTERACTION OF AN UNDEREXPANDED RAREFIED JET AND A CONICAL SKIMMER [TECHENIE V OBLASTI VZAIMODEISTVIIA NEDORASSHIRENNOI RAZREZHENNOI STRUI S KONICHESKIM SKIMMEROM]

A. N. VERENCHIKOV, V. I. NIKOLAEV, and I. V. SHATALOV IN: The dynamics of homogeneous and inhomogeneous media. Leningrad, Izdatel'stvo Leningradskogo Universiteta, 1987, p. 149-156. In Russian. refs

Experimental results are presented on the shock-wave structure and flow pattern in the shock layer of a supersonic underexpanded jet flowing onto a cone placed on a flat plate. The location of the central shock of the jet and pressure behind the conical skimmer are investigated in relation to the the main initial parameters of the jet, including the degree of rarefaction and the interaction geometry. Conditions for the appearance of circulating flows in the interaction region are established. B.J.

A89-13379#

COMPARISON OF MINIMUM LENGTH NOZZLES

G. EMANUEL (Oklahoma, University, Norman) and B. M. ARGROW ASME, Transactions, Journal of Fluids Engineering (ISSN 0098-2202), vol. 110, Sept. 1988, p. 283-288. refs

A second-order accurate method-of-characteristics algorithm is used to determine the flow field and wall contour for a supersonic, axisymmetric, minimum length nozzle with a straight sonic line. Results are presented for this nozzle and compared with three other minimum length nozzle configurations. It is shown that the one investigated actually possesses the shortest length as well as the smallest initial wall turn angle at the throat. It also has an inflection point on the wall contour, in contrast to the other configurations. Author

A89-13401#

THIN ELLIPSE IN GROUND EFFECT - LIFT WITHOUT CIRCULATION

A. PLOTKIN (San Diego State University, CA) ASME, Transactions, Journal of Applied Mechanics (ISSN 0021-8936), vol. 55, Sept. 1988, p. 735, 736. refs

A modification of the method of Plotkin and Kennell (1981) is used to solve the problem of ground effect for a thin ellipse, an example of lift without circulation. The steady two-dimensional incompressible irrotational flow of a uniform stream past a thin ellipse is considered. The method can be used to determine the differences in the nature of the solution for an airfoil with circulation and a comparable thin body without circulation. R.R.

A89-13497

TRANSONIC FLOW CALCULATION VIA FINITE ELEMENTS

PETR KLOUCEK and JOSEF MALEK (Karlova Universita, Prague, Czechoslovakia) Aplikace Matematiky (ISSN 0373-6725), vol. 33, no. 4, 1988, p. 296-321. refs

Two types of algorithms for computing transonic flows have been constructed, based on a convenient entropy condition. A sequence of solutions are determined for the linearized problem. The solutions are checked by verifying the entropy condition. The convergence of the sequence to the physical solution of transonic flow is shown for several situations. Numerical results are presented for the case of flow past NACA 230012 airfoil. R.B.

A89-13502#

THE INTERNATIONAL VORTEX FLOW EXPERIMENT FOR COMPUTER CODE VALIDATION

GEORG DROUGGE (Flygtekniska Forsoksanstalten, Bromma, Sweden) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. XXXV-XLI. Research supported by the Forsvarets Materielverk. refs

An account is given of the collaborative organization and experimental design of an international test program concerned with the characterization of vortex flow phenomena in the case of a delta wing/canard configuration over the Mach number range of 0.4-4.0, and angles of attack up to 25 deg. The experimental study program gave attention to the interaction of shock-induced wing leading edge primary vortices with terminating shocks near the trailing edge, as well as to the comparative results of Navier-Stokes and Euler computations for the velocity vector in the spanwise and leading-edge normal plane. O.C.

A89-13517#

DESIGN AND EXPERIMENTAL VERIFICATION OF AN ADVANCED FOWLER FLAPPED NATURAL LAMINAR FLOW AIRFOIL

R. BERTOCCHI (Israel Aircraft Industries, Ltd., Lod) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 113-120. refs

An experimental evaluation of a new advanced laminar flow airfoil, Profile 76, was conducted in a low speed wind-tunnel. The airfoil was designed to achieve a substantial amount of laminar flow at cruise conditions, while a specially designed Fowler flap was utilized to ensure the airfoil's high efficiency at intermediate and high lift coefficients. The experimental results showed that Profile 76 met or exceeded most of the design goals regarding pressure distributions, flow-quality, circulation control, and maximum lift coefficients. The airfoil also proved to have almost stall-proof behavior, with no pitching moment changes after stall. Author

A89-13518#

THREE DIMENSIONAL INVISCID FLOW CALCULATIONS IN TURBOMACHINERY COMPONENTS

TONY ARTS (Institut Von Karman de Dynamique des Fluides, Rhode-Saint-Genese, Belgium) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 121-132. refs

The application of an Euler solver to the three dimensional, rotational, inviscid flow of a perfect gas in turbomachinery components is presented. The method is based on a time marching technique and a finite volume discretization procedure. The results on five different configurations are presented and compared either to experimental data or to other numerical procedures in order to demonstrate the generality and robustness of the method with respect to the type of geometry (axial/radial), of flow regime (subsonic/transonic) and of configuration (isolated blade row/full stage). Author

A89-13519#

NUMERICAL SIMULATION OF TURBULENT FLOW THROUGH TANDEM CASCADE

DIAO XU and GUO-CHUAN WU (Nanjing Aeronautical Institute, People's Republic of China) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 133-137. refs

Turbulent flows through single and tandem cascades of airfoils are numerically simulated using the finite analytic numerical method. The k-epsilon turbulence model and wall-function approach are utilized to describe the turbulent flow process and wall-proximity region in the numerical simulations. In order to solve more practical engineering problems, body-fitted coordinate transformation is incorporated in the finite analytic method. The finite analytic method is first introduced into the numerical calculations of cascade flow fields. Excellent agreement with others' solutions and experimental data are obtained. Author

A89-13525#
ACT WIND TUNNEL EXPERIMENTS OF A TRANSPORT-TYPE WING
T. UEDA, H. MATSUSHITA, S. SUZUKI, Y. MIYAZAWA (National Aerospace Laboratory, Chofu, Japan), and Y. MATSUZAKI (Nagoya University, Japan) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 194-204. refs

Experimental results of a cantilevered elastic wing model with two control surfaces driven independently by small electric torque motors have been obtained in a low-speed wind tunnel. In gust alleviation tests performed with a Dryden-type random gust, a 25 percent rms bending moment reduction at the wing root was achieved using a single aileron control. In an active flutter suppression (AFS) test, the flutter boundary was increased by 13 percent in speed when two control surfaces were activated simultaneously. The leading edge control surface was shown to be effective in AFS. R.R.

A89-13527#
TRANSONIC INVESTIGATIONS ON HIGH ASPECT RATIO FORWARD- AND AFT-SWEPT WINGS
TAKESHI OHNUKI and NOBUHIKO KAMIYA (National Aerospace Laboratory, Chofu, Japan) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 216-222. refs

The effect of sweep angle change on the performance of wing-fuselage configurations has been experimentally investigated for Mach numbers ranging from 0.7 to 0.85. The present wing half model has no twist and has the same symmetrical airfoil sections at every spanwise section. A three-component strain gage balance is used to survey wing wakes and to determine lift, drag, and pitching moments. It is found that forward-swept wings have smaller wave drag, cleaner boundary layers, and larger induced drag than structurally equivalent aft-swept wings. R.R.

A89-13536#
A DIRECT AEROFOIL PERFORMANCE CODE INCORPORATING LAMINAR SEPARATION BUBBLE EFFECTS
F. N. COTON and R. A. MCD. GALBRAITH (Glasgow, University, Scotland) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 329-338. refs

The paper describes a direct scheme for the prediction of laminar separation bubbles designed to provide a criterion for transition on low Reynolds number aerofoils. The method was found to be sensitive to the empirical input of pressure distribution with implied fixed transition. Indeed, minor physically realistic modifications to it yielded significant effects on the predicted lift values. It is postulated that inverse methods tackling a similar problem will have comparable sensitivity which renders both schemes to have an accuracy dependent on the empirical inputs chosen. The current method has value in the ease with which future investigations and postulations of bubble development may be made. Author

A89-13545#
ON THE COMPENSATION OF THE PHUGOID MODE INDUCED BY INITIAL CONDITIONS AND WINDSHEARS
L. M. B. C. CAMPOS (Instituto Superior Tecnico, Lisbon, Portugal) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 435-444. Research supported by the Junta Nacional de Investigacao Cientifica e Tecnologica of Portugal. refs

Suppression of the phugoid mode (excited by wind shears) via a suitable pitch control schedule which keeps the aircraft on a constant glide slope is theoretically demonstrated. It is shown that the aerodynamic forces and moments acting upon an aircraft in a perturbed atmosphere can be determined from the airspeed vector along each point of the flight path. The effects of atmospheric disturbances on flight performance can be specified by the disturbance intensity. R.R.

A89-13548*# Vigyan Research Associates, Inc., Hampton, VA.
AN AERODYNAMIC COMPARISON OF PLANAR AND NON-PLANAR OUTBOARD WING PLANFORMS
D. A. NAIK (Vigyan Research Associates, Inc., Hampton, VA) and C. OSTOWARI (Texas A & M University, College Station) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 468-480. Research supported by Texas A & M University and NASA. refs

An investigation of seven different configurations for two different spans confirms that an experimentally derived span efficiency of greater than one is possible for a nonplanar wing. It is suggested that the induced drag benefits of wings with nonplanar outboard planforms relate to the movement of vorticity away from the center of the span line. Both the position of the vortex and its effect on the wing's downwash distribution are found to significantly effect nonplanar wing performance. R.R.

A89-13549#
FLOW PROPERTIES ASSOCIATED WITH WING/BODY JUNCTIONS IN WIND TUNNEL AND FLIGHT
A. BERTELRUD, J. OLSSON (Flygtekniska Forsoksanstalten, Bromma, Sweden), and J. SZODRUCH (Messerschmitt-Boelkow-Blohm GmbH, Bremen, Federal Republic of Germany) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 481-494. refs

The complex flow occurring in the wing/body junction of aircraft, i.e. in the pod/wing junction or the pod/nacelle junction, has been identified as a source of drag increase in most cases. While attached boundary layers (three- as well as two-dimensional) are becoming commonplace to compute with various types of boundary layer codes, it is not yet clear how to do a proper modeling for a computational prediction of this type of flow. In the present paper experimental data is presented concerning three-dimensional time-averaged and turbulence data obtained within the junction during flight tests, and from the wake region in a wind tunnel test. Author

A89-13552#
THICKNESS EFFECTS IN THE UNSTEADY AERODYNAMICS OF INTERFERING LIFTING SURFACES
L. P. RUIZ-CALAVERA (Instituto Nacional de Tecnica Aeroespacial, Torrejon de Ardoz, Spain) and W. GEISSLER (DFVLR, Institut fuer Aeroelastik, Goettingen, Federal Republic of Germany) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 514-523. refs

A panel method, originally developed to calculate steady and unsteady pressure distributions on harmonically oscillating wings in incompressible flow, has been generalized to study interference configurations. Differing from normally used mean-surface theories, in this method the geometric boundary condition is matched on the real body surface, thus taking into account thickness effects. Application is made to three different cases: T-Tail Wing-Tail and Engine-Wing interference. The influence of thickness is discussed comparing the results of the present method with other linearized methods as well as with experimental data. Author

A89-13553#
UNSTEADY SUPERSONIC FLOW COMPUTATIONS FOR ARBITRARY THREE-DIMENSIONAL CONFIGURATIONS
D. D. LIU (Arizona State University, Tempe), P. C. CHEN (Zona Technology, Inc., Mesa, AZ), and PABLO GARCIA-FOGEDA

(Escuela Tecnica Superior de Ingenieros Aeronauticos, Madrid, Spain) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 524-544. refs

Two unsteady supersonic methods which are based on the harmonic gradient method (the surface panel method and the bundled triplet method) are used to study wing-body configurations. Results obtained for cases including NACA and NASA wing-body configurations and an NLR/F-5 wing with external stores show good agreement with previous findings. A two-model study of a generic fighter reveals the inability of the lifting surface model to completely represent an aircraft. R.R.

A89-13560#

EXPERIMENTAL AND NUMERICAL STUDY OF PROPELLER WAKES IN AXIAL FLIGHT REGIME

D. FAVIER, C. MARESCA, C. BARBI (Aix-Marseille II, Universite, Marseille, France), and A. ETTAOUIL IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 602-616. refs

(Contract DRET-85-115; DRET-87-095)

An experimental and numerical investigation of the axial flight regime of a propeller operating either in the isolated configuration or in the propeller/nacelle/wing combination is described. For the isolated propeller configuration the numerical approach is based on a free-wake analysis code, and the code prediction efficiency is checked by comparison with experimental data obtained on both the overall propeller performance and the associated wake velocity field. In the interaction case a series of wind tunnel experiments is performed on each component of the propeller/nacelle/wing configuration. Overall lift, drag and moment coefficients as well as chordwise pressure distributions are measured at different spanwise sections of the wing. Author

A89-13566#

INVESTIGATIONS ON THE VORTICITY SHEETS OF A CLOSE-COUPLED DELTA-CANARD CONFIGURATION

HANS-CHRISTOPH OELKER and DIETRICH HUMMEL (Braunschweig, Technische Universitaet, Brunswick, Federal Republic of Germany) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 649-662. refs

(Contract DFG-HU-254/8)

Comprehensive aerodynamic investigations have been carried out on a close-coupled A = 2.31 delta-canard configuration at low speed. Results of three-component, surface-pressure, and flow-field measurements as well as oilflow patterns are presented for the canard-off and for the canard-on configuration. The main interference effects take place above the wing. The formation of the wing vortices is delayed considerably to positions down-stream of the apex. The canard vortices pass the wing leading-edge relatively high, and they are moved downwards and inwards above the wing. During this process, a fusion between the canard's vorticity sheet and the suction-side boundary layer of the wing takes place in the inner portion of the wing. The canard vortex system is maintained up to stations downstream of the wing trailing-edge. Author

A89-13568#

NUMERICAL AND EXPERIMENTAL DETERMINATION OF SECONDARY SEPARATION AT THE LEEWARD SIDE OF A DELTA WING IN COMPRESSIBLE FLOW

E. M. HOUTMAN and W. J. BANNINK (Delft, Technische Hogeschool, Netherlands) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 673-680. refs

The turbulent boundary layer flow at the leeward side of a planar delta wing at high angles of attack and high subsonic Mach numbers has been studied. A quasi-three dimensional boundary layer method has been developed, assuming a conical external flow and similar velocity profiles along rays through the apex. The solution takes place at a constant chord position, while the marching direction is away from an attachment line until separation is reached. The present method has been tested with experimental pressure distributions as input. The predicted surface flow compared with oil flow visualization tests showed good agreement as far as the limiting streamlines and the secondary separation positions are concerned. Author

A89-13569#

INVESTIGATION OF FLOW OVER CAVITY-BLUNT BODY COMBINATION AT SUPERSONIC SPEED

O. H. RHO, D. H. LEE, J. H. KIM, and S. J. KIM (Seoul National University, Republic of Korea) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 681-686. Research supported by the Korea Science and Engineering Foundation. refs

In order to understand drag reduction on a blunt body at supersonic speed, an investigation has been carried out experimentally and analytically for the two-dimensional cavity flow model (simplified from the three-dimensional axisymmetric cavity flow on the conical-tip/spiked-blunt-body combination). The flow has been observed and described systematically by visualizing the flow from schlieren pictures and by measuring the pressure distribution. The cavity flow field was also analytically computed by solving the two-dimensional Euler equations based on the finite-volume method. The numerical results agree with those of the experiments. Author

A89-13573#

NEW GUIDE FOR ACCURATE NAVIER-STOKES SOLUTION OF TWO-DIMENSIONAL EXTERNAL COMPRESSION INLET WITH BLEED

C. K. FORESTER and E. TJONNELAND (Boeing Co., Seattle, WA) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 709-718. refs

(Contract F49620-85-C-0126)

The solution of the flow field in the aperture region of an external compression inlet with bleed and spillage flow by Navier-Stokes analysis is presented. Measures of numerical errors in the analysis process, including total pressure, artificial diffusion ratios for mass, energy, and momentum are explored. Preliminary correlation of thse error measures show that the artificial diffusion ratio (ADR) provides guidance for grid and smoothing level selection. The application of ADR to the problem under consideration yields a solution to the flow field which shows good agreement with experimental results. C.D.

A89-13577#

EFFECTIVENESS OF COMBINATION OF APEX AND LEADING-EDGE VORTEX FLAP ON A 74 DEGREE DELTA-WING WITH OR WITHOUT TRAILING-EDGE FLAP

T. D. HSING, K. X. SHEN, Z. F. WANG, F. G. ZHUANG (Beijing University of Aeronautics and Astronautics, People's Republic of China), and W. H. GUO IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 749-757. Research supported by the Ministry of Aviation Industry of the People's Republic of China. refs

Various experimental methods were used to study the effect of apex and trailing-edge flaps on the aerodynamic characteristics of a 74 deg, swept delta wing equipped with leading-edge vortex flap. The leading-edge flap reduces the drag, but diminishes the lift at lower angle of attack. The nose-up deflected apex flap, along with the tail-down deflected trailing edge flap, can increase the lift markedly, slightly decreasing the lift-drag ratio at higher angle of attack and more at lower angle of attack. Fitting the apex flap and the trailing-edge flap on a highly swept delta wing equipped with a leading-edge vortex flap increases the lift and lift-drag ratio. A discrete vortex method based on slender body theory is used to compute the roll-up of vortices shedding from the leading edge and the pressure distribution on the flap and wing, with good results. C.D.

A89-13578#

THE BEHAVIOUR AND PERFORMANCE OF LEADING-EDGE VORTEX FLAPS

D. G. ELLIS and J. L. STOLLERY (Cranfield Institute of Technology, England) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 758-765. refs

A series of low-speed wind tunnel tests were conducted on various leading-edge vortex flap (LEVF) configurations in an attempt to optimize the performance of a 60-deg delta wing. To describe the behavior of LEVFs, extensive surface pressure distributions have been related to assorted flow visualization results. The influence of the various separation and attachment lines have been clearly identified together with the effects of vortex breakdown. Results indicate that as much as 40 percent increase in lift-drag ratio is obtainable over a moderate lift coefficient range without any apparent loss in longitudinal stability. The additional benefits of fitting a trailing-edge flap to the vortex flapped wing are also reported. Author

A89-13579*# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Goettingen (Germany, F.R.).

VISCOUS/INVISCID INTERACTION PROCEDURE FOR HIGH-AMPLITUDE OSCILLATING AIRFOILS

W. GEISSLER (DFVLR, Institut fuer Aeroelastik, Goettingen, Federal Republic of Germany), L. W. CARR (NASA, Ames Research Center; U.S. Army, Aeromechanics Laboratory, Moffett Field, CA), and T. CEBECI (California State University, Long Beach) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 766-778. refs

A coupling procedure between an inviscid potential theoretical panel method and an unsteady interactive boundary layer calculation procedure has been developed for calculating unsteady airloads on oscillating airfoils in the high-incidence regime. A coordinate transformation into a time-dependent surface coordinate has been incorporated into the boundary layer code to avoid a quasi-steady treatment of the viscous flow equations in the leading edge region. The upper and lower sides of the airfoil are calculated with the complete set of unsteady equations. The interactive region of the boundary layer calculation can be straightforwardly extended over the complete upper surface of the airfoil while accounting for interaction areas in the region of strong adverse pressure gradients with incipient separation. Comparisons of sample calculations with experimental data show reasonably good agreement even for unsteady drag coefficients. C.D.

A89-13580#

TIME-CONSISTENT COMPUTATION OF TRANSONIC BUFFET OVER AIRFOILS

P. GIRODROUX-LAVIGNE and J. C. LE BALLEUR (ONERA, Chatillon-sous-Bagneux, France) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 779-787. Research supported by the Service Technique des Programmes Aeronautiques. refs

A fully time-consistent viscous-inviscid interaction method (developed previously for the computation of unsteady attached or separated viscous flows at high Reynolds numbers) is used to predict the onset of transonic buffet over steady airfoils, and to describe the unsteady behavior of the flow. Based on the defect formulation theory, and on thin-layer approximations, the method solves unsteady defect integral equations for attached or separated turbulent flows, interacted with a small perturbation potential solver. The method is found capable to predict steady or unsteady solutions, according to the incidence, over the RA16SC1 and NACA0012 airfoils. Author

A89-13585#

3D FLOW COMPUTATIONS IN A CENTRIFUGAL COMPRESSOR WITH SPLITTER BLADE INCLUDING VISCOUS EFFECT SIMULATION

VALERIE MILLOUR (ONERA, Chatillon-sous-Bagneux, France) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 842-847.

Optimization of centrifugal compressors is based on the knowledge of the inner aerodynanic characteristics of the impeller and more precisely the rotor 'alone'. This paper describes the results of a 3-dimensional nonviscous steady flow computation in a centrifugal rotor with splitter vanes. The splitter may be in various positions and have any shape. The software used has been developed at ONERA and tested in several turbomachines cases. It consists of a general computer code solving the full Euler equations directly in the absolute physical space in cylindrical coordinates. Author

A89-13586#

DETAILED MEASUREMENTS OF THE FLOW IN THE VANED DIFFUSER OF A BACKSWEPT TRANSONIC CENTRIFUGAL IMPELLER

CH. FRADIN (ONERA, Chatillon-sous-Bagneux, France) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 848-854. refs

A detailed experimental analysis has been made of the flow field in the throat and in the outlet of a diffuser channel. The transonic centrifugal impeller has backward leaning blades and is equipped with splitter vanes. The vaned diffuser is of the cambered vane type. The distribution of the time-averaged flow Mach number and flow angle is found to be very heterogeneous in both the axial and tangential directions. Three-dimensional boundary layers are observed near the front wall and back wall. Time-dependent measurements reveal that the flow structure is highly unsteady in the diffuser throat. The blade-to-blade heterogeneities delivered by the impeller do not decrease rapidly in the semivaned diffuser. Time-averaged measurements performed at the vaned diffuser outlet show that the flow distortions increase in the divergent channel. More mass flow is located near the vane suction side. Secondary flow is found in the vicinity of the vane pressure side. Separation occurs at the diffuser outlet. C.D.

A89-13593#

AN ARTIFICIAL VISCOSITY MODEL AND BOUNDARY CONDITION IMPLEMENTATION OF FINITE VOLUME METHODS FOR THE EULER EQUATIONS

LEI WANG and FENGGAN ZHUANG (Beijing Institute of Aeronautics and Astronautics, People's Republic of China) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 898-903. refs

The paper analyzes the artificial viscosity model used in the explicit multistage finite volume methods for the solutions of the Euler equations, and suggests an alternative way to determine the coefficients contained in the model. The modified approach is applied to calculate transonic flows around airfoils, and the dependence of the numerical results on the magnitude of the artificial dissipations is examined. In addition, the effects of implementation of boundary conditions are discussed. Author

A89-13599#

THE CALCULATION OF AERODYNAMIC FORCES ON FLEXIBLE WINGS OF AGRICULTURAL AIRCRAFT

T. GAUSZ (Budapesti Muszaki Egyetem, Budapest, Hungary) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 966-968. refs

The aerodynamic problems that arise from the flight of agricultural aircraft at altitudes sufficiently low for the ground-effect phenomenon to exert a significant influence are presently addressed by local coordinate system computations, with a view to consequences for wing elasticity. The aircraft in question is of the M 18 'Dromander' type frequently used in Hungary. It is found that the aerodynamic forces arising at low altitudes in the unsteady stream, for constant velocity and angle of attack, undergo their greatest reduction in the wing's midspan section, but only negligible reduction at the outer part of the wing. O.C.

A89-13601#
FLIGHT AND WINDTUNNEL INVESTIGATIONS ON BOUNDARY LAYER TRANSITION AT REYNOLDS NUMBERS UP TO 10 TO THE 7TH
K. H. HORSTMANN, A. QUAST, and G. REDEKER (DFVLR, Institut fuer Entwurfsaerodynamik, Brunswick, Federal Republic of Germany) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 979-986. refs
For the design of laminar airfoils reliable transition prediction criteria are indispensable. By means of the linear stability theory of laminar boundary layers the transition prediction procedure can be based on a sophisticated background. This paper describes carefully planned and executed experiments in free flight and in wind tunnels for the determination of limiting N-values of Tollmien-Schlichting waves to serve as transition criterion. The results show that the limiting N-values are nearly independent of Reynolds number and are in the wind tunnel of the same order of magnitude as in free flight, demonstrating the excellent flow quality of the wind tunnel used. Author

A89-13602#
EXPERIMENTAL STUDY OF THE BEHAVIOR OF NACA 0009 PROFILE IN A TRANSONIC LEBU CONFIGURATION
J. P. BONNET, J. DELVILLE, and J. LEMAY (Poitiers, Universite, France) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 987-998. Research supported by Airbus Industrie. refs
A large eddy break-up (LEBU) device has undergone a parametric experimental study in a transonic turbulent boundary layer with a NACA 0009 manipulator. Freestream Mach number was in the 0.7-0.8 range, and the manipulating device was placed at variable distances from the wall with angles-of-attack lying between -1 and +1. Minimum drag occurs when the LEBU is located at a distance from the wall that is of the order of 70 percent of the boundary layer thickness. Drag is very sensitive to LEBU angle-of-attack; important critical Mach number effects are noted for several configurations. O.C.

A89-13603#
TURBULENT BOUNDARY LAYER MANIPULATION IN ZERO PRESSURE GRADIENT
E. COUSTOLS and J. COUSTEIX (ONERA, Centre d'Etudes et de Recherches de Toulouse, France) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 999-1013. refs
Interest in reducing the drag of aerodynamic surfaces has led to the control of turbulent skin friction evolution. The problem of explaining cause-and-effect relationships is one of the most challenging tasks; this has been undertaken with two drag-reducing methods: (1) thin flat plate or airfoil section devices embedded within the boundary layer, and (2) surface modification in the form of longitudinal ribs ('riblet' surfaces). This paper presents detailed anemometry measurements, wall shear stress measurements, and pressure fluctuation spectra for these two passive approaches. Detailed experimental information is available which provides a good description of mechanisms leading to turbulent drag reduction. Author

A89-13605#
A PARALLEL ALGORITHM OF AF-2 SCHEME FOR PLANE STEADY TRANSONIC POTENTIAL FLOW WITH SMALL TRANSVERSE DISTURBANCE
SHOU-YING LI, QI-WEI LIAO (National University of Defence Technology, Changsha, People's Republic of China), and SHI-JUN LUO (Northwestern Polytechnical University, Xian, People's Republic of China) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 1024-1028. refs
A parallel algorithm for the implicit approximate factorization scheme has been developed in order to solve the plane steady transonic potential equation with transverse small disturbance for flows about a NACA 0012 airfoil. Attention is given to a multipivot elements-based parallel elimination method for solving a system of equations within a tridiagonal coefficients matrix. The computational efficiencies of parallel and serial operation are compared by computational experiment. It is found that parallel operation is approximately 16 times faster than serial operation. O.C.

A89-13624#
AN EFFICIENT METHOD FOR COMPUTING TRANSONIC AND SUPERSONIC FLOWS ABOUT AIRCRAFT
G. VOLPE (Grumman Corporate Research Center, Bethpage, NY) and A. JAMESON (Princeton University, NJ) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 1224-1236. refs
A numerical method for computing flow fields about fighter-type aircraft is described in the paper. The time-dependent Euler equations are discretized on a single-block mesh in finite volume form and integrated to steady state via a Runge-Kutta scheme with a local time step. Convergence is accelerated by employing enthalpy damping and residual smoothing, in addition to a multigrid sequencing of the computational mesh. While specifically designed for application in the transonic regime, the method can be used efficiently even at supersonic and low subsonic speeds. Very realistic fighter configurations can be handled as demonstrated by the examples presented. Author

A89-13630#
THE APPLICATION AND IMPROVEMENT OF 'WALL PRESSURE SIGNATURE' CORRECTION METHOD FOR THE TUNNEL WALL INTERFERENCE
GUIQING JIANG (China Aerodynamic Research and Development Centre, Sichuan, People's Republic of China) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 1291-1298. refs
The application and improvement of the 'wall pressure signature' correction method developed by Hackett et al. (1981) is presented in this paper. The improvement of the method is characterized by a higher accuracy of correction results and great reduction of the computing time for the real-time correction of test data by simplifying the algorithm. More than ten demonstration test results for the model pressure measurement and force measurement are presented here while some important problems concerning the correction for tunnel wall interference are analyzed, demonstrated and computed. Author

A89-13631#
UNSTEADY MOTION OF VORTEX-BREAKDOWN POSITIONS ON DELTA WINGS
H. PORTNOY (Rafael Armament Development Authority, Haifa, Israel) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 1299-1303. refs
Water-tunnel flow-visualization is presently employed to characterize the oscillatory relative motion of vortex-breakdown positions on the upper and lower surfaces of delta wings. This motion, which occurs at high incidence immediately before vortex system degeneration into a disorganized bluff-body wake, may play a role in the initiation of wing rock. Attention is given to the relative influence of the parameters of wing size, sweep, incidence,

and flow speed. An attempt is made to correlate the results obtained, which encompassed a lower-incidence fore-aft oscillation and a higher-incidence side-to-side one, using dimensional analysis. O.C.

A89-13640#

EXPERIMENTAL INVESTIGATION OF THE COMPLEX 3-D FLOW AROUND A BODY OF REVOLUTION AT INCIDENCE - A SINO-ITALIAN COOPERATIVE RESEARCH PROGRAM

G. IUSO, M. ONORATO (Torino, Politecnico, Turin, Italy), S. DE PONTE (Milano, Politecnico, Milan, Italy), M. S. OGGIANO (CNR, Centro di Studio sulla Dinamica dei Fluidi, Turin, Italy), YUZHONG BIAN (Harbin Aerodynamics Research Institute, People's Republic of China) et al. IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 1382-1391. Research supported by the Ministero della Pubblica Istruzione and CNR. refs

In this paper some significant results obtained during a cooperative research program between the Chinese Aeronautical Establishment, some Italian Universities and the 'Centro Studi Dinamica Fluidi' of CNR are shown. The research program is about the experimental study of the three-dimensional complex flow around a prolate ellipsoid at angle of attack. Many different tests have been carried out in different wind tunnels in China and in Italy: flow visualizations, pressure and force measurements, boundary layer surveys and LDV measurements. The results are discussed in an attempt to give a physical picture of the complex flow around the model. Author

A89-13642#

SOME TYPES OF SCALE EFFECT IN LOW-SPEED, HIGH-LIFT FLOWS

D. S. WOODWARD, B. C. HARDY, and P. R. ASHILL (Royal Aircraft Establishment, Farnborough, England) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 1402-1416. refs

Previous classifications of types of scale effect, especially on aerofoils at maximum lift, are reviewed and the salient features of each are explained. A new classification of five types of scale effect is then introduced, for high-lift flows, which embraces both the previous classification for aerofoils and observed scale effects on wings with slotted high-lift systems. Examples are given of each of these types from tests in RAE tunnels, and the important features of each are discussed, especially those which result in adverse scale effect. Author

A89-13643*# Vigyan Research Associates, Inc., Hampton, VA.

AERODYNAMIC APPLICATIONS OF AN EFFICIENT INCOMPRESSIBLE NAVIER-STOKES SOLVER

PETER M. HARTWICH, C.-H. HSU (Vigyan Research Associates, Inc., Hampton, VA), JAMES M. LUCKRING, and C. H. LIU (NASA, Langley Research Center, Hampton, VA) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 1417-1427. refs
(Contract NAS1-17919)

A robust and accurate upwind scheme based on flux-difference splitting for three-dimensional, incompressible flows in general coordinates is described. Viscous effects are included through a thin-layer approximation to the Navier-Stokes equations. Turbulent flows are simulated with extensions to the Baldwin-Lomax (1978) turbulence model. The effects of accuracy and gridding on the computed flow field results are assessed. The results obtained from the code for vortical flows over a delta wing, a double delta wing, and a tangent-ogive forebody compare well with experimental data. Author

A89-13644#

BASIC ANALYSIS OF THE FLOW FIELDS OF SLENDER DELTA WINGS USING THE EULER EQUATIONS

S. SHERR and A. DAS (DFVLR, Institut fuer Entwurfsaerodynamik, Brunswick, Federal Republic of Germany) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 1428-1436. refs

The physics of delta wings moving in an inviscid medium is discussed. Numerical simulation of the flowfield around a closely coupled canard-delta wing configuration is performed for a range of angles of attack in subsonic and transonic free-stream conditions. These results are compared with calculations for the delta wing without canard to illustrate the influence of the canard on the flow. Subsequently the physics of the flowfields with vortical flux lines is analyzed in detail. The origin of total pressure losses inside the spiraling vortices and the onset of vortex breakdown at higher incidence are discussed. Author

A89-13645#

MODELING OF VORTEX DOMINATED FLOWFIELDS IN THE EULER FORMULATION

K. D. LEE and S. A. BRANDT (Illinois, University, Urbana) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 1437-1450. Research supported by McDonnell Douglas Aircraft Co. refs

This paper describes a computational approach which uses the Euler formulation for vortex dominated flowfields around highly swept wings coupled with an algebraic model derived from the Navier-Stokes equations to represent the viscous physics within the vortex core. The approach also accounts for viscosity effects near the wing surface through a modified surface boundary condition. With the developed viscous model, the Euler formulation can give better prediction of leading edge separation, vortex bursting, and secondary vortex formation. Results for several cases are compared with those from wind tunnel tests and Euler and Navier-Stokes computer codes. Author

A89-13655#

THE CAUSE AND CURE OF PERIODIC FLOWS AT TRANSONIC SPEEDS

J. GIBB (Cranfield Institute of Technology, England) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 1522-1530. refs

It is very important to understand fully the cause of periodic flows at transonic speeds in order to be able to prevent their occurrence in new designs and to be able to apply cures to any problems in existing designs. Experimental results are presented which describe in some detail the physics of the cause of periodic flows at transonic speeds and will also show results of several techniques which have successfully eliminated the problem. Results are given for the 14-percent thick Biconvex aerofoil and the NACA 0012 aerofoil. Author

A89-13656#

CALCULATION AND MEASUREMENT OF TRANSONIC FLOWS OVER AEROFOILS WITH NOVEL REAR SECTIONS

P. R. ASHILL (Royal Aircraft Establishment, Bedford, England) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 1531-1541. refs

A combined theoretical and experimental investigation into transonic flows over aerofoils of advanced design is described. The experiments have been performed at high subsonic speeds and over a wide range of Reynolds number up to 20 million on a number of aerofoils with rear pressure distributions of differing form and severity. Three families of aerofoils have been studied, all of which are of 14 percent thickness and have a high degree of rear camber. Data for aerofoil pressure distributions and overall forces are compared with predictions by a calculation method based on the viscous-inviscid interaction concept and including allowance in the modeling of the turbulent shear layers for effects which become important as separation is approached. Author

A89-13675#

VORTICAL FLOWS AROUND DELTA WINGS IN UNSTEADY MANEUVERS AND GUSTS

ROLF STAUFENBIEL, BERND STECKEMETZ, and SHANGXIANG ZHU (Aachen, Rheinisch-Westfaelishe Technische Hochschule, Federal Republic of Germany) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 1714-1724. DFG-supported research. refs

This paper presents experimental investigations of two delta wings with aspect ratio of 1 and 2 operating under unsteady conditions at high angles of attack and sideslip. It includes the influence of gusts produced by a gust generator in front of a wing fixed in a wind tunnel, and a plunging motion caused by a forced motion of the wing. Observed unsteady effects are related to the time-dependent strength of the leading edge vortices and, in particular, to unsteady breakdown phenomena. Displacement of the breakdown points of the leading edge vortices is quantitatively evaluated from water-tunnel flow visualization showing hysteresis loops and considerable time lags. Also, considerable changes in lift and pitching moment in symmetrical flow states and rolling moment under unsymmetrical conditions have been found in wind-tunnel tests. Simulations using these experimental data indicate a strong impact on the flight dynamic characteristics of the delta wing configurations. Author

A89-13676#

QUANTITATIVE FLOW FIELD VISUALIZATION IN WIND TUNNELS BY MEANS OF PARTICLE IMAGE VELOCIMETRY

J. KOMPENHANS (DFVLR, Institut fuer experimentelle Stroemungsmechanik, Goettingen, Federal Republic of Germany) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 1725-1730. refs

The instantaneous and nonintrusive measurement of the flow velocity in a two-dimensional plane of a flow field can be performed by means of a new experimental technique, called Particle Image Velocimetry (PIV). An experimental set-up for the application of PIV in wind tunnels has been developed. Results of the investigation of flow fields in a low turbulence wind tunnel at U = 10 m/s are presented. Furthermore, PIV has been applied to jet flows up to Ma = 1. Problems affecting the operation of PIV in a large wind tunnel are discussed. Author

A89-13677#

VORTEX BREAKDOWN - INVESTIGATIONS BY USING THE ULTRASONIC-LASER-METHOD AND LASER-SHEET TECHNIQUE

R. H. ENGLER (DFVLR, Goettingen, Federal Republic of Germany) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 1731-1737. refs

An ultrasonic-laser measuring system has been developed which is useful for fast and nondisturbing exploration of the flow field around models in wind tunnels, especially velocity, vorticity, circulation distribution, and stability of vortices. This technique is based on the measurement of flow-induced travel time differences of short ultrasonic pulses, propagating along a measuring sound beam between two or more laser beams. Particularly the vortex breakdown of leading edge vortices has been investigated. Furthermore, the method's capability is shown for evaluating instabilities on the rolled-up shear layer. A video film, photographs, and measurements confirm these facts. Author

A89-13685#

TRANSONIC SHOCK BOUNDARY LAYER INTERACTION WITH PASSIVE CONTROL

S. RAGHUNATHAN and S. T. MCILWAIN (Belfast, Queen's University, Northern Ireland) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 1826-1834. refs

Passive control experiments were conducted on a wall mounted part section supercritical aerofoil at R-theta = 5,700 and in the shock Mach number range 1.2-1.34. The porosity of the porous surface was 2.14 percent. The results of the experiments were in agreement with earlier experiments on a wall mounted circular arc model at R-theta = 10,000. Some of the results were in disagreement with experiments conducted by Nagamatsu et al. (1985) on the same supercritical aerofoil model at R-theta = 3,000. It is suggested that detailed experiments be conducted on a large scale model to fully understand the mechanism and benefits of passive controlled shock boundary layer interaction. Author

A89-13686#

WIND TUNNEL BLOCKAGE CORRECTIONS FOR BLUFF BODIES WITH LIFT

G. N. V. RAO and J. DHEENADHAYALAN (Indian Institute of Science, Bangalore, India) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 1835-1844. refs

The effect of solid boundaries on the forces and moments on an arbitrary lifting body has been analyzed using a flow model in the inviscid domain. The flow model consists of the free streamlines representing the viscous separated shear layer and stagnant fluid of constant width, the width being determined by equating the momentum loss of the fluid in the far wake to the upstream momentum of the stagnant fluid. The results suggest that inviscid modeling does not necessarily yield proper trends, and it is suggested that additional constraints, like the Kutta Condition in airfoil theory, may have to be invoked. Author

A89-13687#

FLOW FIELD VISUALIZATION STUDY ON A 65-DEG DELTA WING

K. A. BUETEFISCH (DFVLR, Institut fuer experimentelle Stroemungsmechanik, Goettingen, Federal Republic of Germany) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 1845-1851. refs

The aim of this study is to provide experimental flow field data on a delta wing with rounded leading edge for a better understanding of the physical behavior of the flow field which is strongly dominated by the formation, development and decay of vortices. For this purpose complementary to force, pressure, and velocity measurements, the flow was visualized by means of the laser light sheet and the oil flow technique. A 420-mm chord model was tested at a Mach number of 0.85 and angles of attack 10, 20, and 25 deg in a 1 x 1 sq m transonic wind tunnel. The Reynolds number based on model chord was 4.5 x 10 to the 6th. The development of the primary and secondary vortical system has been observed, sudden changes of the structure of the flow field have been found, and quantitative data of the positions of the vortices have been obtained by means of a digital image processing system. Author

A89-13688#

NONLINEAR AERODYNAMICS OF DELTA WINGS IN COMBINED PITCH AND ROLL

J. ER-EL, D. WEIHS (Technion - Israel Institute of Technology, Haifa), and D. SETER IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 1852-1858. refs

This paper presents an experimental study on the effects of roll on the loading and rolling moment of a 60-deg swept delta wing. The experiments were carried out at angles of incidence which include cases where vortex breakdown is present on the wing (25 deg or less). Results indicate that when vortex breakdown is not present, the effects of roll on the wing loading and rolling moment are in reasonable agreement with predictions obtained from an approximate model. When vortex breakdown is present, the magnitude of the measured rolling moment coefficient is reduced considerably and its sign can even be altered. The changes in the rolling moment characteristics due to vortex breakdown can be attributed to the roll-induced spanwise displacement of the leading-edge vortices. Author

A89-13691#

BODY WING TAIL INTERFERENCE STUDIES AT HIGH ANGLES OF ATTACK AND VARIABLE REYNOLDS NUMBERS

K. HARTMANN, V. KANAGARAJAN (DFVLR, Institut fuer experimentelle Stroemungsmechanik, Goettingen, Federal Republic of Germany), and D. NIKOLITSCH (Messerschmitt-Boelkow-Blohm GmbH, Ottobrunn, Federal Republic of Germany) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 1871-1885. refs

Six-component measurements were carried out in two wind tunnels on several combinations of an ogive-circular cylinder body without and with lifting surfaces having rectangular planform area and sharp leading and trailing edges. These experiments were performed in the incompressible and subsonic compressible speed range at various Reynolds numbers up to high angles of attack. For the same geometries, the forces and moments were calculated and compared with the experimental results. It was the aim of these combined investigations to get a better understanding of the vortex flows over such body-wing-tail combinations, to verify the applied prediction methods, and to obtain hints for a more accurate theoretical modeling of the flow field. Author

A89-13692#

EFFECT OF AERODYNAMIC HEATING ON DEFORMATION OF COMPOSITE CYLINDRICAL PANELS IN A GAS FLOW

VICTOR BIRMAN (New Orleans, University, LA), CHARLES W. BERT (Oklahoma, University, Norman), and ISAAK ELISHAKOFF (Technion - Israel Institute of Technology, Haifa) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 1886-1892. refs

Motions of composite cylindrical panels in a gas flow are considered. It is shown that the main factor contributing to large static deformations is a nonuniform aerodynamic heating, while aerodynamic pressure is of secondary importance, at high Mach number. The main factor resulting in the increase of deformations is the nonuniform distribution of temperature along the curved edges. Author

A89-13696

DYNAMIC STALLING OF AN AIRFOIL OSCILLATING IN PITCH [DECROCHAGE DYNAMIQUE D'UNE AILE EN TANGAGE]

KO FOA TCHON, DIMITRI FOUSSEKIS, and CLAUDE BEGUIER (Institut de Mecanique Statistique de la Turbulence, Marseille, France) Academie des Sciences (Paris), Comptes Rendus, Serie II - Mecanique, Physique, Chimie, Sciences de l'Univers, Sciences de la Terre (ISSN 0249-6305), vol. 307, no. 8, Aug. 30, 1988, p. 883-888. In French. refs

Chronophotography is used to experimentally investigate the dynamic stall of a NACA 0018 airfoil undergoing an oscillating pitch motion. Two successive separations of the boundary layer were identified during the quarter periods with decreasing angle: (1) one at the leading edge, creating a turbulent vortex and triggering the transition to turbulence of the boundary layer; and (2) one at halfchord which creates a convected laminar vortex. Results are presented for the trajectories and the convection and rotation velocities of the turbulent and laminar vortices. R.R.

A89-14038

THE POSSIBILITY OF DRAG REDUCTION BY OUTER LAYER MANIPULATORS IN TURBULENT BOUNDARY LAYERS

ALEXANDER SAHLIN, ARNE V. JOHANSSON, and P. HENRIK ALFREDSSON (Kungliga Tekniska Hogskolan, Stockholm, Sweden) Physics of Fluids (ISSN 0031-9171), vol. 31, Oct. 1988, p. 2814-2820. Research supported by Marintekniska Institutet SSPA. refs

The possibility of obtaining net drag reduction with airfoil-shaped LEBUs at high Reynolds numbers is investigated. The highest chord Reynolds number tested was 260,000. In spite of the good LEBU performance and the large parameter range investigated, no drag reduction could be found; this makes any substantial net drag reduction based on the use of high Reynolds number LEBUs seem implausible. K.K.

A89-14039

SPACE-TIME CORRELATIONS OF WALL PRESSURE FLUCTUATIONS IN SHOCK-INDUCED SEPARATED TURBULENT FLOWS

J. P. BONNET (Poitiers, Universite, France) Physics of Fluids (ISSN 0031-9171), vol. 31, Oct. 1988, p. 2821-2833. refs

The structure of wall pressure fluctuations is studied in shock-induced separated supersonic turbulent flows. Two test conditions are considered for external Mach numbers of 2.25 at low Reynolds number and Mach 3.3 at high Reynolds number. Results are given for several positions in the incoming boundary layer, at the mean shock location, and in the recirculation region. K.K.

A89-14199* Department of the Army, Washington, DC.

COMPARISON OF SHOCK STRUCTURE SOLUTIONS USING INDEPENDENT CONTINUUM AND KINETIC THEORY APPROACHES

KURT A. FISCKO (U.S. Army, Washington, DC; Stanford University, CA) and DEAN R. CHAPMAN (Stanford University, CA) IN: Sensing, discrimination, and signal processing and superconducting materials and instrumentation; Proceedings of the Meeting, Los Angeles, CA, Jan. 12-14, 1988. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1988, p. 113-122. SDIO-supported research. refs

(Contract DAAL03-86-K-0139; NAGW-965)

A vehicle traversing the atmosphere will experience flight regimes at high altitudes in which the thickness of a hypersonic shock wave is not small compared to the shock standoff distance from the hard body. When this occurs, it is essential to compute accurate flow field solutions within the shock structure. In this paper, one-dimensional shock structure is investigated for various monatomic gases from Mach 1.4 to Mach 35. Kinetic theory solutions are computed using the Direct Simulation Monte Carlo method. Steady-state solutions of the Navier-Stokes equations and of a slightly truncated form of the Burnett equations are determined by relaxation to a steady state of the time-dependent continuum equations. Monte Carlo results are in excellent agreement with published experimental data and are used as bases of comparison for continuum solutions. For a Maxwellian gas, the truncated Burnett equations are shown to produce far more accurate solutions of shock structure than the Navier-Stokes equations. C.D.

A89-14200* Stanford Univ., CA.

A NUMERICAL METHOD FOR PREDICTING HYPERSONIC FLOWFIELDS

ROBERT W. MACCORMACK and GRAHAM V. CANDLER (Stanford University, CA) IN: Sensing, discrimination, and signal processing and superconducting materials and instrumentation; Proceedings of the Meeting, Los Angeles, CA, Jan. 12-14, 1988. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1988, p. 123-129. SDIO-supported research. refs

(Contract DAAL03-86-K-0139; NAGW-965; F33615-86-C-3015)

The flow about a body traveling at hypersonic speed is energetic enough to cause the atmospheric gases to react chemically and reach states in thermal nonequilibrium. In this paper, a new procedure based on Gauss-Seidel line relaxation is shown to solve the equations of hypersonic flow fields containing finite reaction rate chemistry and thermal nonequilibrium. The method requires a few hundred time steps and small computer times for axisymmetric flows about simple body shapes. The extension to more complex two-dimensional body geometries appears straightforward. C.D.

A89-14769
ASYMPTOTIC THEORY OF BOUNDARY LAYER INTERACTION AND SEPARATION IN SUPERSONIC GAS FLOW [ASIMPTOTICHESKAIA TEORIIA VZAIMODEISTVIIA I OTRYVA POGRANICHNOGO SLOIA V SVERKHZVUKOVOM POTOKE GAZA]
V. IA. NEILAND IN: Mechanics and scientific-technological progress. Volume 2. Moscow, Izdatel'stvo Nauka, 1987, p. 128-145. In Russian. refs
The asymptotic approach to the solution of problems in the dynamics of supersonic flows of a viscous gas at large Reynolds numbers has made it possible to study a wide class of problems of theoretical and practical importance which are not necessarily reduced to a three-layer scheme and which are not described in terms of classical boundary layer theory. It is emphasized that the asymptotic approach is particularly important because of the difficulties associated with obtaining numerical solutions at large Reynolds numbers. Another advantage of the asymptotic approach is that it yields convenient approximate similarity laws. V.L.

A89-14772
HYPERSONIC FLOW OF A VISCOUS HEAT-CONDUCTING CHEMICALLY REACTING GAS PAST BODIES OVER A WIDE RANGE OF REYNOLDS NUMBERS [GIPERZVUKOVOE OBTEKANIE TEL VIAZKIM TEPLOPROVODNYM KHIMICHESKI REAGIRUIUSHCHIM GAZOM V SHIROKOM DIAPAZONE CHISEL REINOL'DSA]
G. A. TIRSKII IN: Mechanics and scientific-technological progress. Volume 2. Moscow, Izdatel'stvo Nauka, 1987, p. 261-281. In Russian. refs
A fast and memory-efficient computer algorithm for solving two-dimensional problems of supersonic and hypersonic flow past bodies is described which involves solving full stationary equations of a viscous shock layer at Mach larger than 1 over a wide range of Reynolds numbers. The method is based on global iterations with relaxation of the pressure and head shock angle. Results are presented for hypersonic flow past spheres and blunt cones of large length (several hundred bluntness radii) at Reynolds numbers up to 10 to the eighth - 10 to the ninth. V.L.

A89-14951#
ITERATIVE COMPUTATIONS ON S1/S2 STREAMSURFACES IN CAS TRANSONIC COMPRESSOR ROTOR AND COMPARISON WITH L2F MEASUREMENTS
XIAOLU ZHAO, LISEN QIN, and CHUNG-HUA WU (Chinese Academy of Sciences, Institute of Engineering Thermophysics, Beijing, People's Republic of China) Journal of Engineering Thermophysics (ISSN 0253-231X), vol. 9, May 1988, p. 119-124. In Chinese, with abstract in English. refs
Based on Wu's (1980) general theory for turbomachinery, a quasi-three-dimensional solution method has been developed for computing the transonic flow field in the CAS transonic compressor rotor. This solution was obtained by iterative calculations between 11 S1 stream surfaces of revolution and an S2m stream surface. In order to make the convergent procedure stable, suitable damping has been imposed. The comparisons of computed results with L2F measurements (at 80 or 90 percent of design speed and with pressure ratios corresponding to peak-efficiency operating conditions) demonstrate the capacity of the present iterative system in transonic turbomachinery flow. Author

A89-14976*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
INVESTIGATION OF OSCILLATING CASCADE AERODYNAMICS BY AN EXPERIMENTAL INFLUENCE COEFFICIENT TECHNIQUE
DANIEL H. BUFFUM (NASA, Lewis Research Center, Cleveland, OH) and SANFORD FLEETER (Purdue University, West Lafayette, IN) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 12 p. Previously announced in STAR as N88-28041. refs
(AIAA PAPER 88-2815)
Fundamental experiments are performed in the NASA Lewis Transonic Oscillating Cascade Facility to investigate the torsion mode unsteady aerodynamics of a biconvex airfoil cascade at realistic values of the reduced frequency for all interblade phase angles at a specified mean flow condition. In particular, an unsteady aerodynamic influence coefficient technique is developed and utilized in which only one airfoil in the cascade is oscillated at a time and the resulting airfoil surface unsteady pressure distribution measured on one dynamically instrumented airfoil. The unsteady aerodynamics of an equivalent cascade with all airfoils oscillating at a specified interblade phase angle are then determined through a vector summation of these data. These influence coefficient determined oscillating cascade data are correlated with data obtained in this cascade with all airfoils oscillating at several interblade phase angle values. The influence coefficients are then utilized to determine the unsteady aerodynamics of the cascade for all interblade phase angles, with these unique data subsequently correlated with predictions from a linearized unsteady cascade model. Author

A89-14980*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
HIGH SPEED INLET CALCULATIONS WITH REAL GAS EFFECTS
WILLIAM J. COIRIER (NASA, Lewis Research Center; Sverdrup Technology, Inc., Cleveland, OH) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 7 p. Previously announced in STAR as N88-26336. refs
(Contract NAS3-24105)
(AIAA PAPER 88-3076)
A 2-D steady-state Navier-Stokes solver has been upgraded to include the effects of frozen and equilibrium air chemistry for applications to high speed flight vehicles. To provide a computationally economical first order approximation to the high temperature physics, variable thermodynamic data is used for the chemically frozen mode to allow for a variation with temperature of the air specific heats and enthalpy. For calculations involving air in chemical equilibrium, a specially modified version of the NASA Lewis Chemical Equilibrium Code, CEC, is used to compute the chemical composition and resultant thermochemical properties. The upgraded solver is demonstrated by comparing results from calorically perfect (C sub p=constant), thermally perfect (frozen) and equilibrium air calculations for a variety of geometries, and flight Mach numbers. Author

A89-14982*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
THREE DIMENSIONAL SIMULATION OF AN UNDEREXPANDED JET INTERACTING WITH A SUPERSONIC CROSS FLOW
SHENG-TAO YU and JIAN-SHUN SHUEN (NASA, Lewis Research Center; Sverdrup Technology, Inc., Cleveland, OH) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 12 p. refs
(AIAA PAPER 88-3181)
A new three-dimensional computational fluid dynamics (CFD) code has been developed to simulate the flow fields of an underexpanded jet transversely injected into supersonic air stream inside the combustors of ramjets and scramjets. The code employs an implicit finite volume, lower-upper (LU) time marching method to solve the complete three-dimensional Navier-Stokes equations in a fully-coupled and very efficient manner. Results clearly depict the flow characteristics, including the shock structure, separated flow regions around the injector, and the wake flow in the lee of the injector. Author

A89-14984#
A COMPARISON OF NAVIER-STOKES AND MONTE CARLO METHODS
LYLE N. LONG (Lockheed Aeronautical Systems Co., Burbank, CA) AIAA, Thermophysics, Plasmadynamics, and Lasers Conference, San Antonio, TX, June 27-29, 1988. 14 p. refs
(AIAA PAPER 88-2730)
As interest in hypersonic flight is once again growing, this is

an opportune time to reexamine the applicability and limitations of the gasdynamic models. It is particularly important to address the flow regime between noncontinuum and continuum gasdynamics (the slip or transitional regime) because these flows may be common on future hypersonic vehicles and they are very poorly understood. This paper uses a full Navier-Stokes method and a molecular simulation method to analyze an indented nose cone at hypersonic Mach numbers. The Navier-Stokes code is based upon a finite-volume, explicit Runge-Kutta time-marching scheme. The molecular simulation method is based on the Direct Simulation Monte Carlo (DSMC) method. Theoretical and numerical differences between the two methods are discussed. Heat transfer predictions are compared to experimental data. Author

A89-15021* New York Univ., New York.
AN EXACT INVERSE METHOD FOR SUBSONIC FLOWS
PRABIR DARIPA (New York University, NY) Quarterly of Applied Mathematics (ISSN 0033-569X), vol. 46, Sept. 1988, p. 505-526. refs
(Contract DE-AC02-76ER-03077; NSG-1617; AF-AFOSR-83-0336)

A new inverse method for the aerodynamic design of airfoils is presented for subcritical flows. The pressure distribution in this method can be prescribed as a function of the arclength of the still unknown body. It is shown that this inverse problem is mathematically equivalent to solving only one nonlinear boundary value problem subject to known Dirichlet data on the boundary. K.K.

A89-15654
A LOCAL MULTIGRID STRATEGY FOR VISCOUS TRANSONIC FLOWS AROUND AIRFOILS
F. BASSI (Milano, Politecnico, Milan, Italy), F. GRASSO (Roma I, Universita, Rome, Italy), and M. SAVINI (CNR, CNPM, Peschiera Borromeo, Italy) IN: GAMM-Conference on Numerical Methods in Fluid Mechanics, 7th, Louvain-la-Neuve, Belgium, Sept. 9-11, 1987, Proceedings. Brunswick, Federal Republic of Germany, Friedr. Vieweg und Sohn, 1988, p. 17-24. MPI-supported research. refs
(Contract CNR-PFE2-86,00758,59)

A grid embedding technique for viscous flow computations has been developed. The method exploits a local multigrid strategy, and the mesh embedding procedure is on a cell-by-cell basis. Second-order interpolation is used to obtain interface boundary conditions. Computations of viscous flows around NACA0012 and RAE2822 airfoils are presented. The method yields accurate results with a rather coarse grid, and the interface treatment does not produce spurious oscillations. Author

A89-15656
UNSTEADY TRANSONIC FLOWS PAST AIRFOILS USING A FAST IMPLICIT GODUNOV TYPE EULER SOLVER
A. BRENNEIS and A. EBERLE (Messerschmitt-Boelkow-Blohm GmbH, Munich, Federal Republic of Germany) IN: GAMM-Conference on Numerical Methods in Fluid Mechanics, 7th, Louvain-la-Neuve, Belgium, Sept. 9-11, 1987, Proceedings. Brunswick, Federal Republic of Germany, Friedr. Vieweg und Sohn, 1988, p. 37-47. refs

Numerical techniques for computing the inviscid transonic flow over a harmonically oscillating airfoil with rigid-body motion are described and demonstrated. The governing equations for the model, the explicit time step, the implicit relaxation method, the boundary conditions, and the grid-generation procedure are briefly characterized, and results for a NACA 64A010 configuration with harmonically varying angle of attack are presented in extensive tables and graphs and discussed in detail. T.K.

A89-15665
APPLICATION OF A 3-D TIME-MARCHING EULER CODE TO TRANSONIC TURBOMACHINERY FLOW
H. W. HAPPEL and B. STUBERT (MTU Motoren- und Turbinen-Union Muenchen GmbH, Munich, Federal Republic of Germany) IN: GAMM-Conference on Numerical Methods in Fluid Mechanics, 7th, Louvain-la-Neuve, Belgium, Sept. 9-11, 1987, Proceedings. Brunswick, Federal Republic of Germany, Friedr. Vieweg und Sohn, 1988, p. 120-129. BMFT-supported research.

This paper describes a time-marching finite-volume method to obtain the steady three-dimensional Euler solution within a stator or rotor blade row. The accuracy and computational efficiency of the computer code are demonstrated for realistic blade geometries. The comparison with measurements shows good agreement for turbine and compressor blades. Author

A89-15666
A TREATMENT OF MULTIVALUE SINGULARITY OF SHARP CORNER IN INVISCID HYPERSONIC FLOW
WEI JI (Chinese Academy of Sciences, Institute of Mechanics, Beijing, People's Republic of China) IN: GAMM-Conference on Numerical Methods in Fluid Mechanics, 7th, Louvain-la-Neuve, Belgium, Sept. 9-11, 1987, Proceedings. Brunswick, Federal Republic of Germany, Friedr. Vieweg und Sohn, 1988, p. 130-137. refs

Based on the steady Prandtl-Meyer solution, an approximate method is presented for dealing with the multivalue singularity at a sharp corner in an inviscid hypersonic flow. The method is used to treat the corner point of the step in a Mach-3 wind tunnel. The excessive numerical error caused by numerical method is successfully reduced. The occurrence of a spurious entropy layer above the step is avoided. More physically reasonable results are obtained. Author

A89-15672
NUMERICAL SIMULATION OF THE STRONG INTERACTION BETWEEN A COMPRESSOR BLADE CLEARANCE JET AND STALLED PASSAGE FLOW
N. M. MCDOUGALL and W. N. DAWES (Cambridge University, England) IN: GAMM-Conference on Numerical Methods in Fluid Mechanics, 7th, Louvain-la-Neuve, Belgium, Sept. 9-11, 1987, Proceedings. Brunswick, Federal Republic of Germany, Friedr. Vieweg und Sohn, 1988, p. 183-190. refs

A three-dimensional Navier-Stokes solver for turbomachine flows is developed and demonstrated. Consideration is given to the numerical solution procedure (based on a finite-volume formulation), the boundary conditions, the preprocessed algorithm, and the multigrid convergence acceleration. Results for a strongly separated flow in a compressor-blade row are presented graphically and shown to be in good agreement with experimental data obtained in the low-speed axial-compressor test facility at Whittle Laboratory. T.K.

A89-15679
NAVIER-STOKES SOLUTION FOR TRANSONIC FLOW OVER WINGS
BERNHARD MUELLER and ARTHUR RIZZI (Fkygtekniska Forsoksanstalten, Bromma, Sweden) IN: GAMM-Conference on Numerical Methods in Fluid Mechanics, 7th, Louvain-la-Neuve, Belgium, Sept. 9-11, 1987, Proceedings. Brunswick, Federal Republic of Germany, Friedr. Vieweg und Sohn, 1988, p. 247-255. Research supported by the Styrelsen for Teknisk Utveckling. refs

A three-dimensional finite-volume Navier-Stokes solver has been developed to simulate laminar and turbulent compressible flow over quadrilateral wings. The code is applied to compute (1) laminar primary and secondary separation vortices at transonic speeds over a 65-deg-swept delta wing with round leading edges and cropped tips and (2) attached turbulent flow around the ONERA M6 wing. Author

A89-15686
EULER FLOWS IN HYDRAULIC TURBINES AND DUCTS RELATED TO BOUNDARY CONDITIONS FORMULATION
A. SAXER, H. FELICI, C. NEURY, and I. L. RYHMING (Lausanne, Ecole Polytechnique Federale, Switzerland) IN: GAMM-Conference on Numerical Methods in Fluid Mechanics, 7th, Louvain-la-Neuve, Belgium, Sept. 9-11, 1987, Proceedings.

Brunswick, Federal Republic of Germany, Friedr. Vieweg und Sohn, 1988, p. 343-354. refs

The flow in a Francis turbine runner with a vortical three-dimensional velocity field at the entrance is considered. The governing equations and numerical procedure are described as well as boundary conditions. K.K.

A89-15689

AN IMPLICIT METHOD FOR THE COMPUTATION OF UNSTEADY INCOMPRESSIBLE VISCOUS FLOWS

H. SCHUETZ and F. THIELE (Berlin, Technische Universitaet, Federal Republic of Germany) IN: GAMM-Conference on Numerical Methods in Fluid Mechanics, 7th, Louvain-la-Neuve, Belgium, Sept. 9-11, 1987, Proceedings. Brunswick, Federal Republic of Germany, Friedr. Vieweg und Sohn, 1988, p. 371-378. DFG-supported research. refs

A finite-difference method for the solution of the two-dimensional incompressible, unsteady Navier-Stokes equations in terms of the stream function is presented. The implicit procedure applies backward time and central space approximation to the fourth-order differential equation. Newton linearization together with the direct solution of the linear system of finite-difference equations leads to a successive correct solution to the unsteady Navier-Stokes equations. For the circular cylinder and the symmetric airfoil, the unsteady flow is numerically calculated and compared with available data. Author

A89-15690

COMPUTATION OF VISCOUS SUPERSONIC FLOW AROUND BLUNT BODIES

R. SCHWANE and D. HAENEL (Aachen, Rheinisch-Westfaelische Technische Hochschule, Federal Republic of Germany) IN: GAMM-Conference on Numerical Methods in Fluid Mechanics, 7th, Louvain-la-Neuve, Belgium, Sept. 9-11, 1987, Proceedings. Brunswick, Federal Republic of Germany, Friedr. Vieweg und Sohn, 1988, p. 379-386. refs

The three-dimensional Navier-Stokes equations are solved with an upwind relaxation scheme combined with a shock fitting procedure. The three-dimensional grid generation is carried out by an optimization procedure. Computational results are presented for supersonic flow around two blunt body configurations. Author

A89-15695

A METHOD FOR THE SOLUTION OF THE REYNOLDS-AVERAGED NAVIER-STOKES EQUATIONS ON TRIANGULAR GRIDS

N. P. WEATHERILL, L. J. JOHNSTON, A. J. PEACE, and J. A. SHAW (Aircraft Research Association, Ltd., Bedford, England) IN: GAMM-Conference on Numerical Methods in Fluid Mechanics, 7th, Louvain-la-Neuve, Belgium, Sept. 9-11, 1987, Proceedings. Brunswick, Federal Republic of Germany, Friedr. Vieweg und Sohn, 1988, p. 418-425. Research supported by the Aircraft Research Association, Ltd. refs

A numerical method for the solution of the Reynolds-averaged Navier-Stokes equations is presented. The approach, which utilizes the concept of a triangular mesh and a finite volume algorithm for the governing flow equations, is demonstrated by simulating turbulent flow over a single aerofoil and laminar flow over a two-element high lift aerofoil/flap configuration. Author

A89-15696

EULER SOLVERS FOR HYPERSONIC AEROTHERMODYNAMIC PROBLEMS

C. WEILAND, M. PFITZNER, and G. HARTMANN (Messerschmitt-Boelkow-Blohm GmbH, Munich, Federal Republic of Germany) IN: GAMM-Conference on Numerical Methods in Fluid Mechanics, 7th, Louvain-la-Neuve, Belgium, Sept. 9-11, 1987, Proceedings. Brunswick, Federal Republic of Germany, Friedr. Vieweg und Sohn, 1988, p. 426-433. refs

Euler solvers for the prediction of hypersonic flow fields are considered. Time-marching and space-marching methods are developed including equilibrium real gas effects. The equations of state used are discussed. For the space-marching method some aspects of the equations and the solution algorithm are presented in detail. Calculations of the flow fields around and through real configurations are given. Author

A89-15697

COUPLED EULERIAN AND LAGRANGIAN NUMERICAL METHODS FOR THE COMPUTATION OF THE FLOWFIELD AROUND AN AIRFOIL

A. ZERVOS and S. VOUTSINAS (Athens, National Technical University, Greece) IN: GAMM-Conference on Numerical Methods in Fluid Mechanics, 7th, Louvain-la-Neuve, Belgium, Sept. 9-11, 1987, Proceedings. Brunswick, Federal Republic of Germany, Friedr. Vieweg und Sohn, 1988, p. 434-441. refs

A numerical method is proposed for the prediction of the incompressible flowfield around an airfoil. The flowfield is decomposed into two regions. The Eulerian-FEM is used in the inner region and the Lagrangian vortex particle method in the outer region. The two regions are connected with an integral equation on a common smooth boundary which is solved by the boundary element method. In order to have a grid-free formulation in the outer region, vorticity is approximated there as a sum of vortex particles. All vortex particles are displaced by using the transport equations. A local diffusion process is incorporated in the numerical procedure. The first results for the starting flow of an airfoil show that the method is promising. Author

A89-15698

GAMM WORKSHOP - NUMERICAL SIMULATION OF COMPRESSIBLE NAVIER-STOKES FLOWS PRESENTATION OF PROBLEMS AND DISCUSSION OF RESULTS

M. O. BRISTEAU (Institut National de Recherche en Informatique et Automatique, Le Chesnay, France), R. GLOWINSKI (Houston, University, TX), J. PERIAUX (Avions Marcel Dassault-Breguet Aviation, S.A., Saint-Cloud, France), and H. VIVIAND (ONERA, Chatillon-sous-Bagneux, France) IN: GAMM-Conference on Numerical Methods in Fluid Mechanics, 7th, Louvain-la-Neuve, Belgium, Sept. 9-11, 1987, Proceedings. Brunswick, Federal Republic of Germany, Friedr. Vieweg und Sohn, 1988, p. 442-450. refs

The GAMM workshop compared the accuracy and efficiency of Navier-Stokes solvers on selected external and internal flow problems using different numerical approaches. The test problems were defined on simple analytical geometries and correspond to two-dimensional laminar flows with moderate gradients. This paper presents an overview of the test problems, of the comparisons made in the workshop, and of the main conclusions. C.D.

A89-15967*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

AUTOMATED DESIGN OF CONTROLLED-DIFFUSION BLADES

J. M. SANZ (NASA, Lewis Research Center, Cleveland, OH) ASME, Transactions, Journal of Turbomachinery (ISSN 0889-504X), vol. 110, Oct. 1988, p. 540-544. Previously announced in STAR as N88-13304. refs

(ASME PAPER 88-GT-139)

A numerical automation procedure has been developed to be used in conjunction with an inverse hodograph method for the design of controlled diffusion blades. With this procedure a cascade of airfoils with a prescribed solidity, inlet Mach number, inlet air flow angle, and air flow turning can be produced automatically. The trailing edge thickness of the airfoil, an important quantity in inverse methods, is also prescribed. The automation procedure consists of a multidimensional Newton iteration in which the objective design conditions are achieved by acting on the hodograph input parameters of the underlying inverse code. The method, although more general in scope, is applied in this paper to the design of axial flow compressor blade sections, and a wide range of examples is presented. Author

A89-16091#

COMBINED TRANSLATION/PITCH MOTION - A NEW AIRFOIL DYNAMIC STALL SIMULATION

D. FAVIER, A. AGNES, C. BARBI, and C. MARESCA (CNRS;

Aix-Marseille II, Universite, Marseille, France) Journal of Aircraft (ISSN 0021-8669), vol. 25, Sept. 1988, p. 805-814. Sponsorship: Service Technique des Programmes Aeronautiques. Previously cited in issue 19, p. 2940, Accession no. A87-44915. refs (Contract STPA-86-95011)

A89-16092*# Notre Dame Univ., IN.
LEADING-EDGE VORTEX DYNAMICS ON A SLENDER OSCILLATING WING
YOUNG-WHOON JUN and ROBERT C. NELSON (Notre Dame, University, IN) Journal of Aircraft (ISSN 0021-8669), vol. 25, Sept. 1988, p. 815-819. Research supported by the University of Notre Dame. Previously cited in issue 08, p. 1037, Accession no. A87-22566. refs
(Contract NAG1-727)

A89-16093*# Old Dominion Univ., Norfolk, VA.
GRID GENERATION AND INVISCID FLOW COMPUTATION ABOUT A CRANKED-WINGED AIRPLANE GEOMETRY
L.-E. ERIKSSON (Old Dominion University, Norfolk, VA), R. E. SMITH (NASA, Langley Research Center, Hampton, VA), M. R. WIESE, and N. FARR (Computer Sciences Corp., Hampton, VA) (Computational Fluid Dynamics Conference, 8th, Honolulu, HI, June 9-11, 1987, Technical Papers, p. 272-282) Journal of Aircraft (ISSN 0021-8669), vol. 25, Sept. 1988, p. 820-826. Previously cited in issue 18, p. 2800, Accession no. A87-42074. refs

A89-16094#
FINNED, MULTIBODY AERODYNAMIC INTERFERENCE AT TRANSONIC MACH NUMBERS
CHARLES J. COTTRELL and LAWRENCE E. LIJEWSKI (USAF, Armament Laboratory, Eglin AFB, FL) Journal of Aircraft (ISSN 0021-8669), vol. 25, Sept. 1988, p. 827-834. Previously cited in issue 21, p. 3339, Accession no. A87-49096. refs

A89-16095*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
SPUR-TYPE INSTABILITY OBSERVED ON NUMERICALLY SIMULATED VORTEX FILAMENTS
VERNON J. ROSSOW (NASA, Ames Research Center, Moffett Field, CA) Journal of Aircraft (ISSN 0021-8669), vol. 25, Sept. 1988, p. 835-841. refs

An instability observed on vortex filaments during numerical simulations of the three-dimensional, time-dependent dynamics of vortex wakes is studied to determine when and why it occurs. It is concluded that the observed instability is a consequence of the use of straight-line vortex segments of finite length to model continuously curving vortex filaments. The instability appears to occur only when the link length is a sizable fraction of the vortex span and, therefore, is not expected in an experiment. Guidelines are then given that help avoid numerical instabilities when vortex filaments are used in flow simulations. Author

A89-16096#
NAVIER-STOKES SIMULATION FOR FLOW PAST AN OPEN CAVITY
DEEPAK OM (Boeing Co., Seattle, WA) Journal of Aircraft (ISSN 0021-8669), vol. 25, Sept. 1988, p. 842-848. Research supported by the Boeing Commercial Airplane Co. Previously cited in issue 05, p. 586, Accession no. A87-17887. refs

A89-16097*# Ohio State Univ., Columbus.
EXPERIMENTAL AERODYNAMIC CHARACTERISTICS OF AN NACA 0012 AIRFOIL WITH SIMULATED GLAZE ICE
M. B. BRAGG (Ohio State University, Columbus) Journal of Aircraft (ISSN 0021-8669), vol. 25, Sept. 1988, p. 849-854. NASA-supported research. refs

The effect of a simulated glaze-ice accretion on the aerodynamic performance of a NACA 0012 airfoil was studied experimentally. Two ice shapes were tested: one from an experimentally measured accretion, and one from an accretion predicted using a computer model given the same icing conditions. Lift, drag, and pitching moment were measured for the airfoil with both smooth and rough ice shapes. The ice shapes caused large lift and drag penalties, primarily due to large separation bubbles. Surface pressure distributions clearly showed the regions of separated flow. The aerodynamic performance of the two shapes compared well at positive, but not negative, angles of attack. Author

A89-16110#
DEVELOPMENT OF AIRFOIL WAKE IN A LONGITUDINALLY CURVED STREAM
V. RAMJEE, E. G. TULAPURKARA, and R. RAJASEKAR (Indian Institute of Technology, Madras, India) AIAA Journal (ISSN 0001-1452), vol. 26, Aug. 1988, p. 948-953. refs

Measurements of mean velocity and longitudinal turbulent fluctuations in the wake of an airfoil are carried out in a straight duct and in two curved ducts. The velocity profiles of the wake in the curved ducts are asymmetric. The thickness of the shear layer is higher on the inner side than on the outer side. The inner side is the portion of the flow between the centerline of the curved duct and the wall nearer to the center of the curvature. The intensity of the longitudinal turbulence fluctuations is enhanced on the inner side of the flow and not appreciably affected on the outer side of the flow between the centerline and the outer wall of the curved duct. Author

A89-16114#
COMPUTATION OF UNSTEADY TRANSONIC FLOWS BY THE SOLUTION OF EULER EQUATIONS
V. VENKATAKRISHNAN (AS & M, Inc., Hampton, VA) and A. JAMESON (Princeton University, NJ) (Computational Fluid Dynamics Conference, 7th, Cincinnati, OH, July 15-17, 1985, Technical Papers, p. 242-253) AIAA Journal (ISSN 0001-1452), vol. 26, Aug. 1988, p. 974-981. Previously cited in issue 19, p. 2743, Accession no. A85-40949. refs

A89-16258*#
MEASUREMENTS OF FLUCTUATIONS OF THERMODYNAMIC VARIABLES AND MASS FLUX IN SUPERSONIC TURBULENCE
PAMELA LOGAN IN: Current trends in turbulence research; Proceedings of the Fifth Beersheba International Seminar on Magnetohydrodynamics Flow and Turbulence, Beersheba, Israel, Mar. 2-6, 1987. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 116-140. NASA-supported research. refs

The paper describes an experiment in which hot-wire anemometry and laser-induced fluorescence are combined to produce measurements of fluctuations of temperature, density, pressure, and streamwise velocity, and their correlations. Implications of the measurements for the structure of compressible turbulence and for turbulence modeling are considered. K.K.

A89-16313#
CALCULATION OF COMPRESSIBLE LAMINAR SEPARATED FLOWS OVER A BODY OF REVOLUTION AT ANGLE OF ATTACK
AN-MING WU (National Taiwan University, Taipei, Republic of China), ZUU-CHANG HONG (National Central University, Chungli, Republic of China), and CHENG-SHENG WANG (Chungshan Institute of Science and Technology, Lungtan, Republic of China) Chinese Society of Mechanical Engineers, Journal (ISSN 0257-9731), vol. 9, April 1988, p. 85-95. refs

A computational procedure is developed to investigate three-dimensional laminar separated flows past bodies of revolution by solving the compressible Navier-Stokes equations. The differential equations are discretized by the finite-volume formulation to achieve simplicity and accuracy. The difference equations are then integrated by the MacCormack implicit time-marching scheme. The computed results are presented for a hemisphere cylinder at Mach 1.2, angle of attack 19 deg, and Reynolds numbers 300 and 4.5 x 10 to the 5th. Author

A89-16325
A THREE-DIMENSIONAL FIELD-INTEGRAL METHOD FOR THE CALCULATION OF TRANSONIC FLOW ON COMPLEX CONFIGURATIONS - THEORY AND PRELIMINARY RESULTS

P. M. SINCLAIR (British Aerospace, PLC, Military Aircraft Div., Brough, England) Aeronautical Journal (ISSN 0001-9240), vol. 92, June-July 1988, p. 235-241. refs

A three-dimensional integral formulation for the solution of the full potential equation and the associated numerical algorithm, the field-integral method, are presented. Results are presented for the flow over body shapes and a complex winglet configuration, and are compared with existing transonic methods and experiments with good agreement. Author

A89-16352
TOTAL PRESSURE LOSS IN SUPERSONIC NOZZLE FLOWS WITH CONDENSATION - NUMERICAL ANALYSES
SOON BUM KWON (Kyungpook National University, Taegu, Republic of Korea), KAZUYASU MATSUO, SHIGETOSHI KAWAGOE, and SHIGERU MATSUO (Kyushu University, Fukuoka, Japan) JSME International Journal, Series II (ISSN 0914-8817), vol. 31, Feb. 1988, p. 16-21. refs

A method is presented for calculating a loss in total pressure due to condensation generated by a rapid expansion of moist air in a supersonic circular nozzle. The loss in total pressure has been determined from the amount of increment in the entropy produced as the result of the irreversibility in the nonequilibrium condensation process. Based on the calculated results, the effects of the degree of supersaturation of moist air and the shape of the nozzle on the total pressure loss have been clarified quantitatively. Author

A89-16436#
A WALL PRESSURE CORRECTION METHOD FOR CLOSED SUBSONIC WIND TUNNEL TEST SECTIONS
WENHUA ZHANG (Nanjing Aeronautical Institute, People's Republic of China) and GERHARD SCHULZ (DFVLR, Cologne, Federal Republic of Germany) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 9, Oct. 1988, p. B454-B461. In Chinese, with abstract in English. refs

A wall pressure correction method for closed rectangular subsonic test sections is presented. This paper gives the calculation of wall interference by the method of influence function. Experimental examinations of the method give good results on high lift measurements, as well as the blockage correction in the presence of a large wake region behind the model. The data provided by this paper are applicable for practical purposes. Author

A89-16447#
EXPERIMENTAL INVESTIGATION OF GROOVED WALL TECHNIQUE FOR SUBSONIC DIFFUSERS
FENG BAO (Shenyang Institute of Aeronautical Engineering, People's Republic of China) and XIJUNG HUANG (Beijing University of Aeronautics and Astronautics, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 9, Oct. 1988, p. B521-B524. In Chinese, with abstract in English. refs

An effective inner boundary layer separation control method was investigated experimentally. The influence of grooving treatment on the overall performance of the subsonic diffuser was studied, emphasizing the mechanisms of the boundary layer (BL) separation phenomenon and of the separation delay effect of grooves. It was found that the BL separation process is closely related to the development and distributions of vorticities within the BL, while the groove treatment is aimed at controlling the vortex distributions to delay BL separation. The method could be useful to the choice of a diffuser separation control method. C.D.

A89-16459#
TWO-DIMENSIONAL NUMERICAL ANALYSIS FOR INLETS AT SUBSONIC THROUGH HYPERSONIC SPEEDS
R. H. BUSH, P. G. VOGEL, W. P. NORBY, and B. A. HAEFFELE (McDonnell Douglas Corp., Saint Louis, MO) Journal of Propulsion and Power (ISSN 0748-4658), vol. 4, Nov.-Dec. 1988, p. 549-556. Previously cited in issue 20, p. 3142, Accession no. A87-45184. refs

A89-16463#
DIRECT OPTIMIZATION METHOD FOR ESTIMATION OF SUPERSONIC FLOW TURBINE STATOR PROFILES
RHONALD M. JENKINS (Auburn University, AL) and JOHN A. HATFIELD (Morton Thiokol, Inc., Huntsville, AL) Journal of Propulsion and Power (ISSN 0748-4658), vol. 4, Nov.-Dec. 1988, p. 580-585. refs

An iterative technique for generating approximate wall contours of the diverging portions of a supersonic turbine stator flow passage is described. A pattern-search optimization method is used to minimize the difference between desired nozzle exit conditions and those exit conditions calculated with specified polynomial wall contours. Nozzle exit conditions are characterized by wall-to-wall distributions of flow angularity and flow Mach number. Results are compared with so-called 'perfect' nozzle contours calculated with assumed uniform throat mass flux conditions. Calculations are then extended to two simple models of nonuniform throat mass flux conditions, one of which is symmetric about the throat centerline and one of which is skewed toward a passage wall. Good matches of desired exit conditions and calculated exit conditions are obtained for each case. Flow angularity (deviations from the overall throughflow direction) appear to be more sensitive to the optimization procedure than Mach number, and care must be taken to insure sufficient downstream flow angle uniformity. Author

A89-16477#
CALCULATION OF INTERNAL FLOWS USING A SINGLE PASS PARABOLIZED NAVIER-STOKES ANALYSIS
ROBERT F. KUNZ, CHAE M. RHIE, and ROBERT E. MALECKI (United Technologies Corp., Pratt and Whitney Group, East Hartford, CT) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 15 p. refs
(AIAA PAPER 88-3005)

A computationally efficient single-pass subsonic parabolized Navier-Stokes (PNS) procedure is developed to analyze three-dimensional viscous flows through passages having an arbitrary cross section. The procedure incorporates a finite-volume formulation using a strong conservation form of the PNS equations in generalized curvilinear coordinates. It is shown that the inviscid pressure field distortions induced by the elliptic transport of inlet vorticity can be a significant component of streamwise pressure fluctuations. K.K.

A89-16478#
NUMERICAL INVESTIGATION OF HOT STREAKS IN TURBINES
BJORN KROUTHEN and MICHAEL B. GILES (MIT, Cambridge, MA) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 16 p. refs
(AIAA PAPER 88-3015)

A numerical method for the simulation of hot streak redistribution in a two-dimensional model of a turbine rotor is presented. Computations are carried out using three different flow comditions. The computed solution from all three test cases predicts a migration of hot gas to the pressure surface. K.K.

A89-16482#
PLANAR WAVE STABILITY MARGIN LOSS METHODOLOGY
WILLIAM G. STEENKEN (General Electric Co., Aircraft Engine Business Group, Cincinnati, OH) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 7 p. refs
(AIAA PAPER 88-3264)

The present method for estimating the loss of stability pressure ratio in aircraft engine faces due to inlet planar waves accounts for the rms of the stability-pressure ratio by integrating over the frequency range of interest. The methodology works equally well for planar waves with pure sinusoidal, harmonic, or random content, or any combination thereof. An analysis is undertaken of the effect of ingested landing-gear waves, and a generalized sensitivity curve is presented. O.C.

A89-16503*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
COMPUTATIONAL FLUID DYNAMICS FOR HYPERSONIC AIRBREATHING AIRPLANES
DOUGLAS L. DWOYER (NASA, Langley Research Center, Hampton, VA) GAMNI/SMAI Joint US-Europe Short Course on Hypersonics, Paris, France, Dec. 7-11, 1987, Paper. 61 p. refs

Computational fluid dynamics (CFD) technology is discussed as it relates to the computation of flowfields associated with hypersonic air-breathing airplanes. It is shown that the unique aerodynamics of these vehicles places different demands on CFD than reentry bodies do. The major areas requiring the use of advanced CFD techniques are the prediction of airframe aerodynamics, propulsion/airframe flowfield interaction, and internal engine flows. C.D.

A89-16527#
RESULTS OF AN INDUSTRY REPRESENTATIVE STUDY OF CODE TO CODE VALIDATION OF AXISYMMETRIC CONFIGURATIONS AT HYPERVELOCITY FLIGHT CONDITIONS
R. D. NEUMANN and J. L. PATTERSON (USAF, Flight Dynamics Laboratory, Wright-Patterson AFB, OH) AIAA, Thermophysics, Plasmadynamics and Lasers Conference, San Antonio, TX, June 27-29, 1988. 23 p. refs
(AIAA PAPER 88-2691)

A code-to-code comparison has been conducted on a generic, axisymmetric configuration at hypervelocity flow conditions in order to investigate the consistency of computations made by various parabolized Navier-Stokes (PNS) methods in operation within engineering organizations. This paper presents the results of this comparison and discusses a subsequent parametric study conducted by AFWAL to understand the reasons for differences between the submitted computations and the trends occurring with changes in computational technique. The paper further provides a documented data base against which future solutions can be compared as well as some guidance concerning how such studies should be conducted. Author

A89-16548#
FLOW FIELDS VISUALIZATION AROUND AN ISOLATED ROTOR IN THE VERTICAL AUTOROTATION AND THEIR APPLICATION TO PERFORMANCE PREDICTION
TOMOARI NAGASHIMA, TAKEICHIRYO HIROSE, and MASAYUKI OKAMOTO Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 36, no. 415, 1988, p. 380-388. In Japanese, with abstract in English. refs

A simplified wake model representing dominant tip and root helical vortices by definite numbers of the circular ring vortices is proposed. Numerical analyses of the flow fields are carried out. The numerical results are in good agreement with those obtained during visualization and wake surveys using a hot wire anemometer. K.K.

A89-16827#
A UNIFIED APPROACH TO THE OVERALL BODY MOTION STABILITY AND FLUTTER CHARACTERISTICS OF ELASTIC AIRCRAFT
QIANGANG LIU and YONGNIAN YANG (Northwestern Polytechnical University, Xian, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 9, Sept. 1988, p. A409-A417. In Chinese, with abstract in English. refs

A Green's function method for fully unsteady aerodynamics around three-dimensional bodies is outlined. This method can be used to evaluate the unsteady aerodynamic loads and derivatives of elastic aircraft. The equations of motion of an elastic aircraft are presented. A unified method is employed to analyze the overall body motion stability and the flutter characteristics of an elastic aircraft. Numerical examples show that the results of the present method are in good agreement with the results of other methods. Author

A89-16833#
PREDICTIONS OF SIDE-SPILLAGE OF SUPERSONIC RAMP INLETS
JIEYUAN PAN (Beijing University of Aeronautics and Astronautics, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 9, Sept. 1988, p. A451-A458. In Chinese, with abstract in English. refs

Based on supersonic linearized theory, the flow field in the region near the side-edge of the ramp is calculated, and then a formula of mass flow ratio of side-spillage is derived using the mass flow integral technique. Using Carafoli's method on the basis of Busemann's conical flow theory, the method and the computing curves for predicting the effects of sweepback side-plate are given. Comparison between the results of theoretical calculation and available experimental data shows the agreements are satisfactory. Author

A89-16835#
A DISCRETE VORTEX METHOD FOR SLENDER WING VORTEX-SHEET COMPUTATION
ZHONGRONG LU, KEFENG XU, and DINGDING XIN (Beijing Institute of Aeronautics and Astronautics, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 9, Sept. 1988, p. A475-A478. In Chinese, with abstract in English. refs

A discrete vortex method based on the slender body theory is presented. It involves setting vortex elements on the wing and point vortices on the free vortex sheets to simulate the flow pattern of the rolling up of vortices separated from the leading and trailing edges of a slender wing. A 74-deg swept delta wing and its modification equipped with vortex and apex flaps were chosen to calculate their separated vortex flow patterns. K.K.

A89-16881
LINEAR STABILITY ANALYSIS OF NONHOMENTROPIC, INVISCID COMPRESSIBLE FLOWS
V. D. DJORDJEVIC and L. G. REDEKOPP (Southern California, University, Los Angeles, CA) Physics of Fluids (ISSN 0031-9171), vol. 31, Nov. 1988, p. 3239-3245. refs
(Contract F49620-85-C-0080)

The linear stability of inviscid, compressible shear flows is studied. Some previous results for homentropic flows are extended to include adiabatic flows with variable temperature. Specific neutral solutions are obtained for both a shear layer and a wake in the subsonic regime that are stability boundaries. Unstable solutions are calculated for both streamwise and oblique disturbances in the shear layer flow. Other neutrally stable solutions are presented, which do not correspond to stability boundaries, describing stationary oscillations of supersonic shear flows. Author

A89-16930
CFD TECHNOLOGY FOR HYPERSONIC VEHICLE DESIGN
GERALD C. PAYNTER (Boeing Military Airplane Co., Seattle, WA) (George Washington University and NASA, Symposium on Advances and Trends in Computational Structural Mechanics and Fluid Dynamics, Washington, DC, Oct. 17-19, 1988) Computers and Structures (ISSN 0045-7949), vol. 30, no. 1-2, 1988, p. 39-46. refs

Because of the recent national interest in hypersonic aircraft, CFD technology with hypersonic application has been and is under intensive development at Boeing. A substantial CFD capability now exists that can be applied to a wide range of hypersonic flows, including those with finite-rate chemistry effects. The paper describes this hypersonic CFD development progress. It includes a review of the code features required for hypersonic application, the development approach, progress and a discussion of the limitations of the current physical modeling. Author

A89-16931* Virginia Polytechnic Inst. and State Univ., Blacksburg.
ZONAL TECHNIQUES FOR FLOWFIELD SIMULATION ABOUT AIRCRAFT
ROBERT W. WALTERS, TAEKYU REU (Virginia Polytechnic

Institute and State University, Blacksburg), WILLIAM D. MCGRORY (NASA, Langley Research Center, Hampton, VA), and JAMES L. THOMAS (George Washington University and NASA, Symposium on Advances and Trends in Computational Structural Mechanics and Fluid Dynamics, Washington, DC, Oct. 17-19, 1988) Computers and Structures (ISSN 0045-7949), vol. 30, no. 1-2, 1988, p. 47-54. refs
(Contract NAG1-776; NAG1-866)

A technique for performing conservative flowfield calculations on zonal meshes is described. The underlying flow solver is an implicit, upwind finite volume scheme which can incorporate either a perfect gas or an equilibrium air equation of state. Two different approaches which yield identical results, in terms of performing a conservative flux calculation on a zonal interface, are described and compared in terms of numerical efficiency. The capability of the method to handle relatively complex geometries is demonstrated by considering the flowfield about a model SR71 aircraft. Author

A89-16932
SOLUTIONS OF THE EULER EQUATIONS FOR TRANSONIC AND SUPERSONIC AIRCRAFT
G. VOLPE (Grumman Corporate Research Center, Bethpage, NY) (George Washington University and NASA, Symposium on Advances and Trends in Computational Structural Mechanics and Fluid Dynamics, Washington, DC, Oct. 17-19, 1988) Computers and Structures (ISSN 0045-7949), vol. 30, no. 1-2, 1988, p. 55-67. refs

A method for numerically computing steady incompressible flow fields about fighter-type aircraft at transonic and supersonic speeds is described. Discretization of the physical space around the aircraft is accomplished with a single-block H-O type mesh. The compressible Euler equations are discretized on this mesh using a fully conservative finite-volume method and are integrated to steady state via a five-stage Runge-Kutta scheme. Examples of flow fields computed on a variety of aircraft at subsonic, transonic and supersonic speeds are included. Author

A89-16944
THREE-DIMENSIONAL HYBRID FINITE VOLUME SOLUTIONS TO THE EULER EQUATIONS FOR SUPERSONIC VEHICLES
M. J. SICLARI (Grumman Corporate Research Center, Bethpage, NY) (George Washington University and NASA, Symposium on Advances and Trends in Computational Structural Mechanics and Fluid Dynamics, Washington, DC, Oct. 17-19, 1988) Computers and Structures (ISSN 0045-7949), vol. 30, no. 1-2, 1988, p. 233-246. refs

A new efficient numerical scheme is presented to solve the Euler equations about three-dimensional surfaces for supersonic flows. The unsteady Euler equations are cast in a spherical coordinate system. The method has been found (Jameson, 1986) to be successful in treating both wings and bodies. The present paper extends the application of this method to aircraft configurations with and without inlets. The computed results for two aircraft configurations are presented, illustrating both attached and separated flows. Author

A89-16952
ADAPTIVE SOLUTIONS OF THE EULER EQUATIONS USING FINITE QUADTREE AND OCTREE GRIDS
RAYMOND A. LUDWIG, JOSEPH E. FLAHERTY, FABIO GUERINONI, PEGGY L. BAEHMANN, and MARK S. SHEPHARD (Rensselaer Polytechnic Institute, Troy, NY) (George Washington University and NASA, Symposium on Advances and Trends in Computational Structural Mechanics and Fluid Dynamics, Washington, DC, Oct. 17-19, 1988) Computers and Structures (ISSN 0045-7949), vol. 30, no. 1-2, 1988, p. 327-336. Research supported by the General Dynamics Corp. refs
(Contract NSF DMC-86-03025)

Numerical techniques for the solution of the Euler equations for inviscid compressible flows are described and demonstrated. Particular attention is given to mesh generation, the finite-volume implementation, and adaptive mesh refinement. Numerical results for sample problems involving NACA 0012 airfoils are presented graphically and discussed in detail. T.K.

A89-17009
TRENDS IN CFD FOR AERONAUTICAL 3-D STEADY APPLICATIONS - THE DUTCH SITUATION
J. W. BOERSTOEL, A. E. P. VELDMAN, J. VAN DER VOOREN, and A. J. VAN DER WEES (Nationaal Lucht- en Ruimtevaartlaboratorium, Amsterdam, Netherlands) IN: Research in numerical fluid mechanics. Brunswick, Federal Republic of Germany, Friedr. Vieweg und Sohn, 1987, p. 1-17. refs

Progress made in computational three-dimensional steady aerodynamics software is discussed. Particular attention is given to the efficient aerodynamic design of the next generation of transport aircraft. The need for a modern vectorcomputer of the class CRAY-2, CRAY X-MP, NEC SX-2, ETA-10 is stressed. K.K.

A89-17015
EXPERIMENTAL FLOWFIELDS AROUND NACA 0012 AIRFOILS LOCATED IN SUBSONIC AND SUPERSONIC RAREFIED AIR STREAMS
J. ALLEGRE, M. RAFFIN (Societe pour l'Etude des Souffleries Supersoniques de l'Industrie Aeronautique, Paris, France), and J. C. LENGRAND (CNRS, Laboratoire d'Aerothermique, Meudon, France) IN: Numerical simulation of compressible Navier-Stokes flows. Brunswick, Federal Republic of Germany, Friedr. Vieweg und Sohn, 1987, p. 59-68. DRET-supported research.

The accuracy of recent numerical simulations of subsonic and supersonic flows is investigated by comparison with wind-tunnel measurements on a 4-cm-long NACA 0012 airfoil, obtained in the SR3 facility at Meudon at Mach 0.8 and 2 (corresponding to chord Reynolds numbers 73 and 106). The results are presented in extensive graphs and briefly characterized. Significant discrepancies between theoretical and experimental density distributions are found in the supersonic regime. T.K.

A89-17018
A MULTISTAGE MULTIGRID METHOD FOR THE COMPRESSIBLE NAVIER-STOKES EQUATIONS
F. GRASSO (Napoli, Universita, Naples, Italy), A. JAMESON, and L. MARTINELLI (Princeton University, NJ) IN: Numerical simulation of compressible Navier-Stokes flows. Brunswick, Federal Republic of Germany, Friedr. Vieweg und Sohn, 1987, p. 123-138. refs

The effects of changes in Reynolds number and angle of attack on the transonic or supersonic laminar flow around a NACA 0012 airfoil are investigated by means of numerical simulations. A three-stage explicit finite-volume method is applied, and the results are presented in extensive graphs. The accuracy and robustness of the present technique are demonstrated by comparison with published experimental data and numerical results obtained by other methods. T.K.

A89-17019
SOLUTIONS OF THE NAVIER-STOKES EQUATIONS FOR SUB- AND SUPERSONIC FLOWS IN RAREFIED GASES
WERNER HAASE (Dornier GmbH, Friedrichshafen, Federal Republic of Germany) IN: Numerical simulation of compressible Navier-Stokes flows. Brunswick, Federal Republic of Germany, Friedr. Vieweg und Sohn, 1987, p. 139-157. refs

For sub- and supersonic flows in rarefied gases, solutions of the Navier-Stokes equations are presented. The governing equations are solved by means of a finite-volume technique combined with a Runge-Kutta time-stepping scheme. The method is applied to two-dimensional isothermal flows around a NACA 0012 airfoil. Author

A89-17021
USING AN UNFACTORED IMPLICIT PREDICTOR-CORRECTOR METHOD - RESULTS WITH A RESEARCH CODE
W. KORDULLA (DFVLR, Goettingen, Federal Republic of Germany) IN: Numerical simulation of compressible Navier-Stokes

flows. Brunswick, Federal Republic of Germany, Friedr. Vieweg und Sohn, 1987, p. 165-182.

The practical implementation and utilization of a MacCormack-type implicit predictor-corrector scheme for the solution of the Navier-Stokes equations in the thin-layer formulation are discussed. Particular attention is given to the spatially unfactored solution of the implicit step by means of a Gauss-Seidel relaxation scheme. Sample results are presented in extensive graphs and briefly characterized. T.K.

A89-17022

IMPLICIT CENTRAL DIFFERENCE SIMULATION OF COMPRESSIBLE NAVIER-STOKES FLOW OVER A NACA0012 AIRFOIL

B. MUELLER, T. BERGLIND, and A. RIZZI (Flygtekniska Forsoksanstalten, Bromma, Sweden) IN: Numerical simulation of compressible Navier-Stokes flows. Brunswick, Federal Republic of Germany, Friedr. Vieweg und Sohn, 1987, p. 183-200. refs

The two-dimensional compressible transonic laminar flow over a NACA 0012 airfoil at Reynolds numbers 73, 106, and 500 is characterized, summarizing the results of Mueller (1986). The numerical simulations are based on the implicit central-difference scheme of Beam and Warming (1979). The algorithm, mesh, initial and boundary conditions, and numerical implementation are briefly discussed, and the results are presented in extensive graphs. T.K.

A89-17024

COMPRESSIBLE VISCOUS FLOW AROUND A NACA-0012 AIRFOIL

GOURI DHATT, DINH NGUYEN (Universite Laval, Quebec, Canada), and YVES SECRETAN IN: Numerical simulation of compressible Navier-Stokes flows. Brunswick, Federal Republic of Germany, Friedr. Vieweg und Sohn, 1987, p. 219-236. refs

Numerical techniques for the solution of the two-dimensional Navier-Stokes equations for viscous compressible flow around a NACA 0012 airfoil are developed and demonstrated. A finite-element model is derived, and the resulting nonlinear system of equations is solved by a multimesh technique in which a Newton-Raphson procedure is coupled with least-squares matrix decomposition. Results for four test problems are presented in extensive graphs and briefly characterized. T.K.

A89-17025

SOLUTION OF THE COMPRESSIBLE NAVIER-STOKES EQUATIONS FOR A DOUBLE THROAT NOZZLE

F. BASSI (Milano, Politecnico, Milan, Italy), F. GRASSO (Napoli, Universita, Naples, Italy), A. JAMESON, L. MARTINELLI (Princeton University, NJ), and M. SAVINI (CNR, Istituto sulla Propulsione e sull'Energetica, Peschiera Borromeo, Italy) IN: Numerical simulation of compressible Navier-Stokes flows. Brunswick, Federal Republic of Germany, Friedr. Vieweg und Sohn, 1987, p. 237-254. refs

(Contract CNR-84,02644,59)

An explicit multistage finite-volume method for the solution of the compressible Navier-Stokes equations has been applied to resolve the transonic flow through a double-throat nozzle. The accuracy and robustness of the method are shown by the accurate predictions of the extent of recirculation region, the effects of the Reynolds number on the shock structure, and the viscous-inviscid interaction. Author

A89-17063

SOUND GENERATED FROM THE INTERRUPTION OF A STEADY FLOW BY A SUPERSONICALLY MOVING AEROFOIL

J. E. FFOWCS WILLIAMS and Y. P. GUO (Cambridge University, England) Journal of Fluid Mechanics (ISSN 0022-1120), vol. 195, Oct. 1988, p. 113-135. Research supported by Rolls-Royce, PLC. refs

The level and directionality of the sound generated by the interruption of axial vortex-core flow by a supersonic blade have been studied. It is found that the peak sound pressures are independent of blade speed at high supersonic tip velocity, and that the energy radiated in the pulse attenuates as the supersonic speed increases. The results suggest that the higher the speed, the quieter will be the stage interaction sound of a contrarotating supersonic propeller. R.R.

A89-17121

ON THE THEORY OF OSCILLATING WINGS IN SONIC FLOW

LAZAR DRAGOS (Bucuresti, Universitatea, Bucharest, Rumania) Zeitschrift fuer angewandte Mathematik und Mechanik (ISSN 0044-2267), vol. 68, no. 8, 1988, p. 373-381. refs

The oscillatory motion of a wing in uniform sonic flow is investigated analytically. The fundamental solutions of Dragos (1983 and 1985) are applied, and the derivation of the governing equations is given in detail. Numerical results for the lift and moment coefficients of a rectangular flat plate (as functions of plate position) are presented in tables. T.K.

N89-11695# National Aeronautical Lab., Bangalore (India). Aerodynamics Div.

VORTICAL FLOWS ON THE LEE SURFACE OF DELTA WINGS

K. Y. NARAYAN and S. N. SESHADRI Jun. 1988 13 p

(TM-AE-8802) Avail: NTIS HC A03/MF A01

In the more than three decades of research on the lee surface flow of delta wings, starting from the identification of a single pair of counterrotating vortices springing from the leading edges, multiple vortices (secondary, tertiary), squashed vortices, vortices embedded in boundary layers, shock waves on the wing, on, underneath, and in between the vortices, shock wave boundary layer interaction, shock-induced separation, vortex bursting, asymmetric flow behavior and so on have been progressively discovered. In a gross sense, the geometric and free stream condition under which each of these flow phenomena occurs are reasonably well understood. However, the physical mechanisms underlying some of the flow phenomena remain far from clear. Significant progress has been made in recent times in the computation of the complex 3-D flows of delta wings; however, solutions for even the simplest flow type (flow with a pair of leading edge vortices) tax the resources of the largest available computer. Solutions for the more complex flow types including multiple separations, shocks, etc., appear to be realizable only in the distant future. Author

N89-11696 Old Dominion Univ., Norfolk, VA.

DIRECT SIMULATION OF HYPERSONIC TRANSITIONAL FLOWS OVER BLUNT SLENDER BODIES Ph.D. Thesis

VINCENT CUDA, JR. 1987 115 p

Avail: Univ. Microfilms Order No. DA8805575

Hypersonic transitional flow was studied using the Direct Simulation Monte Carlo method. The cylindrically blunted wedge and spherically blunted cone were examined for body half angles of 0, 5, and 10 degrees, at a flight velocity of 7.5 km/s, zero angle of incidence and altitudes of 70 to 100 km. Those geometries and flow conditions are important considerations for hypersonic vehicles currently under design. Surface chemistry was examined for diffuse, finite-catalytic surfaces. Nonequilibrium chemistry and nonequilibrium thermodynamics were considered for both configurations at all altitudes. Numerical simulations showed that rarefied gas effects, such as surface temperature jump and velocity slip, exist. Slip conditions were more significant for the axisymmetric cases and the onset of chemical dissociation occurred first for the two-dimensional configuration ay 96 km. Comparisons between the numerical simulation and viscous shocklayer calculations at the higher altitudes show significant differences in the calculated heat-transfer rate, body drag and flowfield structure. A comparison with hypersonic wind tunnel heat-transfer rate data showed good agreement. Dissert. Abstr.

N89-11697# National Aeronautical Lab., Bangalore (India). Fluid Mechanics Div.

FLOW VISUALISATION OF LEADING EDGE VORTICES ON A DELTA WING BY LASER SHEET TECHNIQUE

P. R. GOPINATH, S. SUNDARAM, K. T. MADHAVAN, S. R.

SIDDALINGAPPA, and K. S. YAJNIK Mar. 1988 21 p
(PD-FM-8804) Avail: NTIS HC A03/MF A01

A technique for illuminating a section of the flow past a delta wing uses a sheet of light obtained while expanding a laser beam by passing it through a cylindrical lens system. This report gives the results of the first application of this technique in the National Aeronautical Laboratory (NAL). A delta wing of aspect ratio 0.53 was placed in the NAL boundary layer tunnel at various incidences up to 35 deg and sideslip angles up to 20 deg. The freestream speed was 3 m/s, the chord Reynolds number being 0.53 x 10 to the 5th. Smoke was introduced upstream of the apex of the wing model. Vertical planes at 40 to 75 percent of chord were illuminated by the laser sheet by traversing the laser. The cross sections of the flow within the vortices above the delta wing model and also downstream of the trailing edge were photographed. The pictures show sharp vortex cores changing into diffused cores over a relatively small distance. There is a secondary instability of shear layer visibility in some photographs especially in the transition region. Author

N89-11698*# Vigyan Research Associates, Inc., Hampton, VA.
ADAPTIVE WALL TECHNOLOGY FOR MINIMIZATION OF WALL INTERFERENCES IN TRANSONIC WIND TUNNELS
STEPHEN W. D. WOLF Washington NASA Nov. 1988 30 p
(Contract NAS1-17919)
(NASA-CR-4191; NAS 1.26:4191) Avail: NTIS HC A03/MF A01 CSCL 01A

Modern experimental techniques to improve free air simulations in transonic wind tunnels by use of adaptive wall technology are reviewed. Considered are the significant advantages of adaptive wall testing techniques with respect to wall interferences, Reynolds number, tunnel drive power, and flow quality. The application of these testing techniques relies on making the test section boundaries adjustable and using a rapid wall adjustment procedure. A historical overview shows how the disjointed development of these testing techniques, since 1938, is closely linked to available computer support. An overview of Adaptive Wall Test Section (AWTS) designs shows a preference for use of relatively simple designs with solid adaptive walls in 2- and 3-D testing. Operational aspects of AWTS's are discussed with regard to production type operation where adaptive wall adjustments need to be quick. Both 2- and 3-D data are presented to illustrate the quality of AWTS data over the transonic speed range. Adaptive wall technology is available for general use in 2-D testing, even in cryogenic wind tunnels. In 3-D testing, more refinement of the adaptive wall testing techniques is required before more widespread use can be planned. Author

N89-11699 Colorado State Univ., Fort Collins.
COHERENT RAMAN SPECTROSCOPY FOR SUPERSONIC FLOW MEASUREMENTS Ph.D. Thesis
GREGORY CHARLES HERRING 1987 121 p
Avail: Univ. Microfilms Order No. DA8808946

Inverse Raman spectroscopy is used to measure non-intrusively the velocity, temperature, and density in a supersonic nitrogen gas flow. The present measurement uses two lasers, operating at different visible frequencies, to drive coherently the vibrational resonances in the flowing N2. A miniature wind tunnel produces the Mach 2 supersonic flow. Flow velocities are determined by measuring the flow induced Doppler shift of the Q-branch vibrational Raman transitions, while the rotational temperature is deduced from the relative strengths of two adjacent rotational lines in the Q-branch. Densities are obtained using the temperature measurement along with a measurement of the relative strength of a single rotational transition between the unknown flow density and a known reference density. Statistical measurement uncertainties are approximately 3 percent for velocities, 3 percent for temperatures, and 10 percent for densities. The measurements are in general agreement with the approximations of a one-dimensional supersonic flow model. Dissert. Abstr.

N89-11700 Arizona Univ., Tucson.
A TRUNCATION ERROR INJECTION APPROACH TO VISCOUS-INVISCID INTERACTION Ph.D. Thesis
BRIAN DEAN GOBLE 1988 153 p
Avail: Univ. Microfilms Order No. DA8809936

A numerical procedure is presented which uses the truncation error injection methodology to efficiently achieve accurate approximations to complex problems having disparate length scales in the context of solving viscous, transonic flow over an airfoil. The truncation error distribution is estimated using the solution on a coarse grid. Local fine grids are formed which improve the resolution in regions of large truncation error. A fast fourth-order accurate scheme is presented for interpolating and relating the solutions between the generalized curvilinear coordinate systems of the local and global grids. It is shown that accurate solutions can be obtained on global grids. It is shown that accurate solutions can be obtained on a global coarse grid with correction information obtained on local fine grids, which may or may not be topologically similar to the global grid as long as they are capable of resolving the local length scale. Dirichlet boundary conditions for the local grid yield the best results. The scheme also serves as the basis of a local refinement technique wherein a grid local to the nose of an airfoil is used to resolve a supersonic zone terminated by a shock and its interaction with a turbulent boundary layer. The solution on the local grid reveals details of the shock structure and a jet-like flow emanating from the root of the normal shock in the shock boundary layer interaction zone. Dissert. Abstr.

N89-11701 Tennessee Univ., Knoxville.
FREE WAKE ANALYSIS OF HELICOPTER ROTOR BLADES IN HOVER USING A FINITE VOLUME TECHNIQUE Ph.D. Thesis
RAMACHANDRAN KRISHNAMURTHI 1987 96 p
Avail: Univ. Microfilms Order No. DA8810370

In the computation of helicopter rotor flow fields, wake effects can be very important since each blade passes close to the wake produced by the preceding ones, cause a large local effect. Also, the vortical flow from the wake of a number of blade passages causes a large global effect. A method was developed which like integral methods does not constrain or spread the wake. Also, like finite difference methods, it can treat compressibility effects. This method was developed into a computer program for the computation of rotor flow fields in hover with free wakes. The method utilizes a finite volume potential flow technique. The basic approach involves modifying the potential flow wake treatment so that, within the numerical approximation, the momentum is conserved there as in the rest of the flow field. Results computed by this approach for the circulation and wake geometry are compared with experimentally measured data. Cases treated include subsonic and transonic flows, high and low aspect ratios, and two and four bladed rotor configurations. Dissert. Abstr.

N89-11703 Texas A&M Univ., College Station.
AN INVESTIGATION OF THE AERODYNAMIC CHARACTERISTICS OF PLANAR AND NON-PLANAR OUTBOARD WING PLANFORMS Ph.D. Thesis
DINESH ANTHONY NAIK 1987 233 p
Avail: Univ. Microfilms Order No. DA8808807

The outboard planforms of wings have been found to be of prime importance in studies of induced drag reduction. This conclusion is based on an experimental and theoretical study of the aerodynamic characteristics of planar and nonplanar outboard wing forms. Seven different configurations, baseline rectangular, elliptical, swept and tapered, swept and tapered with dihedral, swept and tapered with anhedral, rising arc, and dropping arc were investigated for two different spans. Span efficiencies as much as 20 percent greater than baseline can be realized with nonplanar wing forms. Optimization studies show that this advantage can be achieved along with a bending moment benefit. However, parasite drag and lateral stability estimations were not included in the analysis. The induced drag benefits are believed to accrue from the movement of vorticity away from the center of span line. Self-induced velocity components from the nonplanar lifting surface could conceivably alter the downwash distribution enough to lower the induced drag. The importance of wake curvature to account for the nonplanar alignment of the vortex sheet is also stressed. Flow surveys show the vortex roll-up. An extensive comparison of the separated flow behavior of the configurations is also documented with flow visualization photographs. Dissert. Abstr.

N89-11706 California Univ., Davis.
VELOCITY-SCALAR PDF METHODS FOR TURBULENT SHEAR FLOWS WITH TWO-POINT TIME SCALES Ph.D. Thesis
ARTHUR CHENG-HSIN WU 1987 81 p
Avail: Univ. Microfilms Order No. DA8809799

The transport equations for the pdf of velocity and scalars are analyzed in the Lagrangian and Eulerian frames. A closed form of the two-time pdf is developed. The time scale for the turbulent velocity fluctuations is determined from the integral of auto-correlation in time as being proportional to the Langrangian micro-time scale. Thus no equation for the dissipation rate or another quality for the calculation of time scale has to be solved together with the pdf equation. The method of numerical solution of the closed version of the pdf equation is a stochastic simulation technique, and the model is applied to two cases: a homogeneous turbulence and a turbulent plane mixing layer. Dissert. Abstr.

N89-11707 Rensselaer Polytechnic Inst., Troy, NY.
THE EFFECT OF INCIDENT WAKE FLOW ON BLUNT-BODY TRANSFER RATES Ph.D. Thesis
NEIL THOMAS VANDRESAR 1987 235 p
Avail: Univ. Microfilms Order No. DA8808200

Presently, a large degree of understanding is involved in predicting heat transfer rates at the leading edge of a gas turbine airfoil. A principal cause of this uncertainty is considered to be the improper modeling of the unsteady incident flow. The unsteady nature of the flow is primarily due to turbulent wakes from the upstream row which pass over the leading edge of the airfoils. The effect of a wake-generated, incident turbulent flow upon the local transfer rate at the stagnation regions was conducted using a simplified experimental model. Measurements of the velocity, turbulence intensity, intermittency, and integral length scale within the wake are presented to quantify the turbulence characteristics of the incident wake flow. Comparison with the mass transfer results indicates that the increase in mass transfer from the cylinder along the wake centerline depends on the turbulence intensity, length scale, and possibly other factors. In addition, a simple quasi-steady theory is developed to account for the unsteady effects caused by the passing of wakes in the incident flow on the stagnation transfer rate at the leading edge of a gas turbine airfoil. Dissert. Abstr.

N89-11708# Air Force Wright Aeronautical Labs., Wright-Patterson AFB, OH.
MODIFICATION OF AN UNSTEADY TRANSONIC SMALL DISTURBANCE PROCEDURE TO ALLOW A PRESCRIBED STEADY-STATE INITIAL CONDITION Interim Report, Jan. 1987 - Jan. 1988
DON W. KINSEY Jan. 1988 61 p
(AD-A196744; AFWAL-TR-88-3022) Avail: NTIS HC A04/MF A01 CSCL 01A

Many attempts have been made to extend the useful range of the 2-D unsteady transonic small disturbance procedure, called LTRAN2. This report describes another such extension. LTRAN2 modifications are described that allow the procedure to determine the geometry corresponding to a prescribed pressure distribution. This new geometry would account for all compressible and viscous effects, and would, therefore, be a much better starting point for the unsteady calculations. We present the transonic small disturbance governing equations and boundary conditions. Then the modifications required for the inverse geometry definition are described. Results for three different airfoils (NACA 0012, NACA 64A010, and NLR 7301) are presented and discussed. The NACA 0012 and NLR 7301 results are much improved using this procedure. GRA

N89-11709# Naval Postgraduate School, Monterey, CA.
DYNAMIC STALL ANALYSIS UTILIZING INTERACTIVE COMPUTER GRAPHICS M.S. Thesis
ERIC L. PAGENKOPF Mar. 1988 90 p
(AD-A196812) Avail: NTIS HC A05/MF A01 CSCL 12E

A Navier-Stokes problem solver, developed by L. N. Sankar, is modified to provide dynamic, interactive graphical presentations of predicted flow field solutions about a NACA-0012 airfoil section oscillating in pitch, in order to demonstrate the capabilities of dynamic graphics applications in the study of complex, unsteady flows. Flow field solutions in the form of pressure coefficient and stream function contour plots about an airfoil experiencing dynamic stall are plotted utilizing an IRIS 3000-series workstation and Graphical Animation System (GAS) software, developed by Sterling Software for NASA. These full cycle solutions, in conjunction with dynamic surface pressure distribution plots and integrated lift, pitching moment and drag coefficient data, are compared to existing experimental data in order to provide an indication of the validity of the code's far-field solution. Full procedural documentation is maintained in order to provide an efficient analysis tool for use in future oscillating airfoil studies planned by the NASA-Ames Fluid Mechanics Laboratory and the Naval Postgraduate School Department of Aeronautics and Astronautics. GRA

N89-11711# General Dynamics/Fort Worth, TX.
UNSTEADY LOW-SPEED WINDTUNNEL TEST OF A STRAKED DELTA WING, OSCILLATING IN PITCH. PART 3. PLOTS OF THE ZEROTH AND FIRST HARMONIC UNSTEADY PRESSURE DISTRIBUTIONS (CONCLUDED) AND PLOTS OF STEADY AND FIRST HARMONIC UNSTEADY OVERALL LOADS Final Report, Jun. 1985 - Aug. 1987
A. M. CUNNINGHAM, JR., R. G. DEN BOER, C. S. DOGGER, E. G. GEURTS, and A. J. PERSOON Apr. 1988 194 p
(Contract F33615-85-C-3013)
(AD-A197541; AFWAL-TR-87-3098-PT-3) Avail: NTIS HC A09/MF A01 CSCL 01A

This report contains results of a wind tunnel test of an oscillating straked wing. It provides unsteady airloads and pressure distributions for a range of incidences (-8 to 50 deg.) and amplitudes (1 to 16 deg.). The wind speed was 80 meters/second, which provided reduced frequencies up to 0.50 based on root chord. The zeroth and first harmonic as well as the continuous time history of the pressure and overall loads were measured. Flow visualization was performed for flow of 30 meters/second using a pulsating laser light sheet. In this part, appendix A presents the remainder of the unsteady zeroth and first order harmonic components of the unsteady pressure distribution plots for which the preceding runs were given in appendix B of part 2. In appendix B, plots of the steady and the zeroth and first order harmonic components of the unsteady overall loads are presented. These results are presented as functions of angle of attack, frequency and amplitude in various forms for all measured components. GRA

N89-11713# National Aerospace Lab., Amsterdam (Netherlands). Fluid Dynamics Div.
ACCURACY OF VARIOUS WALL-CORRECTION METHODS FOR 3D SUBSONIC WIND TUNNEL TESTING
R. A. MAARSINGH, TH. E. LABRUJERE, and J. SMITH 30 Jul. 1987 17 p Presented at the AGARD-FDP Symposium on Aerodynamic Data Accuracy and Quality. Requirements and Capabilities in Wind Tunnel Testing, Naples, Italy, 28 Sep.-1 Oct. 1987
(NLR-MP-87039-U; B8809807; ETN-88-93397) Avail: NTIS HC A03/MF A01

On the basis of wind tunnel measurements on a simple, unpowered, but complete transport aircraft model in a small and a very large solid-wall test section, the accuracy of four measured boundary condition methods, as well as two classical methods, was analyzed at low speed conditions. Large reductions in the amount of in situ measured data are shown to be possible, yet yielding results which match almost with those of calculations using multiples of input data. Classical methods need not be abandoned at once in low speed solid wall testing. Higher priority should be given to the interpretation problem: the determination of the actual model reaction upon the wall-induced flow field. ESA

N89-11714# National Aerospace Lab., Amsterdam (Netherlands). Aerodynamics Div.

ON REYNOLDS NUMBER EFFECTS AND SIMULATION: REPORT OF THE REVIEW COMMITTEE OF AGARD WORKING GROUP 09

A. ELSENAAER 30 Jun. 1987 27 p Presented at the AGARD-FDP Symposium on Aerodynamic Data Accuracy and Quality. Requirements and Capabilities in Wind Tunnel Testing, Naples, Italy, 28 Sep.-1 Oct. 1987
(NLR-MP-87041-U; B8807285; ETN-88-93398; AD-B119984L) Avail: NTIS HC A03/MF A01

Reynolds number effects in transonic flow are reviewed. Two-dimensional airfoils are emphasized, but three-dimensional configurations, including delta wings and slender bodies, are discussed. Examples of the so-called aft-fixation technique to simulate the high Reynolds number pressure distribution are given. Pseudo Reynolds number effects due to the wind tunnel environment are discussed. ESA

N89-11715# National Aerospace Lab., Amsterdam (Netherlands). Fluid Dynamics Div.

A WIND TUNNEL INVESTIGATION AT LOW SPEED OF THE FLOW ABOUT A STRAKED DELTA WING, OSCILLATING IN PITCH

R. G. DENBOER and A. M. CUNNINGHAM, JR. (General Dynamics/Fort Worth, Tex.) Jul. 1987 17 p Presented at the Atmospheric Flight Mechanics Conference, Monterey, Calif., 17-19 Aug.1987
(NLR-MP-87046-U; B8809806; ETN-88-93400; AD-B120423L) Avail: NTIS HC A03/MF A01

A low speed wind tunnel test on a straked delta wing, oscillating in pitch, was conducted. Measurements of unsteady overall airloads and pressure distributions were performed covering a wide range of incidences (-8 to 50 deg) and amplitudes (1 to 16 deg). Most test cases were carried out at a wind speed of 80 m/sec. The zeroth and first harmonic of the pressures and overall loads were measured. Time recordings were made for study of higher harmonics, power spectra, and cross correlation functions. At 30 m/sec visualization of the unsteady flow is performed, using a smoke tube fixed to the model and a pulsating laser light sheet. A limited number of runs with maneuver-like inputs was carried out. At these runs only time recordings of the balance signal were made. The test setup and the procedures used, and examples of the results are shown. ESA

N89-11716# National Aerospace Lab., Amsterdam (Netherlands). Aerodynamic Div.

REQUIREMENTS AND CAPABILITIES IN UNSTEADY WIND TUNNEL TESTING

R. G. DENBOER, R. HOUWINK, and R. J. ZWAAN 30 Aug. 1987 29 p Presented at the AGARD-FDP Symposium on Aerodynamic Data Accuracy and Quality. Requirements and Capabilities in Wind Tunnel Testing, Naples, Italy, 28 Sep. - 1 Oct. 1987
(NLR-MP-87066-U; B8809139; ETN-88-93403; AD-B119520L) Avail: NTIS HC A03/MF A01

The accuracy required for aeroelastic applications concerning full-scale aircraft wind tunnel tests are discussed. Accuracy in unsteady wind tunnel testing is considered. ESA

N89-11717*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

INTERACTIVE GRID GENERATION FOR TURBOMACHINERY FLOW FIELD SIMULATIONS

YUNG K. CHOO, PETER R. EISEMAN (Columbia Univ., New York, N.Y.), and CHARLES RENO 1988 10 p Presented at the 2nd International Conference on Numerical Grid Generation in Computational Fluid Dynamics, Miami Beach, Fla., 5-8 Dec. 1988; sponsored by NASA, AFOSR and Miami Univ.
(NASA-TM-101301; E-4282; NAS 1.15:101301) Avail: NTIS HC A02/MF A01 CSCL 01A

The control point form of algebraic grid generation presented provides the means that are needed to generate well structured grids for turbomachinery flow simulations. It uses a sparse collection of control points distributed over the flow domain. The shape and position of coordinate curves can be adjusted from these control points while the grid conforms precisely to all boundaries. An interactive program called TURBO, which uses the control point form, is being developed. Basic features of the code are discussed and sample grids are presented. A finite volume LU implicit scheme is used to simulate flow in a turbine cascade on the grid generated by the program. Author

N89-11718*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

THREE-DIMENSIONAL SELF-ADAPTIVE GRID METHOD FOR COMPLEX FLOWS

M. JAHED DJOMEHRI and GEORGE S. DEIWERT Nov. 1988 21 p
(NASA-TM-101027; A-88277; NAS 1.15:101027) Avail: NTIS HC A03/MF A01 CSCL 01A

A self-adaptive grid procedure for efficient computation of three-dimensional complex flow fields is described. The method is based on variational principles to minimize the energy of a spring system analogy which redistributes the grid points. Grid control parameters are determined by specifying maximum and minimum grid spacing. Multidirectional adaptation is achieved by splitting the procedure into a sequence of successive applications of a unidirectional adaptation. One-sided, two-directional constraints for orthogonality and smoothness are used to enhance the efficiency of the method. Feasibility of the scheme is demonstrated by application to a multinozzle, afterbody, plume flow field. Application of the algorithm for initial grid generation is illustrated by constructing a three-dimensional grid about a bump-like geometry. Author

N89-11719*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

FLOW VISUALIZATION TECHNIQUES FOR FLIGHT RESEARCH

DAVID F. FISHER and ROBERT R. MEYER, JR. Oct. 1988 35 p Presented at the 73rd AGARD Symposium of the Flight Mechanics Panel on Flight Test Techniques, Edwards AFB, Calif., 17-20 Oct. 1988
(NASA-TM-100455; H-1524; NAS 1.15:100455; AGARD-PAPER-20) Avail: NTIS HC A03/MF A01 CSCL 01A

In-flight flow visualization techniques used at the Dryden Flight Research Facility of NASA Ames Research Center (Ames-Dryden) and its predecessor organizations are described. Results from flight tests which visualized surface flows using flow cones, tufts, oil flows, liquid crystals, sublimating chemicals, and emitted fluids have been obtained. Off-surface flow visualization of vortical flow has been obtained from natural condensation and two methods using smoke generator systems. Recent results from flight tests at NASA Langley Research Center using a propylene glycol smoker and an infrared imager are also included. Results from photo-chase aircraft, onboard and postflight photography are presented. Author

N89-11720# Technische Hochschule, Aachen (Germany, F.R.). Fakultaet fuer Maschinenwesen.

EXPERIMENTAL INVESTIGATION OF TRANSONIC FLOW ON WING PROFILES IN WIND TUNNELS OF REDUCED MEASUREMENT SECTION Ph.D. Thesis [EXPERIMENTELLE UNTERSUCHUNG SCHALLNAH ANGESTROEMTER TRAGFLUEGELPROFILE IN KANAELEN MIT GERINGER MESSKAMMERBREITE]

THOMAS WOLFGANG FRANKE 1987 184 p In GERMAN
(ETN-88-93233) Avail: NTIS HC A09/MF A01

Investigations of stationary flow around supercritical profiles are carried out in a wind tunnel of reduced measurement section and flexible top walls. Three-dimensional sidewall effects on pressure measurement are optically processed to evaluate flow density, velocity, and wall load tension. Wall interaction is studied by adaptation of top walls and reduction of boundary layer suction. Unsteady flow phenomena on supercritical profiles and the interaction on pressure distribution, shock oscillations and vortex configurations behind wing profiles are analyzed. ESA

N89-11721# Technische Hochschule, Aachen (Germany, F.R.). Mathematisch-Naturwissenschaftlichen Fakultaet.
MODELING OF VORTEX LAYERS OVER DELTA WINGS WITH A VORTEX LINE ADAPTED PANEL METHOD Ph.D. Thesis [MODELLIERUNG FREIER WIRBELSCHICHTEN AN DELTAFLUEGELN MIT EINER WIRBELLINIENANGEPASSTEN PANELMETHODE]
PETER WIEMER 1987 92 p In GERMAN
(ETN-88-93235) Avail: NTIS HC A05/MF A01

Free leading-edge vortex effects over delta wings, aerodynamic characteristics, and local pressure distribution are analyzed with a panel method of higher order. Numerical simulation by dipole surfaces is performed of the flow field vortex surfaces. The panels of the vortex sheets are limited by vortex lines on the both sides. Mathematical resolution of the hydrodynamic problem is attained by the collocation method applied to the nonlinear integral equations. Kutta conditions are applied for the wing grids and Newton procedure is used for iteration of geometry independant parameter variations. ESA

N89-12540 Auburn Univ., AL.
THE LAMINAR BOUNDARY LAYER ON AN AIRFOIL STARTED IMPULSIVELY FROM REST Ph.D. Thesis
RUBEN ROJASOVIEDO 1987 130 p
Avail: Univ. Microfilms Order No. DA8805021

The numerical solution to the unsteady two-dimensional boundary layer equations was obtained for the Joukowski and Karman-Treftz airfoils, impulsively set into uniform motion. The boundary layer development is calculated using an implicit finite difference technique. For a Joukowski airfoil 9.6 percent thick at zero angle of attack, the resulting flow structure shows that as time increases, a bubble of recirculating fluid forms near the trailing edge, increases size, becoming open at the trailing edge, and finally bursting, perturbing further calculations. These results indicate the formation of a system of symmetric vortices near the trailing edge. The computed characteristics of the boundary layer support the concept of a spontaneous singularity at separation. The effects of certain numerical parameters on the numerical calculation and on the computed boundary layer characteristics are also investigated. For the Karman-Treftz airfoil, 12.66 percent thick at zero angle of attack, the results indicate the immediate occurrence of a singularity at the trailing edge of the airfoil. Dissert. Abstr.

N89-12541 Lehigh Univ., Bethlehem, PA.
UNSTEADY STRUCTURE OF FLOW PAST A PITCHING DELTA WING Ph.D. Thesis
RASHEED A. ATTA 1987 226 p
Avail: Univ. Microfilms Order No. DA8729528

The unsteady flow structure generated by flow past a delta wing is addressed. The wing oscillates in the pitching mode about its trailing-edge. Emphasis is on the structure of the instabilities arising from flow separation at the leading- and trailing-edges of the wing. Dissert. Abstr.

N89-12542*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
A TWO-DIMENSIONAL NUMERICAL SIMULATION OF A SUPERSONIC, CHEMICALLY REACTING MIXING LAYER
J. PHILIP DRUMMOND Washington, D.C. Dec. 1988 106 p
(NASA-TM-4055; L-16415; NAS 1.15:4055) Avail: NTIS HC A06/MF A01 CSCL 01A

Research has been undertaken to achieve an improved understanding of physical phenomena present when a supersonic flow undergoes chemical reaction. A detailed understanding of supersonic reacting flows is necessary to successfully develop advanced propulsion systems now planned for use late in this century and beyond. In order to explore such flows, a study was begun to create appropriate physical models for describing supersonic combustion, and to develop accurate and efficient numerical techniques for solving the governing equations that result from these models. From this work, two computer programs were written to study reacting flows. Both programs were constructed to consider the multicomponent diffusion and convection of important chemical species, the finite rate reaction of these species, and the resulting interaction of the fluid mechanics and the chemistry. The first program employed a finite difference scheme for integrating the governing equations, whereas the second used a hybrid Chebyshev pseudospectral technique for improved accuracy. Author

N89-12543*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
A SPECTRAL COLLOCATION SOLUTION TO THE COMPRESSIBLE STABILITY EIGENVALUE PROBLEM
MICHELE G. MACARAEG, CRAIG L. STREETT, and M. YOUSUFF HUSSAINI Washington, D.C. Dec. 1988 42 p
(NASA-TP-2858; L-16470; NAS 1.60:2858) Avail: NTIS HC A03/MF A01 CSCL 01A

A newly developed spectral compressible linear stability code (SPECLS) (staggered pressure mesh) is presented for analysis of shear flow stability, and applied to high speed boundary layers and free shear flows. The formulation utilizes the first application of a staggered mesh for a compressible flow analysis by a spectral technique. An order of magnitude less number of points is needed for equivalent accuracy of growth rates compared to those calculated by a finite difference formulation. Supersonic disturbances which are found to have oscillatory structures were resolved by a spectral multi-domain discretization, which requires a factor of three fewer points than the single domain spectral stability code. It is indicated, as expected, that stability of mixing layers is enhanced by viscosity and increasing Mach number. The mean flow involves a jet being injected into a quiescent gas. Higher temperatures of the injected gas is also found to enhance stability characteristics of the free shear layer. Author

N89-12544*# Vigyan Research Associates, Inc., Hampton, VA.
SIDEWALL BOUNDARY-LAYER MEASUREMENTS WITH UPSTREAM SUCTION IN THE LANGLEY 0.3-METER TRANSONIC CRYOGENIC TUNNEL
A. V. MURTHY Washington NASA Nov. 1988 57 p
(Contract NAS1-17919)
(NASA-CR-4192; NAS 1.26:4192) Avail: NTIS HC A04/MF A01 CSCL 01A

The Langley 0.3 Meter Transonic Cryogenic Tunnel has provision for boundary removal from the sidewalls to reduce sidewall interference effects on the test data. The tests carried out to determine the change in the empty test section sidewall boundary layer thickness at the model station with upstream boundary layer mass removal are described. The boundary layer measurements showed that the upstream removal region is effective in reducing the boundary layer thickness at the model station. The boundary layer displacement thickness reduced from about 1.2 percent to about .4 percent of the test section width. The boundary layer velocity profiles followed a power law variation in the outer region and showed good correlation when plotted in terms of boundary layer momentum thickness. Author

N89-12545 George Washington Univ., Washington, DC.
THEORETICAL AND EXPERIMENTAL STUDIES OF THE TRANSONIC FLOW FIELD AND ASSOCIATED BOUNDARY CONDITIONS NEAR A LONGITUDINALLY-SLOTTED WIND-TUNNEL WALL Ph.D. Thesis
JOEL LEE EVERHART 1988 320 p
Avail: Univ. Microfilms Order No. DA8808314

A theoretical examination of the slotted-wall flow field is conducted to determine the appropriate wall pressure-drop (or boundary condition) equation. This analysis improves the understanding of the fluid physics of these types of flow fields and helps to evaluate uncertainties and limitations existing in previous mathematical developments. It is shown that the resulting slotted-wall boundary conditions contains contributions due to the airfoil-induced streamline curvature and the nonlinear quadratic, slot cross-flow in addition to an often-neglected, linear term that results from viscous shearing in the slot. Existing and newly acquired experimental data are examined in light of this formulation and previous theoretical development. A detailed, previously unpublished set of slot-flow measurements obtained in the NASA Langley Research Center's diffuser flow apparatus is analyzed, and the resulting conclusions on the character of slot flows are discussed. A description is also given of a series of wind-tunnel experiments conducted expressly for this investigation in the Research Center's 6 x 19 inch transonic tunnel. Dissert. Abstr.

N89-12546 Leicester Univ. (England).
FLOW FIELD CHARACTERISTICS AROUND BLUFF PARACHUTE CANOPIES Ph.D. Thesis
C. Q. SHEN 1987 227 p
Avail: Univ. Microfilms Order No. BRD-81832

The objectives of the present investigation are to determine the nature of the flow field around bluff parachute canopies, considering the effects of canopy shape parameters on this flow and hence on the resulting aerodynamic forces and moments which are developed on the canopy surface. To relate the flow field developed around bluff parachute canopies to their aerodynamic characteristics, a series of experiments in the Leicester University wind tunnel has been conducted on a family of particularly significant canopy shapes. These cross-shaped canopies have excellent drag and stability characteristics if arm ratios of about 4:1 are selected. Flow visualization, using both helium bubbles and wool tufts, was used to determine the flow field around the canopy. The most probable description of the wake flow is chains of irregularly-shaped vortex loops which move at about 0.7 times the undisturbed free stream velocity. Aerodynamic forces and moments measured on the various canopies correspond with the observed flow characteristics. Statistical correlation analyses made with hot wire anemometers in their wake indicate the periodic structure of the wakes formed behind these bluff bodies and reveal their basic similarities. Strouhal numbers of about 0.15 were obtained in the wake formed behind an imporous rigid hemispherical canopy. These are increased as canopy porosity is made larger. Dissert. Abstr.

N89-12547 Pennsylvania State Univ., University Park.
A ZONAL EQUATION METHOD FOR THREE-DIMENSIONAL LOCALLY ELLIPTIC LAMINAR AND TURBULENT FLOWS Ph.D. Thesis
MATTHEW JAMES WARFIELD 1987 194 p
Avail: Univ. Microfilms Order No. DA8807877

The Navier-Stokes equations governing fluid flow are computationally expensive to solve in exact form. Parabolized equations, when suitable, greatly increase the efficiency of the solution. This thesis describes a zonal equation method whereby incompressible elliptic and parabolic fluid flow formulations are utilized in distinct zones to efficiently resolve two- and three-dimensional laminar and turbulent flow-fields. In the present application the elliptic formulation consisted of the full Navier-Stokes equations and was solved by the pseudo-compressibility time-marching technique while the parabolic formulation consisted of the parabolized Navier-Stokes equations and was solved by space-marching. The zonal equation method, as applied, is a viscous/viscous interaction technique with overlapping zonal boundaries and both local and global interaction. Local interaction is achieved either through direct variable exchange at the zonal boundaries or by the proposed solution of a simplified set of correction equations which correct the base parabolic solution within the buffer region between zones. The concept of localized ellipticity is examined and ellipticity parameters are proposed for use with the zonal equation method algorithm. Dissert. Abstr.

N89-12549# Air Force Inst. of Tech., Wright-Patterson AFB, OH.
A VORTEX PANEL METHOD FOR POTENTIAL FLOWS WITH APPLICATIONS TO DYNAMICS AND CONTROL Ph.D. Thesis
CURTIS P. MRACEK Aug. 1988 312 p
(AD-A197091; AFIT/CI/NR-88-182) Avail: NTIS HC A14/MF A01 CSCL 20D

A general nonlinear, nonplanar unsteady vortex panel method for potential-flow is developed. The surface is modeled as a collection of triangular elements on which the vorticity vector is piecewise linearly varying. The wake emanates from the sides and trailing edges of the thin lifting surfaces and is modeled as a progressively formed collection of vortex filaments. This model provides a continuous pressure distribution on the surface while allowing the wake to roll up as tightly as needed. The wake position is determined as part of the solution and no prior knowledge of the position or strength is assumed. An adaptive grid technique is used to redistribute the circulation of the vortex filaments of the wake as the wake sheet spreads. The aerodynamic model is coupled with dynamic equations of motion. Forced oscillation tests are conducted on flat rectangular and delta wings. Dynamic tests are performed to predict wing rock of a slender delta wing restricted to one degree of freedom in roll. The aerodynamic/dynamic model is coupled with control laws that govern the motion of flaperons so that a prescribed pitch motion is executed and wing rock is suppressed. GRA

N89-12551* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
METHOD FOR LAMINAR BOUNDARY LAYER TRANSITION VISUALIZATION IN FLIGHT Patent
BRUCE J. HOLMES, inventor (to NASA) and PETER D. GALL, inventor (to NASA) 4 Oct. 1988 5 p Filed 13 Nov. 1986 Supersedes N87-18535 (25 - 11, p 1435)
(NASA-CASE-LAR-13554-1; US-PATENT-4,774,835; US-PATENT-APPL-SN-929862; US-PATENT-CLASS-73-147; US-PATENT-CLASS-116-265; US-PATENT-CLASS-116-DIG.43)
Avail: US Patent and Trademark Office CSCL 01A

Disclosed is a method of visualizing laminar to turbulent boundary layer transition, shock location, and laminar separation bubbles around a test surface. A liquid crystal coating is formulated using an unencapsulated liquid crystal operable in a temperature bandwidth compatible with the temperature environment around the test surface. The liquid crystal coating is applied to the test surface, which is preferably pretreated by painting with a flat, black paint to achieve a deep matte coating, after which the surface is subjected to a liquid or gas flow. Color change in the liquid crystal coating is produced in response to differences in relative shear stress within the boundary layer around the test surface. The novelty of this invention resides in the use of liquid crystals which are sensitive to shear stress to show aerodynamic phenomena such as a boundary layer transition, shock location, and laminar separation bubbles around a test surface.
Official Gazette of the U.S. Patent and Trademark Office

N89-12552*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
CONTROL OF LAMINAR SEPARATION OVER AIRFOILS BY ACOUSTIC EXCITATION
K. B. M. Q. ZAMAN and D. J. MCKINZIE 1988 19 p Prepared for presentation at the 27th Aerospace Sciences Meeting, Reno, Nev., 9-12 Jan. 1989; sponsored in part by AIAA
(NASA-TM-101379; E-4434; NAS 1.15:101379; AIAA-89-0565)
Avail: NTIS HC A03/MF A01 CSCL 01A

The effect of acoustic excitation in reducing laminar separation over two-dimensional airfoils at low angles of attack is investigated experimentally. Airfoils of two different cross sections, each with two different chord lengths, are studied in the chord Reynolds number range of 25,000 is less than R sub c is less than 100,000. While keeping the amplitude of the excitation induced velocity perturbation a constant, it is found that the most effective frequency scales as U (sup 3/2)(sub infinity). The parameter St/R (sup

1/2)(sub c), corresponding to the most effective f sub p for all the cases studied, falls in the range of 0.02 to 0.03, St being the Strouhal number based on the chord. Author

N89-12553*# Cincinnati Univ., OH. Dept. of Aerospace Engineering and Engineering Mechanics.
SIMULATION OF 2-DIMENSIONAL VISCOUS FLOW THROUGH CASCADES USING A SEMI-ELLIPTIC ANALYSIS AND HYBRID C-H GRIDS Final Report
R. RAMAMURTI, U. GHIA, and K. N. GHIA Washington NASA Oct. 1988 194 p
(Contract NAG3-194)
(NASA-CR-4180; REPT-86-9-71; E-4286; NAS 1.26:4180) Avail: NTIS HC A09/MF A01 CSCL 01A

A semi-elliptic formulation, termed the interacting parabolized Navier-Stokes (IPNS) formulation, is developed for the analysis of a class of subsonic viscous flows for which streamwise diffusion is neglible but which are significantly influenced by upstream interactions. The IPNS equations are obtained from the Navier-Stokes equations by dropping the streamwise viscous-diffusion terms but retaining upstream influence via the streamwise pressure-gradient. A two-step alternating-direction-explicit numerical scheme is developed to solve these equations. The quasi-linearization and discretization of the equations are carefully examined so that no artificial viscosity is added externally to the scheme. Also, solutions to compressible as well as nearly compressible flows are obtained without any modification either in the analysis or in the solution process. The procedure is applied to constricted channels and cascade passages formed by airfoils of various shapes. These geometries are represented using numerically generated curilinear boundary-oriented coordinates forming an H-grid. A hybrid C-H grid, more appropriate for cascade of airfoils with rounded leading edges, was also developed. Satisfactory results are obtained for flows through cascades of Joukowski airfoils. Author

N89-12554*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
DEVELOPMENT AND VALIDATION OF AN ADVANCED LOW-ORDER PANEL METHOD
DALE L. ASHBY, STEVEN K. IGUCHI (Sterling Federal Systems, Inc., Palo Alto, Calif.), and MICHAEL DUDLEY Oct. 1988 48 p
(NASA-TM-101024; A-88275; NAS 1.15:101024) Avail: NTIS HC A03/MF A01 CSCL 01A

A low-order potential-flow panel code, PMARC, for modeling complex three-dimensional geometries, is currently being developed at NASA Ames Research Center. The PMARC code was derived from a code named VSAERO that was developed for Ames Research Center by Analytical Methods, Inc. In addition to modeling potential flow over three-dimensional geometries, the present version of PMARC includes several advanced features such as an internal flow model, a simple jet wake model, and a time-stepping wake model. Data management within the code was optimized by the use of adjustable size arrays for rapidly changing the size capability of the code, reorganization of the output file and adopting a new plot file format. Preliminary versions of a geometry preprocessor and a geometry/aerodynamic data postprocessor are also available for use with PMARC. Several test cases are discussed to highlight the capabilities of the internal flow model, the jet wake model, and the time-stepping wake model. Author

N89-12555*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
EVALUATION OF THREE TURBULENCE MODELS FOR THE PREDICTION OF STEADY AND UNSTEADY AIRLOADS
JIUNN-CHI WU, DENNIS L. HUFF, and L. N. SANKAR (Georgia Inst. of Tech., Atlanta.) 1988 13 p Proposed for presentation at the 27th Aerospace Sciences Meeting, Reno, Nev., 9-12 Jan. 1989; sponsored by AIAA
(NASA-TM-101413; E-4507; NAS 1.15:101413; AIAA-89-0609) Avail: NTIS HC A03/MF A01 CSCL 01A

Two dimensional quasi-three dimensional Navier-Stokes solvers were used to predict the static and dynamic airload characteristics of airfoils. The following three turbulence models were used: the Baldwin-Lomax algebraic model, the Johnson-King ODE model for maximum turbulent shear stress, and a two equation k-e model with law-of-the-wall boundary conditions. It was found that in attached flow the three models have good agreement with experimental data. In unsteady separated flows, these models give only a fair correlation with experimental data. Author

03

AIR TRANSPORTATION AND SAFETY

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

A89-13682#
ICING DEGREE MODERATE TO SEVERE - IF AND WHERE IN CLOUDS
H.-E. HOFFMAN (DFVLR, Institut fuer Physik der Atmosphaere, Wessling, Federal Republic of Germany) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 1801-1812. refs

Icing phenomena study flights conducted by the DFVLR have indicated a substantial degree of icing on the Do 28 test aircraft at the relatively high temperature of -3.7 C on the wing lower surface; this ice was comparatively elastic, and accordingly difficult to remove completely by means of the pneumatic wing leading-edge boot deicing system. The vertical structure of the clouds was such as to result in severe icing hazards that were limited to narrow altitude bands within the cloud. O.C.

A89-15937
EMP SUSCEPTIBILITY INSIGHTS FROM AIRCRAFT EXPOSURE TO LIGHTNING
JOSEPH E. NANEVICZ, E. F. VANCE, WILLIAM RADASKY, M. A. UMAN, GORDON K. SOPER (SRI International, Menlo Park, CA) et al. IEEE Transactions on Electromagnetic Compatibility (ISSN 0018-9375), vol. 30, Nov. 1988, p. 463-472. refs

The authors examine the interactions of natural lightning and the nuclear electromagnetic pulse (EMP) with aircraft. They evaluate the propositions that it is possible to use (1) normal exposure to lightning to provide information on EMP protection, and (2) deliberate exposure to lightning to test EMP protection. It is concluded that the rarity of encountering lightning, its random occurrence and variability (necessitating extensive onboard instrumentation), and its apparent deficiency in energy at high frequencies make the use of lightning for an EMP surveillance or test impractical. I.E.

N89-11725*# California State Univ., Long Beach.
EFFECTS OF ENVIRONMENTALLY IMPOSED ROUGHNESS ON AIRFOIL PERFORMANCE Final Contractor Report
TUNCER CEBECI Jun. 1987 44 p Presented at the Von Karman Inst. for Fluid Dynamics Lecture Series on Influence of Environmental Factors on Aircraft Wing Performance, 16-18 Feb. 1987 Previously announced as N88-15778
(Contract NAG3-601; NSF MEA-80-18565)
(NASA-CR-179639; NAS 1.26:179639) Avail: NTIS HC A03/MF A01 CSCL 01A

The experimental evidence for the effects of rain, insects, and ice on airfoil performance are examined. The extent to which the available information can be incorporated in a calculation method in terms of change of shape and surface roughness is discussed. The methods described are based on the interactive boundary procedure of Cebeci or on the thin layer Navier Stokes procedure developed at NASA. Cases presented show that extensive flow separation occurs on the rough surfaces. Author

N89-12556# Henschel Flugzeug-Werke G.m.b.H., Kassel (Germany, F.R.).
LOCATING AND SEARCH PROCEDURES WITH HELICOPTERS FOR SEA AND/OR AIR EMERGENCIES Final Report
GERALD ABICH, HANS-DIETER EISBRECHER, ULRICH VONEITZEN, and KLAUS KOENIG Bonn, Fed. Republic of Germany BMFT Mar. 1987 58 p In GERMAN; ENGLISH summary Sponsored by BMFT Prepared in cooperation with Reedereigemeinschaft Forschungsschiffahrt G.m.b.H., Bremen, Fed. Republic of Germany
(FPN-0079; ETN-88-93222) Avail: NTIS HC A04/MF A01

Helicopter flight procedures and tables to assist locating and search procedures were developed. The variety of problems encountered in flight tests reveals that most of the equipment available from industry sources for the intended application is either unusable or not compatible. Actual values were determined, followed by deliberations and, where possible, tests and trials to find the reasons for the nonsatisfactory operation. These results and the instruments and equipment available are a basis for further tests to establish the general engineering specifications for the design of such equipment. Underwater sound ranging tests yield positive results. ESA

04

AIRCRAFT COMMUNICATIONS AND NAVIGATION

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

A89-13080
PARTIAL DECOMPOSITION OF STOCHASTIC SYSTEMS [O CHASTICHNOI DEKOMPOZITSII STOKHASTICHESKIKH SISTEM]
V. A. IATSENKO (AN USSR, Institut Kibernetiki, Kiev, Ukrainian SSR) Kibernetika i Vychislitel'naia Tekhnika (ISSN 0454-9910), no. 77, 1988, p. 42-46. In Russian. refs

An approach to the development of simplified stochastic models of a visual situation permitting partial decomposition is proposed. The approach is demonstrated for a simulation model in which a set of continuous functions models the trajectories of a number of aircraft in the observation range of a radar. The possibility of simplifying the solution of multidimensional Fokker-Planck equations is discussed. V.L.

A89-13554#
ATSAM (AIR TRAFFIC SIMULATION ANALYSIS MODEL) - A SIMULATION-TOOL TO ANALYZE EN-ROUTE AIR TRAFFIC SCENARIOS
ANDREAS HOERMANN (Berlin, Technische Universitaet, Federal Republic of Germany) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 545-553. refs

ATSAM (Air Traffic Simulation Analysis Model) is a flexible fast-time simulation-tool, designed to support ATC-related research regarding en-route air traffic scenarios, e.g. to develop new ATC/ATM procedures. The ATSAM model is based on a generalized, somewhat object-oriented modeling of ATS scenario elements/ATM control actions and a detailed continuous aircraft/flight simulation model considering error influences modeled by discrete events. ATSAM allows assessment of safety and economy related parameters within en-route ATS scenarios for numerous operational, environmental, traffic-related or aircraft-related boundary conditions. Currently, ATSAM is used to analyze, develop and optimize air traffic flow control and management procedures for the German ATS. Author

A89-13556#
APPROACH FLIGHT GUIDANCE OF A REGIONAL AIR TRAFFIC AIRCRAFT USING GPS IN DIFFERENTIAL MODE
TH. JACOB (Braunschweig, Technische Universitaet, Brunswick, Federal Republic of Germany) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 566-574. BMFT-sponsored research. refs

The adequacy of the present position determination capacities for the realization of an approach flight guidance system using GPS is addressed. The tolerability of errors in the flight guidance system in this application is considered. A sensor concept of the Integrated Flight Guidance System is examined, and some flight test results are discussed. C.D.

A89-14491
EVALUATION OF THE PERFORMANCE OF A VOCAL RECOGNITION SYSTEM IN AIR TRAFFIC CONTROL TASKS - VOCAL WORKSTATION OF AN AIR TRAFFIC CONTROL SIMULATOR [EVALUATION DES PERFORMANCES D'UN SYSTEME DE RECONNAISSANCE VOCALE DANS DES TACHES DE CONTROLE AERIEN - POSTE VOCAL D'UN SIMULATEUR DE CONTROLE AERIEN]
CHRISTINE BAILLEUL (Centre d'Etudes de la Navigation Aerienne, Orly, France) Journal d'Acoustique, vol. 1, Sept. 1988, p. 237-240. In French. refs

Experimental results were obtained in order to evaluate the performance of the vocal recognition system of a vocal workstation prototype capable of piloting an air traffic simulator by voice. Tests were first performed to study the performance of the vocal terminal in the autonomous mode. A system for evaluating performance was developed, and it is found that the uncorrected recognition error rates allow the results of different studies to be compared. Tests were also performed in a dynamic work situation and during the course of a simulation. R.R.

A89-15795
LASER COMMUNICATIONS AIRBORNE TESTBED - POTENTIAL FOR AN AIR-TO-SATELLITE LASER COMMUNICATIONS LINK
ROBERT J. FELDMANN (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) IN: Free-space laser communication technologies; Proceedings of the Meeting, Los Angeles, CA, Jan. 11, 12, 1988. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1988, p. 10-17.

Lasers are potentially secure, jam-resistant, difficult-to-detect technological bases for communications. A C-135E aircraft is to undergo modifications in order to serve as the Laser Communications Airborne Testbed (LCAT) of NASA's Advanced Communications Technology Satellite (ACTS). An analysis is presently made of the pertinence of LCAT characteristics to ACTS's direct-detection communications link; the results obtained furnish a measure of the feasibility of developing an airborne laser terminal that can interface directly to the LCAT. O.C.

A89-15797
AIRBORNE LASER COMMUNICATIONS SCINTILLATION MEASUREMENTS AND MODEL - A COMPARISON OF RESULTS
ROBERT J. FELDMANN (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) and STEVEN K. ROGERS (USAF, Institute of Technology, Wright-Patterson AFB, OH) IN: Free-space laser communication technologies; Proceedings of the Meeting, Los Angeles, CA, Jan. 11, 12, 1988. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1988, p. 24-30. refs

As part of USAF's Laser Airborne Communications Experiment (LACE) program, optical scintillation data have been collected and analyzed in order to aid future determinations of the degree of scintillation and its effect on communications performance. Since the LACE terminals employ direct detection of pulsed laser energy, random variations in received signal strength can be used to evaluate the atmospheric turbulence-induced amplitude scintillations. The data obtained to date are presently compared with a model for the air-to-air communications channel. O.C.

A89-15812
LASER COMMUNICATION TERMINALS WITH AUTOMATIC VIDEO TRACKING
G. S. MECHERLE and J. D. BARRY (Hughes Aircraft Co., El Segundo, CA) IN: Free-space laser communication technologies; Proceedings of the Meeting, Los Angeles, CA, Jan. 11, 12, 1988. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1988, p. 153-163. Research supported by Hughes Aircraft Co.

Two automatic-tracking lasercom terminals built before 1984, as proof-of-concept hardware for ship and laser communications with low probability-of-intercept and high jamming resistance, have been upgraded to include separate apertures for the transmit, receive, and tracking functions. These terminals demonstrate that a CCD video camera, gyrostabilized gimbal, and servo electronics, can perform precision tracking in support of aircraft laser communications. O.C.

A89-16204#
MODERNIZATION PLANS AND PROGRESS IN THE UNITED STATES
MARTIN T. POZESKY (FAA, Washington, DC) IN: Radio Technical Commission for Aeronautics, Annual Assembly Meeting and Technical Symposium, Washington, DC, Nov. 17-19, 1987, Proceedings. Washington, DC, Radio Technical Commission for Aeronautics, 1987, p. 71-76.

The FAA's ATC-upgrading program is proceeding incrementally, first replacing existing hardware and software, then realigning and consolidating facilities, and finally installing novel automation functions. An account is given of the place within this scheme of the Initial Sector Suite System, the Terminal Advanced Automation System, the Tower Control Computer Complex, and the Area Control Computer Complex. O.C.

A89-16205#
MODERNIZATION PLANNING IN THE WESTEN PACIFIC
KYOJI YONEMOTO (Ministry of Transport, Electronic Navigation Research Institute, Mitaka, Japan) IN: Radio Technical Commission for Aeronautics, Annual Assembly Meeting and Technical Symposium, Washington, DC, Nov. 17-19, 1987, Proceedings. Washington, DC, Radio Technical Commission for Aeronautics, 1987, p. 77-84.

An account is given of ATC-related modernization efforts in Japan and its geographical region. As required by the ICAO, MLS systems will be incorporated into Japanese ATC in the near future; a prototype is already operating at Sendai airport. Attention is presently given to terminal and en route system plans, communications systems, the Aeronautical Satellite System, and the Remote Monitoring System for Ground Facilities. O.C.

N89-11726*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
A SIMULATOR INVESTIGATION OF THE USE OF DIGITAL DATA LINK FOR PILOT/ATC COMMUNICATIONS IN A SINGLE PILOT OPERATION
DAVID A. HINTON and GARY W. LOHR (Embry-Riddle Aeronautical Univ., Daytona Beach, Fla.) Jun. 1988 41 p
(NASA-TP-2837; L-16457; NAS 1.60:2837) Avail: NTIS HC A03/MF A01 CSCL 17B

Studies have shown that radio communications between pilots and air traffic control contribute to high pilot workload and are subject to various errors. These errors result from congestion on the voice radio channel, and missed and misunderstood messages. The use of digital data link has been proposed as a means of reducing this workload and error rate. A critical factor, however, in determining the potential benefit of data link will be the interface between future data link systems and the operator of those systems, both in the air and on the ground. The purpose of this effort was to evaluate the pilot interface with various levels of data link capability, in simulated general aviation, single-pilot instrument flight rule operations. Results show that the data link reduced demands on pilots' short-term memory, reduced the number of communication transmissions, and permitted the pilots to more easily allocate time to critical cockpit tasks while receiving air traffic control messages. The pilots who participated unanimously indicated a preference for data link communications over voice-only communications. There were, however, situations in which the pilot preferred the use of voice communications, and the ability for pilots to delay processing the data link messages, during high workload events, caused delays in the acknowledgement of messages to air traffic control. Author

N89-11727# Federal Aviation Agency, Atlantic City, NJ.
AIRCRAFT POSITION REPORT DEMONSTRATION PLAN
JOAN GRELIS Jun. 1988 12 p
(AD-A196564; DOT/FAA/CT-TN88/21) Avail: NTIS HC A03/MF A01 CSCL 25B

This plan describes the Aircraft Position Report Demonstration which was designed to implement and verify an aircraft/satellite data link for aircraft position reports. The demonstration will implement the Automatic Dependent Surveillance (ADS) function which will provide frequent aircraft position updates for oceanic flights outside the coverage of land based radar. Aircraft equipped with satellite communication avionics will transmit position reports to a satellite which will relay signals to a ground receiving station. From the ground station, the messages will be sent via the Aeronautical Radio, Inc. (ARINC) network to the Federal Aviation Administration (FAA) Technical Center at the Atlantic City International Airport. The position reports will be processed and displayed on a map showing routes, sectors, and fixes at the FAA Technical Center and a remote processor and display will allow demonstrations to be viewed at Air Route Traffic Control Centers. GRA

N89-11728# Federal Aviation Administration, Washington, DC. Office of Management Systems.
FAA (FEDERAL AVIATION ADMINISTRATION) AIR TRAFFIC ACTIVITY: FISCAL YEAR 1987 Report, 1 Oct. 1986 - 30 Sep. 1987
NANCY TREMBLEY 30 Sep. 1987 230 p
(AD-A196625) Avail: NTIS HC A11/MF A01 CSCL 01E

This report furnishes terminal and en route air traffic activity information of the National Airspace System. The data have been reported by the FAA-operated Airport Traffic Control Towers (ATCTs), Air Route Traffic Control Centers (ARTCCs), Flight Service Stations (FSSs), International Flight Service Stations (IFSSs), Approach Control Facilities and FAA contract-operated control towers. GRA

N89-11729# Air Force Inst. of Tech., Wright-Patterson AFB, OH.
DETERMINATION OF DEFLECTIONS OF THE VERTICAL USING THE GLOBAL POSITIONING SYSTEM M.S. Thesis
ANDREY ARISTOV 1988 52 p
(AD-A196680; AFIT/CI/NR-88-84) Avail: NTIS HC A04/MF A01 CSCL 17G

Modern astrogeodetic methods, although accurate, are inefficient and too complex to rapidly determine deflections of the vertical. This problem is the impetus for finding a more useful technique that can yield results much more quickly. The Global Positioning System (GPS), with its ability to provide coordinate differences in interferometric modes, can be used to determine these deflections. Using highly accurate coordinate differences in conjunction with orthometric height differences, one can develop a surface of the geoidal undulations as a function of latitude and longitude. Given three GPS stations, a local surface can only be approximated by a plane. With more points, however, the modeled surface will more accurately resemble the true undulation differences. From this modeled surface, one uses least squares fitting of polynomials to interpolate the 'average' partial of N with respect to phi and partial of N with respect to lambda in the survey area. Finally, the deflections zeta and eta are computed and a study of propagation of both absolute and relative errors is made. GRA

N89-11730# Lear Siegler, Inc., Grand Rapids, MI. Inst. Div.
STRESS ANALYSIS REPORT FOR THE MICROWAVE LANDING SYSTEM (MLS) CLASS V MODIFICATION C-130 AIRCRAFT
15 Jan. 1988 58 p
(Contract F09603-85-C-1224)
(AD-A196722; ID-6216-039) Avail: NTIS HC A04/MF A01 CSCL 01C

The contents of this stress analysis report on components of the Microwave Landing System are as follows: Structural Loading Criteria; Summary of Minimum Margins of Safety; Analysis; Unoccupied Areas; Receiver Installation Models C-130E/H, WC-130E/H, HC-130H/N/P; Data Bus Coupler/Signal Splitter Installation Models C-130E/H, WC-130E/H, HC-130H/N/P; Receiver/Data Bus Coupler Installation Model C-130B; Signal Splitter/Relay Panel Installation Model C-130B; Front Antenna Installation; AFT Antenna Installation; AFT Antenna Installation; AFT Pressure Feed-Thru; Crew Occupied Areas; Top Antenna Installation; Relay Panel Installation; Relay Panel - Models C-130E/H/B; Relay Panel - Models C-130H (Late); Relay Panel - Models HC-130H/N/P, WC-130E/H; Forward Pressure Feed-Thru. GRA

N89-11731# Naval Postgraduate School, Monterey, CA.
HUMAN FACTORS ASPECTS OF THE TRAFFIC ALERT AND COLLISION AVOIDANCE SYSTEM (TCAS II) M.S. Thesis
ROBERT J. TUTTELL Mar. 1988 84 p
(AD-A196811) Avail: NTIS HC A05/MF A01 CSCL 17G

The objective of this study was to investigate three areas of interaction between pilots and the TCAS II Collision Avoidance System in order to examine the following areas of concern: (1) pilot maneuver on traffic advisory (TA) information; (2) the effect of pilot use of the system on the miss distance between conflicting aircraft; (3) the effectiveness of an alternative design for the resolution advisory (RA) display versus the current display. The first two areas were answered with data obtained from a NASA-Ames simulation using airline crews and a Boeing 727 flight simulator. Evaluation of these data reveal 14 incidents were pilots successfully maneuvered their aircraft using TA information. Forty scenarios where the TCAS II system directed evasive maneuvers were examined. These results show that the recommended avoidance maneuvers increased aircraft miss distance in 37 cases. Alternate designs for the resolution advisory display were evaluated using military and civilian pilots reacting to a computer display simulation. These results demonstrate that a red and green RA display is more effective than the current red only RA display. GRA

N89-12557*# Boeing Commercial Airplane Co., Seattle, WA.
PILOT FACTORS GUIDELINES FOR THE OPERATIONAL INSPECTION OF NAVIGATION SYSTEMS Final Report
J. F. SADLER and G. P. BOUCEK Sep. 1988 179 p
(Contract NAS1-18027)
(NASA-CR-181644; NAS 1.26:181644) Avail: NTIS HC A09/MF A01 CSCL 17G

A computerized human engineered inspection technique is developed for use by FAA inspectors in evaluating the pilot factors aspects of aircraft navigation systems. The short title for this project is Nav Handbook. A menu-driven checklist, computer program and data base (Human Factors Design Criteria) were developed and merged to form a self-contained, portable, human factors inspection checklist tool for use in a laboratory or field setting. The automated checklist is tailored for general aviation navigation systems and can be expanded for use with other aircraft systems, transports or military aircraft. The Nav Handbook inspection concept was demonstrated using a lap-top computer and an Omega/VLF CDU. The program generates standardized inspection reports. Automated checklists for LORAN/C and R NAV were also developed. A Nav Handbook User's Guide is included. Author

N89-12558# Federal Aviation Administration, Atlantic City, NJ. Technical Center.
LORAN C OFFSHORE FLIGHT FOLLOWING (LOFF) IN THE GULF OF MEXICO
FRANK LORGE Feb. 1988 68 p
(AD-A197179; DOT/FAA/CT-TN88/8) Avail: NTIS HC A04/MF A01 CSCL 17G

This report describes results of tests conducted by the FAA Technical Center to evaluate the LOFF system. Simulation and flight test were used to measure system performance under operational conditions. The LOFF system is the first implementation of Automatic Dependent Surveillance (ADS) by the FAA to track aircraft. It uses aircraft derived position as determined by Loran, transmitted by VHF data link for use by air traffic controllers. A converter unit was installed in the Houston Air Route Traffic Control Center (ARTCC) to process incoming LOFF messages and convert them into a radar data format. Results of this conversion are input to the Enhanced Direct Access Radar Channel (EDARC) which presents the aircraft as a conventional radar target. The system provides coverage in areas not currently served by radar, offshore in the Gulf of Mexico. Simulated inputs were used during testing to determine accuracy of the LOFF converter, to measure timing delays, and to relate aircraft position in latitude/longitude to a displayed position as seen by the controller. Flight tests were conducted to determine VHF coverage using the system, to measure Loran accuracy in the area, to compare dynamic performance with nondynamic performance of the EDARC system, and to provide an overall evaluation of the operational system. Overall results of the LOFF test program were favorable. The system performs in a predictable and reasonable manner and is comparable to that of radar. GRA

N89-12559# Air Force Inst. of Tech., Wright-Patterson AFB, OH.
VOICE RECOGNITION AND ARTIFICIAL INTELLIGENCE IN AN AIR TRAFFIC CONTROL ENVIRONMENT M.S. Thesis
ROBERT F. HALL May 1988 117 p
(AD-A197219; AFIT/CI/NR-88-171) Avail: NTIS HC A06/MF A01 CSCL 25D

The rapid growth of air carrier, general aviation, and military traffic has strained this nation's Air Traffic Control (ATC) system. The symptoms of this strain appear as controller fatigue, low controller moral, and the occasional creation of a hazardous situation caused by human error. The current method employed to improve the ATC system has been in the form of increasing its air traffic handling capacity by adding more machinery and manpower. Thus, machines with greater processing power and more humans are coupled into a man machine system which is destined to continually grow. Little has been done to find new forms of technology to increase the joint efficiency of man and machine. Two relatively new technologies which could create a path towards greater system efficiency are the technologies of voice recognition and artificial intelligence. With greater system efficiency, less controller fatigue and better air safety are expected. Where to apply these technologies, in what form, and how deep these technologies can be integrated into the ATC system are questions which deserve inquiry. This research details a method to answer these questions, develops prototype equipment from which to experiment, and establishes a basis from which other research efforts may be launched. A review of literature indicates that current efforts at applying voice recognition in flight operations are centered around pilot task improvement and special projects such as the space shuttle. GRA

N89-12560# Aeronautical Systems Div., Wright-Patterson AFB, OH.
AN EVALUATION OF GROUND COLLISION AVOIDANCE SYSTEM ALGORITHM Final Report
HORACE A. ORR, RICHARD GEISELHART, and MARK A. DIPADUA Oct. 1987 83 p
(AD-A197831; ASD-TR-87-5040) Avail: NTIS HC A05/MF A01 CSCL 01B

Controlled flight into terrain (CFIT) accidents, which constitute the second largest category of tactical Air Force Class A mishaps, could be greatly reduced by installing forward-looking Terrain-Following Radar (TFR) Systems. In an effort to design a less costly solution to this problem, a software-oriented generic Ground Collision Avoidance System (GCAS) with application to more complex tactical missions was developed. A simulation study of the system evaluated the adequacy of the algorithm in a variety of tactical scenarios. Results indicate GCAS is a variable system for partial solution of CFIT. Although some modifications to the system are necessary prior to implementation, the concept of terrain estimation may give GCAS a capability unmatched by any similar systems. GRA

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AIRCRAFT DESIGN, TESTING AND PERFORMANCE

Includes aircraft simulation technology.

A89-13501

ICAS, CONGRESS, 16TH, JERUSALEM, ISRAEL, AUG. 28-SEPT. 2, 1988, PROCEEDINGS. VOLUMES 1 & 2

Congress organized by the Israel Society of Aeronautics and Astronautics; Sponsored by ICAS. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. Vol. 1, 1018 p.; vol. 2, 979 p. For individual items see A89-13502 to A89-13692.

The present conference discusses topics in aircraft environmental safety, hypersonic aerothermodynamics, fatigue and damage tolerance, laminar flow regimes, the application of CFD to propulsion, helicopter flight dynamics, active control technologies, next-generation transport aircraft design, optimal aircraft guidance methods, turbulence-modeling methods, primary structure-applicable composite materials, aircraft certification procedures, missile guidance and control methods, materials and structural techniques applicable to hypersonic aircraft design, and aircraft control in windshear conditions. Also discussed are aircraft configuration planform optimization, the nonviscid modeling of unsteady aerodynamics, air traffic control technologies, modern propeller aerodynamics, aircraft dynamics and fatigue phenomena, numerical methods in aerodynamic design, viscous effects in vortex flow, hypersonic propulsion vehicle integration, inlet and nozzle system design, advanced structural materials, vortex flaps, and gas turbine component technology. O.C.

A89-13520#

EXPERIMENTAL INVESTIGATION OF STRONG IN-FLIGHT OSCILLATION ON HELICOPTERS AND ITS PREVENTION

ZHI-MING XIN (Air Force Research Institute, Beijing, People's Republic of China) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 148-153. refs

An evaluation is made of research results for strong, random, inflight oscillation failures for helicopters, with a view to the helicopter flight dynamics models employed and the roles played by control system/autopilot loop oscillation and pilot-induced helicopter oscillation. Attention is given to the insights gained by coupling an operational helicopter to a ground flight simulator and an analog computer, to induce the failure phenomenon and ascertain the causes of failure. Failure-prevention measures involving both helicopter design steps and operational procedures have been formulated. O.C.

A89-13521#

OPTIMIZATION OF HELICOPTER TAKEOFF AND LANDING

T. CERBE and G. REICHERT (Braunschweig, Technische Universitaet, Brunswick, Federal Republic of Germany) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 154-164. refs
(Contract DFG-SFB-212)

The paper is concerned with the optimization of the special runway Cat A takeoff, a procedure applied when the helicopter has to perform a takeoff similar to that of an aircraft. In the event of engine failure, the CDP (critical decision point) is the essential criterion for the pilot's decision whether to continue or abort the takeoff. The takeoff procedure, with or without engine failure, and the relevant performances are discussed. A quasi-stationary simulation model based on performance data fields is presented. Optimization results are examined, and optimal takeoff techniques are discussed. V.L.

A89-13522#

THEORETICAL MODELLING FOR HELICOPTER FLIGHT DYNAMICS - DEVELOPMENT AND VALIDATION

G. D. PADFIELD (Royal Aerospace Establishment, Bedford, England) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 165-177. refs

The complexity of developing a fully validated and accurate mathematical model is discussed, and different modeling levels necessary to predict lateral, directional, longitudinal, and vertical axis dynamics are examined. System identification techniques are employed to compare flight rest results with theoretical predictions. The measurement set required to validate aeroelastic models is considered. R.R.

A89-13528*# Analytical Services and Materials, Inc., Hampton, VA.

DESIGN PHILOSOPHY OF LONG RANGE LFC TRANSPORTS WITH ADVANCED SUPERCRITICAL LFC AIRFOILS

WERNER PFENNINGER and CHANDRA S. VEMURU (Analytical Services and Materials, Inc., Hampton, VA) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 223-241. refs
(Contract NAS1-18235)

The achievement of 70 percent laminar flow using modest boundary layer suction on the wings, empennage, nacelles, and struts of long-range LFC transports, combined with larger wing spans and lower span loadings, could make possible an unrefuelled range halfway around the world up to near sonic cruise speeds with large payloads. It is shown that supercritical LFC airfoils with undercut front and rear lower surfaces, an upper surface static pressure coefficient distribution with an extensive low supersonic flat rooftop, a far upstream supersonic pressure minimum, and a steep subsonic rear pressure rise with suction or a slotted cruise flap could alleviate sweep-induced crossflow and attachment-line boundary-layer instability. Wing-mounted superfans can reduce fuel consumption and engine tone noise. R.R.

A89-13529#

AERODYNAMIC DESIGN AND INTEGRATION OF A VARIABLE CAMBER WING FOR A NEW GENERATION LONG/MEDIUM RANGE AIRCRAFT

E. GREFF (Messerschmitt-Boelkow-Blohm GmbH, Bremen, Federal Republic of Germany) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 242-254. refs

Transport aircraft manufacturers usually try to achieve a high fleet commonality by creating an aircraft family on the basis of one wing and stretched fuselages. The wing designer has to choose an appropriate wing area for the maximum stretched variant then. A transonic wing, however, shows optimum performance at high loadings which are not achieved at entry-into-service with such a conventional fixed geometry wing. Variable Camber (VC) is offering an opportunity to achieve considerable improvements in operational flexibility, buffet boundaries and performance which allow a reduction in optimum wing size. During the aerodynamic development and design integration described in this paper a change in design strategy and several off-design constraints were found. Theoretical and windtunnel results are given as well as a discussion of the effects on the system design, loads, weight, handling qualities, propulsion integration and mission performance. Author

A89-13539#
A REVIEW OF REQUIREMENTS, DESIGN CONSIDERATIONS AND RESULTING EXPERIENCE FOR EXTENDED RANGE OPERATION OF TWO-ENGINE AIRPLANES
F. C. FICKEISEN (Boeing Commercial Airplane Co., Seattle, WA) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 368-373.

The purpose of this paper is to briefly discuss some of the principal aspects of extended range operations. The sources of information employed in the discussion of requirements are the established standards of the CAO and the national standards of the United States, United Kingdom, France, Canada, Australia, New Zealand, and others. Design considerations are based on studies and work accomplished in modifying, and achieving extended range type design approval of 737, 757, and 767 airplanes and associated propulsion systems. Author

A89-13542*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
MATERIALS AND STRUCTURES FOR HYPERSONIC VEHICLES
D. R. TENNEY, W. B. LISAGOR, and S. C. DIXON (NASA, Langley Research Center, Hampton, VA) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 398-415. refs

Hypersonic vehicles are envisioned to require, in addition to carbon-carbon and ceramic-matrix composites for leading edges heated to above 2000 F, such 600-1800 F operating temperature materials as advanced Ti alloys, nickel aluminides, and metal-matrix composites; these possess the necessary low density and high strength and stiffness. The primary design drivers are maximum vehicle heating rate, total heat load, flight envelope, propulsion system type, mission life requirements, and liquid hydrogen containment system. Attention is presently given to aspects of these materials and structures requiring more intensive development. O.C.

A89-13582#
TRANSGRESSION INVESTIGATIONS OF HELICOPTER DYNAMICS
K. SZUMANSKI (Instytut Lotnictwa, Warsaw, Poland) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 797-806. refs

This paper presents a concept of investigating helicopters in limit conditions. This will make it feasible to estimate dynamic parameters of the system when transgressing admissible limits, and utilizing computer aids, laboratory experiments on a research simulator, and flight tests of extreme character. Author

A89-13583#
THE AERODYNAMIC DEVELOPMENT OF THE FOKKER 100
E. OBERT (Fokker Aircraft, Amsterdam, Netherlands) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 807-826.

An overview is presented of the aerodynamic design of the Fokker 100. The development of the aircraft geometry, in particular that of the wing, is described in detail starting from the F28. The estimated performance characteristics such as cruise drag, buffet-onset boundary and maximum lift coefficient are compared with flight test data. Finally, some stability and control characteristics are described, both as pre-flight estimates and as found on the actual aircraft. Author

A89-13584#
EVOLUTION OF THE LAVI FIGHTER AIRCRAFT
S. TSACH and A. PELED (Israel Aircraft Industries, Ltd., Lod) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 827-841.

The four stages of the evolution of the LAVI fighter aircraft are reviewed. The operational requirements, definition of the LAVI configuration, design principles, air-to-ground oriented design, and engine selection are discussed. The compatibility of the aircraft with the operational requirements is addressed. C.D.

A89-13588#
FLIGHT EVALUATION OF THE ATTAS DIGITAL FLY-BY-WIRE/LIGHT FLIGHT CONTROL SYSTEM
D. HANKE and H.-H. LANGE (DFVLR, Institut fuer Flugmechanik, Brunswick, Federal Republic of Germany) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 866-876. refs

An overview of recent development and flight test experiences of the DFVLR's flight test vehicle ATTAS (Advanced Technologies Testing Aircraft System) equipped with a digital fly-by-wire/light flight control system is presented. System design, multiprocessor communication management, parallel data processing, redundancy management as well as software development and validation are summarized. Further, the role of ground based system simulation for development and testing, flight test procedures and some interesting flight test results are dealt with. Author

A89-13600#
AERODYNAMIC AND STRUCTURAL DESIGN OF THE STANDARD CLASS SAILPLANE ASW-24
L. M. M. BOERMANS (Delft, Technische Hogeschool, Netherlands) and G. WAIBEL (Alexander Schleicher Segelflugzeugbau, Federal Republic of Germany) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 969-978. refs

An account is given of the aerodynamic and structural factors in the design of the ASW-24 Standard Class sailplane. An artificial tripping device is used to eliminate drag-generating laminar separation bubbles on the wing airfoil. Attention is given to the comparative properties and advantages of glass, aramid, and carbon reinforcing fibers applicable to structural composites for the wing, fuselage, and empennage airframe components, as well as to the structural design of the cockpit sidewalls to enhance crashworthiness. Flight experience since December 1987 is discussed. O.C.

A89-13604*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
LAMINAR FLOW CONTROL LEADING EDGE SYSTEMS IN SIMULATED AIRLINE SERVICE
R. D. WAGNER, D. V. MADDALON (NASA, Langley Research Center, Hampton, VA), and D. F. FISHER (NASA, Flight Research Center, Edwards, CA) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 1014-1023. refs

The feasibility of two candidate leading-edge flow laminarization systems applicable to airline service was tested using representative airline operational conditions with respect to air traffic, weather, and airport insect infestation. One of the systems involved a perforated Ti alloy suction surface with about 1 million 0.0025-in. diameter holes drilled by electron beam, as well as a Krueger-type flap that offered protective shielding against insect impingement; the other supplied surface suction through a slotted Ti alloy skin with 27 spanwise slots on the upper and lower surface. O.C.

A89-13606#
THE EMBEDDED GRID-CONCEPT AND TSP METHODS APPLIED TO THE CALCULATION OF TRANSONIC FLOW ABOUT WING/BODY/NACELLE/PYLON-CONFIGURATIONS
DIEQIAN WANG (Northwestern Polytechnical University, Xian, People's Republic of China) and SVEN G. HEDMAN (Flygtekniska Forsoksanstalten, Bromma, Sweden) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 1029-1037. Research sponsored by the Styrelsen for Teknisk Utveckling and Chinese Aeronautical Establishment.

The present computation of the transonic flow about an airliner configuration employs a local cylindrical grid that is embedded in a local Cartesian grid; boundary conditions at nacelle and pylon surfaces are given in the cylindrical system, and at wing and fuselage surfaces in the Cartesian system. At the zone in which the grids overlap, the potential values from one system are given as boundary values for the other system. The pressure distributions obtained are compared with experimental data for Mach numbers in the 0.3-0.75 range; essential features of the flow are adequately predicted. O.C.

A89-13607#
MULTIGRID COMPUTATION OF TRANSONIC FLOW ABOUT COMPLEX AIRCRAFT CONFIGURATIONS, USING CARTESIAN GRIDS AND LOCAL REFINEMENT
B. EPSTEIN, A. L. LUNTZ, and A. NACHSHON (Israel Aircraft Industries, Ltd., Tel Aviv) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 1038-1046. refs

The present three-dimensional full potential code employs Cartesian grids, local refinement, and multigrid calculations, and is capable of addressing arbitrary aircraft configurations by treating them as an assembly of elements. Attention is given to the code's application to three cases: (1) a fighter aircraft canard configuration illustrating the importance of the grid-to-shock alignment; (2) the same configuration with an external fuel tank, which shows unexpectedly strong interference; and (3) a civil aircraft configuration illustrating the influence of the wing root fairing on wing pressure distribution. O.C.

A89-13609*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
RESEARCH AND APPLICATIONS IN AEROSERVOELASTICITY AT THE NASA LANGLEY RESEARCH CENTER
IRVING ABEL and THOMAS E. NOLL (NASA, Langley Research Center, Hampton, VA) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 1059-1071. refs

A review of analytical methods used to analyze flexible vehicles with active controls is presented. Methods used to approximate and correct unsteady aerodynamic forces used in the analysis are discussed. Recent advances in the application of optimal methods to digital control law synthesis are presented. The use of active controls in an integrated design process is also discussed. Finally, the results of recent wind-tunnel studies aimed at demonstrating active control concepts and validating the analytical methods are presented. Author

A89-13610*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
AIRCRAFT AEROELASTICITY AND STRUCTURAL DYNAMICS RESEARCH AT THE NASA LANGLEY RESEARCH CENTER - SOME ILLUSTRATIVE RESULTS
ROBERT V. DOGGETT, JR. and F. W. CAZIER, JR. (NASA, Langley Research Center, Hampton, VA) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 1072-1082. Previously announced in STAR as N88-24598. refs

Highlights of nine different research studies are described. Five of these topics relate directly to fixed-wing aircraft and range from flutter studies using relatively simple and inexpensive wind-tunnel models to buffet studies of the vertical tails of an advanced high-performance configuration. The other four topics relate directly to rotary-wing aircraft and range from studies of the performance and vibration characteristics of an advanced rotor design to optimization of airframe structures for vibration attenuation. Author

A89-13611*# Rockwell International Corp., Los Angeles, CA.
OPTIMIZATION OF NONLINEAR AEROELASTIC TAILORING CRITERIA
F. ABDI, H. IDE (Rockwell International Corp., Los Angeles, CA), V. J. SHANKAR (Rockwell International Science Center, Thousand Oaks, CA), and J. S. SOBIESKI (NASA, Langley Research Center, Hampton, VA) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 1083-1091. Research supported by Rockwell International Corp. refs

A static flexible fighter aircraft wing configuration is presently addressed by a multilevel optimization technique, based on both a full-potential concept and a rapid structural optimization program, which can be applied to such aircraft-design problems as maneuver load control, aileron reversal, and lift effectiveness. It is found that nonlinearities are important in the design of an aircraft whose flight envelope encompasses the transonic regime, and that the present structural suboptimization produces a significantly lighter wing by reducing ply thicknesses. O.C.

A89-13612*# California Univ., Los Angeles.
AEROELASTICITY AND STRUCTURAL OPTIMIZATION OF ROTOR BLADES WITH SWEPT TIPS
P. P. FRIEDMANN and R. CELI (California, University, Los Angeles) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 1092-1108. refs
(Contract NAG2-226)

In the present FEM scheme for the aeroelastic modeling of a swept-tip rotor blade, the swept tip of the blade is assumed to undergo moderate deflections in the flap, lag, and torsion degrees-of-freedom. The nonlinear PDEs of motion are discretized by a Galerkin-type FEM. This aeroelastic stability-and-response computational capability is combined with a structural optimization analysis to minimize the n/rev vertical hub shears in forward flight, subject to aeroelastic stability and frequency placement constraints. Tip sweep is used as a design variable to reduce vibration levels in forward flight. O.C.

A89-13615#
MRVS - A SYSTEM FOR MEASURING, RECORDING AND PROCESSING FLIGHT TEST DATA
J. T. M. VAN DOORN, P. J. H. M. MANDERS, O. VAN TEUNENBROEK (Nationaal Lucht- en Ruimtevaartlaboratorium, Amsterdam, Netherlands), G. PASCOE, H. RIEBEEK (Fokker Aircraft, Amsterdam, Netherlands) et al. IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 1127-1144. refs

The flight test data-measuring, recording, and processing instrument designated 'MRVS' has been designed for application to aircraft currently operating in the Netherlands that are as different as the Fokker 50 and 100 and the F-16. MRVS consists of hardware and software modules that have been integrated to satisfy versatility requirements; this system-modularity feature has resulted in a substantial shortening of the time needed for the constitution of a new instrumentation system. The data-base approach to instrumentation-system data management and storage/analysis furnishes quick on-line retrieval for both the instrumentation and analysis personnel involved in the given flight test program. O.C.

A89-13626#
A320 FULL SCALE STRUCTURAL TESTING FOR FATIGUE AND DAMAGE TOLERANCE CERTIFICATION OF METALLIC AND COMPOSITE STRUCTURE
B. BRANDECKER and R. HILGERT (Messerschmitt-Boelkow-Blohm GmbH, Hamburg, Federal Republic of Germany) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 1244-1256. refs

Results are presented from fatigue and damage-tolerance certification-related full-scale structural tests conducted on (1) the center fuselage/wing and rear fuselage metallic structures and (2) the vertical tail composite structure of the A320 airliner. Acceptable correlations are obtained between damage tolerance calculation results and the present test results for both the fuselage/wing and vertical tail articles. The results have verified crack-free life and economical repair life design method predictions. O.C.

A89-13627#
SUMMARY OF THE KFIR FATIGUE EVALUATION PROGRAM
E. REINBERG and A. BROT (Israel Aircraft Industries, Ltd., Lod) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 1257-1266. refs

A fatigue life evaluation program (FEP) has been performed to promote fleet safety and economy for Kfir aircraft in service. The FEP included durability and damage tolerance analyses, specimen and component testing, and the full-scale fatigue test of the aircraft. Fatigue cracks discovered during the test were monitored by NDI and their growth recorded. The test-article passed four lifetimes, followed by a residual strength test; no failures occurred during the full-scale test. A limited tear-down inspection of the airframe was performed. Many design improvements were implemented as a result of the FEP. Author

A89-13634#
SENSITIVITY OF REDUCED FLIGHT DYNAMIC MODEL DEPENDING ON ELASTICITY OF AIRCRAFT STRUCTURE
J. JANKOVIC (Beograd, Univerzitet, Belgrade, Yugoslavia) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 1328-1333. refs

The paper presents a procedure for synthesizing the dynamic sensitivity model of an aircraft depending on the structure elasticity. This procedure can be used to define the system-reduction criterion. B.J.

A89-13635#
ANALYSES OF THE TRANSMISSION OF SOUND INTO THE PASSENGER COMPARTMENT OF A PROPELLER AIRCRAFT USING THE FINITE ELEMENT METHOD
PETER GOERANSSON and FREDERIK DAVIDSSON (Flygtekniska Forsoksanstalten, Bromma, Sweden) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 1334-1341. Research supported by the Styrelsen for Teknisk Utveckling. refs

The finite element method is used to analyze the cross section of a propeller aircraft, and it is shown that the transmission of low-frequency sound is strongly dependent on the dynamics of the fuselage-air-trim-air system. It is found that the maximum SPL may vary from 123 to 118 dB in the extreme cases where only attachment and density of the trim panel are changed. B.J.

A89-13636#
THE ULTRALIGHT AEROPLANE - A 'PAIN IN THE AIR' OF AN ENVIRONMENTALLY ACCEPTABLE FLIGHT VEHICLE?
HANNO HELLER, WERNER DOBRZYNSKI, and HELMUT DAHLEN (DFVLR, Institut fuer Entwurfsaerodynamik, Brunswick, Federal Republic of Germany) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 1342-1355. Research supported by the Umweltbundesamt.

A research program to evaluate the technical feasibility of meeting noise limits imposed on ultralight airplanes by West Germany is presented. The experiments include fly-over and ground static noise measurements on tractor and pusher propeller driven ultralight airplanes and wind tunnel noise measurements on isolated full-scale ultralight airplane propellers. It is found that only tractor propeller driven ultralight airplanes have the potential for meeting the noise requirements. R.B.

A89-13639#
AERODYNAMIC DESIGN OF A MANUAL AILERON CONTROL FOR AN ADVANCED TURBOPROP TRAINER
O. L. P. MASEFIELD (Pilatus-Flugzeugwerke AG, Stans, Switzerland) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 1374-1381. refs

The control surfaces of the PC-9 turboprop trainer have been designed for manual control in order to preclude the added complexity of a hydraulic power boost system, despite the design difficulties that will emerge at flight speeds of the order of 320 kts. The aileron selected for the PC-9 is a mixture between a sealed internal balance, which will be the primary device, and a low-angled bevelled trailing edge to 'fine-tune' the hinge moments. O.C.

A89-13651#
EFFICIENT PROCEDURES FOR THE OPTIMIZATION OF AIRCRAFT STRUCTURES WITH A LARGE NUMBER OF DESIGN VARIABLES
U.-L. BERKES and J. WIEDEMANN (Berlin, Technische Universitaet, Federal Republic of Germany) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 1487-1497. refs

Variable reduction in an optimization process is a necessary task to match acceptable computation times and costs in the predesign phase. A method is presented which reduces the number of design parameters in the optimization process with large structures, without cutting the variational DOF. Both the optimizor and the FEM analysis program are separated, and the parameter set is determined out of an interpolating routine which is controlled by the optimizor itself. The advantage of this procedure is to reduce the computation time rapidly due to the small parameter-set in the optimizor. Variations with the interpolating functions, such as polynomials and splines, are carried out with aircraft structures in comparison to 'full-variable-size' optimizations and those with the classic 'variable slaving' method. Author

A89-13657#
EXPERIENCE IN APPLICATION OF ACTIVE VIBRATION CONTROL TECHNOLOGY TO A WIND TUNNEL MODEL AND TO FLYING AIRBUS
KLAUS KOENIG (Messerschmitt-Boelkow-Blohm GmbH, Bremen, Federal Republic of Germany) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 1542-1552.

Vibration control technology based on the modified optimal control theory has been applied to a wind tunnel model and to the flying Airbus. Analog and digital controllers, tuned observers and broad band controller laws, ailerons, spoilers and wing tip vanes, together with different sensor locations have been tested in calm and turbulent atmospheres as well as with and without failure modes. Test results were promising and allowed larger increase of flutter speed as well as amplitude reduction together with load alleviation for the studied examples. Author

A89-13659#
FLUTTER CALCULATION OF FLUTTER MODELS

VALTER J. E. STARK (Saab-Scania, AB, Linkoping, Sweden) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 1559-1569. Research supported by the Swedish Defence Administration and Saab-Scania, AB. refs

Calculated results for small and thin wing models, some of which have a launcher and missile at the tip, and for a large and likewise thin composite model with flap have been compared with test results for zero incidence. The small models were tested in a small tunnel at high-subsonic speeds and the large model in a large tunnel at transonic and low-supersonic speeds. Since the results from the calculations, which were mainly based on the linearized theory, are in good agreement with those from the carefully performed tests, it is concluded that this theory is satisfactory for flutter calculations of thin wings at zero incidence. Author

A89-13661#

DESIGN AND ANALYSIS OF A HIGH SPEED COMPOSITE MATERIAL WING FLUTTER MODEL

A. P. N. SUTHERLAND (Council for Scientific and Industrial Research, Div. of Aeronautical Systems Technology, Pretoria, Republic of South Africa) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 1580-1590. refs

As an ongoing exercise to establish an experimental aeroelastic capability, the design of a 0.21 Mach scaled (reduced stiffness) cantilever wing was undertaken, for testing in the new National Medium Speed Wind Tunnel. Described are the choice of scaling factors, estimation of full scale properties, materials evaluation, sizing and construction of the first (calibration) model and calibration procedures to be followed. At all times an effort was made to maintain simplicity in the model design, while imposing the limitations of available materials and construction methods. Some preliminary calibration results from the completed model are presented, which indicate good simulation of the full scale wing. Author

A89-13663#

ADVANCED COMPOSITE DEVELOPMENT FOR LARGE TRANSPORT AIRCRAFT

ROBERT D. WILSON (Boeing Co., Boeing Commercial Airplanes, Seattle, WA) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 1600-1604.

The basic technical issues involved in the large-scale heavy composite primary structure incorporation are discussed, with special attention given to three major issues involving large wing structure, empennage, and fuselage: impact/damage tolerance, postbuckled structure design, and economic repair in the field. It is emphasized that cost is the basic driver affecting the success of advanced composites in large commercial transport production. Since composites are not sensitive to corrosion and fatigue, they offer the potential to reduce direct operating costs significantly by reducing maintenance costs. I.S.

A89-13664#

COMPOSITE SECONDARY AND PRIMARY STRUCTURES FOR PILATUS AIRCRAFT - EXPERIENCE FROM THE DEVELOPMENT AND CONSIDERATIONS FOR FUTURE APPLICATIONS

V. DORER and K. WIESLER (Pilatus-Flugzeugwerke AG, Stans, Switzerland) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 1605-1614.

Within an advanced composite technology program, several design and manufacturing methods have been evaluated for a number of composite components on existing Pilatus aircraft, coveirng both secondary and primary structures. Cost-effectiveness, weight reduction, certification requirements and in service implications are taken into consideration. Series production as well as prototype components are described, covering technical and economical aspects of design and fabrication. A summary is presented which shows the potential of the outlined design concepts and manufacturing methods for future applications on the specific aircraft described. Author

A89-13665#

NEW DEVELOPMENTS IN ARALL LAMINATES

L. B. VOGELESANG, J. W. GUNNINK, D. CHEN, G. H. J. J. ROEBROEKS, and A. VLOT (Delft, Technische Hogeschool, Netherlands) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 1615-1633. refs

This paper discusses the characteristics of ARALL laminates, both with aramid fiber and glass fiber, and the applications of these materials in fatigue and impact sensitive aircraft structures. It is shown that the ARALL laminates exhibit high fatigue resistance, high strength, and low density, making them a very promising candidates as aerospace materials. Although the ARALL laminates are notch sensitive, the strength of the four standardized grades of ARALL laminates up to a notch factor of 4 was found to be higher than that of monolithic 2024-T3. It is shown that the combination of ARALL Laminate properties matches well with existing structural integrity requirements; flying with small fatigue cracks does not harm the structure of an ARALL laminate. I.S.

A89-13668#

AIRCRAFT CONFIGURATION ANALYSIS/SYNTHESIS EXPERT SYSTEM - A NEW APPROACH TO PRELIMINARY SIZING OF COMBAT AIRCRAFT

R. BARGETTO, B. MAZZETTI (Aeritalia S.p.A., Gruppo Velivoli Combattimento, Turin, Italy), and G. GARBOLINO (Centro Sistemi Informatici-Piemonte, Turin, Italy) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 1645-1649.

This paper describes the expert system (ES) ACES (Aircraft Configuration Expert System) now under development by AERITALIA, that has been realized on a LISP machine using the KEE (Knowledge Engineering Environment). This ES is an aircraft design tool which is able by itself to generate a set of possible configurations, starting from the requirements and from a set of rules which constitute its knowledge base and to optimize the aircraft varying not only the usual numerical parameters but also configurational elements. Author

A89-13669#

COMPUTER-AIDED STRUCTURAL OPTIMISATION OF AIRCRAFT STRUCTURES

PETER BARTHOLOMEW (Royal Aerospace Establishment, Materials and Structures Dept., Farnborough, England) and HEINRICH WELLEN (Messerschmitt-Boelkow-Blohm GmbH, Bremen, Federal Republic of Germany) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 1650-1663. refs

This paper discusses the principal methods used within the computer program STARS for the computer-aided design of optimum structures subject to a variety of constraints. Attention is given to the Newton STARS method developed for structural optimization of aircraft structures, with special consideration given to the shape optimization developed in the form of a hierarchical approach. Industrial applications of structural optimization are described, such as the FEM models of the frame for a modern fighter aircraft, the wing box of a modern airliner, and a composite fin box. I.S.

A89-13670#

COMPUTATIONAL DESIGN AND EFFICIENCY OPTIMIZATION OF AGRICULTURAL AIRPLANES

ROLF STAUFENBIEL, THOMAS SCHERER (Aachen, Rheinisch-Westfaelische Technische Hochschule, Federal Republic of Germany), and ISTVAN STEIGER (Budapesti Muszaki Egyetem, Budapest, Hungary) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 1664-1676. DFG-supported research. refs

This paper presents a simulation program for optimizing the parameters of the spraying system and the configuration of agricultural aircraft, which yields higher accuracy in calculated spraying distribution, as well as other improvements, in comparison with existing methods. The method incorporates new techniques for describing the roll-up process of the wing wake and the flow characteristics of the propeller slipstream and uses a new statistical method for describing the influence of wind fields and turbulence. Using this simulation program, it was demonstrated that, by installing winglets in the aircraft design, not only aircraft performance but also spray efficiency can be improved. This winglet configuration, in combination with optimized spray nozzle arrangements, was tested in flight tests using an aircraft of the PZL M-18 Dromader type; good agrement was obtained between flight test results and simulation results. I.S.

A89-13672#

A RELIABILITY AND MAINTAINABILITY PREDICTION METHOD FOR AIRCRAFT CONCEPTUAL DESIGN

V. C. SERGHIDES and J. P. FIELDING (Cranfield Institute of Technology, England) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 1683-1692. refs

An account is given of a methodology which is applicable, in conjunction with other aircraft conceptual design methods, to reliability and maintainability prediction based on statistically-derived empirical equations. One or two aircraft design parameters are treated per given aircraft system. Each equation is individually adjusted for advancements in system-related technologies by a statistically-derived factor. The method's application is demonstrated for several combat aircraft and commercial airliners. O.C.

A89-13674#

CANARD/LEF DESIGN FOR A MULTI-MISSION FIGHTER AIRCRAFT

M. SHEPSHELOVICH, D. ABOUDI, E. BAHAREV, B. EPSTEIN, and A. LUNTZ (Israel Aircraft Industries, Ltd., Lod) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 1700-1713. refs

Leading edge flap and canard aerodynamic reshaping for a multi-mission fighter aircraft are discussed. The design target was improving transonic sustained turn performance of nominal aircraft configuration without penalizing supersonic characteristics. The paper presents basic design principles and describes the theoretical design cycle and the experimental testing of newly designed elements. Author

A89-13678#

LOW SPEED WIND TUNNEL INVESTIGATION OF PROPELLER SLIPSTREAM AERODYNAMIC EFFECTS ON DIFFERENT NACELLE/WING COMBINATIONS

INGEMAR SAMUELSSON (Flygtekniska Forsoksanstalten, Bromma, Sweden) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 1749-1765.

Four different nacelle/wing combinations have been investigated in a low speed wind tunnel in order to characterize propeller slipstream/nacelle/wing aerodynamic interference effects at various angles of attack and of yaw, as well as different freestream velocities and propeller thrust coefficients. Three-dimensional velocity and static pressure slipstream flow results are presented; significant propeller slipstream-induced lateral nacelle loads, including side-force, yawing-moment, and rolling-moment loads, are noted. O.C.

A89-13684*# Virginia Polytechnic Inst. and State Univ., Blacksburg.

INTEGRATED STRUCTURAL-AERODYNAMIC DESIGN OPTIMIZATION

R. T. HAFTKA, P. J. KAO, B. GROSSMAN, D. POLEN (Virginia Polytechnic Institute and State University, Blacksburg), and J. SOBIESZCZANSKI-SOBIESKI (NASA, Langley Research Center, Hampton, VA) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 1820-1825. refs
(Contract NAG1-603; NSF DMC-86-15336)

This paper focuses on the processes of simultaneous aerodynamic and structural wing design as a prototype for design integration, with emphasis on the major difficulty associated with multidisciplinary design optimization processes, their enormous computational costs. Methods are presented for reducing this computational burden through the development of efficient methods for cross-sensitivity calculations and the implementation of approximate optimization procedures. Utilizing a modular sensitivity analysis approach, it is shown that the sensitivities can be computed without the expensive calculation of the derivatives of the aerodynamic influence coefficient matrix, and the derivatives of the structural flexibility matrix. The same process is used to efficiently evaluate the sensitivities of the wing divergence constraint, which should be particularly useful, not only in problems of complete integrated aircraft design, but also in aeroelastic tailoring applications. Author

A89-15024

BLACKJACK - AIR DEFENCE CHALLENGE FOR THE 1990S

BILL SWEETMAN Interavia (ISSN 0020-5168), vol. 43, Oct. 1988, p. 1012-1014.

The USSR's 'Blackjack' supersonic cruise-capable bomber is the largest aircraft ever designed for a combat mission, being as much as 50 percent heavier than the U.S. B-1B. The present analysis of its design features, with a view to its intended operational environment, notes the design to emphasize the high speed/altitude corner of the performance envelope, unlike the low-level/subsonic-penetration B-1B. One weapons bay of more than 40-ft length is incorporated ahead of the wing carry-through box; a 25-ft-long bay is located behind it. Both bays can accomodate rotary launchers for six AS-15 cruise missiles; the long forward bay could in addition carry several thermonuclear free-fall bombs. Maximum speed may be in excess of Mach 2 at 60,000 ft. O.C.

A89-15043

SPRITE - AN AFFORDABLE RPH SURVEILLANCE SYSTEM

BRIAN WANSTALL Interavia (ISSN 0020-5168), vol. 43, Sept. 1988, p. 897, 898.

The 'Sprite' remotely-piloted helicopter (RPH) for battlefield surveillance can be carried by two men, requires no launch and recovery equipment, and is able to remain in continuous operation over a battlefield for two hours. The Sprite RPH weighs 40 kg and employs two 6.5-hp engines to drive two contrarotating rotors. Surveillance and targeting functions have a range of 32 km, thereby fitting well into divisional operations. The flattened spheroidal composite fuselage subtends only 1 millirad at 600 m, rendering it very difficult to spot by an enemy at its operating altitude. O.C.

A89-15067

ADVANCES IN SUPERPLASTIC ALUMINUM FORMING

A. J. BARNES (Superform USA, Inc., Riverside, CA) IN: Superplasticity in aerospace; Proceedings of the Topical Symposium, Phoenix, AZ, Jan. 25-28, 1988. Warrendale, PA, Metallurgical Society, Inc., 1988, p. 301-313. refs

The development of superplastic aluminum forming from its early beginning to its current status illustrates the increasing use of this technology by the aerospace industry. The emergence of newer alloys, such as Supral 220, SP7475, 8090 and 2090, heralds an expansion into more structural applications. The significance of process developments, such as back pressure forming and diffusion bonding are discussed and the importance of designing for SPF is emphasized. Author

A89-15077
INTERIOR NOISE AND VIBRATION PREDICTION FOR UDF/727 DEMONSTRATOR AIRCRAFT
L. W. CRAIG, L. M. BUTZEL, G. K. QUEITZSCH, J. E. MANNING, and L. D. POPE (Boeing Commercial Airplane Co., Seattle, WA) IN: NOISE-CON 88 - Noise control design: Methods and practice; Proceedings of the National Conference on Noise Control Engineering, West Lafayette, IN, June 20-22, 1988. Poughkeepsie, NY, Institute of Noise Control Engineering, 1988, p. 87-92.

Three design analysis techniques were chosen to develop detailed models of the UDF/727 demonstator aircraft: finite element analysis, statistical energy analysis, and a combined power flow and modal method. Comparisons of predicted and measured interior noise and vibration were made for ground shake and flight test conditions in order to assess the capabilities of each procedure. B.J.

A89-15078
INTERIOR NOISE RESEARCH ACTIVITIES FOR UHB AIRCRAFT AT MCDONNELL DOUGLAS CORP
MYLES A. SIMPSON and PATRICK M. DRUEZ (Douglas Aircraft Co., Long Beach, CA) IN: NOISE-CON 88 - Noise control design: Methods and practice; Proceedings of the National Conference on Noise Control Engineering, West Lafayette, IN, June 20-22, 1988. Poughkeepsie, NY, Institute of Noise Control Engineering, 1988, p. 93-98.

Two major components of the UHB (ultra high bypass) research effort involving the investigation of UHB noise sources and transmission paths are described. The first component is a ground facility using the aft section of a DC-9 as a full-scale test article, housed in a large anechoic chamber and exposed to simulated UHB acoustic and mechanical loads. The second component is a flight test program using an MD-80 aircraft with one of its JT8D engines replaced by a prototype UHB engine. B.J.

A89-15098
THE DAMPED SOLUTION TO SONIC FATIGUE IN THE KC-135
MICHAEL L. DRAKE and PHILIP A. GRAF (Dayton, University, OH) IN: NOISE-CON 88 - Noise control design: Methods and practice; Proceedings of the National Conference on Noise Control Engineering, West Lafayette, IN, June 20-22, 1988. Poughkeepsie, NY, Institute of Noise Control Engineering, 1988, p. 353-358. USAF-supported research. refs

The paper describes the five major tasks which resulted in a successful sonic-fatigue damping design for the KC-135 aircraft. These tasks were: fuselage dynamic tests, design of the damping system, evaluation of the damping system, damping system implementation, and damping system impact. B.J.

A89-15099
DAMPED AIRCRAFT COMPONENTS FOR MINIMUM WEIGHT
MATTHEW F. KLUESENER and ROBERT BUZDON (Dayton, University, OH) IN: NOISE-CON 88 - Noise control design: Methods and practice; Proceedings of the National Conference on Noise Control Engineering, West Lafayette, IN, June 20-22, 1988. Poughkeepsie, NY, Institute of Noise Control Engineering, 1988, p. 359-364.
(Contract F33615-86-C-3202)

The paper discusses viscoelastic damping designs developed for the B-1B Aft Equipment Bay to evaluate the relative significance and benefit of various damping concepts. Emphasis is placed on minimum weight innovative designs which take into account the benefit of designed-in damping. Several damping configurations are presented for a fuselage skin and a composite access door. Damping in mode 1 was emphasized, since this is the mode that usually responds to acoustic excitation. B.J.

A89-15101
BELL 222 HELICOPTER CABIN NOISE - ANALYTICAL MODELING AND FLIGHT TEST VALIDATION
GOPAL P. MATHUR (Bell Helicopter Textron, Fort Worth, TX), JEROME E. MANNING, and ALLAN C. AUBERT (Cambridge Collaborative, Inc., MA) IN: NOISE-CON 88 - Noise control design: Methods and practice; Proceedings of the National Conference on Noise Control Engineering, West Lafayette, IN, June 20-22, 1988. Poughkeepsie, NY, Institute of Noise Control Engineering, 1988, p. 573-578.
(Contract DAAJ02-85-C-0052)

The application of statistical energy analysis (SEA) to the Bell 222 Helicopter airframe is discussed. The analytical modeling approach is described along with the ground and flight tests conducted to obtain noise and vibration data for analytical model validation. It is concluded that the SEA is a valid noise prediction procedure for complex helicopter structures. B.J.

A89-15507
IDENTIFICATION OF STRUCTURAL VIBRATION CONTROL PARAMETERS USING MODAL CONTRIBUTORS
EDWARD WEI-YUEH LEE and YUNG-TSENG CHUNG (Bell Helicopter Textron, Inc., Fort Worth, TX) IN: International Modal Analysis Conference, 6th, Kissimmee, FL, Feb. 1-4, 1988, Proceedings. Volume 1. Bethel, CT, Society for Experimental Mechanics, Inc., 1988, p. 56-62.

A NASTRAN DMAP ALTER was written to calculate the modal contributors for a structural system with Rayleigh-Ritz damping. Included in the DMAP ALTER are capabilities of projecting modal contributors onto the total response, filtering out unwanted modes, and calculating modal dampings. The procedure of employing modal contributors and structural modification are demonstrated on the AH-1G helicopter NASTRAN model. B.J.

A89-15563
PIAGGIO P180
PAOLO G. CHIARLONE and DAVID MIRANDA (Rinaldo Piaggio - Industrie Aeronautiche e Meccaniche S.p.A., Finale Ligure, Italy) IN: International Modal Analysis Conference, 6th, Kissimmee, FL, Feb. 1-4, 1988, Proceedings. Volume 1. Bethel, CT, Society for Experimental Mechanics, Inc., 1988, p. 679-689.

Experimental and theoretical procedures used to determine the natural frequencies and dampings of the Piaggio P180 aircraft and their variations with speed are presented. The excitation techniques applied for flight flutter testing and the digital analysis methods used on flight flutter test data are described. K.K.

A89-15570
VIBRATIONAL AND ACOUSTICAL BEHAVIOUR OF COMPLEX STRUCTURAL CONFIGURATIONS USING STANDARD FINITE ELEMENT PROGRAM
FRANCESCO MARULO, LEONARDO LECCE (Napoli, Universita, Naples, Italy), and ANTONIO PAONESSA (Aeritalia S.p.A., Naples, Italy) IN: International Modal Analysis Conference, 6th, Kissimmee, FL, Feb. 1-4, 1988, Proceedings. Volume 1. Bethel, CT, Society for Experimental Mechanics, Inc., 1988, p. 827-833. refs

The results of an extensive research program on the fuselage vibroacoustical behavior aimed at cabin noise reduction in turboprop aircraft, are briefly reviewed. The reasons which led to the application of the finite element method are recalled, and results of both theoretical and experimental tests for the structural and acoustic models are presented. Future developments in terms of coupled numerical models and flight tests for the final validation of the methodology are then discussed. Author

A89-15585
THE OPTIMAL DESIGN OF ISOLATOR IN AEROSPACE EQUIPMENT
Y. Z. WANG, K. S. WANG (National Central University, Chung-Li, Republic of China), and S. S. TSAI IN: International Modal Analysis

Conference, 6th, Kissimmee, FL, Feb. 1-4, 1988, Proceedings. Volume 2. Bethel, CT, Society for Experimental Mechanics, Inc., 1988, p. 960-965. refs

The optimal design of a vibration isolator used in aircraft components is considered, with natural frequencies and damping ratios included among the design parameters. Attention is given to different environment situations, including shock during hard landing, random excitation during flying, and the acceleration environment during maneuver. B.J.

A89-15606* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

AIRCRAFT INTERIOR NOISE PREDICTION USING A STRUCTURAL-ACOUSTIC ANALOGY IN NASTRAN MODAL SYNTHESIS

FERDINAND W. GROSVELD, BRENDA M. SULLIVAN (NASA, Langley Research Center; PRC Kentron, Hampton, VA), and FRANCESCO MARULO (Napoli, Universita, Naples, Italy) IN: International Modal Analysis Conference, 6th, Kissimmee, FL, Feb. 1-4, 1988, Proceedings. Volume 2. Bethel, CT, Society for Experimental Mechanics, Inc., 1988, p. 1191-1198. refs

(Contract NAS1-18000)

The noise induced inside a cylindrical fuselage model by shaker excitation is investigated theoretically and experimentally. The NASTRAN modal-synthesis program is used in the theoretical analysis, and the predictions are compared with experimental measurements in extensive graphs. Good general agreement is obtained, but the need for further refinements to account for acoustic-cavity damping and structural-acoustic interaction is indicated. T.K.

A89-15643

COMPARISON OF STEPPED-SINE AND BROAD BAND EXCITATION TO AN AIRCRAFT FRAME

F. LEMBREGTS, J. LIPKENS, J. LEURIDAN, and H. VAN DER AUWERAER (Leuven Measurement and Systems, Belgium) IN: International Modal Analysis Conference, 6th, Kissimmee, FL, Feb. 1-4, 1988, Proceedings. Volume 2. Bethel, CT, Society for Experimental Mechanics, Inc., 1988, p. 1706-1713. refs

This paper describes a modal test on a nonlinear aircraft frame structure. Both stepped-sine and burst random excitation forces were used to estimate frequency response functions relative to four inputs. Comparisons are discussed between both excitation techniques, between single and multiple input excitation, and between the time domain. Polyreference and the frequency domain direct parameter identification techniques. Author

A89-15646

FRACTAL PROPERTIES OF INERTIAL-RANGE TURBULENCE WITH IMPLICATIONS FOR AIRCRAFT RESPONSE

J. G. JONES (Royal Aerospace Establishment, Farnborough, England), G. W. FOSTER, and A. HAYNES (Royal Aerospace Establishment, Bedford, England) Aeronautical Journal (ISSN 0001-9240), vol. 92, Oct. 1988, p. 301-308. refs

Fractal geometry provides a method for modeling the scale dependence of fluctuations in atmospheric-turbulence velocity. Basic concepts are outlined and illustrated by a method of data analysis which, for a fractal process, displays measured probability distributions in scale-invariant form. To a first approximation, the data exhibit statistical self-similarity, consistent with the classical theory of Kolmogorov (1941). However, on more detailed analysis, the more intense fluctuations show systematic departures from self-similarity, consistent with recent theoretical estimates of the fractal dimension of the support of turbulence. Implications for aircraft gust response are discussed. Author

A89-15707#

USING THE MOMENTUM METHOD TO ESTIMATE AIRCRAFT DITCHING LOADS

B. R. LEIGH (Boeing Canada, de Havilland Div., Downsview, Canada) Canadian Aeronautics and Space Journal (ISSN 0008-2821), vol. 34, Sept. 1988, p. 162-169. refs

A procedure has been developed to simulate aircraft behavior during planned emergency water landings (ditching). Because the shape of the immersed part of the aircraft's fuselage is slender, a momentum method based on the assumption that the disturbed water flow is two-dimensional perpendicular to the flight path can be used. The objective is to achieve ditching certification for civil transport category aircraft while avoiding the time and expense associated with ditching model tests. This procedure has been implemented as a computerized simulation model which is used to estimate water loads and aircraft motions in time throughout the event. Simulation results are compared to model test data for the DHC-7 aircraft. Simulation results are also presented for the geometrically comparable DHC-8. Author

A89-16076#

ANALYSIS OF PERFORMANCE MEASUREMENTS FOR A PROPELLER-DRIVEN AIRCRAFT. III - POWER PLANT CHARACTERISTICS [ANALIZA WYNIKOW POMIAROW OSIAGOW SAMOLOTU SMIGLOWEGO. III - CHARAKTERYSTYKA ZESPOLU NAPEDOWEGO]

ANDRZEJ KARDYMOWICZ Technika Lotnicza i Astronautyczna (ISSN 0040-1145), vol. 43, May 1988, p. 8-10, 20, 21. In Polish.

A89-16077

SUPPORTABILITY OF COMPOSITE AIRFRAME STRUCTURES; PROCEEDINGS OF THE WORKSHOP, GLASGOW, SCOTLAND, AUG. 3, 4, 1987

E. DEMUTS, ED. Workshop sponsored by Paisley College of Technology and USAF. Composite Structures (ISSN 0263-8223), vol. 10, no. 1, 1988, 129 p. For individual items see A89-16078 to A89-16085.

The papers presented in this volume provide a definition and assessment of the supportability of composite airframe structures. Topics discussed include nondestructive test analysis and life and residual strength prediction of composite airframe structures; assessment of the effect of impact damage in composites; and damage tolerance and supportability aspects of ARALL laminate aircraft structures. V.L.

A89-16078

NON-DESTRUCTIVE TEST ANALYSIS AND LIFE AND RESIDUAL STRENGTH PREDICTION OF COMPOSITE AIRCRAFT STRUCTURES

I. R. FARROW and J. B. YOUNG (Cranfield Institute of Technology, Bedford, England) (Paisley College of Technology and USAF, Workshop on Supportability of Composite Airframe Structures, Glasgow, Scotland, Aug. 3, 4, 1987) Composite Structures (ISSN 0263-8223), vol. 10, no. 1, 1988, p. 1-15. refs

Supportability is defined in this paper as the ability to assess and reassess the effect of change in operational use on fatigue damage accumulation. To achieve this, a rationalized approach and cumulative damage model are proposed to relate NDE measurements to life and residual strength of advanced composite aircraft structures. Author

A89-16080

SUPPORTABILITY OF COMPOSITE AIRFRAMES - CIVILIAN AND MILITARY ASPECTS

STEFAN KUPCZYK (Dornier GmbH, Friedrichshafen, Federal Republic of Germany) (Paisley College of Technology and USAF, Workshop on Supportability of Composite Airframe Structures, Glasgow, Scotland, Aug. 3, 4, 1987) Composite Structures (ISSN 0263-8223), vol. 10, no. 1, 1988, p. 37-50.

Some problems and risks associated with the use of composite materials in airframe structures are briefly reviewed. In particular, attention is given to such problems as reliability, maintainability, availability, and producibility of composite aircraft components. Approaches which can be used to solve these problems include damage-tolerant structures, simple reliable inspection methods, appropriate maintenance concepts, and simple time-saving and cost-effective repair methods. V.L.

A89-16082

CARBON FIBRE COMPOSITE ON THE VIGGEN AIRCRAFT

ROGER STENBERG (SAAB-Scania, AB, Linkoping, Sweden) (Paisley College of Technology and USAF, Workshop on Supportability of Composite Airframe Structures, Glasgow, Scotland, Aug. 3, 4, 1987) Composite Structures (ISSN 0263-8223), vol. 10, no. 1, 1988, p. 75-81.

The current status of the carbon fiber composite program for the Viggen aircraft, which is aimed at redesigning some metal parts in carbon fiber composites, is briefly reviewed. The parts that have been redesigned in carbon fiber composite include a canard wing flap, a landing gear door, an access panel at the rear of the main wing, and a vertical stabilizer. The required maintenance actions and in-service experience are discussed, and some areas for future consideration are identified. V.L.

A89-16083
DAMAGE TOLERANCE AND SUPPORTABILITY ASPECTS OF ARALL LAMINATE AIRCRAFT STRUCTURES
J. W. GUNNINK (Delft, Technische Hogeschool, Netherlands) (Paisley College of Technology and USAF, Workshop on Supportability of Composite Airframe Structures, Glasgow, Scotland, Aug. 3, 4, 1987) Composite Structures (ISSN 0263-8223), vol. 10, no. 1, 1988, p. 83-104. refs

Comparison of ARALL laminates with other aircraft materials on a structural level shows that ARALL laminate is a very attractive material, especially for fatigue-dominated structural parts. Investigation of this material in relation to the primary aircraft allowables gives some remarkable results. Fatigue and static testing of an ARALL F-27 lower wing panel confirms this. Author

A89-16087*# Kansas Univ., Lawrence.
EFFECTS OF COMPRESSIBILITY ON DESIGN OF SUBSONIC FUSELAGES FOR NATURAL LAMINAR FLOW
P. M. H. W. VIJGEN (Kansas, University, Lawrence), S. S. DODBELE (Vigyan Research Associates, Inc., Hampton, VA), B. J. HOLMES (NASA, Langley Research Center, Hampton, VA), and C. P. VAN DAM (California, University, Davis) Journal of Aircraft (ISSN 0021-8669), vol. 25, Sept. 1988, p. 776-782. refs
(Contract NAG1-345; NAS1-17926)

Compressible linear boundary-layer stability analyses of two representative axisymmetric fuselage geometries indicate that a favorable effect will be exerted on the characteristics of a fuselage's axisymmetric boundary layer by compressibility. A freestream Mach number increase from 0.6 to 0.8 significantly reduces TS wave growth rates in the laminar boundary layer of the fuselages analyzed. The generally destabilizing effect of increasing length Re number on boundary layer stability can be overpowered by the favorable effects of compressibility on the fluid. O.C.

A89-16089#
STATIC AND DYNAMIC ANALYSIS OF AIRSHIPS
V. R. MURTHY (Syracuse University, NY) and JONG-HO WOO Journal of Aircraft (ISSN 0021-8669), vol. 25, Sept. 1988, p. 790-795. refs

Consideration of geometric nonlinearities is important in the static and dynamic design of nonrigid airships. The finite-element method, using MSC/NASTRAN, is applied to perform linear and nonlinear static analyses and to determine the free vibration characteristics of such airships. It is found that the solutions obtained using the linear plus differential stiffness matrix may be quite adequate for airship structural analysis. A procedure to design a wrinkle-free catenary curtain is presented. The necessary solution sequence alterations used to determine the natural vibration characteristics of airships using MSC/NASTRAN are presented. Author

A89-16098*# Virginia Polytechnic Inst. and State Univ., Blacksburg.
INTEGRATED AERODYNAMIC/STRUCTURAL DESIGN OF A SAILPLANE WING
B. GROSSMAN, Z. GURDAL, R. T. HAFTKA (Virginia Polytechnic Institute and State University, Blacksburg, VA), G. J. STRAUCH, and W. M. EPPARD Journal of Aircraft (ISSN 0021-8669), vol. 25, Sept. 1988, p. 855-860. Previously cited in issue 05, p. 589, Accession no. A87-17882. refs
(Contract NAG1-505; NAG1-603)

A89-16215
SECOND X-29 WILL EXECUTE HIGH-ANGLE-OF-ATTACK FLIGHTS
STANLEY W. KANDEBO and WILLIAM B. SCOTT Aviation Week and Space Technology (ISSN 0005-2175), vol. 129, Oct. 31, 1988, p. 36-39, 42.

The most significant features of the second X-29 research aircraft are reviewed, and its testing agility is discussed. Comparisons with the first X-29 research aircraft are made, and wind tunnel test data indicating the significant control improvements of forward swept wing aircraft over aft-swept wing aircraft are given. The funding squeeze experienced by the aircraft is discussed. C.D.

A89-16225
ON THE PROWL IN THE SA-365M PANTHER
DAVID GREEN Rotor and Wing International (ISSN 0191-6408), vol. 22, Nov. 1988, p. 48-50, 52, 53.

The capabilities of the French-built, multirole helicopter SA-365M Panther are addressed. This aircraft can carry out a number of missions, including troop transport, fire support, escort, armed reconnaissance, and day and night antiarmor warfare while absorbing some of the pilot's tasks as well. The helicopter's performance is described by a pilot who took it on a test flight. The acrobatic maneuvers that the aircraft can perform are also described. C.D.

A89-16322
PRESSURE CABINS OF ELLIPTIC CROSS SECTION
H. P. Y. HITCH Aeronautical Journal (ISSN 0001-9240), vol. 92, June-July 1988, p. 207-223.

A study is conducted to ascertain the loading borne by elliptical aircraft pressurized fuselage frames, for the cases of internal pressure and floor shear loading. Attention is given to the effect of such loading of a floor on the major elliptical axis and a tie on the minor, where the tie is considered to be both rigid and flexible. It is noted that the decrease in drag from the smaller wetter area of the elliptical fuselage more than offsets the greater weight of its structure by comparison with the circular case. O.C.

A89-16433#
AIRCRAFT EQUIPMENT INTEGRITY
LIQUN WANG (Air Force, First Institute, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 9, Oct. 1988, p. B433-B439. In Chinese, with abstract in English. refs

The term 'aircraft equipment integrity' is proposed. Both the USAF's aircraft structural integrity program and engine structural integrity program use durability and damage tolerance design as the integrity techique, while USAF's avionics integrity program uses eight main integrity techniques in the design phase, including piece parts selection, parts derating, parts burn-in, environmental stress screen, failure prediction analysis, computer-aided design, instability, and design reviews. These integrity techniques for aircraft structures, engine structures, and avionics are briefly described in this paper. C.D.

A89-16446#
DEVELOPMENT OF CHINESE AND INTERNATIONAL CIVIL AVIATION TURBINE ENGINE-AIRCRAFT DATA AND CONSTRUCTION IMAGE BASE SYSTEM
ZHAOYUAN LI and XINGQIANG NI (Beijing University of Aeronautics and Astronautics, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 9, Oct. 1988, p. B518-B520. In Chinese, with abstract in English.

This paper presents an introduction to the development and implementation technique of Chinese and international civil aviation turbine engine-aircraft data. Also considered are: construction design, query from design and implementation, image generation-interface reference, and decision-making basis for the administrators and technical personnel in aeronautical science and engineering. Author

A89-16524#
RECENT RESULTS WITH ATTAS IN-FLIGHT SIMULATOR
D. ROHLF, D. SCHAFRANEK, and K. WILHELM (DFVLR, Institut fuer Flugmechanik, Brunswick, Federal Republic of Germany) AIAA, Flight Simulation Technologies Conference, Atlanta, GA, Sept. 7-9, 1988. 10 p.
(AIAA PAPER 88-4606)

An airborne simulator called ATTAS (Advanced Technologies Testing Aircraft System), which is based on the light jet transport aircraft VFW 614, is described. Some recent flight test results are presented, with attention given to several characteristics of aerodynamics and actuator dynamics. ATTAS will be an important element in developing and exploring advanced fly-by-wire/light control systems, control modes, and cockpit controllers. K.K.

A89-16547#
AEROELASTIC RESPONSE CHARACTERISTICS OF A HOVERING ROTOR DUE TO HARMONIC BLADE PITCH VARIATION
TOMOARI NAGASHIMA, TAKEICHIRYO HIROSE, and GIZO HASEGAWA Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 36, no. 415, 1988, p. 369-379. In Japanese, with abstract in English. refs

The frequency response of a hovering rotor executing blade pitch variation is studied with attention focused on its aeroelastic behavior. A modal analysis method for predicting the aeroelastic response characteristics of the hub vertical load is developed on the basis of Loewy's two-dimensional wake model. Numerical and experimental results revealed the unique dependence of the hub load response on the blade collective pitch control frequency and amplitude. K.K.

A89-16834#
THE VARIABLE STRUCTURE DESIGN OF AIRCRAFT SERVO LOOP
CHUNLIN SHEN, SHUXUN PAN, and HONGWEI NI (Nanjing Aeronautical Institute, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 9, Sept. 1988, p. A459-A465. In Chinese, with abstract in English. refs

The variable structure system (VSS) theory is used to design an aircraft servo loop. A comparison of a VSS with a general control system shows that the VSS has the following advantages: a rapid transient response, no overshoot, no steady error, and it is more robust to the outside disturbances. K.K.

A89-16929* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
RECENT ADVANCES IN TRANSONIC COMPUTATIONAL AEROELASTICITY
JOHN T. BATINA, ROBERT M. BENNETT, DAVID A. SEIDEL, HERBERT J. CUNNINGHAM, and SAMUEL R. BLAND (NASA, Langley Research Center, Hampton, VA) (George Washington University and NASA, Symposium on Advances and Trends in Computational Structural Mechanics and Fluid Dynamics, Washington, DC, Oct. 17-19, 1988) Computers and Structures (ISSN 0045-7949), vol. 30, no. 1-2, 1988, p. 29-37. Previously announced in STAR as N88-29778. refs

A transonic unsteady aerodynamic and aeroelasticity code called CAP-TSD was developed for application to realistic aircraft configurations. The code permits the calculation of steady and unsteady flows about complete aircraft configurations for aeroelastic analysis in the flutter critical transonic speed range. The CAP-TSD code uses a time accurate approximate factorization algorithm for solution of the unsteady transonic small disturbance potential equation. An overview is given of the CAP-TSD code development effort and results are presented which demonstrate various capabilities of the code. Calculations are presented for several configurations including the General Dynamics 1/9 scale F-16 aircraft model and the ONERA M6 wing. Calculations are also presented from a flutter analysis of a 45 deg sweptback wing which agrees well with the experimental data. Descriptions are presented of the CAP-TSD code and algorithm details along with results and comparisons which demonstrate these recent developments in transonic computational aeroelasticity. Author

A89-17130
DESIGN AND APPLICATION OF A PULTRUSION FOR MULTIPLE USE IN THE FOKKER 100
ARNT OFFRINGA (Fokker Aircraft, Amsterdam, Netherlands) Composite Structures (ISSN 0263-8223), vol. 10, no. 3, 1988, p. 199-209.

Continuous-fiber graphite/epoxy reinforced sections manufactured by the pultrusion process have been designed to substitute for two different extruded aluminum sections in the Fokker 100 interior support structure. The use of the pultrusions provides an overall weight reduction of 11.2 kg per aircraft; the composite sections are also more cost effective than the aluminum ones. The design of the pultruded parts is briefly described. V.L.

N89-11732 Stanford Univ., CA.
INTEGRATING MATRIX SOLUTIONS OF PROBLEMS IN AEROELASTIC TAILORING Ph.D. Thesis
JOHN ANTHONY GREEN 1987 145 p
Avail: Univ. Microfilms Order No. DA8800943

The advent of composite materials with their directional stiffness properties, renewed interest in the concept of aircraft with forward swept wings. The idea of using the ply orientation to prevent static divergence, which would otherwise be a problem, became known as aeroelastic tailoring. A solution procedure is studied. The technique is known as the integrating matrix method, and is a fast and accurate way of sovling two point boundary condition problems. The method is outlined and demonstrated by consideration of a simple example problem: a rod in torsion with different boundary conditions and with concentrated masses placed on the rod. The technique is well suited to the analysis of aeroelastic problems, and because it is a numerical method it permits the study of arbitrary geometries. The use of composite materials mandates consideration of several new design parameters: the number of plies, ply orientation, and stacking sequence.
Dissert. Abstr.

N89-11733*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
APPLICATION OF UNSTEADY AEROELASTIC ANALYSIS TECHNIQUES ON THE NATIONAL AEROSPACE PLANE
ANTHONY S. POTOTZKY, CHARLES V. SPAIN, DAVID L. SOISTMANN (Planning Research Corp., Hampton, Va.), and THOMAS E. NOLL Sep. 1988 35 p Presented at the 4th National Aerospace Plane Technology Symposium, Monterey, Calif., Feb. 1988
(NASA-TM-100648; NAS 1.15:100648) Avail: NTIS HC A03/MF A01 CSCL 01C

A presentation provided at the Fourth National Aerospace Plane Technology Symposium held in Monterey, California, in February 1988 is discussed. The objective is to provide current results of ongoing investigations to develop a methodology for predicting the aerothermoelastic characteristics of NASP-type (hypersonic) flight vehicles. Several existing subsonic and supersonic unsteady aerodynamic codes applicable to the hypersonic class of flight vehicles that are generally available to the aerospace industry are described. These codes were evaluated by comparing calculated results with measured wind-tunnel aeroelastic data. The agreement was quite good in the subsonic speed range but showed mixed agreement in the supersonic range. In addition, a future endeavor to extend the aeroelastic analysis capability to hypersonic speeds is outlined. An investigation to identify the critical parameters affecting the aeroelastic characteristics of a hypersonic vehicle, to define and understand the various flutter mechanisms, and to develop trends for the important parameters using a simplified finite element model of the vehicle is summarized. This study showed the value of performing inexpensive and timely aeroelastic wind-tunnel tests to expand the experimental data base required for code validation using simple to complex models that are representative of the NASP configurations and root boundary conditions are discussed. Author

N89-11734 Technische Hogeschool, Delft (Netherlands).
DESIGN AND EVALUATION OF DYNAMIC FLIGHT TEST MANOEUVRES Ph.D. Thesis
JAN ALBERT MULDER 1986 322 p
Avail: Univ. Microfilms Order No. DA8811251

The accuracy of aerodynamic model parameters estimated from measurements of dynamic flight test maneuvers depends among other things on the form of the control input signals. Several types of longitudinal and lateral control input signals were evaluated in flight using an automatic control system for precise implementation. Sample convariance matrices could be determined by repeating each type of control input signal a number of times. The performance of different types of control input signals with respect to sample standard deviations of parameter estimation errors could subsequently be compared to corresponding theoretical predictions. Significant differences were shown to exist between the performance of different types of control input signals. A technique is described for the optimization of control input signals with respect to certain norms of the information matrix. The technique applies to linear as well as nonlinear systems and is based on the representation of control input signals in terms of a finite number of orthonormal functions. It is shown that in case of linear systems the computational effort required for the optimization can be significantly reduced by computing and storing a set of so-called elementary information matrices. The parameter-state estimation problem of dynamic flight tests is discussed in detail, in the linear and in the nonlinear case. It is shown that under certain conditions the parameter-state estimation problem can be solved in two consecutive steps pertaining to the reconstruction of the state and the estimation of the aerodynamic model parameters respectively. Dissert. Abstr.

N89-11735 Rensselaer Polytechnic Inst., Troy, NY.
NONLINEAR EFFECTS IN HELICOPTER ROTOR FORWARD FLIGHT FORCED RESPONSE Ph.D. Thesis
MATHEW BOBBY MATHEW 1987 245 p
Avail: Univ. Microfilms Order No. DA8808176

A method for analyzing the nonlinear behavior of relatively limber rotor blades is presented. It uses the nonrotating, uncoupled natural modes of a flat, undeformed blade in a vacuum as generalized coordinates. A principal curvature transformation is used in deriving the strain energy, which assumes small strains, but includes all elastic angular deflection terms below the fourth order. The kinetic energy is derived using a velocity component transformation. The complete nonlinear equations of motion as well as the equation for small perturbation about large deformation is given. The mathematical model is applied to a number of cases for which earlier experimental results appear in literature. Excellent correlation with experiments and the use of superposition for nonlinear systems are demonstrated. The same mathematical model is used to examine the forced response of a YUH-61A rotor blade in forward flight. The effects of higher harmonic loads, pretwist, and aerodynamic mesh size are discussed. Both displacement and bending moment results are presented. The instantaneous variation of frequencies and mode spaces around the azimuth is presented and discussed. Dissert. Abstr.

N89-11736 Virginia Polytechnic Inst. and State Univ., Blacksburg.
COMBAT AIRCRAFT MISSION TRADEOFF MODELS FOR CONCEPTUAL DESIGN EVALUATION Ph.D. Thesis
LEV ALEXANDER MALAKHOFF 1988 203 p
Avail: Univ. Microfilms Order No. DA8807892

A methodology is developed to address the analyses of combat aircraft attrition. The operations of an aircraft carrier task force are modeled using the systems dynamics simulation language DYNAMO. The three mission-roles include: surface attack, fighter escort, and carrier defense. The level of analysis is performed over the entire campaign, going beyond traditional single-sortie analysis level. These analysis are performed by determining several measures of effectiveness (MOEs) for whatever constraints are applied to the model. The derived MOEs include: Campaign Survivability (CS), Fraction of Force Lost (FFL), Exchange Ratio (ER), Relative Exchange Ratio (RER), Possible Crew Loss (PCL), and Replacement Cost (RC). RER is felt to be the most useful MOE since it considers the initial inventory levels of both friendly and enemy forces, and its magnitude is easy for the analyst to relate to (an RER greater than one is a prediction of a friendly force's victory). Dissert. Abstr.

N89-11737# Lear Siegler, Inc., Grand Rapids, MI. Inst. Div.
ELECTRICAL LOAD AND POWER SOURCE CAPACITY REPORT FOR THE C-130 AIRCRAFT MICROWAVE LANDING SYSTEM (MLS) SLIASC MODEL 6216
STEVE DAVIS 15 Jan. 1988 7 p Prepared in cooperation with Smiths Industries, Grand Rapids, Mich.
(Contract F09603-85-C-1224)
(AD-A196721; ID-6216-032) Avail: NTIS HC A02/MF A01 CSCL 17G

Power loading data, power loading for the Microwave Landing System (MLS), AC power loading for MLS equipment, dc power loading for MLS equipment, ac electrical power, dc electrical power, ac load, and dc load are discussed. GRA

N89-11738* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
CONTROL SURFACE ACTUATOR Patent
GERHARD E. SEIDEL, inventor (to NASA) (Boeing Commercial Airplane Co., Renton, Wash.) 27 Sep. 1988 6 p Filed 23 Mar. 1987 Supersedes N87-24461 (25 - 18, p 2430)
(NASA-CASE-LAR-12852-1; US-PATENT-4,773,620; US-PATENT-APPL-SN-028832; US-PATENT-CLASS-244-75-R; US-PATENT-CLASS-244-78) Avail: US Patent and Trademark Office CSCL 01C

A device which actuates aircraft control surfaces is disclosed. The actuator is disposed entirely within the control surface structure. This allows the gap between the wing structural box and the control surface to be reduced. Reducing the size of the gap is especially desirable for wings with high aspect ratio, wherein the volume of the structural box is at a premium.
Official Gazette of the U.S. Patent and Trademark Office

N89-11739# National Aerospace Lab., Amsterdam (Netherlands). Structures and Materials Div.
REVIEW OF AERONAUTICAL FATIGUE INVESTIGATIONS DURING THE PERIOD MARCH 1985 - FEBRUARY 1987 IN THE NETHERLANDS
J. B. DEJONGE 30 Mar. 1987 27 p Presented at the 20th ICAF Conference, Ottawa, Canada, 8-9 Jun. 1987
(NLR-MP-87022-U; B8805848; ETN-88-93390) Avail: NTIS HC A03/MF A01

Aeronautical load tests; flight simulation; crack propagation; fatigue of joints; metallic materials evaluation; manufacturing effects; full scale certification tests; composites fatigue; and nondestructive inspection are reviewed. ESA

N89-11740*# Virginia Polytechnic Inst. and State Univ., Blacksburg. Dept. of Aerospace and Ocean Engineering.
SHAPE SENSITIVITY ANALYSIS OF FLUTTER RESPONSE OF A LAMINATED WING
FRED D. BERGEN and RAKESH K. KAPANIA Oct. 1988 95 p
(Contract NAS1-18471)
(NASA-CR-181725; NAS 1.26:181725) Avail: NTIS HC A05/MF A01 CSCL 01C

A method is presented for calculating the shape sensitivity of a wing aeroelastic response with respect to changes in geometric shape. Yates' modified strip method is used in conjunction with Giles' equivalent plate analysis to predict the flutter speed, frequency, and reduced frequency of the wing. Three methods are used to calculate the sensitivity of the eigenvalue. The first method is purely a finite difference calculation of the eigenvalue derivative directly from the solution of the flutter problem corresponding to the two different values of the shape parameters. The second method uses an analytic expression for the eigenvalue sensitivities of a general complex matrix, where the derivatives of the aerodynamic, mass, and stiffness matrices are computed using a finite difference approximation. The third method also uses an analytic expression for the eigenvalue sensitivities, but the aerodynamic matrix is computed analytically. All three methods are found to be in good agreement with each other. The sensitivities of the eigenvalues were used to predict the flutter speed, frequency, and reduced frequency. These approximations were found to be in good agreement with those obtained using a complete reanalysis. Author

N89-11741 Messerschmitt-Boelkow-Blohm G.m.b.H., Bremen (Germany, F.R.).
COMPUTER AIDED OPTIMAL STRUCTURAL DESIGN OF STRINGERS FROM AIRBUS A310-300 WITH STARS: DETAILED OPTIMIZATION MODEL [RECHNERGESTUETZTE STRUKTUROPTIMIERUNG DES SEITENLEITWERKKASTENS VOM AIRBUS A310-300 MIT STARS: DETAILLIERTERES OPTIMIERUNGSMODELL]
K. HERTEL, C. KATHMANN, E. WINKLER, and H. WELLEN 5 May 1988 66 p In GERMAN
(MBB-UT-116/88; ETN-88-93193) Avail: Fachinformationszentrum Karlsruhe, 7514 Eggenstein-Leopoldshafen 2, Fed. Republic of Germany
Computer programs STARS and NASTRAN are used for a detailed optimization model to perform structural weighted optimization of Airbus stingers. Detailed computations are carried out with 386 design variables in view of a comparison of optimal structural programs Lagrange and STARS. Structural mechanical results indicate a width reduction of all segments of the stringers and a global weight reduction of 22 percent taking into account the stability. ESA

N89-11742# Royal Aircraft Establishment, Farnborough (England).
A REVIEW OF WORK IN THE UNITED KINGDOM ON THE FATIGUE OF AIRCRAFT STRUCTURES DURING THE PERIOD MAY 1985 - APRIL 1987
R. COOK, comp. Jan. 1988 100 p Presented at the 20th International Committee on Aeronautical Fatigue, Ottowa, Ontario, Jun. 1987 Submitted for publication
(RAE-TR-87077; RAE-MAT/STR-215; BR106674; ETN-88-93557) Avail: Defence Research Information Centre, 65 Brown Street, Glasgow G2 8EX, Scotland
Studies of the development and growth of fatigue damage in metals and composites, studies of crack propagation and residual strength, and work to increase knowledge of aircraft loading actions are reviewed. ESA

N89-11743# Royal Aerospace Establishment, Farnborough (England).
WING DIVERGENCE AND ROLLING POWER
LL. T. NIBLETT Mar. 1988 27 p
(RAE-TR-88017; RAE-MAT/STR-221; BR107014; ETN-88-93559) Avail: Defence Research Information Centre, 65 Brown Street, Glasgow G2 8EX, Scotland
The fundamental static aeroelastic properties of a swept wing which has freedom to roll are studied. It is shown that the divergence speed of a wing which can roll steadily is high or nonexistent and consequently the rolling power of any aileron varies almost linearly with dynamic pressure and, in particular, remains finite at the fixed-root divergence speed. Inboard ailerons have higher reversal speeds than outboard ailerons when the wing is swept back but the opposite is true when the wing is swept forward. ESA

N89-11744# Royal Aerospace Establishment, Farnborough (England).
INVESTIGATION OF THE EFFECTS OF PAYLOAD PODS AND AIRBRAKES ON THE LONGITUDINAL STABILITY OF THE X-RAE 2 UNMANNED AIRCRAFT IN THE 24 FOOT WIND-TUNNEL
W. J. G. TREBBLE Mar. 1988 32 p
(RAE-TM-AERO-2124; BR106756; ETN-88-93562) Avail: Defence Research Information Centre, 65 Brown Street, Glasgow G2 8EX, Scotland
Low speed wind tunnel tests were made on a full scale model of X-RAE 2 at an airspeed of 30 m/sec to investigate the effects of payload pods and airbrakes on its drag and longitudinal stability. The payload pods and fuselage skid each give drag increments of 0.006 and an extra 3 deg up-elevator is required for trimming with the pods fitted. The airbrakes produce incremental drag coefficients of 1.15 based on their projected frontal area. All the airbrakes tested give significant loss in lift and those positioned so that they touch the fuselage side require an extra 10 deg of up-elevator for trimmed level flight. The maximum value of the lift/drag ratio is reduced from 10.9 without airbrakes to values between 5.5 and 7.6 when the airbrakes are deployed. ESA

N89-12562# Army Aviation Engineering Flight Activity, Edwards AFB, CA.
AH-1F INSTRUMENT METEOROLOGICAL CONDITIONS (IMC) FLIGHT EVALUATIONS Final Report, 9 Jun. 1984 - 10 Feb. 1987
JOHN S. LAWRENCE, JOHN R. MARTIN, AUSTIN R. OMLIE, PATRICK J. SULLIVAN, and TERRANCE L. REININGER Feb. 1988 118 p
(AD-A197128) Avail: NTIS HC A06/MF A01 CSCL 01C
Four deficiencies and seven shortcomings associated with flying the AH-1F in IMC were identified. The deficiencies were: (1) the easily excited lateral gust response; (2) the unsatisfactory location of avionics controls; (3) the poor cyclic flight control system mechanical characteristics; and (4) the large change in airspeed position error in climbs. The AH-1F is unacceptable for flight in IMC. Modifications evaluated in an attempt to correct the aircraft deficiencies included use of the air data system as a pitot-static source, reduction of cyclic control friction, reduction of cyclic centering spring preloads, addition of a Gurney flap to the vertical stabilizer, removal of the 90-degree gearbox fairings, addition of a ventral fin, changes in pitch and roll stability and control augmentation system gains, addition of attitude holds in the pitch and roll axes, and changes in cockpit avionics configurations. The AH-1F is acceptable for flight in IMC when the following modifications are incorporated: attitude hold capability in the pitch and roll axes, cyclic control friction adjusted to 1.0 pounds, and cyclic centering spring preloads adjusted to 3.0 pounds. The suitability of the AH-1F for flight in IMC is enhanced with VOR navigation and VHF communication control panels. GRA

N89-12563# Department of Defense, Washington, DC.
DOD JOINT UNMANNED AERIAL VEHICLE (UAV) PROGRAM MASTER PLAN, 1988 Final Report
RICHARD L. MOSIER 27 Jun. 1988 52 p
(AD-A197751) Avail: NTIS HC A04/MF A01 CSCL 01C
In FY88, the Congress eliminated separate program elements for remotely piloted vehicle (RPV) programs within each of the military Services, consolidated these efforts in a Joint RPV Program in the office of the Secretary of Defense, and authorized and appropriated reduced levels of RDT and E and procurement funding for such activities in FY88. In addition, the Congress directed that FY88 RDT and E funding is available only for the Joint Remotely Piloted Vehicles (RPV) Program and may not be obligated or expended until the Secretary of Defense submits to the Committees on Appropriation of the Senate and the House of Representatives an updated master plan fully explaining his decisions as to which RPVs will be supported with the available funds and assessing the cooperation by the military Services with efforts to coordinate RPV programs and to eliminate duplication within and among the programs (Title IV, Public Law 100-180). This master plan,

developed in response to this direction, describes the changes made by the Department in the management of RPV programs, outlines the requirements for RPV capabilities, defines the Department's strategy for acquisition of a family of RPV systems, and provides the detailed explanation of the programs that are to be supported with available FY88, and requested FY89 funds.
GRA

06

AIRCRAFT INSTRUMENTATION

Includes cockpit and cabin display devices; and flight instruments.

A89-12977#
MEASUREMENT SYSTEM FOR INVESTIGATING AIRCRAFT FLYING QUALITIES [SYSTEM POMIAROWY DO BADANIA WLASCIWOSCI LOTNYCH SAMOLOTOW]
WLADYSLAW ZABKOWICZ (Instytut Techniczny Wojsk Lotniczych, Warsaw, Poland) Technika Lotnicza i Astronautyczna (ISSN 0040-1145), vol. 43, March 1988, p. 7-9. In Polish.
Aspects of the organization of a measurement system for determining the flying qualities of aircraft are examined. An algorithm is presented for calculating the static and dynamic characteristics of a data-acquisition subsystem with oscillograph recording. An example of a system used for actual testing is presented.
B.J.

A89-13618#
CENTRAL FAULT DISPLAY SYSTEMS
F. VAUVERSIN and J. P. POTOCKI DE MONTALK (Airbus Industrie, Blagnac, France) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 1164-1171.
The A 320 airliner is the first aircraft to enter service with BITE systems comprehensively adhering to a single set of design rules, as well as the integration of a common set of controls and displays for these systems into a single Central Fault Display System (CFDS). The CFDS allows fault data to be processed continuously, thereby rendering fault-reporting possible in-flight, if required. The CFDS's messages are in plain English with standard abbreviations. The number of operations in the avionics bay is reduced, since all electronic systems can be integrated from the cockpit.
O.C.

A89-15034
AN ON-BOARD DIAGNOSTIC SYSTEM - SENSORS ON THE LOOKOUT
New-Tech News, no. 3, 1988, p. 27-29.
Increasingly technologically sophisticated gas turbine engines require comprehensive acquisition of data in order to aid service personnel in the pinpointing of defects. Attention is presently given to a diagnostics process for application to engine test stand data-processing systems, which possesses subprograms for thermodynamic analysis and vibration analysis. The diagnostic system is suitable for such aircraft as the BO 105 and PAH-2 helicopters, the Tornado fighter and Alpha Jet trainer, and even the next-generation EFA air-superiority fighter.
O.C.

A89-15778
DESIGN METHODS FOR A HOLOGRAPHIC HEAD-UP DISPLAY CURVED COMBINER
RICHARD L. FISHER (Kaiser Optical Systems, Inc., Ann Arbor, MI) IN: Holographic optics: Design and applications; Proceedings of the Meeting, Los Angeles, CA, Jan. 13, 14, 1988. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1988, p. 28-35.
A wide field of view head-up display is described along with the construction optics required to produce its holographic combiner. Advantages of holography are outlined along with methods used in designing the combiner.
Author

A89-15779
HOLOGRAPHIC AND CLASSICAL HEAD UP DISPLAY TECHNOLOGY FOR COMMERCIAL AND FIGHTER AIRCRAFT
ROBERT B. WOOD (Flight Dynamics, Inc., Portland, OR) and MICHAEL J. HAYFORD (Optical Research Associates, Pasadena, CA) IN: Holographic optics: Design and applications; Proceedings of the Meeting, Los Angeles, CA, Jan. 13, 14, 1988. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1988, p. 36-52. refs
The FAA has certified the first holographic HUD (HHUD) for use by B-727 airliners in landing operations under Category IIIa conditions and for windshear detection and recovery guidance. A conformal reflection holographic optical element has been employed to preclude 'flare' effects during bright object viewing against a dark background. Additional HHUDs have been developed for use in fighter aircraft geometries, using large aspheric wavefront deformations.
O.C.

A89-15877* Coherent Technologies, Inc., Boulder, CO.
PERFORMANCE ANALYSIS AND TECHNICAL ASSESSMENT OF COHERENT LIDAR SYSTEMS FOR AIRBORNE WIND SHEAR DETECTION
R. MILTON HUFFAKER (Coherent Technologies, Inc., Boulder, CO) and RUSSELL TARG (Lockheed Missiles and Space Co., Inc., Research and Development Div., Palo Alto, CA) IN: Airborne and spaceborne lasers for terrestrial geophysical sensing; Proceedings of the Meeting, Los Angeles, CA, Jan. 14, 15, 1988. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1988, p. 65-76. NASA-supported research. refs
Detailed computer simulations of the lidar wind-measuring process have been conducted to evaluate the use of pulsed coherent lidar for airborne windshear monitoring. NASA data fields for an actual microburst event were used in the simulation. Both CO_2 and Ho:YAG laser lidar systems performed well in the microburst test case, and were able to measure wind shear in the severe weather of this wet microburst to ranges in excess of 1.4 km. The consequent warning time gained was about 15 sec.
O.C.

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.

A89-12953*# National Aeronautics and Space Administration, Washington, DC.
RETURN OF THE TURBOPROPS
JOHN R. FACEY (NASA, Office of Aeronautics and Space Technology, Washington, DC), JOHN B. WHITLOW, JR., G. KEITH SIEVERS, JOHN GROENEWEG (NASA, Lewis Research Center, Cleveland, OH), KEVIN SHEPHERD, and WILLIAM HENDERSON (NASA, Langley Research Center, Hampton, VA) Aerospace America (ISSN 0740-722X), vol. 26, Oct. 1988, p. 14-18, 20, 22, 23, 35.
Recent advances in propfan development for commercial aircraft cruising at high transonic speeds are discussed in a series of brief overviews and illustrated with photographs and diagrams. The efficiency and performance advantages and the problem of noise are examined; the history of turboprop design since the 1950s is recalled; NASA, DOT, FAA, and DOD turboprop projects are described; and the results of wind-tunnel and flight tests on particular propeller models are reviewed. Current trends in aircraft

reconfiguration and acoustic redesign to reduce cabin noise levels are also surveyed. T.K.

A89-13503*# Air Force Aero Propulsion Lab., Wright-Patterson AFB, OH.
EMERGING HYPERSONIC PROPULSION TECHNOLOGY
E. T. CURRAN (USAF, Aero Propulsion Laboratory, Wright-Patterson AFB, OH) and H. L. BEACH, JR. (NASA, Langley Research Center, Hampton, VA) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. XLII-LIII. refs

Currently there is a renewal of interest in the utilization of air breathing engines for hypersonic flight. The use of such engines in accelerative missions is discussed, and the nature of the trade-off between engine thrust-to-weight ratio and specific impulse is highlighted. It is also pointed out that the use of a cryogenic fuel such as liquid hydrogen offers the opportunity to develop both precooled derivatives of turboaccelerator engines and new cryogenic engine cycles, where the heat exchange process plays a significant role in the engine concept. The continuing challenges of developing high speed supersonic combustion ramjet engines are discussed. The paper concludes with a brief review of the difficult discipline of vehicle integration, and the challenges of both ground and flight testing. Author

A89-13504*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
NASA/INDUSTRY ADVANCED TURBOPROP TECHNOLOGY PROGRAM
JOSEPH A. ZIEMIANSKI and JOHN B. WHITLOW, JR. (NASA, Lewis Research Center, Cleveland, OH) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. LIV-LXVII. Previously announced in STAR as N88-24641. refs

Experimental and analytical effort shows that use of advanced turboprop (propfan) propulsion instead of conventional turbofans in the older narrow-body airline fleet could reduce fuel consumption for this type of aircraft by up to 50 percent. The NASA Advanced Turboprop (ATP) program was formulated to address the key technologies required for these thin, swept-blade propeller concepts. A NASA, industry, and university team was assembled to develop and validate applicable design codes and prove by ground and flight test the viability of these propeller concepts. Some of the history of the ATP Project, an overview of some of the issues, and a summary of the technology developed to make advanced propellers viable in the high-subsonic cruise speed application are presented. The ATP program was awarded the prestigious Robert J. Collier Trophy for the greatest achievement in aeronautics and astronautics in America in 1987. Author

A89-13511*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
SENSITIVITY OF SUPERSONIC COMBUSTION TO COMBUSTOR/FLAMEHOLDER DESIGN
GLENN S. DISKIN and G. BURTON NORTHAM (NASA, Langley Research Center, Hampton, VA) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 58-66. refs

The present test series was conducted to ascertain the effects of various scale and geometric parameters on the combustion and pressure rise limits of a direct-connect supersonic combustor employing hydrogen fuel in a Mach 2 flow and 1-atm static pressure. The injector configuration was similar to that developed by Wagner et al. (1987). Attention is given to the effects of upstream length, fuel-injection gap, and constant-area combustor length, as well as to those of equivalence ratios and stagnation temperature. It is found that, for a given scale, combustion can be strongly dependent on such geometric factors as the use of either constant-area combustion or immediate expansion. O.C.

A89-13558#
FROM SINGLE ROTATING PROPFAN TO COUNTER ROTATING DUCTED PROPFAN - PROPELLER/FAN CHARACTERISTICS
M. LECHT (DFVLR, Institut fuer Antriebstechnik, Cologne, Federal Republic of Germany) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 578-588.

In this paper the relationship between a propeller, a propfan, and a fan as propulsors is worked out. The advance ratio, thrust- and power coefficient for different blade settings can be converted into the frame of a fan performance map; i.e., pressure ratio against mass flow. For a fixed flight Mach number all possible operating points (that is, rotating speed, blade angle setting, pressure ratio, and mass flow) coincide with one characteristic throttle line, the basis of which can be deduced from one-dimensional gasdynanic considerations. To show this in more detail, the performance behavior of various propfan concepts-unshrouded and shrouded-have been simulated by a computer program on a one-dimensional, compressible basis. Fropm this, an operating line versus flight Mach number may be found, corresponding to an optimal blade angle setting of the first and second rotor. Author

A89-13559#
SINGLE AND CONTRA-ROTATION HIGH SPEED PROPELLERS - FLOW CALCULATION AND PERFORMANCE PREDICTION
P. W. C. WONG, M. MAINA, C. R. FORSEY, and A. J. BOCCI (Aircraft Research Association, Ltd., Bedford, England) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 589-601. Research supported by the Department of Trade and Industry, Dowty Rotol, Ltd., Rolls-Royce, PLC, and British Aerospace, PLC. refs

Theoretical aerodynamic methods suitable for propeller performance and flowfield predictions are discussed and compared with experiment. The methods discussed consist of an advanced strip theory and the Denton Euler method. Features of the methods relevant to high speed, highly disk-loaded propellers are emphasized. Experiment and theory are shown to compare reasonably closely for various types of single rotation propellers. Illustrations of scale effect and the effect of blade deflection under load are included. Consideration is given to the different definitions of thrust in the experiment and their interpretation using the Denton method. Some of the problems arising in the validation and use of the methods for contra-rotation propellers are indicated. Author

A89-13590#
DIGITAL ELECTRONICS ON SMALL HELICOPTER ENGINES
K. J. HICKS (Rolls-Royce, PLC, Leavesden, England) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 880-885.

The evolution of digital electronics on helicopter engines is briefly reviewed, with attention given to the problems introduced by digital electronics and ways of solving these problems. The discussion covers a short history of digital engine control, control software, reliability, electrical failures, torque measurement, user features, and engine monitoring. V.L.

A89-13653#
A TURBOFAN CONTROL SYSTEM USING A NONLINEAR PRECOMPENSATOR AND A MODEL-FOLLOWING RICCATI-FEEDBACK
HARALD SOELTER (Braunschweig, Technische Universitaet, Brunswick, Federal Republic of Germany) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 1505-1510. refs

An interesting control-system concept for turbofan engines was published by Froriep, Joos and Kreisselmeier (1978). The system structure uses an openloop compensator combined with a

Riccati-feedback. In application to a linear engine model, the optimal control gains could be obtained from an explicit formula. This paper discusses the advanced application of this structure in a nonlinear simulation and optimization process. After deriving the specifications of the whole control system from the demands of engine operation, the structure of the control system can be designed, and a cost functional can be defined. In successive optimizations the parameters of the control are then calculated using a numeric optimization technique. The results of the optimization are validated by discussing simulated time histories.
Author

A89-13654#
PROPULSION INTERFACE UNIT (PIU) CONTROLLER ON PW1120/DEEC RE-ENGINED F4 AIRCRAFT
ISRAEL FRISCH, DON IVERSON, and ELLING TJONNELAND (Boeing Co., Seattle, WA) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 1511-1521.

The re-engining of the F-4 Phantom with PW1120 power plants required an intelligent interface subsystem. This paper briefly describes the design, production, testing, and performance of the Propulsion Interface Unit (PIU), developed to perform this function. The PIU is discussed in terms of its electronics, software, and functional verification. The F-4/PIU flight test and Paris Air Show performance is reviewed and briefly critiqued. A possible production version is discussed in terms of architecture and fabrication methods. Aircraft modernization methodology is discussed utilizing PIU type systems as an integration element. Author

A89-13679#
VERY HIGH BYPASS RATIO ENGINES FOR COMMERCIAL TRANSPORT PROPULSION
H. SKAVDAHL, R. A. ZIMBRICK, J. L. COLEHOUR, and G. P. SALLEE (Boeing Co., Boeing Commercial Airplanes, Seattle, WA) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 1766-1772.

This paper is a feasibility study for the application of advanced turbofan engines to commercial transport aircraft. Performance factors for study engines in the bypass ratio range of 9 to 17.5 are considered along with nacelle installation losses. It is concluded that higher bypass ratio engine cycles and innovative nacelle configuration concepts can be combined to yield significant improvements in fuel burned. However, other factors such as increased engine manufacturing and maintenance costs due to increased mechanical complexity may adversely affect the economic benefits resulting from the improved engine performance. Author

A89-13680#
ENGINE SURGE SIMULATION IN WIND-TUNNEL MODEL INLET DUCTS
K. W. LOTTER, R. D. SCHERBAUM (Messerschmitt-Boelkow-Blohm GmbH, Munich, Federal Republic of Germany), and P. A. MACKRODT (DFVLR, Goettingen, Federal Republic of Germany) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 1773-1788. refs

The development and calibration of a surge wave generator to simulate the engine surge pulses on a scaled intake wind-tunnel model is discussed. The surge wave generator was successfully used on a 1:10 scale intake wind tunnel model. Results of the time-variant pressures at various locations in the primary and secondary intake ducts are presented. The use of the data for dynamic load assessment in the intake and for the prediction of time-variant total pressure distortion in the receiving intake is discussed. R.B.

A89-13725*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
RECENT ADVANCES IN CAPACITANCE TYPE OF BLADE TIP CLEARANCE MEASUREMENTS
JOHN P. BARRANGER (NASA, Lewis Research Center, Cleveland, OH) AIAA, NASA, and AFWAL, Conference on Sensors and Measurements Techniques for Aeronautical Applications, Atlanta, GA, Sept. 7-9, 1988. 9 p. Previously announced in STAR as N88-25460. refs
(AIAA PAPER 88-4664)

Two recent electronic advances at NASA-Lewis that meet the blade tip clearance needs of a wide class of fans, compressors, and turbines are described. The first is a frequency modulated (FM) oscillator that requires only a single low cost ultrahigh frequency operational amplifier. Its carrier frequency is 42.8 MHz when used with a 61 cm long hermetically sealed coaxial cable. The oscillator can be calibrated in the static mode and has a negative peak frequency deviation of 400 kHz for a typical rotor blade. High temperature performance tests of the probe and 13 cm of the adjacent cable show good accuracy up to 600 C, the maximum which produces a clearance error of + or - 10 microns at a clearance of 500 microns. In the second advance, a guarded probe configuration allows a longer cable capacitance. The capacitance of the probe is part of a small time constant feedback in a high speed operational amplifier. The solution of the governing differential equation is applied to a ramp type of input. The results show an amplifier output that contains a term which is proportional to the derivative of the feedback capacitance. The capacitance is obtained by subtracting a balancing reference channel followed by an integration stage. Author

A89-14820
CONSIDERATION OF UNSTEADY STATE EFFECTS DURING AIR INTAKE TESTING IN A BLOWDOWN WIND TUNNEL [UCHET EFFEKTOV NESTATSIONARNOSTI PRI ISPYTANIIAKH VOZDUKHOZABORNIKOV V IMPUL'SNOI AERODINAMICHESKOI TRUBE]
V. I. ZVEGINTSEV and A. I. SEDEL'NIKOV (AN SSSR, Institut Teoreticheskoi i Prikladnoi Mekhaniki, Novosibirsk, USSR) Akademiia Nauk SSSR, Sibirskoe Otdelenie, Izvestiia, Seriia Tekhnicheskie Nauki (ISSN 0002-3434), Aug. 1988, p. 63-69. In Russian. refs

The possibility of accounting for unsteady flow in an air intake when measuring its flow rate characteristics in a blowdown wind tunnel is investigated. An algorithm is developed which makes it possible to determine the steady-state flow rate coefficient from the measurements of rapidly changing temperatures and pressures at the air intake outlet. Experimental data are differentiated numerically using an algorithm for constructing regularizing cubic splines. The possibilities of the method are illustrated by test calculations. V.L.

A89-15068
HOLLOW TITANIUM TURBOFAN BLADES
EDWARD D. WEISERT (Ontario Technologies Corp., Menlo Park, CA) IN: Superplasticity in aerospace; Proceedings of the Topical Symposium, Phoenix, AZ, Jan. 25-28, 1988. Warrendale, PA, Metallurgical Society, Inc., 1988, p. 315-330. refs

An active goal of doubling current thrust-to-weight ratios in aircraft powerplants emphasizes weight reduction as the most productive target. Hollow fan blading for the turbofan engines is an important example of a significant factor toward achieving that goal. The superplastic forming/diffusion bonding (SPF/DB) fabrication process is an outstanding candidate for manufacturing advanced hollow blading. Some of the problems encountered in this application of SPF/DB technology and their solutions are discussed. The SPF/DB method is compared with other approaches to fabrication of hollow blading. Significant progress in the evolution of the SPB/DB fan blade application is described.
Author

A89-15079* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
ATP INTERIOR NOISE TECHNOLOGY AND FLIGHT DEMONSTRATION PROGRAM
DAVID G. STEPHENS and CLEMANS A. POWELL (NASA, Langley Research Center, Hampton, VA) IN: NOISE-CON 88 - Noise control design: Methods and practice; Proceedings of the National Conference on Noise Control Engineering, West Lafayette, IN, June 20-22, 1988. Poughkeepsie, NY, Institute of Noise Control Engineering, 1988, p. 99-104. refs

The paper provides an overview of the ATP (Advanced Turboprop Program) acoustics program with emphasis on the NASA technology program and the recent NASA/Industry demonstration programs aimed at understanding and controlling passenger cabin noise. Technology developments in propeller (source) noise, cabin noise transmission, and subjective acoustics are described. Finally, an overview of the industry demonstrator programs is presented. B.J.

A89-15080* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
CRUISE NOISE OF AN ADVANCED COUNTERROTATION TURBOPROP MEASURED FROM AN ADJACENT AIRCRAFT
RICHARD P. WOODWARD, IRVIN J. LOEFFLER, and JAMES H. DITTMAR (NASA, Lewis Research Center, Cleveland, OH) IN: NOISE-CON 88 - Noise control design: Methods and practice; Proceedings of the National Conference on Noise Control Engineering, West Lafayette, IN, June 20-22, 1988. Poughkeepsie, NY, Institute of Noise Control Engineering, 1988, p. 105-110. refs

Acoustic test results are presented for a full-scale counterrotation demonstrator engine installed on a Boeing 727 aircraft in place of the right-side turbofan engine. Sideline acoustic data were acquired from a Learjet chase aircraft instrumented with noise and wing-tip flush mount microphones. Data are presented for a 47.2-m sideline at several engine operating conditions and flight Mach numbers of 0.50 and 0.72. B.J.

A89-15708#
DESIGN AND DEVELOPMENT OF THE GARRETT F109 TURBOFAN ENGINE
KENNETH W. KRIEGER, JAY D. BATSON, HANS F. MAERTINS, and MARK A. STEELE (Allied-Signal Aerospace Co., Garrett Engine Div., Phoenix, AZ) (CASI, Symposium on Aircraft Propulsion Systems, Toronto, Canada, May 25, 26, 1987) Canadian Aeronautics and Space Journal (ISSN 0008-2821), vol. 34, Sept. 1988, p. 170-177.

The F109-GA-100 engine, flat rated at 1330-pounds thrust at sea level static maximum power conditions, was created to address the United States Air Force need for a new primary trainer. As such, it required very low fuel consumption, high reliability, and ease of operation. This paper describes the development program and highlights the Engine Structural Integrity Program (ENSIP) approach to the design and the Accelerated Mission Test (AMT) approach to testing, both of which are new approaches to engine development. Solutions to problems encountered are discussed, and a summary of flight test experience is included. Author

A89-16102*# Michigan State Univ., East Lansing.
THERMAL MEASUREMENTS FOR JETS IN DISTURBED AND UNDISTURBED CROSSWIND CONDITIONS
CANDACE E. WARK and JOHN F. FOSS (Michigan State University, East Lansing) AIAA Journal (ISSN 0001-1452), vol. 26, Aug. 1988, p. 901, 902. refs
(Contract NAG3-245)

A direct comparison is made of the thermal field properties for a low-disturbance and a high-disturbance level condition affecting the low-temperature air jets introduced into gas turbine combustor aft sections in order both to cool the high-temperature gases and quench the combustion reactions. Sixty-four fast-response thermocouples were simultaneously sampled and corrected for their time constant effect at a downstream plane close to the jet exit. Histograms formed from independent samples were sufficiently smooth to approximate a pdf. O.C.

A89-16111*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
DYNAMIC PRESSURE LOADS ASSOCIATED WITH TWIN SUPERSONIC PLUME RESONANCE
JOHN M. SEINER, JAMES C. MANNING, and MICHAEL K. PONTON (NASA, Langley Research Center, Hampton, VA) AIAA Journal (ISSN 0001-1452), vol. 26, Aug. 1988, p. 954-960. Previously cited in issue 20, p. 2920, Accession no. A86-42701. refs

A89-16460#
HIGHLY COMPACT INLET DIFFUSER TECHNOLOGY
R. H. TINDELL (Grumman Corp., Bethpage, NY) Journal of Propulsion and Power (ISSN 0748-4658), vol. 4, Nov.-Dec. 1988, p. 557-563. Previously cited in issue 20, p. 3154, Accession no. A87-45180. refs

A89-16465*# Virginia Univ., Charlottesville.
LASER-INDUCED-FLUORESCENCE VISUALIZATION OF TRANSVERSE GASEOUS INJECTION IN A NONREACTING SUPERSONIC COMBUSTOR
J. C. MCDANIEL and J. GRAVES, JR. (Virginia, University, Charlottesville) Journal of Propulsion and Power (ISSN 0748-4658), vol. 4, Nov.-Dec. 1988, p. 591-597. Previously cited in issue 11, p. 1482, Accession no. A86-26643. refs
(Contract NAG1-373)

A89-16479#
HIGH SPEED AIRBREATHING PROPULSION
B. D. WARD (Rolls-Royce, Inc., Atlanta, GA) and F. A. HEWITT (Rolls-Royce, PLC, Bristol, England) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 8 p. USAF-supported research.
(AIAA PAPER 88-3069)

The results of a comparative USAF study of the performance of five different airbreathing engine types capable of flight in the Mach 4-6 range are presented. The engine cycles in question are (1) the turboramjet, (2) a precooled turbojet, (3) a ducted rocket, (4) the novel air turborocket, and (5) the 'flashjet' variant of the turborocket principle; both sustained hypersonic cruise and payload-to-orbit mission applications are considered. All powerplants are dependent on the use of hydrogen fuel to fulfill mission requirements. O.C.

A89-16858#
RESEARCH ON CONTROL TECHNIQUE OF BLADE FLUTTER
ZHAOHONG SONG (Beijing University of Aeronautics and Astronautics, People's Republic of China) Journal of Aerospace Power (ISSN 1000-8055), vol. 3, Oct. 1988, p. 327-332, 384. In Chinese, with abstract in English. refs

This paper summarizes the author's work on control techniques for blade flutter in recent years. It involves a numerical method for predicting blade flutter boundaries in all frequency ranges, the flutter characteristics of blades with different dispositions of the three centers, the flutter depression characteristics of mistuned blades, the technique of aeroelastic tailoring for controlling blade flutter, and experiments on a series of rotors designed to reproduce flutter. Author

A89-16859#
COUPLING VIBRATION CHARACTERISTICS OF MISTUNED BLADED-DISK ASSEMBLY
DAKUAN SHEN, QUN CHEN, MINGFU LIAO, and YUNJU YAN (Northwestern Polytechnical University, Xian, People's Republic of China) Journal of Aerospace Power (ISSN 1000-8055), vol. 3, Oct. 1988, p. 333-336, 384. In Chinese, with abstract in English.

A 16-blade disk of flat plates is made as a test and mathematical model to study the effects of blade mistuning on the dynamic characteristics of a bladed disk assembly, as well as the effects of mistuning amplitude, mistuning order, and six distribution types of mistuning on the response to forced vibration. The results show that the natural mode of a tuning system can be categorized into single-mode and double-mode. Author

A89-16864#
TEST RESEARCH ON MAIN SHAFT SERVICE LIFE OF AEROENGINE
ZUYING FANG and DUNHUI LIU (Chendu Aeroengine Co., People's Republic of China) Journal of Aerospace Power (ISSN 1000-8055), vol. 3, Oct. 1988, p. 355-360, 386. In Chinese, with abstract in English. refs

A method for determining damage conversion in the main shaft of an aircraft engine is introduced. The standard damage cycles per flight hour, or damage conversion ratio (Ap) for flight can be obtained from comparative residual-life tests of shafts with different service lives. The main-shaft fatigue-life tests indicate that even the worst main shaft can resist the standard load cycle, or predicted safe standard cycle life. If it is divided by Ap, the service life of a main shaft can be determined. Author

A89-16866#
LIFE PREDICTION OF COOLED TURBINE BLADE
GUOWEI LIANG (Northwestern Polytechnical University, Xian, People's Republic of China) Journal of Aerospace Power (ISSN 1000-8055), vol. 3, Oct. 1988, p. 365-370, 387. In Chinese, with abstract in English. refs

The major factors affecting life prediction for turbine blades are discussed; i.e., fatigue-life data for the materials employed and stress and strain analyses of the blade. The emphasis is placed on the influence of material's constitutive relation under cyclic loading on the life prediction and the problems encountered in determining the transient temperature field of the turbine blade under thermal cycling. Author

N89-11745# Naval Research Lab., Washington, DC.
NUMERICAL SIMULATIONS OF THE FLOWFIELD IN CENTRAL-DUMP RAMJET COMBUSTORS. PART 2: EFFECTS OF INLET AND COMBUSTOR ACOUSTICS Interim Report, Oct. 1985 - Jul. 1988
K. KAILASANATH, J. H. GARDNER, J. P. BORIS, and E. S. ORAN 8 Jul. 1988 39 p
(AD-A196743; NRL-MR-6213) Avail: NTIS HC A03/MF A01 CSCL 21E

A potentially important source of large pressure oscillations in compact ramjets is a combustion instability induced by the interaction of large-scale vortex structures with the acoustic modes of the ramjet. To study these interactions, we have performed time-dependent, compressible numerical simulations of the flow field in an idealized ramjet consisting of an axisymmetric inlet and a combustor. The simulations indicate strong coupling between the flow field and the acoustics of both the inlet and the combustor. For the cases studied, forcing at the first longitudinal acoustic mode of the combustor induces vortex-rollup near the combustor entrance at that frequency. A low frequency oscillation is also observed in all the simulations. Pressure and velocity fluctuations in the inlet indicate that the low frequency corresponds to a quarter-wave mode in the inlet. Changing the length of the inlet appropriately changes the observed low frequency. The merging pattern of the inlet is changed. These merging patterns are explained on the basis of an interaction between the vortex rollup frequency and the acoustic modes of the inlet and combustor. GRA

N89-11746# Motoren- und Turbinen-Union Muenchen G.m.b.H. (Germany, F.R.). Abteilung Werkstoffe/ELM.
CONTOUR LINE NEAR TURBINE PARTS FROM NICKEL AND TITANIUM POWDER METAL (PM) MATERIALS BY ADVANCED ENCAPSULATION TECHNIQUE AND CAPSULE FREE FORMING PROCEDURE. ISOSTAT PRESSING OF PM MATERIALS Final Report [KONTURNAHE TURBINENTEILE AUF BASIS VON NICKEL- UND TITAN-PM-WERKSTOFFEN DURCH FORTSCHRITTLICHE KAPSELTECHNIK UND KAPSELFREIE FORMGEBUNGSVERFAHREN. VERBUNDISOSTATPRESSEN VON PM-WERKSTOFFEN]
BARBARA BORCHERT, MAX KRAUS, RAIMUND LACKERMEIER, and WOLFGANG TRACK Dec. 1986 58 p In GERMAN (Contract BMFT-03-ZG-064A3)
(ETN-88-92107) Avail: NTIS HC A04/MF A01

Static and dynamic experiments carried out show that Titan 685 is well adapted to powder metallurgy and joint pressing. Metallographic investigations indicate that thermal mechanical treatment can improve the strength of the manufactured parts. Vibration strength depends highly on fabrication procedure. ESA

N89-11747# Brown, Boveri und Cie, A.G., Mannheim (Germany, F.R.). Zentrales Labor fuer Werkstofftechnik.
CERAMIC THERMAL BARRIER COATINGS FOR GAS TURBINE COMPONENTS EXPOSED TO HOT GASES Final Report
RALF BUERGEL, WING FONG CHU, HERMANN W. GRUENLING, GERHARD LEITER, and FRANZ-JOSEF ROHR Bonn, Fed. Republic of Germany BMFT Sep. 1987 41 p In GERMAN; ENGLISH summary Sponsored by BMFT
(ETN-88-93227) Avail: NTIS HC A03/MF A01

Ceramic thermal barrier coatings which are sufficiently corrosion resistant under crude oil firing conditions were studied. The thermal cycling resistance should be as good as for conventional ZrO2-8Y2O3 systems. Ceramic systems based on the ZrO2-Y2O3 system, and on Al2O3-TiO2 and Al2O3-CrO3 were evaluated. Further tests were concentrated on coatings of the ZrO2-Y2O3-SiO2-(Al2O3) type. The plasma sprayed layers exhibit less corrosion resistance in vanadium containing atmospheres than the reference system ZrO2-8Y2O3. Envelopment of ZrO2/Y2O3 crystallites by silicates does not occur. The thermal shock resistance is worse compared to the ZrO2-8Y2O3 system despite a wide variety of tested parameters. Microsegmentation can not be achieved to a sufficient extent in order to make the ceramic strain tolerant. For these reasons the goals can not be met. ESA

N89-11748# National Aerospace Lab., Amsterdam (Netherlands). Structures and Materials Div.
RINSING WATER ANALYSIS OF HELICOPTER JET ENGINE COMPRESSORS
H. J. KOLKMAN 2 Jun. 1987 31 p
(NLR-TR-87074-U; B8817438; ETN-88-93382; AD-B123093L) Avail: NTIS HC A03/MF A01

The rinsing water of helicopter gas turbine compressors was investigated. The corrosive attack manifested by the presence of metal ions is related to: deposition during flight of the hygroscopic salts (NH4)2SO4 (originating from manure) and MgCl2 (from marine origin); acidification of the wet deposits during shutdown periods by the absorption of the air pollutants SO2 and NO2; and the rinsing frequency. Daily instead of weekly rinsing decreases, but does not eliminate corrosion. ESA

N89-11749# National Aerospace Lab., Amsterdam (Netherlands). Structures and Materials Div.
CORROSION IN GAS TURBINES
H. J. KOLKMAN 15 Sep. 1987 23 p In DUTCH; ENGLISH summary Presented at the Netherlands Corrosion Center's Working Group Meeting Corrosiedagen 1987, Utrecht, Netherlands, 10-12 Nov. 1987
(NLR-MP-87067-U; B8809142; ETN-88-93404; AD-B119877L) Avail: NTIS HC A03/MF A01

Electrochemical corrosion in gas turbine compressors; oxidation in turbines; and sulfidation in turbines are reviewed. Examples of failures by these processes are given. Countermeasures are discussed. ESA

N89-11750*# Flow Research, Inc., Kent, WA.
AERODYNAMIC OPTIMIZATION BY SIMULTANEOUSLY UPDATING FLOW VARIABLES AND DESIGN PARAMETERS WITH APPLICATION TO ADVANCED PROPELLER DESIGNS
MAGDI H. RIZK Jul. 1988 34 p
(Contract NAS3-24855)
(NASA-CR-182181; NAS 1.26:182181; FLOW-RR-447) Avail: NTIS HC A03/MF A01 CSCL 21E

A scheme is developed for solving constrained optimization problems in which the objective function and the constraint function are dependent on the solution of the nonlinear flow equations. The scheme updates the design parameter iterative solutions and the flow variable iterative solutions simultaneously. It is applied to an advanced propeller design problem with the Euler equations used as the flow governing equations. The scheme's accuracy, efficiency and sensitivity to the computational parameters are tested. Author

N89-11751*# Sverdrup Technology, Inc., Cleveland, OH.
A PRELIMINARY DESIGN STUDY OF SUPERSONIC THROUGH-FLOW FAN INLETS Final Report
PAUL J. BARNHART Nov. 1988 12 p Previously announced in IAA as A88-53137
(Contract NAS3-24105)
(NASA-CR-182224; E-4490; NAS 1.26:182224) Avail: NTIS HC A03/MF A01 CSCL 21E

From Mach 3.20 cruise propulsion systems, preliminary design studies for two supersonic through-flow fan primary inlets and a single core inlet were undertaken. Method of characteristics and one dimensional performance techniques were applied to assess the potential improvements supersonic through-flow fan technology has over more conventional systems. A fixed geometry supersonic through-flow fan primary inlet was found to have better performance than a conventional inlet design on the basis of total pressure recovery, air flow, aerodynamic drag and size and weight. Author

N89-12565*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
ADVANCED TURBOPROP PROJECT
ROY D. HAGER and DEBORAH VRABEL (Sverdrup Technology, Inc., Cleveland, Ohio.) 1988 130 p Original contains color illustrations
(NASA-SP-495; NAS 1.21:495; LC88-1690) Avail: NTIS HC A07/MF A01 CSCL 21E

At the direction of Congress, a task force headed by NASA was organized in 1975 to identify potential fuel saving concepts for aviation. The result was the Aircraft Energy Efficiency (ACEE) Program implemented in 1976. An important part of the program was the development of advanced turboprop technology for Mach 0.65 to 0.85 applications having the potential fuel saving of 30 to 50 percent relative to existing turbofan engines. A historical perspective is presented of the development and the accomplishments that brought the turboprop to successful flight tests in 1986 and 1987. Author

N89-12566*# Sverdrup Technology, Inc., Cleveland, OH.
A CONTROL-VOLUME METHOD FOR ANALYSIS OF UNSTEADY THRUST AUGMENTING EJECTOR FLOWS Final Report
COLIN K. DRUMMOND Nov. 1988 170 p
(Contract NAS3-25266)
(NASA-CR-182203; E-4461; NAS 1.26:182203) Avail: NTIS HC A08/MF A01 CSCL 21E

A method for predicting transient thrust augmenting ejector characteristics is presented. The analysis blends classic self-similar turbulent jet descriptions with a control volume mixing region discretization to solicit transient effects in a new way. Division of the ejector into an inlet, diffuser, and mixing region corresponds with the assumption of viscous-dominated phenomenon in the latter. Inlet and diffuser analyses are simplified by a quasi-steady analysis, justified by the assumptions that pressure is the forcing function in those regions. Details of the theoretical foundation, the solution algorithm, and sample calculations are given. Author

N89-12567*# Sverdrup Technology, Inc., Cleveland, OH.
A REVIEW OF TURBOMACHINERY BLADE-ROW INTERACTION RESEARCH Final Report
TODD E. SMITH Nov. 1988 38 p
(Contract NAS3-25266)
(NASA-CR-182211; E-4422; NAS 1.26:182211) Avail: NTIS HC A03/MF A01 CSCL 21E

Analytical and experimental research in the area of unsteady aerodynamics of turbomachinery has conventionally been applied to blading which oscillates when placed in a uniformly flowing fluid. Comparatively less effort has been offered for the study of blading which is subjected to nonuniformities within the flow field. The fluid dynamic environment of a blade-row embedded within multi-stage turbomachines is dominated by such highly unsteady fluid flow conditions. The production of wakes and circumferential pressure variations from adjacent blade-rows causes large unsteady energy transfers between the fluid and the blades. Determination of the forced response of a blade requires the ability to predict the unsteady loads which are induced by these aerodynamic sources. A review of research publications was done to determine recent investigations of the response of turbomachinery blading subjected to aerodynamic excitations. Such excitations are a direct result of the blade-row aerodynamic interaction which occurs between adjacent cascades of blades. The reports and papers reviewed have been organized into areas emphasizing experimental or analytical efforts. Author

N89-12568*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
DEVELOPMENT OF A THERMAL AND STRUCTURAL ANALYSIS PROCEDURE FOR COOLED RADIAL TURBINES
GANESH N. KUMAR and RUSSELL G. DEANNA (Army Aviation Research and Development Command, Cleveland, Ohio.) 1988 10 p Presented at the 33rd International Gas Turbine and Aeroengine Congress and Exposition, Amsterdam, The Netherlands, 6-9 Jun. 1988; sponsored by the American Society of Mechanical Engineers
(NASA-TM-101416; E-4515; NAS 1.15:101416; AVSCOM-TR-88-C-037) Avail: NTIS HC A02/MF A01 CSCL 21E

A procedure for computing the rotor temperature and stress distributions in a cooled radial turbine are considered. Existing codes for modeling the external mainstream flow and the internal cooling flow are used to compute boundary conditions for the heat transfer and stress analysis. The inviscid, quasi three dimensional code computes the external free stream velocity. The external velocity is then used in a boundary layer analysis to compute the external heat transfer coefficients. Coolant temperatures are computed by a viscous three dimensional internal flow cade for the momentum and energy equation. These boundary conditions are input to a three dimensional heat conduction code for the calculation of rotor temperatures. The rotor stress distribution may be determined for the given thermal, pressure and centrifugal loading. The procedure is applied to a cooled radial turbine which will be tested at the NASA Lewis Research Center. Representative results are given. Author

N89-12768# Washington State Univ., Pullman. Dept. of Mechanical and Materials Engineering.
GROUND RUN-UP AFTERBURNER DETECTION AND NOISE SUPPRESSION Final Report
JEFFREY J. GIRARD *In* Universal Energy Systems, Inc., United States Air Force Graduate Student Summer Support Program, Volume 1 8 p Dec. 1987
Avail: NTIS HC A99/MF E03 CSCL 21E

Two projects were completed, both related to aircraft station engine run-up noise. A purchase description was written for an acoustic detection system to determine whether an aircraft in a shelter has engaged afterburners. A test plan was written for a test to supply information required for evaluation of noise suppression techniques employed in hush houses for ground round-up. Author

N89-12877*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
TURBINE ENGINE HOT SECTION TECHNOLOGY (HOST) PROJECT
DANIEL E. SOKOLOWSKI and C. ROBERT ENSIGN *In its* Turbine Engine Hot Section Technology 1986 p 1-6 Oct. 1986 Previously announced as N86-11496
Avail: NTIS HC A21/MF A01 CSCL 20K

The Hot Section Technology (HOST) Project is a NASA-sponsored endeavor to improve the durability of advanced gas turbine engines for commercial and military aircraft. Through improvements in the analytical models and life prediction systems, designs for future hot section components, the combustor and turbine, will be more accurately analyzed and will incorporate features required for longer life in the more hostile operating environment of high performance engines. E.R.

N89-12878*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
HOST INSTRUMENTATION R AND D PROGRAM OVERVIEW
D. R. ENGLUND *In its* Turbine Engine Hot Section Technology 1986 p 7-8 Oct. 1986 Previously announced as N86-11497
Avail: NTIS HC A21/MF A01 CSCL 20K

The HOST Instrumentation R and D program is focused on two categories of instrumentation. One category is that required to characterize the environment imposed on the hot section components of turbine engines. This category includes instruments for measuring gas flow, gas temperature, and heat flux. The second category is that for measuring the effect of the environment on the hot section components. This category includes strain measuring instruments and an optical system for viewing the interior of an operating combustor to detect cracks, buckling, carbon buildup, etc. E.R.

N89-12879*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
HOST COMBUSTION R AND T OVERVIEW
RAYMOND E. GAUGLER *In its* Turbine Engine Hot Section Technology 1986 p 9-11 Oct. 1986
Avail: NTIS HC A21/MF A01 CSCL 21E

The overall objective of the Turbine Engine Hot Section Technology Combustion Project was to develop and verify improved and more accurate numerical analysis methods for increasing the ability to design with confidence combustion systems for advanced aircraft gas turbine engines. The objective was approached from two directions: computational and experimental. On the computational side, the approach was to first assess and evaluate existing combustor aerothermal analysis models. On the experimental side, three types of experiments are identified; first, fundamental experiments directed toward improved understanding of the flow physics and chemistry; second, experiments run to provide data for the empirical modeling of complex phenomena; and third, benchmark experiments for computer code validation. E.R.

N89-12880*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
HOST TURBINE HEAT TRANSFER SUBPROJECT OVERVIEW
HERBERT J. GLADDEN *In its* Turbine Engine Hot Section Technology 1986 p 13-17 Oct. 1986
Avail: NTIS HC A21/MF A01 CSCL 21E

The experimental part of the turbine heat transfer subproject consists of six large experiments, which are highlighted in this overview, and three of somewhat more modest scope. One of the initial efforts was the stator airfoil heat transfer program. The non-film cooled and the showerhead film cooled data have already been reported. The gill region film cooling effort is currently underway. The investigation of secondary flows in a 90 deg curved duct, was completed. The first phase examined flows with a relatively thin inlet boundary layer and low free stream turbulence. The second phase studied a thicker inlet boundary layer and higher free stream turbulence. A comparison of analytical and experimental cross flow velocity vectors is shown for the 60 deg plane. Two experiments were also conducted in the high pressure facility. One examined full coverage film cooled vanes, and the other, advanced instrumentation. The other three large experimental efforts were conducted in a rotation reference frame. An experiment to obtain gas path airfoil heat transfer coefficients in the large, low speed turbine was completed. Single-stage data with both high and low-inlet turbulence were taken. The second phase examined a one and one-half stage turbine and focused on the second vane row. Under phase 3 aerodynamic quantities such as interrow time-averaged and rms values of velocity, flow angle, inlet turbulence, and surface pressure distribution were measured. E.R.

N89-12893*# Garrett Turbine Engine Co., Phoenix, AZ.
COMBUSTOR DIFFUSER INTERACTION PROGRAM
RAM SRINIVASAN and DANIEL THORP *In* NASA, Lewis Research Center, Turbine Engine Hot Section Technology 1986 p 133-139 Oct. 1986
(Contract F33615-84-C-2427)
Avail: NTIS HC A21/MF A01 CSCL 21E

Advances in gas turbine engine performance are achieved by using compressor systems with high stage loading and low part count, which result in high exit Mach numbers. The diffuser and combustor systems in such engines should be optimized to reduce system pressure loss and to maximize the engine thrust-to-weight ratio and minimize length. The state-of-the-art combustor-diffuser systems do not meet these requirements. Detailed understanding of the combustor-diffuser flow field interaction is required for designing advanced gas turbine engines. An experimental study of the combustor-diffuser interaction (CDI) is being conducted to obtain data for the evaluation and improvement of analytical models applicable to a wide variety of diffuser designs. The CDI program consists of four technical phases: Literature Search; Baseline Configuration; Parametric Configurations; and Performance Configurations. Phase 2 of the program is in progress. Author

N89-12907*# General Electric Co., Fairfield, CT.
COMPONENT SPECIFIC MODELING
R. J. MAFFEO, R. L. MCKNIGHT, M. T. TIPTON, and G. WEBER *In* NASA, Lewis Research Center, Turbine Engine Hot Section Technology 1986 p 269-282 Oct. 1986
(Contract NAS3-23687)
Avail: NTIS HC A21/MF A01 CSCL 21E

The overall objective of this program is to develop and verify a series of interdisciplinary modeling and analysis techniques that were specialized to address three specific hot section components. These techniques incorporate data as well as theoretical methods from many diverse areas including cycle and performance analysis, heat transfer analysis, linear and nonlinear stress analysis, and mission analysis. Building on the proven techniques already available in these fields, the new methods developed are integrated to provide an accurate, efficient, and unified approach to analyzing combustor burner liners, hollow air-cooled turbine blades, and air-cooled turbine vanes. For these components, the methods developed predict temperature, deformation, stress, and strain histories throughout a complete flight mission. Author

08

AIRCRAFT STABILITY AND CONTROL

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

A89-12978#
FLIGHT CONTROL SYSTEM OF THE F/A-18 HORNET AIRCRAFT [SYSTEM STEROWANIA LOTEM SAMOLOTU F/A-18 HORNET]
SLAWOMIR MICHALAK (Instytut Techniczny Wojsk Lotniczych, Warsaw, Poland) Technika Lotnicza i Astronautyczna (ISSN 0040-1145), vol. 43, March 1988, p. 17-19. In Polish.
The four-channel remote flight control system of the F/A-18 Hornet equipped with a digital processor is described. Appropriate block diagrams are provided. B.J.

A89-13267
USING THE T-TRANSFORM METHOD FOR SOLVING PROBLEMS IN FLIGHT MECHANICS [PRIMENENIE METODA T-PREOBRAZOVANII DLIA RESHENIIA ZADACH MEKHANIKI POLETA]
IU. N. SOMOV (Kievskii Institut Inzhenerov Grazhdanskoi Aviatsii, Kiev, Ukrainian SSR) Gibridnye Vychislitel'nye Mashiny i Kompleksy (ISSN 0207-0111), no. 11, 1988, p. 11-13. In Russian.
The use of Taylor transforms for increasing the speed of computations for a specified solution accuracy is examined with particular reference to problems in flight mechanics. A specific example is considered which involves the use of Taylor transforms for solving a system of differential equations describing the motion of a helicopter along a vertical for finite velocity and altitude. It is shown that the velocity and altitude values determined by the Taylor transform method are as accurate as those obtained by the Runge-Kutta method, while the number of computations at a single integration step is almost an order of magnitude less since the right term of the equation does not have to be determined at each integration step. V.L.

A89-13507#
TAKEOFF FLIGHT-PATHS IN THE PRESENCE OF WIND AND WIND VARIATION
K.-U. HAHN (Braunschweig, Technische Universitaet, Brunswick, Federal Republic of Germany) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 21-31. DFG-supported research. refs
The results obtained by means of the present universal and simple method for the calculation of aircraft flight performance and flight path deviation in variable wind fields are compared with results from a numerical aircraft simulation of nonlinear differential equations of motion. Attention is given to flight path behavior during takeoff in thunderstorms. A guidance system based on pitch attitude control is presented with which a pilot will be able to cross downbursts on a flight-path that is close to an optimal flight trajectory. Heavy thunderstorms are found to produce wind conditions under which a positive rate-of-climb cannot be established. O.C.

A89-13523#
INTEGRATED CONTROL TECHNOLOGY FOR COMMUTER AIRCRAFT - EXPERIMENTAL RESULTS AND FUTURE POTENTIAL
W. ALLES, H. BOEHRET, and H. WUENNENBERG (Dornier GmbH, Friedrichshafen, Federal Republic of Germany) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 178-183.
The paper defines the technical components of an integrated flight control system for commuter aircraft as well as possible evaluation criteria for the final selection of the components. Examples of already realized systems are presented, and a detailed description of the development and flight testing of an active control system for improving passenger ride comfort is given. B.J.

A89-13524#
ACTIVE FLUTTER SUPPRESSION FOR A WING MODEL
G. L. GHIRINGHELLI, M. LANZ, and P. MANTEGAZZA (Milano, Politecnico, Milan, Italy) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 184-193. refs
The paper presents an experimental verification of a method to design active control flutter suppression systems that allows eigenstructure assignment directly within a p-k flutter approximation. By using a wing model it is shown how different and simple direct feedback control laws can be effective in producing a substantial improvement of the flutter speed and of the overall damping below the critical speed. Difficulties encountered in correlating designs to test by using a Maximum Likelihood identification method are also addressed. Author

A89-13526#
MULTIVARIABLE CONTROL SYSTEM DESIGN FOR AN UNSTABLE CANARD AIRCRAFT
DAVID COWLING (Bristol, University, England) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 205-215. refs
The control of a longitudinally unstable canard aircraft with high order feedback loops is examined, using multiloop analysis methods. Simple control structures which reflect current industrial practice are successfully implemented on two system designs using the eigenstructure assignment method together with a robustness and sensitivity optimization scheme. A true multiloop design which incorporates incidence feedback exhibits better robustness and sensitivity characteristics than the more conventional system which uses only pitch rate feedback. Author

A89-13530#
OPEN LOOP OPTIMAL CONTROL OF MULTI-ENGINE AIRCRAFT AFTER ONE ENGINE FAILURE
WANG JIANPEI and BERND KAUFMANN (Braunschweig, Technische Universitaet, Brunswick, Federal Republic of Germany) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 255-268. refs
Dynamic response of multiengine aircraft after one engine failure, generally speaking, is crucial, if the pilot could not judge and react correctly and timely. Using optimization technique, four time-dependent open-loop optimal control of two typical twin engine civil aircrafts (Airbus-A300 and Dornier-28TNT) after one engine failure are found satisfactory, no matter what initial flight condition is, such as take-off, landing approach or cruise flight. Not only the dynamic behavior after one engine failure is well controlled, but also the optimal control activities which should be taken by the pilot after one engine failure are easily performed by the pilot. The key question of the optimization technique is how to construct the cost function, and this question is discussed in detail as well. Author

A89-13546*# Rice Univ., Houston, TX.
OPTIMIZATION AND GUIDANCE OF LANDING TRAJECTORIES IN A WINDSHEAR
A. MIELE, T. WANG (Rice University, Houston, TX), and W. W. MELVIN (Delta Air Lines, Inc., Atlanta, GA) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 445-462. Research supported by the Boeing Commercial Airplane Co. and Air Line Pilots Association. refs
(Contract NAG1-516)
The problem of the optimization and guidance of landing

trajectories in the presence of a windshear is considered with emphasis on abort landing and penetration landing. For abort landing, optimal trajectories are determined by minimizing the peak value of the altitude drop. For penetration landing, optimal trajectories are determined by minimizing a performance index measuring the deviation of the altitude of the flight trajectory from that of the nominal trajectory, with touchdown path inclination, touchdown velocity tolerance, and touchdown distance tolerance specified. V.L.

A89-13632#

DESIGN OF HIGHER BANDWIDTH MODEL FOLLOWING FOR FLIGHT VEHICLE STABILIZATION AND CONTROL

FROHMUT HENSCHEL and GERHARD BOUWER (DFVLR, Institut fuer Flugmechanik, Brunswick, Federal Republic of Germany) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 1304-1310. refs

The paper describes the general design of a Model Following Control System (MFCS), which is accomplished in several sequential steps. To start with, a suitable structure for the controller is chosen depending on the physical properties of the system and operating constraints. The feedforward gains are determined by calculating a pseudoinverse of the control input matrix assuming the plant to be linear. The feedback gains are obtained by using an interactive vector performance optimization technique. The desired design goals are achieved by selecting a proper set of performance criteria in the time and frequency domain. The design obtained by this procedure is tested extensively using offline and ground-based nonlinear and real-time simulation facilities. The approach is applied both to the fixed wing and helicopter inflight simulators ATTAS (VFW 614) and ATTHeS (BO 105) at DFVLR. Simulation results demonstrate the effectiveness of the MFCS in obtaining good model matching and desired disturbance rejection with good crossover properties. Author

A89-13637#

THE STUDY OF GLOBAL STABILITY AND SENSITIVE ANALYSIS OF HIGH PERFORMANCE AIRCRAFT AT HIGH ANGLES-OF-ATTACK

H. GAO, Z. D. HE, and Z. Q. ZHOU (Northwestern Polytechnical University, Xian, People's Republic of China) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 1356-1363. refs

Attention is presently given to the relationship between the stability criteria commonly used in aircraft design and eigenvalues of the linearized matrices at the equilibrium points, for the case of a high-performance aircraft at high angles-of-attack. The stability criteria may be deduced from the linearized matrices of the aircraft nonlinear dynamic system at a specific flight state; the local stability thus obtained can then be subjected to a sensitivity analysis to study the effects of cross-coupling derivatives and acceleration derivatives on aircraft response. O.C.

A89-13638#

DETERMINATION OF DEPARTURE SUSCEPTIBILITY AND CENTRE OF GRAVITY LIMITATIONS FOR CONTROL AUGMENTED AIRCRAFT

M. MEDINA and M. SHAHAF (Israel Air Force, Tel Aviv) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 1364-1373. refs

A six-degree-of-freedom high fidelity digital computer simulation was developed by the Israeli Air Force for the General Dynamics F-16 Aircraft. The program is run using pilot inputs derived from operational high angle of attack maneuvers that proved to be departure susceptible. By simulating these maneuvers systematically for different configurations/center of gravity positions/flight envelope points and comparing the results with those for well documented and flight tested reference configurations, operational limits and relative departure susceptibilities were determined. The complexity of departure boundary evaluation is shown and the utility of digital simulation in the process is established. Author

A89-13658#

TRANSONIC MAGNUS FORCE ON A FINNED CONFIGURATION

M. RINGEL and A. SEGINER (Technion - Israel Institute of Technology, Haifa) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 1553-1558. refs

Magnus forces are measured on a rotating Basic-Finner configuration at subsonic and transonic speeds. At low angles of attack no significant Magnus forces were observed in the subsonic regime, and 'non-classic' Magnus forces were measured at transonic speeds. At higher angles of attack 'non-classic' Magnus forces were measured at all Mach numbers. These were related to the side forces that existed on the non-rolling model under the same conditions. Author

A89-15611

NON-CLASSICAL FLOW-INDUCED RESPONSES OF A LIFTING SURFACE DUE TO LOCALIZED DISTURBANCES

R. STEARMAN, E. J. POWERS (Texas, University, Austin), and T. KIM IN: International Modal Analysis Conference, 6th, Kissimmee, FL, Feb. 1-4, 1988, Proceedings. Volume 2. Bethel, CT, Society for Experimental Mechanics, Inc., 1988, p. 1288-1299. refs

The aeroelastic response of a lifting surface in subsonic flow to a localized disturbance is investigated analytically using a transient aerodynamic-strip technique. The fundamental physical principles of the structural-damage and aerodynamic-damage models are reviewed; the formulation of the governing equations for a wing aerodynamic-damage model is derived in detail; and results of a preliminary stability analysis are presented in extensive tables and graphs are briefly characterized. T.K.

A89-15705#

THE EFFECT OF REDUCED USEABLE CUE ENVIRONMENTS ON HELICOPTER HANDLING QUALITIES

STEWART W. BAILLIE (National Aeronautical Establishment, Ottawa, Canada) and ROGER H. HOH (Systems Technology, Inc., Hawthorne, CA) (CASI, Flight Test Symposium, Ottawa, Canada, Mar. 24, 1988) Canadian Aeronautics and Space Journal (ISSN 0008-2821), vol. 34, Sept. 1988, p. 144-150.

The paper begins with a summary of past programs on the interaction of usable cue environments and handling qualities. To investigate the area further, advanced in-flight evaluations of rotorcraft handling qualities were carried out in varying visual cue environments. Evaluation pilots were fitted with night vision goggles incorporating adjustable daylight training filters to modify their level of available visual cueing. The test vehicle, the NAE Bell 205 Airborne Simulator, was configured with advanced control modes including attitude command/attitude hold, translational command/position hold and vertical rate command/height hold. Qualitative measures of handling qualities and visual cue environment, coupled with pilot commentary demonstrate the effects of reduced usable cue environments on helicopter handling qualities and validate the concept of augmenting the aircraft control modes to compensate for reduced usable cue conditions. Author

A89-16069#

A MODIFIED CUBIC SPLINE APPROACH FOR TERRAIN FOLLOWING SYSTEM

CHENGFU WU and SHUNDA XIAO (Northwestern Polytechnical University, Xian, People's Republic of China) Northwestern Polytechnical University, Journal (ISSN 1000-2758), vol. 6, Oct. 1988, p. 395-405. In Chinese, with abstract in English. refs

A terrain-following optimal control scheme using a cubic spline path is presented. Of particular interest is a modified scheme: a 'templet-type cubic spline approach'. It is shown that this modified scheme can be implemented more easily than the cubic spline scheme developed by Funk. K.K.

A89-16088#
F-5E DEPARTURE WARNING SYSTEM ALGORITHM DEVELOPMENT AND VALIDATION
J. H. TAYLOR and A. M. SKOW (Eidetics International, Inc., Torrance, CA) Journal of Aircraft (ISSN 0021-8669), vol. 25, Sept. 1988, p. 783-789. USAF-supported research. Previously cited in issue 23, p. 3415, Accession no. A86-47702.

A89-16090#
DETERMINATION OF NONLINEAR AERODYNAMIC COEFFICIENTS USING THE ESTIMATION-BEFORE-MODELING METHOD
MUTHUTHAMBY SRI-JAYANTHA (IBM, Research Div., Yorktown Heights, NY) and ROBERT F. STENGEL (Princeton University, NJ) (Identification and system parameter estimation 1985; Proceedings of the Seventh Symposium, York, England, July 3-7, 1985. Volume 1, p. 837-844) Journal of Aircraft (ISSN 0021-8669), vol. 25, Sept. 1988, p. 796-804. Research supported by the Schultz Foundation. Previously cited in issue 04, p. 447, Accession no. A87-16202. refs

A89-16099#
SIMPLE MODEL FOR PREDICTING TIME TO ROLL WINGS LEVEL IN THE A-7E
ALBERT J. DESANTI (U.S. Naval Weapons Center, China Lake, CA) Journal of Aircraft (ISSN 0021-8669), vol. 25, Sept. 1988, p. 861, 862.

A simple model predicting the amount of time required to roll wings level from an arbitrary bank angle of the A-7E attack aircraft is derived and verified; this approach is generally applicable to tactical aircraft. The model is used in the A-7E's airborne computer flight software in order to furnish improved ground collision avoidance, calculating the altitude loss incurred in a dive. Simplicity has been a primary consideration in the model's development. O.C.

A89-16154#
ENHANCED ASSESSMENT OF ROBUSTNESS FOR AN AIRCRAFT'S SLIDING MODE CONTROLLER
S. K. MUDGE and R. J. PATTON (York, University, Heslington, England) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 11, Nov.-Dec. 1988, p. 500-507. refs

The design of a multivariable sliding mode controller based on the equations of motion of an unmanned aircraft or remotely piloted vehicle (RPV)is described and an emphasis on robust eigenstructure assignment is given. The linear and nonlinear model responses are compared when subjected to the same variable-structure control design. The ability of the controller to cope with uncertain parameter variations is investigated as a problem of robustness assessment. It is shown that after sliding has commenced, the response of the objective system is tracked by the corresponding nonlinear or perturbed system. A measure of sensitivity is defined as the proximity of the actual system modal structure and response to that of the designed objective. The nonlinear system with variable-structure controller is also shown to be robust in the sense that this objective response is always recovered after a disturbance or parameter variation. Author

A89-16156*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
ADVANCED DETECTION, ISOLATION, AND ACCOMMODATION OF SENSOR FAILURES - REAL-TIME EVALUATION
WALTER C. MERRILL, JOHN C. DELAAT, and WILLIAM M. BRUTON (NASA, Lewis Research Center, Cleveland, OH) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 11, Nov.-Dec. 1988, p. 517-526. Previously announced in STAR as N87-25331. refs

The objective of the Advanced Detection, Isolation, and Accommodation (ADIA) program is to improve the overall demonstrated reliability of digital electronic control systems for turbine engines by using analytical redundancy to detect sensor failures. The results of a real-time hybrid computer evaluation of the ADIA algorithm are presented. Minimum detectable levels of sensor failures for an F100 engine control system are determined. Also included are details about the microprocessor implementation of the algorithm as well as a description of the algorithm itself. Author

A89-16157#
FUNDAMENTAL APPROACH TO EQUIVALENT SYSTEMS ANALYSIS
BARTON J. BACON and DAVID K. SCHMIDT (Purdue University, West Lafayette, IN) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 11, Nov.-Dec. 1988, p. 527-534. Previously cited in issue 23, p. 3413, Accession no. A86-47674. refs (Contract N62269-83-C-0220)

A89-16158#
LOOP SEPARATION PARAMETER - A NEW METRIC FOR LANDING FLYING QUALITIES
J. J. MARTZ, D. J. BIEZAD (USAF, Aeronautical Systems Div., Wright-Patterson AFB, OH), and E. D. DIDOMINICO (USAF, Test Pilot School, Edwards AFB, CA) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 11, Nov.-Dec. 1988, p. 535-541. Previously cited in issue 22, p. 3543, Accession no. A87-50537. refs

A89-16437#
THE ROLE OF C(N BETA. DYN) IN THE AIRCRAFT STABILITY AT HIGH ANGLES OF ATTACK
ZHIDAI HE (Northwestern Polytechnical University, Xian, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 9, Oct. 1988, p. B462-B468. In Chinese, with abstract in English. refs

In order to predict aircraft stability at high angles of attack, C(n beta. dyn) is one of the most important criteria. An example is given to explain the effects of some of the aerodynamic derivatives on aircraft stability, and these derivatives are connected to C(n beta. dyn). Time history studies are carried out by programming a set of equations of motion pertinent to a typical fighter on a digital computer by varying some of the aerodynamic derivations in a predeterminate manner and by observing the responses of some of the variables of motion to derivatives applied to the set of equations. Calculative results are presented which show that the aircraft could be unstable at high angles of attack even if the criterion is satisfied. Some reasons for the existence of these exceptions are discussed. C.D.

A89-16442#
FLIGHT STABILITY CRITERIA ANALYSIS OF AIRCRAFT AT HIGH ANGLES-OF-ATTACK
HONG ZHANG (Shanghai Aircraft Design and Research Institute, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 9, Oct. 1988, p. B502-B505. In Chinese, with abstract in English.

A new synthetic flight stability criterion of aircraft at high angles-of-attack is developed in this paper by analyzing the operator matrix of five degree-of-freedom motion equations of aircraft. A brief introduction and interpretation are given of several simplified criteria concerned with the flight stability of aircraft, such as the dynamic directional stability parameter, departure predicting criterion, and Phillips parameter which is closely involved with the stability of aircraft at high angles-of-attack. The new criterion synthesizes all these simplified criteria and reveals the relationships among them. C.D.

A89-16632
MULTIFACTOR MODEL OF ERRORS CONNECTED WITH AIRCRAFT CONTROL [MNOGOFAKTORNAIA MODEL' OSHIBOK PRI UPRAVLENII VOZDUSHNYM SUDNOM]
V. N. GOLEGO (Kievskii Institut Inzhenerov Grazhdanskoi Aviatsii,

Kiev, Ukrainian SSR) Kibernetika i Vychislitel'naia Tekhnika (ISSN 0454-9910), no. 76, 1987, p. 86-92. In Russian.

The paper examines the development of a hierarchical pilot model based on a multifactor analysis of statistical information on pilot errors in the aircraft flight control process. It is suggested that this model can be used for a quantitative evaluation of aircraft accidents associated with pilot errors. A method for classifying various factors according to the degree of hazard involved is presented. B.J.

A89-16826#
A STUDY OF AIRCRAFT GLOBAL DYNAMIC STABILITY IN MANEUVER BY USING THE BIFURCATION AND CATASTROPHE THEORY
CHANG LIU and BO ZHAO (Nanjing Aeronautical Institute, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 9, Sept. 1988, p. A399-A408. In Chinese, with abstract in English. refs

The main theorems of bifurcation and catastrophe theory as well as the qualitative theory of differential equations are used to study aircraft global dynamic stability during maneuvers. An analytical formula for determining the critical steady-state value of roll rate is obtained in the state-control space. Nonlinear jump and periodic oscillation phenomena are discussed in detail. K.K.

N89-11752*# TAU Corp., Los Gatos, CA.
AUTONOMOUS FLIGHT AND REMOTE SITE LANDING GUIDANCE RESEARCH FOR HELICOPTERS
R. V. DENTON, N. J. PECKLESMA, and F. W. SMITH Aug. 1987 104 p
(Contract NAS2-12180)
(NASA-CR-177478; NAS 1.26:177478) Avail: NTIS HC A06/MF A01 CSCL 01C

Automated low-altitude flight and landing in remote areas within a civilian environment are investigated, where initial cost, ongoing maintenance costs, and system productivity are important considerations. An approach has been taken which has: (1) utilized those technologies developed for military applications which are directly transferable to a civilian mission; (2) exploited and developed technology areas where new methods or concepts are required; and (3) undertaken research with the potential to lead to innovative methods or concepts required to achieve a manual and fully automatic remote area low-altitude and landing capability. The project has resulted in a definition of system operational concept that includes a sensor subsystem, a sensor fusion/feature extraction capability, and a guidance and control law concept. These subsystem concepts have been developed to sufficient depth to enable further exploration within the NASA simulation environment, and to support programs leading to the flight test. Author

N89-11753*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
APPROXIMATION THEORY FOR LQG (LINEAR-QUADRATIC-GAUSSIAN) OPTIMAL CONTROL OF FLEXIBLE STRUCTURES Final Report
J. S. GIBSON and A. ADAMIAN (California Univ., Los Angeles.) Aug. 1988 121 p Submitted for publication
(Contract NAS1-17070; NAS1-18107)
(NASA-CR-181705; ICASE-88-48; NAS 1.26:181705; AD-A200257) Avail: NTIS HC A06/MF A01 CSCL 01C

An approximation theory is presented for the LQG (Linear-Quadratic-Gaussian) optimal control problem for flexible structures whose distributed models have bounded input and output operators. The main purpose of the theory is to guide the design of finite dimensional compensators that approximate closely the optimal compensator. The optimal LQG problem separates into an optimal linear-quadratic regulator problem and an optimal state estimation problem. The solution of the former problem lies in the solution to an infinite dimensional Riccati operator equation. The approximation scheme approximates the infinite dimensional LQG problem with a sequence of finite dimensional LQG problems defined for a sequence of finite dimensional, usually finite element or modal, approximations of the distributed model of the structure. Two Riccati matrix equations determine the solution to each approximating problem. The finite dimensional equations for numerical approximation are developed, including formulas for converting matrix control and estimator gains to their functional representation to allow comparison of gains based on different orders of approximation. Convergence of the approximating control and estimator gains and of the corresponding finite dimensional compensators is studied. Also, convergence and stability of the closed-loop systems produced with the finite dimensional compensators are discussed. The convergence theory is based on the convergence of the solutions of the finite dimensional Riccati equations to the solutions of the infinite dimensional Riccati equations. A numerical example with a flexible beam, a rotating rigid body, and a lumped mass is given. Author

N89-11754# National Aerospace Lab., Amsterdam (Netherlands). Flight Div.
FREQUENCY RESPONSE ANALYSIS OF HYBRID SYSTEMS
J. SCHURING 27 Apr. 1987 78 p
(Contract NIVR-313.3-01902N)
(NLR-TR-87059-U; B8817852; ETN-88-93381) Avail: NTIS HC A05/MF A01

A dedicated frequency response analysis method was developed for hybrid digital control systems. For practical use of the method, it was expanded to an analysis method generally applicable to multi-input, multi-rate, linear time-invariant hybrid systems. Computer programs to apply the method were developed. The calculated frequency responses are presented graphically in Bode, Nyquist, and Nichols plots. An application of the method in aircraft control is elaborated. A tolerance to less conservative digital system design is clearly indicated. ESA

N89-12569*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
SINGULAR PERTURBATIONS AND TIME SCALES IN THE DESIGN OF DIGITAL FLIGHT CONTROL SYSTEMS
DESINENI S. NAIDU (Old Dominion Univ., Norfolk, Va.) and DOUGLAS B. PRICE Washington, D.C. Dec. 1988 30 p
(NASA-TP-2844; L-16440; NAS 1.60:2844) Avail: NTIS HC A03/MF A01 CSCL 01C

The results are presented of application of the methodology of Singular Perturbations and Time Scales (SPATS) to the control of digital flight systems. A block diagonalization method is described to decouple a full order, two time (slow and fast) scale, discrete control system into reduced order slow and fast subsystems. Basic properties and numerical aspects of the method are discussed. A composite, closed-loop, suboptimal control system is constructed as the sum of the slow and fast optimal feedback controls. The application of this technique to an aircraft model shows close agreement between the exact solutions and the decoupled (or composite) solutions. The main advantage of the method is the considerable reduction in the overall computational requirements for the evaluation of optimal guidance and control laws. The significance of the results is that it can be used for real time, onboard simulation. A brief survey is also presented of digital flight systems. Author

N89-12570*# Princeton Univ., NJ. Dept. of Mechanical and Aerospace Engineering.
DESIGN AND NUMERICAL EVALUATION OF FULL-AUTHORITY FLIGHT CONTROL SYSTEMS FOR CONVENTIONAL AND THRUSTER-AUGMENTED HELICOPTERS EMPLOYED IN NOE OPERATIONS Interim Report
TODD A. PERRI, R. M. MCKILLIP, JR., and H. C. CURTISS, JR. Aug. 1987 199 p
(Contract NAG2-244)
(NASA-CR-183311; NAS 1.26:183311; TR-1789T) Avail: NTIS HC A09/MF A01 CSCL 01C

The development and methodology is presented for development of full-authority implicit model-following and explicit model-following optimal controllers for use on helicopters operating in the Nap-of-the Earth (NOE) environment. Pole placement, input-output frequency response, and step input response were used to evaluate handling qualities performance. The pilot was equipped with velocity-command inputs. A mathematical/computational trajectory optimization method was employed to evaluate the ability of each controller to fly NOE maneuvers. The method determines the optimal swashplate and thruster input histories from the helicopter's dynamics and the prescribed geometry and desired flying qualities of the maneuver. Three maneuvers were investigated for both the implicit and explicit controllers with and without auxiliary propulsion installed: pop-up/dash/descent, bob-up at 40 knots, and glideslope. The explicit controller proved to be superior to the implicit controller in performance and ease of design. Author

N89-12571# Centre Aeroporte de Toulouse (France).
REMOTE GUIDANCE OF PAYLOADS UNDER MANEUVERABLE PARACHUTES [TELEGUIDAGE DES CHARGES SOUS PARACHUTES MANOEUVRABLES]
M. CAROL Mar. 1988 173 p In FRENCH
(E-639; REPT-88/03; ETN-88-93109) Avail: NTIS HC A08/MF A01

A remote control system for testing on maneuverable parachutes was designed. The feasibility of trajectory control of heavy load parachutes by a remote system was analyzed. The feasibility of automatic guidance of payloads accompanied by a parachutist was examined. A parachute wing and a parachute model were constructed. Analysis and test results enabled the characteristics of an operational system to be derived. ESA

09

RESEARCH AND SUPPORT FACILITIES (AIR)

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

A89-13505#
SIMULATED ENVIRONMENT TESTING FOR AIRCRAFT
P. W. SMITH (Aeroplane and Armament Experimental Establishment, Salisbury, England) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 1-6.

An account is given of the U.K. Aeroplane and Armament Experimental Establishment's efforts to assess the operational performance of service aircraft under conditions fully representative of extremes of temperature, humidity, solar radiation, kinetic heating, rain, and icing. The alternative to indoor simulation of these conditions is expensive and intrinsically unsafe overseas testing in potential operational regions with manned aircraft. The test apparatus employed for aircraft environmental testing is discussed; costs of merely 33 percent of those which would be incurred in overseas testing have been achieved. O.C.

A89-13555#
FLIGHT SIMULATIONS ON MLS-GUIDED INTERCEPTION PROCEDURES AND CURVED APPROACH PATH PARAMETERS
LOUIS J. J. ERKELENS (Nationaal Lucht- en Ruimtevaartlaboratorium, Amsterdam, Netherlands) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 554-565. refs

Two investigations were performed using a B-747 simulation model in order to explore the greater operational potential of the MLS approach and landing system. The effectiveness of four MLS guided interception methods was first evaluated, with emphasis on the appropriate turn techniques and required avionics equipment. In the second study, the approach path parameters for seven oblique approach paths which varied in both straight final length and oblique angle were determined. Data were obtained for various operating minima, and the investigation takes into account the effects of wind, turbulence, and cloud base. R.R.

A89-13619#
SOME NEW TEST RESULTS IN THE ADAPTIVE RUBBER TUBE TEST SECTION OF THE DFVLR GOETTINGEN
A. HEDDERGOTT and E. WEDEMEYER (DFVLR, Institut fuer experimentelle Stroemungsmechanik, Goettingen, Federal Republic of Germany) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 1172-1180. refs

The DFVLR adaptive rubber tube wind-tunnel test section has been in operation now for four years. More test results and experiences have been gained so that the capability of the test section can be compared with other transonic test facilities. While previous tests were mainly performed to thick models producing large blockage effects, more recent force and pressure measurements were made on models of transport airplanes. As a first approach to wall adaptation at supersonic speeds, tests with a cone-cylinder model were performed at a Mach number of 1.2. Most of the test results reported here could be compared with reference data which are considered interference-free, as they were obtained for small blockage and wing span ratios in wind tunnels with ventilated walls. Author

A89-13620#
APPLICATION OF A FLEXIBLE WALL TESTING TECHNIQUE TO THE NASA LANGLEY 0.3-M TRANSONIC CRYOGENIC TUNNEL
STEPHEN W. D. WOLF (Southampton, University, England) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 1181-1191. refs

Wind tunnel wall interference can be minimized by means of a flexible wall technique, whose application to the NASA-Langley 0.3-m Transonic Cryogenic Tunnel (TCT) is presently discussed. The adaptable test section employed by the TCT has four solid walls, of which only the floor and ceiling are adaptable; these are computer-controlled to minimize wall contour-definition times, and can operate at cryogenic temperatures and high pressures despite large wall deflections. Both two- and three-dimensional test data illustrative of the experience gained with the TCT system over the course of two and a half years of operation are presented. O.C.

A89-13621#
BLOCKAGE CORRECTIONS AT HIGH ANGLES OF ATTACK IN A WIND TUNNEL
P. A. GILI, D. M. PASTRONE, F. B. QUAGLIOTTI (Torino, Politecnico, Turin, Italy), and E. BARBANTINI (Aeritalia, S.p.A., Turin, Italy) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 1192-1198. refs

A validation has been conducted of results obtained in a 4 sq m cross-section wind tunnel test section, for a calibration model in poststall conditions, on the basis of results from a 32.4 sq m test-section wind tunnel of well-established reliability, whose size rendered boundary-interference corrections unnecessary. In addition, a data-correction method for blockage that could be applied in the course of on-line data-reduction problem-solving was developed. The corrections achieved for lift and moment coefficients were satisfactory, but those for drag coefficient were excessive. O.C.

A89-13622*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
CRYOGENIC WIND TUNNELS FOR HIGH REYNOLDS NUMBER TESTING
ROBERT A. KILGORE and PIERCE L. LAWING (NASA, Langley

Research Center, Hampton, VA) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 1199-1209. refs

This paper begins with a brief review of cryogenic wind tunnels and their use for high Reynolds number testing. Emphasis is on operational experience and recent aerodynamic tesing in the NASA Langley 0.3-m Transonic Cryogenic Tunnel (TCT). Specific area covered in this paper include development of test techniques and aerodynamic testing in cryogenic tunnels. Details of research experience in developing model construction techniques, including airfoils as thin as 5 percent, are given. The use of advanced testing techniques to increase the value of cryogenic tunnels to the research community is recommended. These include adaptive wall test sections using solid but flexible top and bottom walls and magnetic suspension and balance systems. Author

A89-13633#

PHASE II FLIGHT SIMULATOR MATHEMATICAL MODEL AND DATA-PACKAGE, BASED ON FLIGHT TEST AND SIMULATION TECHNIQUES

A. M. H. NIEUWPOORT, J. H. BREEMAN (Nationaal Lucht- en Ruimtevaartlaboratorium, Amsterdam, Netherlands), M. BAARSPUL, and J. A. MULDER (Delft, Technische Hogeschool, Netherlands) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 1311-1327. refs

The development of a ground-based simulation system for Cessna Citation 500 aircraft is discussed. The processing and analysis of flight test data to generate the required mathematical simulation models and corresponding data set is examined. The instrumentation system, data processing, parameter identification, and the synthesis of the models used in the program are presented. R.B.

A89-15560

ULTRA-LOW FREQUENCY VIBRATION DATA ACQUISITION CONCERNS IN OPERATING FLIGHT SIMULATORS

BLAKE W. VAN HOY (Martin Marietta Energy Systems, Inc., Oak Ridge; Oak Ridge National Laboratory, TN) IN: International Modal Analysis Conference, 6th, Kissimmee, FL, Feb. 1-4, 1988, Proceedings. Volume 1. Bethel, CT, Society for Experimental Mechanics, Inc., 1988, p. 646-652.

(Contract DE-AC05-84OR-21400)

Results of a study of ultralow frequency vibrations (0.01-1.0 Hz) in motion based flight simulators are reported. The discussion covers methods of measurement, the selection of transducers, recorders, and analyzers, the development of the test plan, and types of analysis. The data acquired during the study are used to evaluate the effect of low frequency energy on the vestibular system of the air crew. V.L.

A89-16323

A NEW BOUNDARY LAYER WIND TUNNEL

P. E. ROACH (Rolls-Royce, PLC, Advanced Research Laboratory, Derby, England) Aeronautical Journal (ISSN 0001-9240), vol. 92, June-July 1988, p. 224-229. refs

The procedures employed for the design of a closed-circuit boundary-layer wind tunnel are described. The tunnel was designed for the generation of relatively large-scale two dimensional boundary layers with Reynolds numbers, pressure gradients, and free-stream turbulence levels typical of the turbomachinery environment. The results of a series of tests to evaluate the tunnel performance are also described. Author

A89-16515*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

USE OF DYNAMICALLY SCALED MODELS FOR STUDIES OF THE HIGH-ANGLE-OF-ATTACK BEHAVIOR OF AIRPLANES

JOSEPH R. CHAMBERS (NASA, Langley Research Center, Hampton, VA) International Symposium on Scale Modeling, Tokyo, Japan, July 18-22, 1988, Paper. 11 p. refs

Dynamically scaled, free-flying models are used by the National Aeronautics and Space Administration (NASA) to study the stalling and spinning characteristics of civil and military airplane configurations. Such tests have been conducted for many different designs, and it has been possible to correlate the results predicted by the model tests with flight test results obtained in the investigations. The present paper describes four of the dynamic model testing techniques used at the NASA Langley Research Center, including the scaling laws used in the construction of models and in the interpretation of results. Predictions of stall/spin behavior based on model results have generally been very accurate, and the model tests are regarded as an invaluable precursor to full-scale flight tests. However, aerodynamic scale effects between some models and full-scale airplanes due to differences in test values of Reynolds number have resulted in erroneous predictions for a few configurations. A discussion of these effects is provided, together with the approach used to modify the model so that its behavior more closely matches that of the airplane. Finally, two typical applications of the techniques to the X-29A research airplane and several general aviation research airplanes are presented to illustrate the type of information provided by the tests. Author

A89-16738

RECENT ADVANCES IN COMPUTER IMAGE GENERATION SIMULATION

HAL E. GELTMACHER (USAF, Human Resources Laboratory, Williams AFB, AZ) Aviation, Space, and Environmental Medicine (ISSN 0095-6562), vol. 59, Nov. 1988, p. A39-A45. refs

This paper overviews recent progress made in computer image generation simulation, along with advances made in the simulator handling qualities, real-time computation systems, electrooptical displays, and very high speed integrated circuits. The impact that these achievements will make on future USAF aircrew simulator training is discussed. Some possibilities that are considered include multiship full-mission simulators at replacement training units, miniaturized unit level mission rehearsal training simulators, onboard embedded training capability, and national scale simulator networking. I.S.

N89-11755# Aeronautical Research Labs., Melbourne (Australia).

DESIGN OF A NEW CONTRACTION FOR THE ARL LOW SPEED WIND TUNNEL

J. H. WATMUFF Aug. 1986 39 p

(ARL-AERO-R-171; AR-004-496) Avail: NTIS HC A03/MF A01

A numerical method is developed for the solution of the Stokes' stream function. The method is applied to the existing Low Speed Wind Tunnel (LSWT) contraction shape. The calculated wall pressure coefficient distribution is compared to experimental measurements to test the approximation of axial symmetry made for the octagonal sections and for the effects of neglecting viscous forces. Reasonable agreement is obtained. The existing contraction is known to suffer from intermittent boundary layer separation near the entry caused by adverse pressure gradients. A new contraction shape is suggested that uses the contraction ratio of the existing LSWT so that the new design can be installed within the existing LSWT in the form of an inner skin. The new design, which is about 10 percent longer than the existing contraction, has an adverse pressure gradient near the inlet which is about 20 percent of that of the existing contraction while the adverse pressure gradient near the exit is around the same value. It is expected that the reduced adverse pressure gradient near the entry will be small enough to allow the inlet boundary layer to remain attached thus leading to a substantial improvement to the working section flow quality. Author

N89-11756*# Queensland Univ., St. Lucia (Australia). Dept. of M. E.

EXPANSION TUBE TEST TIME PREDICTIONS Final Report

CHRISTOPHER M. GOURLAY Sep. 1988 98 p

(Contract NAGW-674)

(NASA-CR-181722; REPT-8/88; NAS 1.26:181722) Avail: NTIS HC A05/MF A01 CSCL 14B

The interaction of an interface between two gases and strong expansion is investigated and the effect on flow in an expansion tube is examined. Two mechanisms for the unsteady Pitot-pressure fluctuations found in the test section of an expansion tube are proposed. The first mechanism depends on the Rayleigh-Taylor instability of the driver-test gas interface in the presence of a strong expansion. The second mechanism depends on the reflection of the strong expansion from the interface. Predictions compare favorably with experimental results. The theory is expected to be independent of the absolute values of the initial expansion tube filling pressures. Author

N89-11757# Marine Corps, Washington, DC.
REQUIRED OPERATIONAL CAPABILITY (ROC) FOR A PORTABLE HELIPORT LIGHTING SET (PHLS)
19 Jan. 1988 12 p
(AD-A196372; USMC-ROC-LOG-216.1.2) Avail: NTIS HC A03/MF A01 CSCL 01E

In order to provide the unit commander with the greatest possible flexibility, the PHLS should consist of two components (an approach path indicator (API) and Landing Zone (LZ) marker lights) packaged as a set. The API will provide a tricolored glidepath to assist the pilot to a safe landing in a designated permissive LZ. The remotely controlled LZ markers will be used to mark the perimeter of the LZ and will have both an infrared (IR) and incandescent light capability. This would enable the markers to be used in conjunction with the API or separately to designate a non-permissive LZ. In the incandescent mode, the API and the LZ marker lights would be used to train pilots in night vertical assault operations and also would be used for missions flown into permissive LZ's. Pilots flying in a night vertical assault may use NVG's and employ terrain-following flight techniques. As elements of the flight cross the initial point (LP), the flight leader activates an IR LZ marker/identifier (a strobing marker light) using the aircraft's UHF radio transmitter. Once the LZ has been visually identified the pilot turn the marker off. It can then be turned back on by each successive wave, if required. GRA

N89-11759# Technische Univ., Hanover (Germany, F.R.). Inst. fuer Verkehrswirtschaft.
AIRCRAFT FLEXIBLE PAVEMENT OVERLAY DESIGN AND EVOLUTION Ph.D. Thesis [ZUR BEMESSUNG UND BEWERTUNG VON FLUGPLATZBEFESTIGUNGEN MIT FLEXIBLEN DECKEN]
JUERGEN SCHLUESING 1988 158 p In GERMAN
(ETN-88-93230) Avail: NTIS HC A08/MF A01

Theoretical and empirical procedures for highway development and design are outlined. Design of flexible overlays is examined in consideration of single wheel path load effects. Dynamic behavior under horizontal and vertical load effects, climatic conditions and underground configurations are analyzed together with mechanical stresses in a computer program. ESA

N89-12572*# Old Dominion Univ., Norfolk, VA. Dept. of Electrical and Computer Engineering.
SUPPORT OF THE EIGHT-FOOT HIGH-TEMPERATURE TUNNEL MODIFICATIONS PROJECT Final Report. 16 May 1985 - 15 May 1986
DONALD Y. HODGES and JOHN V. SHEBALIN Dec. 1987 3 p
(Contract NAS1-17993)
(NASA-CR-183356; NAS 1.26:183356) Avail: NTIS HC A02/MF A01 CSCL 14B

An ultrasonic level sensor was developed to measure the liquid level in a storage vessel under high pressures, namely up to 6000 psi. The sensor is described. A prototype sensor was installed in the cooling-water storage vessel of the Eight-Foot High-Temperature Tunnel. Plans are being made to install the readout instrument in the control room, so that tunnel operators can monitor the water level during the course of a tunnel run. It was discovered that the sensor will operate at cryogenic temperatures. Consequently, a sensor will be installed in the modified Eight-Foot High-Temperature Tunnel to measure the sound speed of liquid oxygen (LOX) as it is transferred from a storage vessel to the tunnel combustor at pressure of about 3000 psi. The sound speed is known to be a reliable indicator of contamination of LOX by pressurized gaseous nitrogen, which will be used to effect the transfer. Subjecting the sensor to a temperature cycle from room temperature to liquid nitrogen temperature and back again several times revealed no deterioration in sensor performance. The method using this sensor is superior to the original method, which was to bleed samples of LOX from the storage vessel to an independent chamber for measurement of the sound speed. Author

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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.

A89-13570#
SAENGER II, A HYPERSONIC FLIGHT AND SPACE TRANSPORTATION SYSTEM
DIETRICH E. KOELLE (Messerschmitt-Boelkow-Blohm GmbH, Munich, Federal Republic of Germany) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 687-693.

The paper presents the actual design status of the Saenger advanced space transportation system which comprises a hypersonic aircraft as first stage (EHTV). This vehicle (European Hypersonic Transport Vehicle) has been conceived for a dual purpose: to serve as the first stage of a launch vehicle with cruise capability, which is required to reach the space station orbit (28.5 deg) from Europe, and in the same basic configuration as passenger plane with some 230 passengers for a range of more than 10,000 km. The optimum cruise speed seems to be Mach 4.4 in 24.5 km altitude for economic and environmental reasons. Author

A89-16526#
INSTRUMENTATION OF HYPERSONIC STRUCTURES - A REVIEW OF PAST APPLICATIONS AND NEEDS FOR THE FUTURE
RICHARD D. NEUMANN, PETER J. ERBLAND, and LAWRENCE O. KRETZ (USAF, Flight Dynamics Laboratory, Wright-Patterson AFB, OH) AIAA, Thermophysics, Plasmadynamics and Lasers Conference, San Antonio, TX, June 27-29, 1988. 30 p. refs
(AIAA PAPER 88-2612)

The success of hypersonic flight research vehicle instrumentation efforts depends on the design of the instrumentation and its integration in parallel with the design of the structure. Historical experience indicates that it is preferable not to use off-the-shelf sensors; new designs will aid the process of sensor integration. Attention will have to be given to high temperature strain and heat flux interference problem for novel sensors. O.C.

N89-11786*# Lunar and Planetary Inst., Houston, TX.
ADVANCED ANALYTICAL FACILITIES REPORT OF THE PLANETARY MATERIALS AND GEOCHEMISTRY WORKING GROUP
9 Nov. 1988 45 p
(NASA-CR-183338; NAS 1.26:183338; LPI-TRN-88-11) Avail: NTIS HC A03/MF A01 CSCL 14B

The aircraft industry is concerned with the increase of drag on planes due to the sticking of insects on critical airfoil areas. The effects of surface energy and elasticity on the number of insects sticking onto the polymer coatings on a modified aircraft wing were investigated and the mechanism by which insects stick onto surfaces during a high velocity impact was determined. Analyses including scanning electron microscopy, electron spectroscopy for chemical analysis and contact angle measurements of uncoated and polymer coated aluminum surfaces were performed. An air gun was designed to accelerate insects to high speeds and impact them onto modified wing surfaces in a lab environment. A direct relation between the number of insects sticking on a sample and its surface energy was obtained. 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.

A89-13176

FORMATION OF LIQUID-PHASE DEPOSITS IN JET FUELS [FORMIROVANIE ZHIDKOFAZNYKH OSADKOV I REAKTIVNYKH TOPLIVAKH]

B. G. BEDRIK, V. N. GOLUBUSHKIN, N. M. LIKHTEROVA, A. F. IAKOVLEVA, S. I. USPENSKII et al. Khimiia i Tekhnologiia Topliv i Masel (ISSN 0023-1169), no. 8, 1988, p. 28, 29. In Russian. refs

The composition of liquid-phase deposits in jet fuel is investigated chromatographically to get a better understanding of the mechanisms of the formation of liquid-phase deposits in aircraft fuel systems. It is shown that surfactants contained in the fuel, such as ethyl cellosolve and other water crystallization inhibitors, are major contributors to the formation of deposits in jet fuels. Ways of preventing the formation of liquid-phase deposits in fuels are suggested. V.L.

A89-13177

PRODUCTION OF THE BASE COMPONENT OF B-91/115 AVIATION GASOLINE USING A METAL-ZEOLITE CATALYST [POLUCHENIE BAZOVOGO KOMPONENTA AVIABENZINA B-91/115 NA MATALLTSEOLITNOM KATALIZATORE]

V. IU. BORTOV, V. V. SHIPIKIN, R. A. ZAINULLIN, I. N. TOLKACHEVA, and V. N. MOZHAIKO (Nauchno-Proizvodstvennoe Ob'edinenie Lenneftekhim, Kuibyshev, USSR) Khimiia i Tekhnologiia Topliv i Masel (ISSN 0023-1169), no. 9, 1988, p. 20-22. In Russian.

A method for the production of the base component of B-91/115 gasoline by processing the directly distilled 62-150 C gasoline fraction using a metal-zeolite catalyst is presented. An analysis of the process parameters indicates that the process can be implemented on the existing catalytic reforming equipment. The method proposed here significantly increases the cost effectiveness of B-91/115 gasoline production. V.L.

A89-13178

PREDICTION OF THE SERVICE LIVES OF AVIATION GAS TURBINE ENGINE OILS [PROGNOZIROVANIE SROKOV SLUZHBY MASEL DLIA AVIATSIONNYKH GAZOTURBINNYKH DVIGATELEI]

E. P. FEDOROV, V. V. GORIACHEV, and O. A. ZAPOROZHSKAIA Khimiia i Tekhnologiia Topliv i Masel (ISSN 0023-1169), no. 9, 1988, p. 38-41. In Russian.

A method is presented for predicting the service lives of oils for aviation gas turbine engines from laboratory test results. It is noted that the service lives determined by this method are approximate and should be corrected in the process of bench testing and service. The discussion is illustrated by results obtained for a variety of turbine engine oils, including MK-8p, MS-8p, IPM-10, B-3V, LZ-240, 36/1Ku-A, VNII NP 50-1-4f, and experimental oils. V.L.

A89-13283

CRACK GROWTH RESISTANCE OF HEAVY EXTRUDED AND ROLLED SEMIFINISHED PRODUCTS OF NEW ALUMINUM ALLOYS [SOPROTIVLENIE RAZVITIIU TRESHCHINY KRUPNOGABARITNYKH PRESSOVANNYKH I KATANYKH POLUFABRIKATOV IZ NOVYKH ALIUMINIEVYKH SPLAVOV]

A. G. VOVNIANKO, L. A. BUKREEVA, and E. A. ZAKHARENKO Metallovedenie i Termicheskaia Obrabotka Metallov (ISSN 0026-0819), no. 9, 1988, p. 8-11. In Russian. refs

Experimental data are presented on crack propagation rates in extruded and rolled panels of new aluminum alloys 1161, 1163, and 1973 used in load-bearing wing structures. The results obtained for these alloys are compared with crack growth data for the traditional D16ch and V95pch alloys. It is shown that the fracture toughness of the new alloys is significantly higher than that of D16ch and V95pch, making it possible to increase the life of aircraft components and permissible loads while reducing the aircraft weight. It is also shown that the use of extruded instead of rolled panels makes it possible to increase nominal stresses. V.L.

A89-13561#

FATIGUE LIFE IMPROVEMENT OF THICK SECTIONS BY HOLE COLD EXPANSION

J. Y. MANN, P. W. BEAVER, and J. G. SPARROW (Department of Defence, Aeronautical Research Laboratories, Melbourne, Australia) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 617-625. refs

Flight-by-flight fatigue tests were carried out on flat specimens of A7-U4SG-T651 (2214-T651) aluminum alloy of thickness between 8 and 30 mm which incorporated open holes of about 8.5 mm in diameter, either reamed or cold-expanded using a tapered mandrel. A comprehensive study was made of the deformation characteristics of the holes during and after cold expansion, and this was supported by fractographic studies of crack initiation and propagation. Evidence is presented to show that there are differences (which are thickness dependent) in the deformation characteristics of the material at the mandrel entry and exit ends of the hole and that these influence the sequences of fatigue crack initiation along the hole and the subsequent shape of the fatigue crack as it propagates through the section. Author

A89-14899

A FRACTURE MECHANICS CRITERION FOR THERMAL-MECHANICAL FATIGUE CRACK GROWTH OF GAS TURBINE MATERIALS

N. J. MARCHAND (Montreal, Universite, Montreal, Canada), R. M. PELLOUX (MIT, Cambridge, MA), and B. ILSCHNER (Lausanne, Ecole Polytechnique Federale, Switzerland) Engineering Fracture Mechanics (ISSN 0013-7944), vol. 31, no. 3, 1988, p. 535-551. refs

This paper assesses the applicability of various fracture mechanics data-correlation parameters for predicting the crack propagation life of turbine engine hot section materials. Isothermal and thermal-mechanical crack propagation tests were carried out in Hastelloy-X and (B-1900 + Hf) materials, and the crack growth data were reduced using the stress intensity factor, the strain intensity factor, and the J-integral. Results showed that none of these parameters successfully correlated the crack growth data. However, a modified stress intensity factor termed Delta-K(sigma) was effective in correlating high-temperature and variable-temperature crack growth. Delta-K(sigma) is shown to rationalize the effect of testing mode (stress- vs strain-controlled) and the mode of fracture. I.S.

A89-15065

SUPERPLASTIC FORMING OF ALUMINUM-LITHIUM ALLOY 2090-OE16

C. C. BAMPTON, B. A. CHENEY, A. CHO (Alcoa Laboratories, Alcoa Center, PA), A. K. GHOSH, and C. GANDHI (Rockwell International Science Center, Thousand Oaks, CA) IN:

Superplasticity in aerospace; Proceedings of the Topical Symposium, Phoenix, AZ, Jan. 25-28, 1988. Warrendale, PA, Metallurgical Society, Inc., 1988, p. 247-259. refs

Development work on aluminum-lithium alloy 2090-OE16 (specially processed for improved superplastic formability) is discussed. Emphasis is placed on the technical issues concerned with near-term airframe applications. The superplastic forming characteristics of the alloy are reviewed. Heat treatment response, texture and other microstructural characteristics after superplastic forming are described. Author

A89-15203

DETERMINATION OF JET FUEL LUMINOSITY - A FREE DROPLET TECHNIQUE FOR ASSESSING FUEL EFFECTS ON COMBUSTION PERFORMANCE IN AVIATION TURBINES

G. L. GREEN and T. Y. YAN (Mobil Central Research Laboratory, Princeton, NJ) IN: 1988 IECEC; Proceedings of the Twenty-third Intersociety Energy Conversion Engineering Conference, Denver, CO, July 31-Aug. 5, 1988. Volume 1. New York, American Society of Mechanical Engineers, 1988, p. 291-296. refs

A method for measuring this luminosity of jet fuel has been demonstrated using a free droplet combustion technique. The results compare well with those of large combustor test rigs and correlate well with the combustor liner temperature rises reported for an actual engine. The results are generally consistent with ASTM smoke point and luminometer number methods and are, therefore, useful in assessing fuel quality in light of industry-accepted standards. In this method, a stream of well-spaced, uniformly-sized droplets is generated and burned with flowing hot gas in a quartz duct. The luminosity of the burning droplets is measured directly with photodiodes. The test is performed over a temperature range typical of an engine to measure the luminosity of the fuels free of influences from spray interactions, aerodynamics and other physical configuration effects. Because the test is simple, rapid and gives reproducible measurements with small samples, it can be used conveniently as a laboratory method. Author

A89-15747

SHORT-TERM HIGH-TEMPERATURE PROPERTIES OF REINFORCED METAL MATRIX COMPOSITES

PETER L. BOLAND, PETER R. DIGIOVANNI, and LARRY FRANCESCHI (Raytheon Missile Systems Laboratories, Tewksbury, MA) IN: Testing technology of metal matrix composites. Philadelphia, PA, American Society for Testing Materials, 1988, p. 346-375.

Methods for obtaining short-term high-temperature tensile, flexural, and pin bearing data for reinforced MMC are detailed. Consideration is also given to coupon design and fabrication, instrumentation, measurement techniques, and some lessons learned. It is shown that, while the tensile strength of MMCs subjected to rapid heating greatly exceed those strengths obtained for long-term heating, flexure and pin bearing strength show only moderate increases. K.K.

A89-16172

ALUMINUM-LITHIUM ALLOYS

JOHN W. MARTIN (Oxford University, England) IN: Annual review of materials science. Volume 18. Palo Alto, CA, Annual Reviews, Inc., 1988, p. 101-119. refs

Recent experimental investigations of the properties of Al-Li alloys are reviewed, with an emphasis on aircraft applications. Consideration is given to U.S. and UK development programs, phase transformation in binary and ternary Al-Li alloys, deformation and fracture, elastic modulus and hardening mechanisms, high-temperature properties, and future developments. Diagrams, micrographs, graphs, and tables of numerical data are provided. T.K.

A89-16357

PROMOTION OF COMBUSTION BY ELECTRIC DISCHARGES - THE ROLE OF VIBRATIONALLY EXCITED SPECIES

ITSURO KIMURA (Tokai University, Hiratsuka, Japan) JSME International Journal, Series II (ISSN 0914-8817), vol. 31, Aug. 1988, p. 376-386. refs

Two investigations on the mechanisms of combustion promotion, one involving plasma jet injection and the other involving a direct electric discharge, are reviewed. Experimental results are then presented on the effect of plasma jet in supersonic combustion or high-velocity-stream combustion. The role of vibrationally excited species in combustion promotion is discussed. V.L.

A89-16778

ADVANCES IN TITANIUM ALLOY CASTING TECHNOLOGY

J. K. THORNE and W. J. BARICE (Precision Castparts Corp., Portland, OR) SAMPE Quarterly (ISSN 0036-0821), vol. 20, Oct. 1988, p. 24-27.

Industrial large part-size capabilities that have emerged in conjunction with HIP, precision chemical milling, preformed cores, exotic alloy compositions, and improved heat treatments, are among the most important recent advancements in foundry technology for Ti-alloy investment castings. Casting programs for critical airframe-structure and net-shape turbofan blade and compressor rotor blade products are currently approaching production status. Rigorous process and quality control methods have also been developed. O.C.

N89-11819# Air Force Inst. of Tech., Wright-Patterson AFB, OH.

DIMUNITION AND LONGITUDINAL SPLITTING OF CARBON FIBERS DUE TO GRINDING M.S. Thesis

JOHN F. SEIBERT 1988 56 p

(AD-A196697; AFIT/CI/NR-88-70) Avail: NTIS HC A04/MF A01 CSCL 11D

Lightweight composite materials composed of a carbon fiber/epoxy resin matrix are being used in increasing quantities in the aircraft production and the aerospace industry. The use of these composites is also expanding to the non-aerospace industries. Carbon fibers may become a potential airborne hazard during drilling and machining of composite materials. Air sampling by some investigators have indicated that all airborne fibers are of their original diameter (6 to 8 microns), and are non-respirable, while others have noted longitudinal fracturing of fibers into smaller diameter respirable fibers. This research was performed to determine the degree of fracturing during grinding, and to compare this fracturing to that of glass fibers. Carbon and glass fibers without epoxy resin or sizing material were ground in a ball mill. The resulting particles were very similar for carbon and glass. GRA

N89-11827*# Virginia Polytechnic Inst. and State Univ., Blacksburg. Dept. of Engineering Science and Mechanics.

STRUCTURAL EFFICIENCY STUDY OF COMPOSITE WING RIB STRUCTURES

GARY D. SWANSON, ZAFER GURDAL, and JAMES H. STARNES, JR. Sep. 1988 211 p

(Contract NAG1-343)

(NASA-CR-183004; NAS 1.26:183004; CCMS-88-18; VPI-E-88-29) Avail: NTIS HC A10/MF A01 CSCL 11D

A series of short stiffened panel designs which may be applied to a preliminary design assessment of an aircraft wing rib is presented. The computer program PASCO is used as the primary design and analysis tool to assess the structural efficiency and geometry of a tailored corrugated panel, a corrugated panel with a continuous laminate, a hat stiffened panel, a blade stiffened panel, and an unstiffened flat plate. To correct some of the shortcomings in the PASCO analysis when shear is present, a two step iterative process using the computer program VICON is used. The loadings considered include combinations of axial compression, shear, and lateral pressure. The loading ranges considered are broad enough such that the designs presented may be applied to other stiffened panel applications. An assessment is made of laminate variations, increased spacing, and nonoptimum geometric variations, including a beaded panel, on the design of the panels. Author

N89-11880# Royal Aerospace Establishment, Farnborough (England).

VARIABLE AMPLITUDE FATIGUE CRACK GROWTH IN TITANIUM ALLOY TI-4AL-4MO-2SN-0.5SI (IMI 550)

C. M. WARD-CLOSE and R. O. RITCHIE Mar. 1988 9 p
(RAE-MEMO-MAT/STR-1103; BR106577; ETN-88-93561; AD-A197931) Avail: Defence Research Information Centre, 65 Brown Street, Glasgow G2 8EX, Scotland

Fatigue crack growth behavior in the alpha/Beta titanium alloy Ti-4Al-4Mo-2Sn-0.5Si (IMI 550), subject to single tensile overloads and the FALSTAFF flight simulation loading spectrum was studied. Fatigue overloads produce crack growth rate acceleration, followed by delayed retardation. The transient changes in crack growth rates are associated with large changes in crack closure immediately behind the crack tip. For single overloads and flight simulation loading, the greatest load-interaction effects are at the lowest load amplitudes. Microstructures has only a slight influence on load-interaction effects associated with single tensile overloads. However, at the higher stress amplitudes, the Beta annealed material shows greater retardation than the alpha/Beta material under simulated flight loading. ESA

N89-11918# Environmental Research Lab., Gulf Breeze, FL.

ENVIRONMENTAL FATE AND EFFECTS OF SHALE-DERIVED JET FUEL Final Report, Oct. 1984 - Mar. 1986

P. H. PRITCHARD, T. P. MAZIARZ, L. H. MUELLER, and A. W. BOURQUIN Jun. 1988 99 p
(AD-A197683; MIPR-N85-16; AFESC/ESL-TR-87-09) Avail: NTIS HC A05/MF A01 CSCL 21D

Tests were conducted to compare the environmental fate of shale oil-derived jet fuel with that of petroleum-derived jet fuel. These tests included chemical characterization of the fuels and the water-soluble fraction of each fuel, as well as measurement of volatilization and biodegradation rates in laboratory systems designed to simulate three disparate aquatic environments. No major differences in the volatilization and biodegradation rates of the two fuels were found. Differences in composition were generally small and should not cause the behavior of the fuels in aquatic environments to differ. GRA

N89-12717*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

INFLUENCE OF ALLOYING ELEMENTS ON THE OXIDATION BEHAVIOR OF NBAL3

M. G. HEBSUR (Sverdrup Technology, Inc., Cleveland, Ohio.), J. R. STEPHENS, J. L. SMIALEK, C. A. BARRETT, and D. S. FOX 30 Sep. 1988 14 p Presented at the Workshop on the Oxidation of High-Temperature Intermetallics, 22-23 Sep. 1988; sponsored in part by NASA-Lewis Research Center, ASM International, Case Western Reserve Univ., The Metallurgical Society of AIME and TMS-AIME, Cleveland
(NASA-TM-101398; E-4275; NAS 1.15:101398) Avail: NTIS HC A03/MF A01 CSCL 11F

NbAL3 is one candidate material for advanced aeropropulsion systems because of its high melting point, low density, and good oxidation resistance. Although NbAl3 has the lowest oxidation rate among the binary Nb-Al alloys, it does not form exclusive layers of protective Al2O3 scales. Recently Perkin et al., have shown the feasibility of forming alumina scales on Nb-Al alloys at greatly reduced Al contents. However, the objective was to maintain the high Al content, and hence low density, while achieving the capability of growing protective alumina scales. Alloy development followed approaches similar to those used successfully for superalloys and oxidation resistant MCrAlY coatings. Among the three elements examined (Ti, Si, and Cr) as ternary additions to Nb-Al3, Cr was the most effective in favoring the selective oxidation of Al. Nb-41Al-8Cr formed exclusive layers of alumina and had a k sub p value of 0.22 mg squared/cm (sup 4)/hr at 1200 C. The addition of 1 wt percent Y to this alloy was also beneficial, resulting in nearly an order of magnitude decrease in K sub p at 1200 C. Further improvements were achieved by adding about 1 wt percent Si to the quaternary alloy. The k sub p value of 0.012 mg squared/cm (sup 4)/hr for Nb-40Al-8Cr-1Y-1Si at 1200 C was identical to the best NiAl + Zr alloys. These NbAl3 alloys also exhibited excellent cyclic oxidation resistance for 100 hr at 1200 C, being nearly equivalent to NiAl + Zr. Author

N89-12750# Air Force Wright Aeronautical Labs., Wright-Patterson AFB, OH.

PROPERTIES OF JP-8 JET FUEL Summary Report, Aug. 1984 - Apr. 1988

CHARLES R. MARTEL May 1988 19 p
(AD-A197270; AD-E900802; AFWAL-TR-88-2040) Avail: NTIS HC A03/MF A01 CSCL 21D

This report provides a summary of 80 JP-8 jet fuels produced over the time period of August 1984 to April 1988. The data were obtained from the test reports provided by the fuel supplier or receiving terminal. Averages, standards deviations, minimum and maximum values of the various data have been determined and are reported. GRA

N89-12883*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

HOST SURFACE PROTECTION R AND T OVERVIEW

ROBERT A. MILLER *In its* Turbine Engine Hot Section Technology 1986 p 45-50 Oct. 1986
Avail: NTIS HC A21/MF A01 CSCL 11C

Most of the efforts in the HOST Surface Protection Subproject were focused on thermal barrier coating (TBC) life prediction. Also, a small effort, consisting primarily of wrapping up and reporting the work of previous years, remained on the airfoil deposition modeling. The work performed under the airfoil deposition modeling program element was concerned with modeling the deposition of corrodants onto turbine airfoils. Accomplishments included verification of the chemically frozen boundary (CFBL) theory. Encouraging results were also achieved with the recently developed local thermochemical equilibrium (LTCE) theory. The surface protection subprogram was devoted to thermal-barrier-coating life modeling. This modeling is an essential step in the development of TBC's. E.R.

N89-12912*# Connecticut Univ., Storrs.

CONSTITUTIVE MODELLING OF SINGLE CRYSTAL AND DIRECTIONALLY SOLIDIFIED SUPERALLOYS Progress Report

E. H. JORDAN and K. P. WALKER (Engineering Science Software, Inc., Smithfield, R.I.) *In* NASA, Lewis Research Center, Turbine Engine Hot Section Technology 1986 p 335-339 Oct. 1986
(Contract NAG3-512)
Avail: NTIS HC A21/MF A01 CSCL 11F

The trend towards improved engine efficiency and durability places increasing demands on materials that operate in the hot section of the gas turbine engine. These demands are being met by new coatings and materials such as single crystal and directionally solidified nickel-base superalloys which have greater creep/fatigue resistance at elevated temperatures and reduced susceptibility to grain boundary creep, corrosion and oxidation than conventionally cast alloys. Work carried out as part of a research program aimed at the development of constitutive equations to describe the elevated temperature stress-strain-time behavior of single crystal and directionally solidified turbine blade superalloys is discussed. The program involves both development of suitable constitutive models and their verification through elevated temperature tension-torsion testing of single crystals of PWA 1480. Author

N89-12919*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

A STUDY ON THERMAL BARRIER COATINGS INCLUDING THERMAL EXPANSION MISMATCH AND BOND COAT OXIDATION

GEORGE C. CHANG, WORAPHAT PHUCHAROEN (Cleveland State Univ., Ohio.), and ROBERT A. MILLER *In its* Turbine Engine Hot Section Technology 1986 p 415-434 Oct. 1986
(Contract NCC3-27)
Avail: NTIS HC A21/MF A01 CSCL 11C

The present investigation deals with a plasma-sprayed thermal barrier coating (TBC) intended for high temperature applications to advanced gas turbine blades. Typically, this type of coating system consists of a zirconia-yttria ceramic layer with a nickel-chromium-aluminum bond coat on a superalloy substrate. The problem on hand is a complex one due to the fact that bond coat oxidation and thermal mismatch occur in the TBC. Cracking in the TBC has also been experimentally illustrated. A clearer understanding of the mechanical behavior of the TBC is investigated. The stress states in a model thermal barrier coating as it cools down in air is studied. The powerful finite element method was utilized to model a coating cylindrical specimen. Four successively refined finite element models were developed. Some results obtained using the first two models have been reported previously. The major accomplishment is the successful development of an elastic TBC finite element model known as TBCG with interface geometry between the ceramic layer and the bond coat. An equally important milestone is the near-completion of the new elastic-plastic TBC finite element model called TBCGEP which yielded initial results. Representative results are presented. Author

N89-12920*# Garrett Turbine Engine Co., Phoenix, AZ.
THERMAL BARRIER COATING LIFE PREDICTION MODEL DEVELOPMENT
T. E. STRANGMAN, J. F. NEUMANN, and A. LIU *In* NASA, Lewis Research Center, Turbine Engine Hot Section Technology 1986 p 435-445 Oct. 1986
(Contract NAS3-23945)
Avail: NTIS HC A21/MF A01 CSCL 11C

Thermal barrier coatings (TBCs) for turbine airfoils in high-performance engines represent an advanced materials technology with both performance and durability benefits. The foremost TBC benefit is the reduction of heat transferred into air-cooled components, which yields performance and durability benefits. This program focuses on predicting the lives of two types of strain-tolerant and oxidation-resistant TBC systems that are produced by commercial coating suppliers to the gas turbine industry. The plasma-sprayed TBC system, composed of a low-pressure plasma-spray (LPPS) or an argon shrouded plasma-spray (ASPS) applied oxidation resistant NiCrAlY (or CoNiCrAlY) bond coating and an air-plasma-sprayed yttria (8 percent) partially stabilized zirconia insulative layer, is applied by Chromalloy, Klock, and Union Carbide. The second type of TBC is applied by the electron beam-physical vapor deposition (EB-PVD) process by Temescal. Author

N89-12922*# Pratt and Whitney Aircraft, East Hartford, CT.
THERMAL BARRIER COATING LIFE PREDICTION MODEL DEVELOPMENT
J. T. DEMASI and K. D. SHEFFLER *In* NASA, Lewis Research Center, Turbine Engine Hot Section Technology 1986 p 469-483 Oct. 1986
(Contract NAS3-23944)
Avail: NTIS HC A21/MF A01 CSCL 11C

The objective of this program is to establish a methodology to predict Thermal Barrier Coating (TBC) life on gas turbine engine components. The approach involves experimental life measurement coupled with analytical modeling of relevant degradation modes. The coating being studied is a flight qualified two layer system, designated PWA 264, consisting of a nominal ten mil layer of seven percent yttria partially stabilized zirconia plasma deposited over a nominal five mil layer of low pressure plasma deposited NiCoCrAlY. Thermal barrier coating degradation modes being investigated include: thermomechanical fatigue, oxidation, erosion, hot corrosion, and foreign object damage. Author

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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.

A89-13339
SHAPE CALCULATION OF BODIES ABLATING UNDER THE EFFECT OF AERODYNAMIC HEATING DURING MOTION IN AN ARBITRARY TRAJECTORY [RASCHET FORMY TEL, RAZRUSHAIUSHCHIKHSIA POD DEISTVIEM AERODINAMICHESKOGO NAGREVA PRI DVIZHENII PO PROIZVOL'NOI TRAEKTORII]
A. F. POLIANSKII and L. I. SKURIN IN: The dynamics of homogeneous and inhomogeneous media. Leningrad, Izdatel'stvo Leningradskogo Universiteta, 1987, p. 77-85. In Russian. refs

The effective-length method is used for an approximate calculation of heat fluxes along elongated blunt cones for a wide Reynolds-number range. The heating and ablation of cones moving in a trajectory in the earth's atmosphere are investigated through the numerical integration of the equations of motion of the body, heat conduction, and ablation. B.J.

A89-13378#
TURBULENCE MEASUREMENTS WITH SYMMETRICALLY BENT V-SHAPED HOT-WIRES. I - PRINCIPLES OF OPERATION. II - MEASURING VELOCITY COMPONENTS AND TURBULENT SHEAR STRESSES
M. HISHIDA and Y. NAGANO (Nagoya Institute of Technology, Japan) ASME, Transactions, Journal of Fluids Engineering (ISSN 0098-2202), vol. 110, Sept. 1988, p. 264-274. refs

The heat transfer characteristics of symmetrically bent V-shaped hot-wires in a fluctuating velocity field are investigated, and a new method for measuring the three components of velocity and turbulent shear stresses using these wires is presented. The described technique eliminates various errors due to aerodynamic disturbances caused by the wire supports and is shown to be highly effective for the measurement of turbulence in close proximity to the wall, where a conventional X-wire anemometry technique is either subject to large errors or at worst cannot be used. The details of effective cooling velocities of a V-shaped hot-wire are described, and its aeroelastic deformation and vibration are discussed. A V-shaped hot-wire is found to work in the same manner as a conventional inclined straight wire. The V-shaped wire is less sensitive than a conventional wire to the w-component of velocity. C.D.

A89-13515#
A NEW APPROACH TO LOAD TRANSFER IN BOLTED JOINTS
V. WEISSBERG, K. WANDER, and R. ITZHAKOV (Israel Aircraft Industries, Ltd., Lod) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 96-101. refs

Bolt diameter and bolt tightening torque were the parameters of a series of tests performed on a bolted single-shear joint. Two distinct zones are noted on the load-deflection diagrams derived from test results: a friction zone and an elastic one. It is established that the shear load transferred by the friction mechanism is proportional to the tightening torque. These test results may be used to improve the accuracy of fatigue and damage tolerance analyses of bolted lap joints. A three-dimensional FEM analysis using contact nonlinear elements was performed to obtain joint stiffness, and the value was in agreement with the elastic portion of the test results. O.C.

A89-13538*# Virginia Polytechnic Inst. and State Univ., Blacksburg.

A GEOMETRICALLY NONLINEAR THEORY OF SHEAR DEFORMABLE LAMINATED COMPOSITE PLATES AND ITS USE IN THE POSTBUCKLING ANALYSIS

L. LIBRESCU (Virginia Polytechnic Institute and State University, Blacksburg) and M. STEIN (NASA, Langley Research Center, Hampton, VA) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 349-359. refs

This paper is devoted to the formulation of a higher-order, geometrically nonlinear theory of anisotropic symmetrically-laminated composite plates and to the analysis, in this context, of their postbuckling behavior. Special attention is given to the postbuckling analysis of plates made of transversely isotropic layers for which case, the influence played by the degree of transversal-isotropy of the layers as well as by the goemetrical parameters of the panel is investigated. Finally, the results obtained within the present higher-order theory are compared with their first order transverse shear deformation as well as with their classical (Kirchhoff) counterparts and a number of conclusions concerning their range of applicability and the influence of various parameters are presented. Author

A89-13544*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

APPLICATION OF INTEGRATED FLUID-THERMAL STRUCTURAL ANALYSIS METHODS

ALLAN R. WIETING, PRAMOTE DECHAUMPHAI, KIM S. BEY (NASA, Langley Research Center, Hampton, VA), EARL A. THORNTON (Old Dominion University, Norfolk, VA), and KEN MORGAN (University of Wales, Swansea) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 424-434. Previously announced in STAR as N88-24001. refs

Hypersonic vehicles operate in a hostile aerothermal environment which has a significant impact on their aerothermostructural performance. Significant coupling occurs between the aerodynamic flow field, structural heat transfer, and structural response creating a multidisciplinary interaction. Interfacing state-of-the-art disciplinary analysis methods are not efficient, hence interdisciplinary analysis methods integrated into a single aerothermostructural analyzer are needed. The NASA Langley Research Center is developing such methods in an analyzer called LIFTS (Langley Integrated Fluid-Thermal-Structural) analyzer. The evolution and status of LIFTS is reviewed and illustrated through applications. Author

A89-13562#

THE USE OF STATIC ANALYSIS AND THE STRESS MODES APPROACH AS AN ENGINEERING ORIENTED PROCEDURE FOR CALCULATING THE RESPONSE OF AERONAUTICAL STRUCTURES TO RANDOM EXCITATION

G. MAYMON (Rafael Armament Development Authority, Haifa, Israel) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 626-630. refs

Solution to the dynamic behavior of aeronautical structures subjected to random excitation is obtained by using characteristic results from static analysis. The dynamic response problem is solved by using the concept of 'stress modes', which is also presented in this paper. Static results are also used in the solution of geometrically nonlinear problems. It is believed that the use of this approach will contribute to a better intuitive 'feel' of the design engineer, and thus to a better physical understanding of the structure's behavior. Schematic procedure for the application of the outlined approach is presented. Author

A89-13563#

QUADRILATERAL COONS SURFACE SHELL FINITE ELEMENT WITH DISCRETE PRINCIPAL CURVATURE LINES

T. Q. YE and YUERANG ZHAO (Northwestern Polytechnical University, Xian, People's Republic of China) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 631-637. Research supported by the Natural Sciences Fund of the People's Republic of China. refs

A new 48 degree-of-freedom quadrilateral thin shell finite element has been developed in this paper. B-spline Coons surfaces are used to model the middle surface of shells. The method of 'discrete principal curvatures' is presented. This thin elastic shell finite element can be applied to analyze the shells of arbitrary shape which are encountered in structures of modern aircrafts and aerospace vehicles. Hence, the finite element analysis of thin shells can work with the computer aided design system. Numerical results show the efficiency of this finite element. Author

A89-13581*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

APPLICATION OF UNSTEADY AERODYNAMIC METHODS FOR TRANSONIC AEROELASTIC ANALYSIS

WOODROW WHITLOW, JR. (NASA, Langley Research Center, Hampton, VA) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 788-796. refs

Aerodynamic methods for aeroelastic analysis are applied to various flow problems. These methods include those that solve the three-dimensional transonic small disturbance (TSD) potential equation, the two-dimensional full potential (FP) equation, and the thin-layer Navier-Stokes equations. Flutter analysis performed using TSD aerodynamics shows that such methods can be used to analyze some aeroelastic phenomena. For thicker bodies and larger amplitude motions a nonisentropic full potential method is presented. Author

A89-13589#

AN INTELLIGENT FIBEROPTIC DATA BUS FOR FLY-BY-LIGHT APPLICATIONS

L. C. MANOHARAN and S. MUTHUVEL (National Aeronautical Laboratory, Bangalore, India) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 877-879. refs

An active fiberoptic data bus compatible with MIL-STD-1553B, which could be used for fly-by-light, stores management, AEW etc., on an aircraft has been developed. The data bus is considered intelligent because it can automatically sense which station is in the transmit mode and control the active interface accordingly, so that smooth flow of data takes place on the bus. The tests carried out on the bus including those on the Jaguar Avionics Rig to check its validity are also described. As no software is involved in the operation of the bus, this could be used on any aircraft having its own software. Author

A89-13594#

BUCKLING AND POSTBUCKLING BEHAVIOUR OF COMPOSITE PANELS

B. GEIER (DFVLR, Institut fuer Strukturmechanik, Brunswick, Federal Republic of Germany) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 904-912. refs

Structural-behavior computer codes are presently evaluated as predictors in buckling and postbuckling studies of composite panels whose planform dimensions were at least an order of magnitude greater than the panel thicknesses. Kirchhoff-Love-type theories, together with the classical lamination theory for the definition of the constitutive law, have been found adequate. Most of the programs considered were used to predict bifurcation buckling loads; it is shown that calculated buckling loads give a good indication of the load level for accelerated growth of out-of-plane displacements. O.C.

A89-13595#
THE BUCKLING AND POSTBUCKLING BEHAVIOUR OF CURVED CFRP LAMINATED SHEAR PANELS
K. WOLF and H. KOSSIRA (Braunschweig, Technische Universitaet, Brunswick, Federal Republic of Germany) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 920-930. DFG-supported research. refs

The present computational results for the buckling and postbuckling behavior of curved CFRP panels subjected to shear loading were obtained by means of a novel nonlinear FEM program that indicates the effects of curvature, boundary conditions, and initial imperfections, on buckling and postbuckling behavior. Linear buckling loads and nonlinear postbuckling behaviors obtained encompass snap-through and material-failure phenomena. Experimental results are obtained to verify the theoretical predictions; good correlation is obtained between computation and experiment. O.C.

A89-13616#
NON-DESTRUCTIVE METHODS APPLIED TO AVIATION EQUIPMENT TESTING IN SERVICE
J. LEWITOWICZ (Polish Society of Mechanical Engineers and Technicians, Warsaw, Poland) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 1145-1154. refs

An account is given of the NDE methods that may be used to detect incipient failures in such aircraft systems as helicopter and fixed-wing aircraft gas turbine powerplants, especially where tribologically taxed components are of critical importance. Wear process testing and crack-detection by vibroacoustical, XRF, and spectral analysis methods are discussed, with attention to the incorporation of stochastic process models in pdf calculations for the damage levels and suitable diagnostics of various structural and mechanical elements. O.C.

A89-13649#
CONTROLLED NON-CONFORMING FINITE ELEMENTS AND DATA BASE AS APPROACH TO THE ANALYSIS OF AIRCRAFT STRUCTURE
Z. BOJANIC and M. JOSIFOVIC (Beograd, Univerzitet, Belgrade, Yugoslavia) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 1472-1479.

A modified version of the finite element method is proposed which provides an improved solution for nodal displacements with a relatively small number of elements. The approach makes use of the quick convergence of nonconforming elements and monotonic convergence of conforming elements. Details of the method are described, and illustrative examples are given. V.L.

A89-13650#
OPTIMAL DESIGN OF LARGE LAMINATED STRUCTURES
R. I. WATKINS (Advanced Technologies and Engineering Co., Halfway House, Republic of South Africa) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 1480-1486. refs

A technique for optimizing large laminated composite structures using a multilevel optimization scheme is described. The multilevel approach allows both ply thicknesses and orientations to be used as design variables since it serves to reduce the number of variables and constraints that need be considered at any given stage in the computational process. This system has been used to optimize various aircraft-type structures using strain, displacement, buckling and gauge constraints. Author

A89-13652#
VARIATION OF ANISOTROPIC AXES DUE TO MULTIPLE CONSTRAINTS IN STRUCTURAL OPTIMIZATION
D. W. MATHIAS, G. HORNUNG, and H. ROEHRLE (Dornier GmbH, Friedrichshafen, Federal Republic of Germany) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 1498-1504.

An approach to minimum weight design is examined with reference to a finite element optimization procedure aimed at minimizing the structural mass of a wing box made of a carbon fiber reinforced plastic. In particular, attention is given to the effect of variation of the anisotropic axes and layer thickness. The constraints to be satisfied include displacement constraints, slope constraints, constraints against failure, and side constraints for layers. The optimum design is determined within convergence criteria following 16 iterations. V.L.

A89-13666#
RADOME TECHNOLOGY
MANFRED NATTER, HANS-WOLFGANG SCHROEDER (Dornier GmbH, Friedrichshafen, Federal Republic of Germany), and WOLFGANG SCHAEFER (Dornier System GmbH, Friedrichshafen, Federal Republic of Germany) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 1634-1640.

The paper gives a comprehensive view of the manifold field of radome technology, specifies the parameters influencing the choice of materials and the structural design of advanced aircraft radomes, and deals with the technical disciplines contributing to radome technology. In this connection, recently developed computational methods, materials and manufacturing techniques, as well as test procedures and test facilities, are considered. The wide ranging application of radome technology is outlined. The strong connection between radome materials and materials for medical implant and the fruitful interaction between rain erosion testing and shock wave research for medical applications are described. Author

A89-13673#
MECHANICAL FAILURE ANALYSIS AS A MEANS OF IMPROVING QUALITY ASSURANCE IN THE AERONAUTICAL INDUSTRY
M. KENDLER and E. MAKEVET (Israel Air Force, Tel Aviv, Israel) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 1693-1699.

Failure analysis is capable of a valuable contribution to the improvement of the quality assurance of aeronautical parts. When failures of these parts are traced to defective manufacture, corrective measures may be taken to improve the quality assurance procedures applied, so as to prevent the re-occurrence of such failures. This article presents six detailed case-histories of manufacture-originated failures which occurred in the Israeli Air Force (IAF) and were investigated by the IAF Material and Process Engineering Laboratories. All these cases demonstrate the contribution of the laboratory findings to the improvement of the quality assurance systems concerned, in practice. Author

A89-14548#
PRIMARY DESIGN AND STRESS ANALYSIS ON THE EXTERNAL LOAD STRUCTURE CONNECTED ON A HELICOPTER
CHING-LO SU (Lunghwa Junior College of Technology, Taoyuan, Republic of China) Journal of Technology, vol. 3, March 1988, p. 19-26. In Chinese, with abstract in English. refs

This paper proposes a new idea for the fabrication of external load structures to be connected to a helicopter for both civil and military objectives. The new structure is welded from steel plates and transformed into curved, hollow, and box-shaped containers to substitute for the conventional solid structures made from forged Al alloy. A series of conventional stress analyses and computer-aided computations follow the primary design of the new structure. Author

A89-14697
DESCRIPTION OF A RAPID, HIGH-SENSITIVITY REAL-TIME RADIOGRAPHIC SYSTEM
R. A. BETZ and R. C. BARRY (Lockheed Missiles and Space Co., Inc., Mountain View, CA) Materials Evaluation (ISSN 0025-5327), vol. 46, Oct. 1988, p. 1424-1428.

This paper describes a rapid high-sensitivity real-time radiography (RTR) system for the inspection of jet engine turbine blades, together with suitable image-processing techniques and the system software, which includes three separate programs: INSPECT, REVIEW, and SUPERVISOR. An image-subtraction technique employed by the RTR system yields images in which contrast and brightness can be enhanced to reveal details not visible in either real-time or a simple integrated images. The sensitivity of the system was demonstrated using an actual part with small holes. It was shown that the RTR system can inspect critical jet engine parts to a radiographic sensitivity of 2-1T (1.4 percent) at rates of up to 70 parts per hour. I.S.

A89-14975
THE INFLUENCES OF TIP CLEARANCE ON THE PERFORMANCE OF NOZZLE BLADES OF RADIAL TURBINES - EXPERIMENT AND PERFORMANCE PREDICTION AT THREE NOZZLE ANGLES
YONG-IK HYUN, MICHITERU YAMAGUCHI, HIROSHI HAYAMI (Kyushu University, Fukuoka, Japan), and YASUTOSHI SENOO (Miura Co., Ltd., Matsuyama, Japan) JSME International Journal, Series II (ISSN 0914-8817), vol. 31, May 1988, p. 258-262. refs

In order to study the influence of tip clearance on the turning angle and pressure loss of turbine nozzles, experimental results were obtained for nozzle angles at which the throat area was 0.8 and 1.4 times the rated condition. Contour maps of the total pressure loss and of the spanwise distributions of the mean exit-flow angle have been obtained. Although the two-layer flow model of Senoo et al., (1987) is shown to accurately predict the effects of tip clearance, it underestimates the clearance effect for a lightly loaded condition. R.R.

A89-15004
THE EIGENVALUE DEPENDENCE OF REDUCED TILTING PAD BEARING STIFFNESS AND DAMPING COEFFICIENTS
L. E. BARRETT, P. E. ALLAIRE (Virginia, University, Charlottesville), and B. W. WILSON (General Electric Co., Schenectady, NY) (STLE and ASME, Tribology Conference, San Antonio, TX, Oct. 5-8, 1987) STLE Tribology Transactions (ISSN 0569-8197), vol. 31, Oct. 1988, p. 411-419. refs

The dynamic reduction of tilting pad bearing stiffness is analyzed as well as the damping coefficients for general free damped vibratory motion. The analysis eliminates the explicit dependence of the pad degrees of freedom and reduces the required number of stiffness and damping coefficients from $2(5n + 4)$ to eight. Calculations are performed for a five pad tilting pad bearing with the static load directed between pads and with negligible pad inertia effects. K.K.

A89-15008
EXPERIMENTS AND STABILITY PREDICTIONS OF TWO SETS OF TILTING PAD BEARINGS ON AN OVERHUNG ROTOR
C. J. ZUCK, R. D. FLACK, J. D. KNIGHT, and L. E. BARRETT (Virginia, University, Charlottesville) (STLE, Annual Meeting, 43rd, Cleveland, OH, May 9-12, 1988) STLE Tribology Transactions (ISSN 0569-8197), vol. 31, Oct. 1988, p. 468-475. Research supported by the University of Virginia. refs

Two sets of five shoe tilting pad bearings were used to test an overhung rotor. The preload factors of the two sets were 0.1 and 0.5, respectively, and the factor had critical speeds at 3000 and 6800 rpm. When mounted on the first set of bearings, the rotor remained stable for speeds over 11,000 rpm; when mounted in the second set of bearings, the system went unstable due to whip at 10,400 rpm. It is shown that subsynchronously reduced bearing coefficients should be used in stability analyses. K.K.

A89-15070
PRODUCTION OF AEROSPACE PARTS USING SUPERPLASTIC FORMING AND DIFFUSION BONDING OF TITANIUM
THOMAS T. ANDERSON and LAMONT HISLOP (Flameco Engineering, Inc., Ogden, UT) IN: Superplasticity in aerospace; Proceedings of the Topical Symposium, Phoenix, AZ, Jan. 25-28, 1988. Warrendale, PA, Metallurgical Society, Inc., 1988, p. 345-360. refs

An account is given of state-of-the-art, but commercially feasible superplastic forming (SPF) methods that have been developed for the fabrication of aerospace structural elements from Ti-6Al-4V; this alloy can undergo deformations of 750-1100 percent in SPF, and has been used to generate strong aircraft structures in conjunction with superplastic bonding. The SPF structures presently discussed consist of one, two, or three, and in some cases more than three, hollow-section elements. Attention is given to the degree of SPF process automation that has been achieved to date. O.C.

A89-15071
PUTTING PARTS ONTO PLANES - SPF COMES OF AGE
P. N. COMLEY (Murdock, Inc., Compton, CA) IN: Superplasticity in aerospace; Proceedings of the Topical Symposium, Phoenix, AZ, Jan. 25-28, 1988. Warrendale, PA, Metallurgical Society, Inc., 1988, p. 361-370.

An evaluation is made of the development status of superplastically formed (SPF) aluminum and metal alloy structural component applications currently popular in commercial aircraft, with a view to their economic advantages vis-a-vis composite and more conventional metallic structures of comparable performance. The most frequently employed alloys are Ti-6-4 and the 2004 and 7475 Al alloys. Attention is given to the structural and geometric complexities of Ti-alloy aircraft structures that would be prohibitively expensive to realize by means other than SPF. O.C.

A89-15096* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
POWER FLOW IN A BEAM USING A 5-ACCELEROMETER PROBE
J. MICAH DOWNING and KEVIN P. SHEPHERD (NASA, Langley Research Center, Hampton, VA) IN: NOISE-CON 88 - Noise control design: Methods and practice; Proceedings of the National Conference on Noise Control Engineering, West Lafayette, IN, June 20-22, 1988. Poughkeepsie, NY, Institute of Noise Control Engineering, 1988, p. 335-340.

A method to determine structure-borne power flow is examined which uses central finite differences to approximate the field variables required to calculate the shear and bending components of flexural vibration. An experimental study using a beam driven by a shaker was performed with the aim of comparing estimates using this proposed five-accelerometer method and the conventional two-accelerometer, free-field method. The advantages and disadvantages of the new method are pointed out. B.J.

A89-15097
MEASURING VIBRATION TRANSMISSION IN STRUCTURES
R. P. KENDIG (Westinghouse Research and Development Center, Pittsburgh, PA) IN: NOISE-CON 88 - Noise control design: Methods and practice; Proceedings of the National Conference on Noise Control Engineering, West Lafayette, IN, June 20-22, 1988. Poughkeepsie, NY, Institute of Noise Control Engineering, 1988, p. 341-346.

Applications of structural intensity measurements in simple structures in the laboratory are presented. It is shown that of particular concern for the transmission of vibrations in shells and plates is the flow of compressional and in-plane shear waves. In-plane wave phenomena may propagate throughout the structure as a source of unwanted noise. B.J.

A89-15119
PERFORMANCE IMPROVEMENT OF FLIGHT SIMULATOR SERVOACTUATORS [AMELIORATION DES PERFORMANCES DES SERVOS VERINS DES SIMULATEURS DE VOL]
M. LEBRUN (Lyon I, Universite, Roanne, France) and H. BOVY (Thomson-CSF, Division Simulateurs, Arcueil, France) L'Aeronautique et l'Astronautique (ISSN 0001-9275), no. 131, 1988, p. 62-68. In French. refs

A theoretical investigation has led to the development of an electrohydraulic servovalve for a flight simulator which minimizes acceleration jolts. Factors considered include the consequences of the asymmetry in cross-section and volume of the actuator, the effect of zero impact of the slide valve, and the control technology of the valve. The servoactuator design has been modified at the first stage by a position loop and at the second stage by asymmetry of the slide valve. Experimental tests have demonstrated a performance improvement, in agreement with theoretical expectations. R.R.

A89-15423 Duke Univ., Durham, NC.
STUDIES IN NONLINEAR AEROELASTICITY
EARL H. DOWELL (Duke University, Durham, NC) and MARAT ILGAMOV (AN SSSR, Kazan, USSR) Research supported by USAF, U.S. Navy, U.S. Army, NASA, and NSF. New York, Springer-Verlag, 1988, 471 p. refs

The mathematical analysis of nonlinear problems in aeroelasticity is examined in a general introduction. Chapters are devoted to a general review of continuum mechanics, the interaction of a shell with a fluid flow, the bending of a cylindrical shell in transverse flow, the effect of shell permeability, self-excited nonlinear oscillations of elastic bodies in a flow, and unsteady transonic aerodynamics and aeroelasticity. Particular attention is given to chaotic oscillations in mechanical systems, the effects of compliant walls on transition and turbulence, the observation and evolution of chaos in an autonomous system, an approximate method for calculating the vortex-induced oscillation of bluff bodies in air and water, and models of unsteady separated flow. T.K.

A89-15488* College of William and Mary, Williamsburg, VA.
PULSE SHAPING AND EXTRACTION OF INFORMATION FROM ULTRASONIC REFLECTIONS IN COMPOSITE MATERIALS
DORON KISHONI (College of William and Mary, Williamsburg, VA) IN: Signal processing and pattern recognition in nondestructive evaluation of materials; Proceedings of the NATO Advanced Research Workshop, Lac Beauport, Canada, Aug. 19-22, 1987. Berlin and New York, Springer-Verlag, 1988, p. 117-127. refs
(Contract NAS1-17303)

The application of ultrasonic inspection to the nondestructive testing of composite materials is examined with reference to specific examples including monitoring of epoxy curing, evaluation of impact damage in a graphite/epoxy laminate, and monitoring of a repaired area in a composite wing plate. Signal processing methods are described which improve time resolution, facilitating identification of discrete echoes corresponding to events in the material. V.L.

A89-15557
ADMITTANCE MODELING - FREQUENCY DOMAIN, PHYSICAL COORDINATE METHODS FOR MULTI-COMPONENT SYSTEMS
DAVID A. KIENHOLZ and KEVIN E. SMITH (CSA Engineering, Inc., Palo Alto, CA) IN: International Modal Analysis Conference, 6th, Kissimmee, FL, Feb. 1-4, 1988, Proceedings. Volume 1. Bethel, CT, Society for Experimental Mechanics, Inc., 1988, p. 608-614. USAF-supported research. refs

The theory underlying the method of admittance modeling is briefly reviewed, and some test problems are examined. In particular, it is noted that the method has potential for solving equivalent excitation problems. Its unique feature is that it can model, from practical measured data, not only the dynamic properties of a complicated directly excited body (e.g., an airframe) but also the unknown service loads imposed upon it. A software package implementing data collection and processing tasks for admittance modeling is described. V.L.

A89-15596
FINITE ELEMENT IMPLEMENTATION OF FULL FLUID/STRUCTURE INTERACTION USING MODAL METHODS
N. R. BEAGLEY, J. M. O'KEEFFE, and C. W. PERRIN (SDRC Engineering Services, Ltd., Hitchin, England) IN: International Modal Analysis Conference, 6th, Kissimmee, FL, Feb. 1-4, 1988, Proceedings. Volume 2. Bethel, CT, Society for Experimental Mechanics, Inc., 1988, p. 1077-1081.

The paper describes a practical approach to implement the fluid structure interaction formulation derived by Dowell et al. (1977), using carefully selected engineering approximations to model relatively large structures. The approach uses a combination of special-purpose software interfaced with commercially available codes. An application example for a typical aerospace structure is presented. B.J.

A89-15657
NAVIER-STOKES COMPUTATIONS OF LAMINAR COMPRESSIBLE AND INCOMPRESSIBLE VORTEX FLOWS IN A CHANNEL
U. BROCKMEIER, N. K. MITRA, and M. FIEBIG (Bochum, Ruhr-Universitaet, Federal Republic of Germany) IN: GAMM-Conference on Numerical Methods in Fluid Mechanics, 7th, Louvain-la-Neuve, Belgium, Sept. 9-11, 1987, Proceedings. Brunswick, Federal Republic of Germany, Friedr. Vieweg und Sohn, 1988, p. 48-55. DFG-supported research.

To investigate the structure of compressible and incompressible vortices behind a small delta wing in a channel at low Reynolds and Mach numbers, computer programs have been developed to solve complete three-dimensional Navier-Stokes and energy equations. Results show qualitatively similar vortex formation, flattening of the vortex core, and movement of the core away from the channel center and towards the bottom wall for both incompressible and compressible flows. Author

A89-15736
DEVELOPMENT OF DESIGN ALLOWABLES FOR METAL MATRIX MATERIALS
CLAYTON L. HARMSWORTH (USAF, Materials Laboratory, Wright-Patterson AFB, OH) IN: Testing technology of metal matrix composites. Philadelphia, PA, American Society for Testing Materials, 1988, p. 197-204.

The requirements for the development of design allowables are reviewed together with potential problems which may be encountered in developing allowables for metal matrix composites. It is noted that the DOD and the FAA require the use of MIL-HDBK-5 (for metals) and MIL-HDBK (for composites) allowables unless alternate values are approved by these organizations. It is believed that the major benefit of handbook allowables is the reliability and confidence that comes to the designer in being able to use a material with predictable property values. K.K.

A89-15785
COMPACT HOLOGRAPHIC SIGHT
JURIS UPATNIEKS (Michigan, Environmental Research Institute, Ann Arbor) IN: Holographic optics: Design and applications; Proceedings of the Meeting, Los Angeles, CA, Jan. 13, 14, 1988. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1988, p. 171-176. refs

The present evaluation of size reductions achievable for reflex-type sights and HUDs by means of holographic components shows the image formed by a high-quality optical system that uses a holographic recording plate to be capable of duplicating the original image's quality. The illuminating beam enters the hologram plate through its edge; the laser is remotely located, with light being guided through a fiber-optics cable to the HUD sight. HUDs can be made more compact by attaching a pair of gratings to a flat glass plate that guides the display to a position in front of the pilot. O.C.

A89-15897
SYNTHETIC IR SCENE GENERATION
J. STETS, J. CONANT, J. GRUNINGER, and B. RYALI (Aerodyne

Research, Inc., Billerica, MA) IN: Infrared systems and components II; Proceedings of the Meeting, Los Angeles, CA, Jan. 14, 15, 1988. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1988, p. 130-146. refs

Testing sensor systems against accurate simulated laboratory data furnishes a higher level of confidence in actual flight test planning and evaluation of the test results. An account is presently given of an IR scene-generation model consisting of images from the AERIE terrain model, the ACM cloud model, and the SPIRITS target model. IR scene synthesis will be useful in studies of observables for air vehicle detection and for systems vulnerability analysis, as well as in sensor system evaluation. O.C.

A89-15968#

A NEW HYDRODYNAMIC GAS BEARING CONCEPT

M. W. EUSEPI (Mechanical Technology, Inc., Experimental Programs Research and Development Div., Latham, NY) and D. F. WILCOCK (Tribolock, Inc., Schenectady, NY) ASME, Transactions, Journal of Tribology (ISSN 0742-4787), vol. 110, Oct. 1988, p. 614-620.
(Contract F33615-84-C-2429)

The design of a 3.5 in.. diameter Hydroflex bearing is described together with its fabrication and testing. A four-pad design, with each pad subtending an arc of 80 deg, was selected. The feasibility of the Hydroflex design approach was demonstrated on a simple test rotor with a 3.5 in. Hydroflex bearing at speeds up to 30,000 r/min. K.K.

A89-16109#

INVESTIGATION OF THE INTERACTING FLOW OF NONSYMMETRIC JETS IN CROSSFLOW

J. M. WU, A. D. VAKILI, and F. M. YU (Tennessee, University, Tullahoma) AIAA Journal (ISSN 0001-1452), vol. 26, Aug. 1988, p. 940-947. Previously cited in issue 11, p. 1541, Accession no. A86-26619. refs
(Contract AF-AFOSR-84-0114; AF-AFOSR-86-0155)

A89-16358

HEAT TRANSFER AND FLOW AROUND ELLIPTIC CYLINDERS IN TANDEM ARRANGEMENT

HIDEYA NISHIYAMA (Akita University, Japan), TERUKAZU OTA (Tohoku University, Sendai, Japan), and TOHRU MATSUNO (Tokuda Manufacturing Co., Ltd., Zama, Japan) JSME International Journal, Series II (ISSN 0914-8817), vol. 31, Aug. 1988, p. 410-419. refs

Heat transfer and flow around four elliptic cylinders with an axis ratio of 1:2, in a tandem arrangment, are investigated experimentally in the Reynolds number range 15000-70000 at angles of attack ranging from 0 to 90 deg. Heat transfer is found to vary over a wide range with the angle of attack and with cylinder spacing. It is also found that, at narrower cylinder spacings and smaller angles of attack, the heat transfer capacity of the elliptical cylinders considered here is comparable to that of in-line circular cylinders. V.L.

A89-16438#

ANALYSIS OF THERMAL PERFORMANCE FOR AVIATION - MOIST AIR CROSS FLOW HEAT EXCHANGER

QINFANG YU (Nanjing Aeronautical Institute, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 9, Oct. 1988, p. B469-B474. In Chinese, with abstract in English. refs

The thermal performance of a moist air cross flow heat exchanger with two unmixed fluids is studied. Heat and mass balances are used to establish a set of partial differential equations. Finite difference theory is used to convert these equations into difference equations. These equations, when calculated by computer, provide results in satisfactory agreement with experimental results. C.D.

A89-16443#

CALCULATION OF TORSIONAL STIFFNESS FOR CROSS SECTIONS OF COMPOSITE ROTOR BLADES

ZHONG XU, ZHEMIN ZOU, and WEIXUN FAN (Nanjing Aeronautical Institute, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 9, Oct. 1988, p. B506-B509. In Chinese, with abstract in English.

This paper improves the finite element solution for Saint-Venant torsion presented by Krahula and Lauterbach (1969) and presents the numerical results of rotor blade cross sections of two helicopters. Finally, the calculated results are compared with experimental data, and good agreement is observed. Author

A89-16458*# Calspan-Buffalo Univ. Research Center, NY.

TURBINE-STAGE HEAT TRANSFER - COMPARISON OF SHORT-DURATION MEASUREMENTS WITH STATE-OF-THE-ART PREDICTIONS

WILLIAM J. RAE, DALE B. TAULBEE, MICHAEL G. DUNN (Calspan-Buffalo University Research Center, NY), and KESTUTIS C. CIVINSKAS (NASA, Lewis Research Center, Cleveland, OH) Journal of Propulsion and Power (ISSN 0748-4658), vol. 4, Nov.-Dec. 1988, p. 541-548. Previously cited in issue 20, p. 2961, Accession no. A86-42656. refs
(Contract NAG3-469; NAG3-581)

A89-16850#

PRELIMINARY NUMERICAL SIMULATIONS OF A PULSED DETONATION WAVE ENGINE

JEAN-LUC CAMBIER (Analatom, Inc., San Jose, CA) and HENRY G. ADELMAN (Eloret Institute, Palo Alto, CA) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 13 p. refs
(AIAA PAPER 88-2960)

It is known that detonations propagate through combustible mixtures at supersonic speeds that are orders of magnitude faster than the diffusive flame propagation rates typical of subsonic combustion ramjet cycles. Attention is presently given to the cyclic charging and combustion rates of a pulsed-detonation wave engine, in order to predict ideal engine performance characteristics; calculation results are presented which demonstrate that the engine has high fuel-specific impulse levels which are fully competitive with ramjet performance. O.C.

A89-16856#

SIMPLE BALANCE METHODS OF HIGH-SPEED ROTORS IN FIELD

LITANG YAN, ZIGEN ZHU, and QIHAN LI (Beijing University of Aeronautics and Astronautics, People's Republic of China) Journal of Aerospace Power (ISSN 1000-8055), vol. 3, Oct. 1988, p. 319-322, 383. In Chinese, with abstract in English.

Some simple dynamic-balance methods for rotor systems are investigated. These methods, featuring simplicity and ease without recourse to any complicated instrumentation and calculation system, are particularly suitable for rotor balancing in the field. The simple method with influence coefficients and that with least squares are presented. The balance problems of rotors with non-axisymmetrical support stiffness and for rigid rotor systems in the field are also discussed. Author

A89-16862#

THERMOELASTOPLASTIC CREEP ANALYSIS FOR TURBINE DISK

XIAYING MU and XIRUI LIU (Xian Jiaotong University, People's Republic of China) Journal of Aerospace Power (ISSN 1000-8055), vol. 3, Oct. 1988, p. 347-350, 385, 386. In Chinese, with abstract in English.

This paper deals with the strength analysis for aircraft-engine turbine disks. A finite-element analysis program for thermoelastoplastic creep is formulated which imitates a cyclic loading in flight. Considering the influence of factors of creep, changes of material properties, and the process of temperature elevation, the stress analysis of the disk body is accomplished under various working conditions. Moreover, the residual stress resulting from a cyclic loading is calculated. Author

A89-16865#
STRENGTH ANALYSIS AND FATIGUE LIFE PREDICTION FOR LOAD-BEARING CASING OF AEROENGINE UNDER COMPLEX LOADING
WEIJUN SHANG and MINGDA LI (Nanjing Aeronautical Institute, People's Republic of China) Journal of Aerospace Power (ISSN 1000-8055), vol. 3, Oct. 1988, p. 361-364, 387. In Chinese, with abstract in English. refs

Calculations and tests of stress distributions for load-bearing casings of aircraft engines are presented. It is noted that the stress finite-element analysis of the casing may be divided into three steps (model evaluation, stress distribution calculation, and detailed calculation of partial structures. Author

A89-16927* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
INTERACTION OF FLUIDS AND STRUCTURES FOR AIRCRAFT APPLICATIONS
GURU P. GURUSWAMY (NASA, Ames Research Center, Moffett Field, CA) (George Washington University and NASA, Symposium on Advances and Trends in Computational Structural Mechanics and Fluid Dynamics, Washington, DC, Oct. 17-19, 1988) Computers and Structures (ISSN 0045-7949), vol. 30, no. 1-2, 1988, p. 1-13. refs

Strong interactions occur between the flow about an aircraft and its structural components, which result in several important aeroelastic phenomena which can significantly influence performance. For example, aircraft with highly swept wings experience vortex-induced aeroelastic oscillations. The simulation of these complex aeroelastic phenomena requires coupling the fluid and structural analysis. This paper provides a summary of the development of such coupled methods and their applications to aeroelasticity. Results based on the transonic small-perturbation equations and the Euler equations are presented. Author

A89-16928
AEROELASTIC COMPUTATIONS OF FLEXIBLE CONFIGURATIONS
VIJAYA SHANKAR and HIROSHI IDE (Rockwell International Science Center, Thousand Oaks, CA) (George Washington University and NASA, Symposium on Advances and Trends in Computational Structural Mechanics and Fluid Dynamics, Washington, DC, Oct. 17-19, 1988) Computers and Structures (ISSN 0045-7949), vol. 30, no. 1-2, 1988, p. 15-28. refs

An aeroelastic package consisting of (1) an aerodynamic solver, (2) a structural response mode, and (3) a grid generation/update program has been developed to study both static and dynamic response of flexible aerospace configurations. The aeroelastic package can handle static rigid, dynamic rigid, static flexible, and dynamic flexible cases. Also, the aerodynamic solver is based on an unsteady formulation and can handle subsonic, transonic, and supersonic flow conditions. Results are presented for rigid and flexible configurations at different Mach numbers ranging from subsonic to supersonic conditions. The dynamic response of a flexible wing below and above its flutter point is demonstrated. Author

A89-16934* Virginia Polytechnic Inst. and State Univ., Blacksburg.
THE COMPUTATION OF NON-EQUILIBRIUM CHEMICALLY-REACTING FLOWS
B. GROSSMAN and P. CINNELLA (Virginia Polytechnic Institute and State University, Blacksburg) (George Washington University and NASA, Symposium on Advances and Trends in Computational Structural Mechanics and Fluid Dynamics, Washington, DC, Oct. 17-19, 1988) Computers and Structures (ISSN 0045-7949), vol. 30, no. 1-2, 1988, p. 79-93. refs
(Contract NAG1-776)

Numerical techniques for the analysis of flows with nonequilibrium thermodynamics and chemistry are developed and demonstrated. Particular attention is given to the formulation of the thermodynamic and chemical gas models, the derivation of the governing equations, and the solution procedures. Results for typical problems involving shock tubes and supersonic diffusers are presented in extensive graphs and briefly characterized. T.K.

A89-17013
NUMERICAL SIMULATION OF COMPRESSIBLE NAVIER-STOKES FLOWS
MARIE ODILE BRISTEAU, ED. (Institut National de Recherche en Informatique et en Automatique, Le Chesnay, France), ROLAND GLOWINSKI, ED. (Houston, University, TX), JACQUES PERIAUX, ED. (Avions Marcel Dassault-Breguet Aviation, Saint-Cloud, France), and HENRI VIVIAND, ED. (ONERA, Chatillon-sous-Bagneux, France) Brunswick, Federal Republic of Germany, Friedr. Vieweg und Sohn (Notes on Numerical Fluid Mechanics. Volume 18), 1987, 349 p. For individual items see A89-17014 to A89-17029.

Recent advances in computational fluid dynamics are discussed in reviews and reports presented at the GAMM workshop held in Nice, France in December 1985. Topics addressed include simulations of compressible viscous flows, experimental studies of the flow around NACA 0012 airfoils in rarefied air streams, least-squares and finite-element solutions of the compressible Navier-Stokes equations, multistage multigrid methods, and an unfactored implicit predictor-corrector scheme. Consideration is given to a rational Runge-Kutta method for the two-dimensional compressible Navier-Stokes equations, double-throat nozzle problems, laminar nozzle flows, and an implicit flux-split algorithm for the compressible Navier-Stokes equations. T.K.

A89-17122
A VECTOR POTENTIAL MODEL FOR VORTEX FORMATION AT THE EDGES OF BODIES IN FLOW [EIN VEKTORPOTENTIALMODELL FUER DIE WIRBELBILDUNG AM RAND UMSTROEMTER KOERPER]
R. RAUTMANN (Paderborn, Universitaet-Gesamthochschule, Federal Republic of Germany) Zeitschrift fuer angewandte Mathematik und Mechanik (ISSN 0044-2267), vol. 68, no. 8, 1988, p. 383-387. In German. DFG-supported research. refs

The formation of vortices in a viscous flow due to skin friction at the edge of a rigid body is investigated analytically. Norm bounds for a simplified version of the method of Chorin (1973) and Marsden (1974) are derived by modeling vortex formation in terms of the curl of a diffused Stokes vector potential (defined as the potential which corrects the Euler equation such that vortex production is minimized and the adherence condition is satisfied). The latter condition is achieved via an orthogonal projection, leading to approximations useful in the analysis of high-Reynolds-number flows. T.K.

N89-12019# Universitaet der Bundeswehr, Neubiberg (Germany, F.R.). Inst. fuer Stroemungsmechanik und Aerodynamik.
STATISTICAL SIMULATION OF TURBULENT FLOW AROUND A CUBE SUBJECTED TO FRONTAL FLOWS [STATISTISCHE SIMULATION DER TURBULENTEN UMSTROEMUNG EINES FRONTAL ANGESTROEMTEN WUERFELS]
H. WERNER, F. BAETKE (Technische Univ., Munich, West Germany), and H. WENGLE 1988 28 p In GERMAN
Sponsored by DFVLR, Cologne, Fed. Republic of Germany
(ETN-88-93215) Avail: NTIS HC A03/MF A01

Buildings aerodynamics is studied in the case of turbulent flow around a cube subjected to a frontal flow. Three dimensional Reynolds equations are numerically solved for the middle flow pattern where the global turbulence effect is examined by a double equation model. Numerical results are compared with experimental ones in two different cases: homogeneous flow with low turbulence ratio, and simulated atmospheric boundary layer with high turbulence ratio. ESA

N89-12026*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
A HIGH HEAT FLUX EXPERIMENT FOR VERIFICATION OF THERMOSTRUCTURAL ANALYSIS
HERBERT J. GLADDEN and MATTHEW E. MELIS Dec. 1988

17 p Presented at the Winter Annual Meeting of the ASME, Chicago, Ill., 28 Nov. - 2 Dec. 1988 Original document contains color illustrations
(NASA-TM-100931; E-4202; NAS 1.15:100931) Avail: NTIS HC A03/MF A01 CSCL 20D

A major concern in advancing the state of the art technologies for hypersonic vehicles is the development of an aeropropulsion system capable of handling the high heat fluxes during flight. The leading edges of such systems must not only tolerate the maximum heating rates, but must also minimize distortions to the flow field due to excessive blunting and/or thermal warping of the compression surface to achieve the high inlet performance required. A combined analytical and experimental effort to study the aerothermodynamic loads on actively cooled structures for hypersonic applications was established. A hydrogen/oxygen rocket engine was modified to establish a high enthalpy high heat flux environment. The facility provides heat flux levels from about 200 up to 10000 Btu/sq ft/sec. Cross flow and parallel flow regeneratively cooled model can be tested and analyzed by using cooling fluids of water and hydrogen. Results are presented of the experiment and the characteristics of the Hot Gas Test Facility. The predicted temperature results of the cross flow model are compared with the experimental data on the first monolithic specimens and are found to be in good agreement. Thermal stress analysis results are also presented. Author

N89-12075# Centre d'Essais Aeronautique Toulouse (France). Lab. d'Analyses non Destructives.
DEVELOPMENT OF AN EDDY CURRENT NONDESTRUCTIVE ANALYSIS METHOD, THE ELOTEST UL4, WITHOUT DISASSEMBLY OF FIXATIONS. TEST REPORT M7-614800 [MISE AU POINT D'UNE METHODE D'ANALYSE NON DESTRUCTIVE PAR COURANTS DE FOUCAULT ELOTEST UL4 SANS DEMONTAGE DES FIXATIONS. PROCES-VERBAL M7-614800]
11 Aug. 1987 51 p In FRENCH Sponsored by the STPA
(REPT-M7-614800; ETN-88-93322) Avail: NTIS HC A04/MF A01

A method was developed for the inspection of structural elements without disassembling. The results obtained on specimens from aircraft elements cover the adjustments of the method parameters, the study of the physical phenomena involved, and the evaluation of the defects found. The method described allows to visualize the evolution of cracks and to detect location. ESA

N89-12081# Carnegie Inst. of Tech., Pittsburgh, PA.
AN EFFICIENT METHOD FOR PREDICTING THE VIBRATORY RESPONSE OF LINEAR STRUCTURES WITH FRICTION INTERFACES. VOLUME 2: STEADY-STATE VIBRATIONS OF A 2-BODY SYSTEM WITH A FRICTIONAL INTERFACE Final Report, May 1983 - Oct. 1986
ENRIGUE BAZAN-ZURITA, JACOBO BIELAK, and JERRY H. GRIFFIN 4 Apr. 1988 74 p
(Contract F33615-83-K-2316)
(AD-A197022; R-86-158-VOL-2; R-86-159-VOL-2; AFWAL-TR-86-2119-VOL-2; R-86-160-VOL-2) Avail: NTIS HC A04/MF A01 CSCL 21E

In recent years it has become increasingly clear that friction damping in joints can affect significantly the dynamic response of structures with friction interfaces. In this report, we analyze the steady-state harmonic response of a system consisting of two spring masses connected by a Coulomb-type friction joint, as the simplest example of structures of this type. Two reasons motivate this work: (1) the simple system can serve as a basis for gaining physical insight into the behavior of more complex systems, and (2) inasmuch as this problem can be solved exactly, the solution can be used to assess the accuracy of approximate methods developed for more general systems. The differential equations governing the motion of the system during slip, partial-slip or stuck conditions of the joint are formulated in dimensionless form in order to identify the parameters controlling the dynamic response and to obtain results that are applicable to a large number of cases. GRA

N89-12091# National Aerospace Lab., Amsterdam (Netherlands). Structures and Materials Div.
STRESS CORROSION CRACKS IN ALUMINUM AIRCRAFT STRUCTURES
L. SCHRA Presented at the NCC'S Working Group Autumn Meeting on Stress Corrosion, 10 Oct. 1987 Jul. 1987 In DUTCH; ENGLISH summary Presented at the Autumn Meeting on Controlled Operating with Materials with Growing Stress Corrosion Cracks, 10 Jun. 1987
(NLR-MP-87048-U; B8805849; ETN-88-93401) Avail: NTIS HC A03/MF A01

Characteristic features of stress corrosion cracks in high strength aluminum alloys are discussed. The potential usefulness of linear elastic fracture mechanics for predicting stress corrosion crack propagation in aluminum aircraft structures is considered. A procedure for extended service life of stress corrosion susceptible structural parts is given. ESA

N89-12629*# Mechanical Technology, Inc., Latham, NY.
THE EFFECTS OF INTERNAL ROTOR FRICTION ON DYNAMIC CHARACTERISTICS OF TURBOPUMPS
J. WALTON, A. ARTILES, J. LUND, and C. LEE *In* NASA, Marshall Space Flight Center, Advanced Earth-To-Orbit Propulsion Technology 1986, Volume 2 p 33-61 Oct. 1986
(Contract NAS8-35601)
Avail: NTIS HC A99/MF E03 CSCL 21H

An analytic model developed to determine the stiffness and damping for an axial spline is presented. Following the analytical development, a series of parametric evolutions showing the destabilizing effects of the axial spline on a supercritical rotor system is also presented. B.G.

N89-12763# Notre Dame Univ., IN. Dept. of Civil Engineering.
INVESTIGATION INTO THE APPLICABILITY OF FRACTURE MECHANICS TECHNIQUES TO AIRCRAFT WHEEL LIFE STUDIES Final Report
THOMAS J. ENNEKING *In* Universal Energy Systems, Inc., United States Air Force Graduate Student Summer Support Program, Volume 1 20 p Dec. 1987
Avail: NTIS HC A99/MF E03 CSCL 20K

In response to a specified logistic need, an in-house program was started in late 1986 to investigate test and analytical methods for wheel life estimation and verification. In conjunction with this program, an additional ten week study was initiated June 1, 1987 to explore analytical techniques for fatigue analysis and experimental methods to verify these analytical techniques. In particular, the applicability and feasibility of applying fracture mechanics concepts to aircraft wheel assemblies was assessed. A literature review was performed to identify current research activity involving aircraft wheels and fatigue studies. This was expanded to include finite element techniques and stochastic methods as applied to wheel life and reliability estimates. Based on the results of this study, and previous studies, a combined analytical and experimental methodology was proposed for the estimation and verification of aircraft wheel service life. This proposed multi-task approach contains several alternatives within the individual tasks. The optimum alternatives, i.e., those with the highest probability of success and an acceptable cost (effort), will be the object of further studies. Author

N89-12786* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
TRUSS-CORE CORRUGATION FOR COMPRESSIVE LOADS Patent
RANDALL C. DAVIS, inventor (to NASA) and ROBERT JACKSON, inventor (to NASA) 13 Sep. 1988 9 p Filed 5 Mar. 1987 Supersedes N87-25496 (25 - 19, p 2601)
(NASA-CASE-LAR-13438-1; US-PATENT-4,769,968; US-PATENT-APPL-SN-022298; US-PATENT-CLASS-52-814; US-PATENT-CLASS-52-821; US-PATENT-CLASS-428-182)
Avail: US Patent and Trademark Office CSCL 13B

A corrugated panel structure for supporting compressive loads is described which includes curved cap strips separated by truss-core web segments. The truss-core web segments are formed from first and second flat panels with a corrugated filler in between them. The corrugated filler extends in the direction of the compressive load. As a result, all components of the panel structure have a compressive load carrying capability resulting in a high strength-to-weight ratio when the compressive load is limiting. Application to rocket and aircraft structures is suggested.

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

N89-12822*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
AERODYNAMIC PRESSURES AND HEATING RATES ON SURFACES BETWEEN SPLIT ELEVONS AT MACH 6.6
L. ROANE HUNT Washington, D.C. Dec. 1988 85 p
(NASA-TP-2855; L-16460; NAS 1.60:2855) Avail: NTIS HC A05/MF A01 CSCL 20D

An aerothermal study was performed in the Langley 8-Foot High Temperature Tunnel at Mach number 6.6 to define the pressures and heating rates on the surfaces between split elevons similar to those used on the Space Shuttle. Tests were performed with both laminar and turbulent boundary layers on the wing surface upstream of the elevons. The flow in the chordwise gap between the elevons was characterized by flow separation at the gap entrance and flow reattachment at a depth into the gap inversely proportional to the gap width. The gap pressure and heating rate increased significantly with decrease of elevon gap width, and the maximum gap heating rate was proportional to the maximum gap pressure. Correlation of the present results indicate that the gap heating was directly proportional to the elevon windward surface pressure and was not dependent upon whether the boundary layer on the windward elevon surface was laminar or turbulent. Author

N89-12837*# Auburn International, Inc., Danvers, MA.
MASS FLOW MEASUREMENT OF LIQUID CRYOGENS USING THE TRIBOELECTRIC EFFECT Final Report
RONALD L. DECHENE 12 Aug. 1986 65 p
(Contract NAS3-24873)
(NASA-CR-179519; NAS 1.26:179519) Avail: NTIS HC A04/MF A01 CSCL 20D

A cross correlator technique using triboelectric technology has been shown to be a feasible method to measure liquid flow rate for liquid nitrogen and JP4 jet fuel. This technology, invented and pioneered by Auburn International, Inc., is also expected to be suitable for use with all other insulating liquids and cryogens. The technology described is particularly well suited for cryogenic use, since the sensor is non-contacting and non-intrusive, and therefore, causes no additional pressure drop within the flow stream. Further development of the in-line sensor is required to produce a prototypical version for the test purposes under SSME fuel flow conditions. However, with the knowledge gained from this feasibility study, it is very likely that an acceptable sensor design for a full test bed evaluation could be produced. Author

N89-12841* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
POROUS PLUG FOR REDUCING ORIFICE INDUCED PRESSURE ERROR IN AIRFOILS Patent
ELIZABETH B. PLENTOVICH, inventor (to NASA), BLAIR B. GLOSS, inventor (to NASA), JOHN W. EVES, inventor (to NASA), and JOHN P. STACK, inventor (to NASA) 13 Sep. 1988 8 p
Filed 5 Feb. 1987 Supersedes N87-25559 (25 - 19, p 2612)
(NASA-CASE-LAR-13569-1; US-PATENT-4,770,032; US-PATENT-APPL-SN-010943; US-PATENT-CLASS-73-147; US-PATENT-CLASS-73-180) Avail: US Patent and Trademark Office CSCL 14B

A porous plug is provided for the reduction or elimination of positive error caused by the orifice during static pressure measurements of airfoils. The porous plug is press fitted into the orifice, thereby preventing the error caused either by fluid flow turning into the exposed orifice or by the fluid flow stagnating at the downstream edge of the orifice. In addition, the porous plug is made flush with the outer surface of the airfoil, by filing and polishing, to provide a smooth surface which alleviates the error caused by imperfections in the orifice. The porous plug is preferably made of sintered metal, which allows air to pass through the pores, so that the static pressure measurements can be made by remote transducers.

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

N89-12845*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
PERFORMANCE OF THE FORWARD SCATTERING SPECTROMETER PROBE IN NASA'S ICING RESEARCH TUNNEL
EDWARD A. HOVENAC and ROBERT F. IDE (Army Aviation Research and Development Command, Cleveland, Ohio.) 1988 11 p Proposed for presentation at the 27th Aerospace Sciences Meeting, Reno, Nev., 9-12 Jan. 1989; sponsored by AIAA
(NASA-TM-101381; E-4435; NAS 1.15:101381; AVSCOM-TR-88-C-036; AIAA-89-0769) Avail: NTIS HC A03/MF A01 CSCL 14B

Two Forward Scattering Spectrometer Probes were used to measure droplet distributions in the NASA Lewis Icing Research Tunnel. The instruments showed good agreement when the median volume diameter (MVD) was approximately 16 micrometers. Coincidence events affect much of the data and caused the measured MVD to be about 2 to 3 micrometers larger than expected. Coincidence events were reduced by shutting down half of the spray bars in the tunnel during certain tests. Author

N89-12864# Dayton Univ., OH. Research Inst.
RESEARCH ON MECHANICAL PROPERTIES FOR ENGINE LIFE PREDICTION Final Report, Aug. 1984 - Sep. 1987
M. KHOBAIB, NOEL E. ASHBAUGH, GEORGE A. HARTMAN, TUSIT WEERASOORIYA, and DAVID C. MAXWELL May 1988 120 p
(Contract F33615-84-C-5051)
(AD-A197816; UDR-TR-88-08; AFWAL-TR-88-4062) Avail: NTIS HC A06/MF A01 CSCL 11F

Analytical and experimental investigations have been performed to determine crack growth behavior of turbine engine disk and blade alloys under various loading conditions typical of service environments. Tests were performed at elevated temperature in vacuum also to evaluate the baseline crack growth behavior. Substructural analysis of creep rupture specimens were conducted to understand the basic mechanism of time-dependent elevated temperature deformation. The work performed can be divided into three categories -- development of experimental techniques, material characterization techniques, and data maintenance and test support activities. The capability of the IDG laser system to monitor extended gage length was analyzed and found feasible. New grips and specimens have been designed and fabricated for high temperature composite testing. Enhancements to existing systems for crack length and displacement measurements were made. GRA

N89-12876*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
TURBINE ENGINE HOT SECTION TECHNOLOGY 1986
Oct. 1986 488 p Workshop held in Cleveland, Ohio, 21-22 Oct. 1986
(NASA-CP-2444; E-3205; NAS 1.55:2444) Avail: NTIS HC A21/MF A01 CSCL 20K

The Turbine Engine Hot Section Technology (HOST) Project of the NASA Lewis Research Center sponsored a workshop to discuss current research pertinent to turbine engine durability problems. Presentations were made concerning the hot-section environment and the behavior of combustion liners, turbine blades, and turbine vanes. The presentations were divided into six sessions: Instrumentation, Combustion, Turbine Heat Transfer, Structural Analysis, Fatigue and Fracture, and Surface Protection. Topics discussed included modeling of thermal and fluid-flow phenomena, structural analysis, fatigue and fracture, surface protective coatings, constitutive behavior of materials, stress-strain response, and life-prediction methods. Researchers from industry, academia, and government presented results of their work sponsored by the HOST project.

N89-12881*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
HOST STRUCTURAL ANALYSIS PROGRAM OVERVIEW
ROBERT L. THOMPSON *In its* Turbine Engine Hot Section Technology 1986 p 19-31 Oct. 1986
Avail: NTIS HC A21/MF A01 CSCL 20K

Hot-section components of aircraft gas turbine engines are subjected to severe thermal structural loading conditions, especially during the startup and takeoff portions of the engine cycle. The most severe and damaging stresses and strains are those induced by the steep thermal gradients induced during the startup transient. These transient stresses and strains are also the most difficult to predict, in part because the temperature gradients and distributions are not well known or readily predictable and, in part, because the cyclic elastic-viscoplastic behavior of the materials at these extremes of temperature and strain are not well known or readily predictable. A broad spectrum of structures related technology programs is underway to address these deficiencies at the basic as well as the applied level. The three key program elements in the HOST structural analysis program are computations, constitutive modeling, and experiments for each research activity. Also shown are tables summarizing each of the activities. E.R.

N89-12882*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
FATIGUE AND FRACTURE OVERVIEW
GARY R. HALFORD *In its* Turbine Engine Hot Section Technology 1986 p 33-43 Oct. 1986
Avail: NTIS HC A21/MF A01 CSCL 20K

The accomplishments achieved under the isotropic creep-fatigue crack initiation life prediction program are summarized. A sizeable creep-fatigue crack initiation data base was generated on the nickel-base superalloy, B-1900. Companion constitutive modeling programs have also generated extensive data bases on the same heat of material. The crack initiation results have formed the basis of a new approach to creep-fatigue life prediction. The term Cyclic Damage Accumulation (CDA) was coined for the method, which was evaluated under isothermal, uniaxial conditions. Stringent laboratory verification experiments were used to test the accuracy of the method. Considering the quite limited material property data needed to evaluate the constants in the approach, the prediction accuracy is acceptable. At the expense of the larger data base required, Lewis developed total strain- strainrange partitioning method (TS-SRP) is capable of a higher degree of accuracy. E.R.

N89-12884*# Pratt and Whitney Aircraft, East Hartford, CT. Engineering Div.
FURTHER DEVELOPMENT OF THE DYNAMIC GAS TEMPERATURE MEASUREMENT SYSTEM
D. L. ELMORE, W. W. ROBINSON, and W. B. WATKINS *In* NASA, Lewis Research Center, Turbine Engine Hot Section Technology 1986 p 51-60 Oct. 1986
(Contract NAS3-24228)
Avail: NTIS HC A21/MF A01 CSCL 14B

The objective of this effort was to experimentally verify a dynamic gas temperature measurement system in laboratory experiments. The dynamic gas temperature measurement system verification program is described. A brief description of the sensor geometry and construction is followed by a discussion of the probe heat transfer analysis and subsequent compensation method. The laboratory experiments are described and experimental results are discussed. Finally, directions for further investigation are given. E.R.

N89-12885*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
LASER ANEMOMETRY: A STATUS REPORT
MARK P. WERNET, RICHARD G. SEASHOLTZ, DONALD H. WEIKLE, and LAWRENCE G. OBERLE *In its* Turbine Engine Hot Section Technology 1986 p 61-68 Oct. 1986
Avail: NTIS HC A21/MF A01 CSCL 20E

A laser anemometer system is being developed for the warm turbine facility as part of the HOST program. The system will be built using results obtained from the analytical and experimental research program. The status report of the laser anemometry applications research effort is presented. The designs for the turbine casing, the windows, and the positioning system were completed. A block diagram of the laser anemometer system, signal processing scheme, and computer system is given. Author

N89-12886*# Northwestern Univ., Evanston, IL.
ELEVATED TEMPERATURE STRAIN GAGES
J. O. BRITTAIN, D. GESLIN, and J. F. LEI *In* NASA, Lewis Research Center, Turbine Engine Hot Section Technology 1986 p 69-84 Oct. 1986
(Contract NAG3-501)
Avail: NTIS HC A21/MF A01 CSCL 14B

One of the goals of the HOST Program is the development of electrical resistance strain gages for static strain measurements at temperatures equal to or greater than 1273 K. Strain gage materials must have a reproducible or predictable response to temperature, time and strain. It is the objective of this research to investigate criteria for the selection of materials for such applications through electrical properties studies. The results of the investigation of two groups of materials, refractory compounds and binary alloy solid solutions are presented. Author

N89-12887*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
DEVELOPMENT OF A HIGH TEMPERATURE STATIC STRAIN SENSOR
CHARLES O. HULSE, RICHARD S. BAILEY, and HOWARD P. GRANT *In* NASA, Lewis Research Center, Turbine Engine Hot Section Technology 1986 p 85-90 Oct. 1986
(Contract NAS3-23722)
Avail: NTIS HC A21/MF A01 CSCL 14B

The goal of this program is to develop an electrical resistance strain gage system which will accurately measure the static strains of superalloy blades and vanes in gas turbine engines running on a test stand. Accurate knowledge of these strains is essential to reaching the goals of the HOST program in the selection and experimental verification of the various theoretical models developed to understand and improve the performance of these engines. The specific objective is to develop a complete system capable of making strain measurements of up to + or - 10 percent of full scale during a 50 hour period at temperatures as high as 1250 K. In addition to survival and stability, attaining a low temperature coefficient of resistance, of the order of 20 ppm/K or less, was a major goal. This requirement arises from the presently unavoidable uncertainties in measurement of the exact temperatures inside gas turbines for use in making corrections for apparent strain due to temperature. Author

N89-12888*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
THE NASA LEWIS STRAIN GAUGE LABORATORY: AN UPDATE
H. F. HOBART *In its* Turbine Engine Hot Section Technology 1986 p 91-96 Oct. 1986
Avail: NTIS HC A21/MF A01 CSCL 14B

Efforts continue in the development and evaluation of electrical resistance strain gauges of the thin film and small diameter wire type. Results obtained early in 1986 on some Chinese gauges and Kanthal A-1 gauges mounted on a Hastelloy-X substrate are presented. More recent efforts include: (1) the determination of the uncertainty in the ability to establish gauge factor, (2) the evaluation of sputtered gauges that were fabricated at Lewis, (3) an investigation of the efficacy of dual element temperature compensated gauges when using strain gauge alloys having large thermal coefficients of resistance, and (4) an evaluation of the practical methods of stabilizing gauges whose apparent strain is dependent on cooling rate (e.g., FeCrAl gauges). Author

N89-12889*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
SUMMARY OF LASER SPECKLE PHOTOGRAMMETRY FOR HOST
FRANK G. POLLACK *In its* Turbine Engine Hot Section Technology 1986 p 97-103 Oct. 1986
Avail: NTIS HC A21/MF A01 CSCL 20E

High temperature static strain measurement capability is important for the success of the HOST program. As part of the NASA Lewis effort to develop the technology for improved hot-section durability, the HOST instrumentation program has, as a major goal, the development of methods for measuring strain at high temperature. Development work includes both improvements in resistance strain-gauge technology and, as an alternative approach, the development of optical techniques for high temperature strain measurement. Author

N89-12890*# General Motors Corp., Detroit, MI. Gas Turbine Engine Div.
AEROTHERMAL MODELING PROGRAM, PHASE 2
K. C. KARKI, H. C. MONGIA, SUHAS V. PATANKAR, and A. K. RUNCHAL *In* NASA, Lewis Research Center, Turbine Engine Hot Section Technology 1986 p 105-113 Oct. 1986
(Contract NAS3-24350)
Avail: NTIS HC A21/MF A01 CSCL 20D

The main objective of the NASA sponsored Aerothermal Modeling Program, Phase 2--Element A, is to develop an improved numerical scheme for predicting combustor flow fields. This effort consists of the following three technical tasks. Task 1 involves the selection and evaluation of various candidate numerical techniques. Task 2 involves an in-depth evaluation of the selected numerical schemes. Task 3 involves the convection-diffusion scheme and the direct solver that will be incorporated in the NASA 3-D elliptic code (COM3S). E.R.

N89-12891*# General Motors Corp., Detroit, MI. Gas Turbine Engine Div.
AEROTHERMAL MODELING PROGRAM, PHASE 2. ELEMENT B: FLOW INTERACTION EXPERIMENT
M. NIKJOOY, H. C. MONGIA, S. N. B. MURTHY, and J. P. SULLIVAN *In* NASA, Lewis Research Center, Turbine Engine Hot Section Technology 1986 p 115-124 Oct. 1986
(Contract NAS3-24350)
Avail: NTIS HC A21/MF A01 CSCL 20D

The design process was improved and the efficiency, life, and maintenance costs of the turbine engine hot section was enhanced. Recently, there has been much emphasis on the need for improved numerical codes for the design of efficient combustors. For the development of improved computational codes, there is a need for an experimentally obtained data base to be used at test cases for the accuracy of the computations. The purpose of Element-B is to establish a benchmark quality velocity and scalar measurements of the flow interaction of circular jets with swirling flow typical of that in the dome region of annular combustor. In addition to the detailed experimental effort, extensive computations of the swirling flows are to be compared with the measurements for the purpose of assessing the accuracy of current and advanced turbulence and scalar transport models. Author

N89-12892*# General Motors Corp., Detroit, MI. Gas Turbine Engine Div.
AEROTHERMAL MODELING PROGRAM, PHASE 2. ELEMENT C: FUEL INJECTOR-AIR SWIRL CHARACTERIZATION
A. A. MOSTAFA, H. C. MONGIA, V. G. MCDONNELL, and G. S. SAMUELSEN *In* NASA, Lewis Research Center, Turbine Engine Hot Section Technology 1986 p 125-131 Oct. 1986
(Contract NAS3-24350)
Avail: NTIS HC A21/MF A01 CSCL 20D

The main objectives of the NASA-sponsored Aerothermal Modeling Program, Phase 2--Element C, are experimental evaluation of the air swirler interaction with a fuel injector in a simulated combustor chamber, assessment of the current two-phase models, and verification of the improved spray evaporation/dispersion models. This experimental and numerical program consists of five major tasks. Brief descriptions of the five tasks are given. Author

N89-12894*# Minnesota Univ., Minneapolis. Dept. of Mechanical Engineering.
EFFICIENT NUMERICAL TECHNIQUES FOR COMPLEX FLUID FLOWS
SUHAS V. PATANKAR *In* NASA, Lewis Research Center, Turbine Engine Hot Section Technology 1986 p 141-143 Oct. 1986
(Contract NAG3-596)
Avail: NTIS HC A21/MF A01 CSCL 20D

The central feature in any flow prediction method is the treatment of the coupling between the momentum and continuity equations. In natural-convection flows, the energy equation also becomes strongly coupled with the momentum equations. Because of the nonlinear nature of the coupling, these equations are solved iteratively. Iterative methods are often prone to slow convergence, divergence, and extreme sensitivity to underrelaxation factors. The aim of the present research is to develop more efficient and reliable solution schemes for the coupled flow equations. Such schemes will significantly reduce the expense of computing complex flows encountered in combustion chambers, gas turbines, heat exchangers, and other practical equipment. In the work completed so far, a technique employing norm reduction in conjunctine with the successive-substitution and Newton-Raphson techniques was developed. Also, a block-correction procedure for the flow equations is currently being formulated and tested. Author

N89-12895*# Avco-Everett Research Lab., MA.
IMPROVED NUMERICAL METHODS FOR TURBULENT VISCOUS RECIRCULATING FLOWS
J. P. VANDOORMAAL, A. TURAN, and G. D. RAITHBY *In* NASA, Lewis Research Center, Turbine Engine Hot Section Technology 1986 p 145-150 Oct. 1986
(Contract NAS3-24351)
Avail: NTIS HC A21/MF A01 CSCL 20D

The objective of the present study is to improve both the accuracy and computational efficiency of existing numerical techniques used to predict viscous recirculating flows in combustors. A review of the status of the study is presented along with some illustrative results. The effort to improve the numerical techniques consists of the following technical tasks: (1) selection of numerical techniques to be evaluated; (2) two dimensional evaluation of selected techniques; and (3) three dimensional evaluation of technique(s) recommended in Task 2. Author

N89-12896*# Tennessee Univ. Space Inst., Tullahoma.
INFLUENCE OF BULK TURBULENCE AND ENTRANCE BOUNDARY LAYER THICKNESS ON THE CURVED DUCT FLOW FIELD
ROGER A. CRAWFORD and CARROLL E. PETERS *In* NASA, Lewis Research Center, Turbine Engine Hot Section Technology 1986 p 151-157 Oct. 1986
(Contract NAG3-617)
Avail: NTIS HC A21/MF A01 CSCL 20D

The objective of this investigation was the experimental evaluation of bulk turbulence and boundary thickness influence on the secondary flow development in a square, 90 deg turning duct. A three dimensional laser velocimetry system was utilized to measure the mean and fluctuating components of velocity in the large curved duct facility. The three dimensional development of the viscous shear layers in the curved duct has a strong influence on the complete flow field. Since ducted three dimensional flows are found in many engineering applications, including gas turbine engines, and contain high turbulence levels and high wall heat transfer rates, they present a difficult challenge to computational fluid mechanics codes. Turbulence modeling remains one of

constraints to CFD advance due to inadequate physical understanding and experimental definition of turbulent shear flows. The results of this investigation expand the curved duct data base to higher turbulence levels and thicker entrance boundary layers. The experimental results provide a challenging benchmark data base for computational fluid dynamics code development and validation. The variation of inlet bulk turbulence intensity provides additional information to aid in turbulence model evaluation.
Author

N89-12897*# United Technologies Research Center, East Hartford, CT.
MEASUREMENT OF AIRFOIL HEAT TRANSFER COEFFICIENTS ON A TURBINE STAGE
ROBERT P. DRING, MICHAEL F. BLAIR, and H. DAVID JOSLYN *In* NASA, Lewis Research Center, Trubine Engine Hot Section Technology 1986 p 159-176 Oct. 1986
(Contract NAS3-2317)
Avail: NTIS HC A21/MF A01 CSCL 20D

The Primary basis for heat transfer analysis of turbine airfoils is experimental data obtained in linear cascades. These data were very valuable in identifying the major heat transfer and fluid flow features of a turbine airfoil. The first program objective is to obtain a detailed set of heat transfer coefficients along the midspan of a stator and a rotor in a rotating turbine stage. The data are to be compared to some standard analysis of blade boundary layer heat transfer which is in use today. A second program objective is to obtain a detailed set of heat transfer coefficients along the midspan of a stator located in the wake of an upstream turbine stage.
E.R.

N89-12898*# Arizona State Univ., Tempe. Dept. of Mechanical and Aerospace Engineering.
HEAT TRANSFER IN THE TIP REGION OF A ROTOR BLADE SIMULATOR
M. K. CHYU, H. K. MOON, and D. E. METZGER *In* NASA, Lewis Research Center, Turbine Engine Hot Section Technology 1986 p 177-192 Oct. 1986
(Contract NAG3-623)
Avail: NTIS HC A21/MF A01 CSCL 20D

In gas turbines, the blades of axial turbine stages rotate in close proximity to a stationary peripheral wall. Differential expansion of the turbine wheel, blades, and the shroud causes variations in the size of the clearance gap between blade tip and stationary shroud. The necessity to tolerate this differential thermal expansion dictates that the clearance gap cannot be eliminated altogether, despite accurate engine machining. Pressure differences between the pressure and suction sides of a blade drives a flow through the clearance gap. This flow, the tip leakage flow, is detrimental to engine performance. The primary detrimental effect of tip leakage flow is the reduction of turbine stage efficiency, and a second is the convective heat transfer associated with the flow. The surface area at the blade tip in contact with the hot working gas represents an additional thermal loading on the blade which, together with heat transfer to the suction and pressure side surface area, must be removed by the blade internal cooling flows. Experimental results concerned with the local heat transfer characteristics on all surfaces of shrouded, rectangular cavities are reported. A brief discussion of the mass transfer system used is given. Author

N89-12899*# Pratt and Whitney Aircraft, East Hartford, CT.
COOLANT PASSAGE HEAT TRANSFER WITH ROTATION
T. J. HAJEK, J. WAGNER, and B. V. JOHNSON *In* NASA, Lewis Research Center, Turbine Engine Hot Section Technology 1986 p 193-206 Oct. 1986
(Contract NAS3-23691)
Avail: NTIS HC A21/MF A01 CSCL 20D

In current and advanced gas turbine engines, increased speeds, pressures and temperatures are used to reduce specific fuel consumption and increase thrust/weight ratios. Hence, the turbine airfoils are subjected to increased heat loads escalating the cooling requirements to satisfy life goals. The efficient use of cooling air requires that the details of local geometry and flow conditions be adequately modeled to predict local heat loads and the corresponding heat transfer coefficients. The objective of this program is to develop a heat transfer and pressure drop data base, computational fluid dynamic techniques and correlations for multi-pass rotating coolant passages with and without flow turbulators. The experimental effort is focused on the simulation of configurations and conditions expected in the blades of advanced aircraft high pressure turbines. With the use of this data base, the effects of Coriolis and buoyancy forces on the coolant side flow can be included in the design of turbine blades. Author

N89-12900*# Stanford Univ., CA. Dept. of Mechanical Engineering.
HEAT TRANSFER WITH VERY HIGH FREE-STREAM TURBULENCE AND STREAMWISE VORTICES
ROBERT J. MOFFAT, PAUL MACIEJEWSKI, JOHN K. EATON, and WAYNE PAULEY *In* NASA, Lewis Research Center, Trubine Engine Hot Section Technology 1986 p 207-217 Oct. 1986
(Contract NAG3-522)
Avail: NTIS HC A21/MF A01 CSCL 20D

Results are presented for two experimental programs related to augmentation of heat transfer by complex flow characteristics. In one program, high free stream turbulence (up to 63 percent) was shown to increase the Stanton number by more than a factor of 5, compared with the normally expected value based on x-Reynolds number. These experiments are being conducted in a free-jet facility, near the margins of the jet. To a limited extent, the mean velocity, turbulence intensity, and integral length scale can be separately varied. The results show that scale is a very important factor in determining the augmentation. Detailed studies of the turbulence structure are being carried out using an orthogonal triple hot-wire anemometer equipped with a fourth wire for measuring temperature. The v' component of turbulence appears to be distributed differently from u' or w'. In the second program, the velocity distributions and boundary layer thicknesses associated with a pair of counter-rotating, streamwise vortices were measured. There is a region of considerably thinned boundary layer between the two vortices when they are of approximately the same strength. If one vortex is much stronger than the other, the weaker vortex may be lifted off the surface and absorbed into the stronger.
Author

N89-12902*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
TURBINE STATOR FLOW FIELD SIMULATIONS
R. C. BUGGELN, W. R. BRILEY, S. J. SHAMROTH, and H. MCDONALD *In* NASA, Lewis Research Center, Trubine Engine Hot Section Technology 1986 p 233-235 Oct. 1986
(Contract NAS3-24358)
Avail: NTIS HC A21/MF A01 CSCL 20D

The increased capability and accessibility of modern computers, coupled with increasingly sophisticated and accurate numerical and physical modeling, has led to a marked impact of numerical simulations upon current turbine design and research problems. The turbine section represents a considerable challenge as it contains significant regions of complex three-dimensional flow, including both aerodynamic and heat transfer phenomena. The focus of the present effort is the development of an efficient and accurate three-dimensional Navier-Stokes calculation procedure for application to the turbine stator and rotor problems. In particular, an effective procedure is sought which: (1) adequately represents the flow physics, (2) allows for sufficient resolution in regions of small length scale, and (3) has sufficiently good convergence properties so as to allow use on a regular basis. Author

N89-12906*# General Electric Co., Fairfield, CT.
ON 3D INELASTIC ANALYSIS METHODS FOR HOT SECTION COMPONENTS
R. L. MCKNIGHT, P. C. CHEN, L. T. DAME, R. V. HOLT, H. HUANG, M. HARTLE, S. GELLIN, D. H. ALLEN, and W. E. HAISLER *In* NASA, Lewis Research Center, Turbine Engine Hot Section Technology 1986 p 257-268 Oct. 1986

(Contract NAS3-23698)
Avail: NTIS HC A21/MF A01 CSCL 20K

Accomplishments are described for the 2-year program, to develop advanced 3-D inelastic structural stress analysis methods and solution strategies for more accurate and cost effective analysis of combustors, turbine blades and vanes. The approach was to develop a matrix of formulation elements and constitutive models. Three constitutive models were developed in conjunction with optimized iterating techniques, accelerators, and convergence criteria within a framework of dynamic time incrementing. Three formulations models were developed; an eight-noded mid-surface shell element, a nine-noded mid-surface shell element and a twenty-noded isoparametric solid element. A separate computer program was developed for each combination of constitutive model-formulation model. Each program provides a functional stand alone capability for performing cyclic nonlinear structural analysis. In addition, the analysis capabilities incorporated into each program can be abstracted in subroutine form for incorporation into other codes or to form new combinations. Author

N89-12909*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
THERMOMECHANICAL CHARACTERIZATION OF HASTELLOY-X UNDER UNIAXIAL CYCLIC LOADING
J. R. ELLIS, P. A. BARTOLOTTA, G. P. ALLEN, and D. N. ROBINSON (Akron Univ., Ohio.) *In its* Turbine Engine Hot Section Technology 1986 p 293-305 Oct. 1986
Avail: NTIS HC A21/MF A01 CSCL 20K

In most high-temperature engineering applications, components are subjected to complex combinations of thermal and mechanical loading during service. A number of viscoplastic constitutive models were proposed which potentially can provide mathematical descriptions of material response under such conditions. Implementation of these models into large finite element codes such as MARC has already resulted in much improved inelastic analysis capability for hot-section aircraft engine components. However, a number of questions remain regarding the validity of methods adopted in characterizing these constitutive models for particular high-temperature materials. One area of concern is that the majority of experimental data available for this purpose are determined under isothermal conditions. This is in contrast to service conditions which, as noted above, almost always involve some form of thermal cycling. The obvious question arises as to whether a constitutive model characterized using an isothermal data base can adequately predict material response under thermomechanical conditions. An experimental program was initiated within the HOST program to address this particular concern. The results of the most recent isothermal and thermomechanical experiments are described. Author

N89-12913*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
HIGH TEMPERATURE STRESS-STRAIN ANALYSIS
ROBERT L. THOMPSON and PAUL E. MOORHEAD *In its* Turbine Engine Hot Section Technology 1986 p 341-357 Oct. 1986
Avail: NTIS HC A21/MF A01 CSCL 20K

The objectives of the high-temperature structures program are threefold: to assist in the development of analytical tools needed to improve design analyses and procedures for the efficient and accurate prediction of the nonlinear structural response of hot-section components; to aid in the calibration, validation, and evaluation of the analytical tools by comparing predictions with experimental data; and to evaluate existing as well as advanced temperature and strain measurement instrumentation. As the analytical tools, test methods, tests, instrumentations, as well as data acquisition, management, and analysis methods are developed and evaluated, a proven, integrated analysis and experiment method will result in a more accurate prediction of the cyclic life of hot section components. Author

N89-12914*# Pratt and Whitney Aircraft, East Hartford, CT.
CREEP FATIGUE LIFE PREDICTION FOR ENGINE HOT SECTION MATERIALS (ISOTROPIC): FOURTH YEAR PROGRESS REVIEW
RICHARD S. NELSON and JOHN F. SCHOENDORF *In* NASA, Lewis Research Center, Turbine Engine Hot Section Technology 1986 p 359-370 Oct. 1986
(Contract NAS3-23288)
Avail: NTIS HC A21/MF A01 CSCL 14D

As gas turbine technology continues to advance, the need for advanced life prediction methods for hot section components is becoming more and more evident. The complex local strain and temperature histories at critical locations must be accurately interpreted to account for the effects of various damage mechanisms (such as fatigue, creep, and oxidation) and their possible interactions. As part of the overall NASA HOST effort, this program is designed to investigate these fundamental damage processes, identify modeling strategies, and develop practical models which can be used to guide the early design and development of new engines and to increase the durability of existing engines. Author

N89-12915*# General Electric Co., Fairfield, CT.
ELEVATED TEMPERATURE CRACK GROWTH
S. N. MALIK, R. H. VANSTONE, K. S. KIM, and J. H. LAFLEN *In* NASA, Lewis Research Center, Turbine Engine Hot Section Technology 1986 p 371-383 Oct. 1986
(Contract NAS3-23940)
Avail: NTIS HC A21/MF A01 CSCL 20K

It is necessary to relate the processes that control crack growth in the immediate vicinity of the crack tip to parameters that can be calculated from remote quantities, such as forces, stresses, or displacements. The most likely parameters appear to be certain path-independent (PI) integrals, several of which have already been proposed for application to high temperature inelastic problems. The ability of currently available PI-integrals to correlate fatigue crack propagation under conditions that simulate the engine combustor liner environment was determined. The utility of advanced fracture mechanics measurements will also be evaluated and determined during the course of the program. E.R.

N89-12916*# Pratt and Whitney Aircraft, East Hartford, CT.
LIFE PREDICTION AND CONSTITUTIVE MODELS FOR ENGINE HOT SECTION
G. A. SWANSON, T. G. MEYER, and D. M. NISSLEY *In* NASA, Lewis Research Center, Turbine Engine Hot Section Technology 1986 p 385-397 Oct. 1986
(Contract NAS3-23939)
Avail: NTIS HC A21/MF A01 CSCL 14D

The purpose of this program is to develop life prediction models for coated anisotropic materials used in gas turbine airfoils. In the program, two single crystal alloys and two coatings are being tested. These include PWA 1480, Alloy 185, overlay coating (PWA 286), and aluminide coating (PWA 273). Constitutive models are also being developed for these materials to predict the time independent (plastic) and time dependent (creep) strain histories of the materials in the lab tests and for actual design conditions. This nonlinear material behavior is particularly important for high temperature gas turbine applications and is basic to any life prediction system. Some of the accomplishments of the program are highlighted. Author

N89-12923*# Old Dominion Univ., Norfolk, VA. Dept. of Mechanical Engineering and Mechanics.
PREDICTION OF STRESSES IN AIRCRAFT PANELS SUBJECTED TO ACOUSTIC FORCES Final Report, 1 Oct. 1985 - 15 Dec. 1987
CHUH MEI Mar. 1988 13 p
(Contract NAS1-17993)
(NASA-CR-182513; NAS 1.26:182513) Avail: NTIS HC A03/MF A01 CSCL 20K

Summarized are the progress and accomplishments performed under NASA/Langley Research Center Master Agreement

NAS1-17993, Task Assignment No. 22, entitled Prediction of Stresses in Aircraft Panels Subjected to Acoustic Forces, for the period October 1, 1985 to December 15, 1987. The primary effort of this task is the development of analytical methods for prediction of stresses in aircraft panels subjected to acoustic forces. The progress and accomplishments of various activities are discussed first. Then, publications, presentations and thesis are presented. Author

N89-13038# Helsinki Univ. of Technology, Espoo (Finland). Dept. of Space Technology.
A 35 GHZ HELICOPTER-BORNE POLARIMETER RADAR
M. T. HALLIKAINEN and J. T. PULLIAINEN *In* ESA, Proceedings of the 1988 International Geoscience and Remote Sensing Symposium (IGARSS 1988) on Remote Sensing: Moving Towards the 21st Century, Volume 1 p 423-424 Aug. 1988
Avail: NTIS HC A99/MF E03; ESA Publications Div., ESTEC, Noordwijk, Netherlands, 120 US dollars or 250 Dutch guilders

A helicopter-borne 35-GHz polarimeter radar is described. An HP 8753A network analyzer is employed in the system as a signal generator and processing unit. The 1 to 3 GHz signal from the network analyzer is up-converted to the 35 to 37 GHz band for transmission. The backscattered signal is down-converted and then processed by the network analyzer. The HP 8753A complex math operation capability includes subtraction of background or leakage noise (from within the system) from the return signal, and averaging of several measurements. These features along with the 90 dB dynamic range and the range-gating capability make the polarimeter radar suitable for several applications. ESA

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GEOSCIENCES

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

A89-13506*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
WINDSHEAR DETECTION AND AVOIDANCE - AIRBORNE SYSTEMS PERSPECTIVE
ROLAND L. BOWLES (NASA, Langley Research Center, Hampton, VA) and RUSSELL TARG (Lockheed Missiles and Space Co., Inc., Research and Development Div., Palo Alto, CA) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 7-20. refs

The generalized windshear hazard index presently defined is derived from aircraft-position wind data and remotely sensed data obtained along the extended flight path by such candidate sensor technologies as microwave Doppler radar, Doppler lidar, and IR radiometry. Attention is given here to the results of a comparative evaluation of CO2 and Ho:YAG lidar sensor-employing windshear-detection systems, over a range 1-3 km ahead of the aircraft (corresponding to 15-45 sec of warning time). While the technology for a 10.6-micron CO2 lidar system is available, an optimum 2-micron REE laser crystal-based system remains to be developed. O.C.

A89-13547#
AIRBUS AIRBORNE WINDSHEAR SYSTEM AND WINDSHEAR WARNING DESIGN PROCESS
PAUL CAMUS (Airbus Industrie, Blagnac, France) and JEAN-LOUIS BONAFE (Aerospatiale, Toulouse, France) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 463-467.

The evolution of the Airbus windshear protection system is described. Windshear and downburst and some basic methods for dealing with them while airborne are briefly reviewed. The design process for the Airbus protection system is outlined, giving targets for performance and nuisance. A comparison with the Aerospatiale approach to windshear protection is made. C.D.

A89-15090
COMPARISONS OF CALCULATION METHODS FOR DETERMINING ATMOSPHERIC ABSORPTION OF SOUND EMITTED BY AIRCRAFT
CURTIS HOLSCLAW (Douglas Aircraft Co., Long Beach, CA) IN: NOISE-CON 88 - Noise control design: Methods and practice; Proceedings of the National Conference on Noise Control Engineering, West Lafayette, IN, June 20-22, 1988. Poughkeepsie, NY, Institute of Noise Control Engineering, 1988, p. 229-234.

Actual flyover noise data are used to compare sound pressure level, maximum tone-corrected perceived noise level, and effective perceived noise level data when the data correction methods described in ARP 866A, ANSI S1.26-1978, and ISO/DP 9613/1 are employed to perform the atmospheric absorption corrections from test-day weather to reference-day weather (77 F, 70 pct RH). Results indicate that, for the given cases, ARP 866A provides slightly lower level spectral data than that obtained with the other methods. B.J.

A89-15706#
CRITICAL SPEED DATA FOR MODEL FLOATING ICE ROADS AND RUNWAYS
M. J. HINCHEY (Newfoundland, Memorial University, Saint John's, Canada) and J. WHITTEN (Canadian Air Cushion Technology Society, International Conference on Air Cushion Technology, Montreal, Canada, Sept. 22-24, 1987) Canadian Aeronautics and Space Journal (ISSN 0008-2821), vol. 34, Sept. 1988, p. 151-161. refs
(Contract NSERC-A-4955)

Transport operators in northern regions who use floating ice roads and runways have been aware of a critical speed phenomenon for many years. At the critical speed, large amplitude flexural-gravity waves are generated by the motion over the sheet. For obvious reasons, operators try to avoid operation at this speed. To study this phenomenon, an artificial ice sheet, constructed from sheets of styrofoam, was installed in the wave tank at Memorial University. The tank's towing carriage was used to move various loads over the sheet. For each load, measurements were made of the sheet deflections generated. The paper describes the details of this work. It shows that a thin plate model for the floating ice sheet explains much of what was seen in the experiments. The work has implications for high speed hovercraft icebreaking and these are also discussed. Author

A89-15876* Lockheed Missiles and Space Co., Palo Alto, CA.
WINDSHEAR AVOIDANCE - REQUIREMENTS AND PROPOSED SYSTEM FOR AIRBORNE LIDAR DETECTION
RUSSELL TARG (Lockheed Missiles and Space Co., Inc., Research and Development Div., Palo Alto, CA) and ROLAND L. BOWLES (NASA, Langley Research Center, Hampton, VA) IN: Airborne and spaceborne lasers for terrestrial geophysical sensing; Proceedings of the Meeting, Los Angeles, CA, Jan. 14, 15, 1988. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1988, p. 54-64. refs

A generalized windshear hazard index is derived from considerations of wind conditions and an aircraft's present and potential altitude. Based on a systems approach to the windshear threat, lidar appears to be a viable methodology for windshear detection and avoidance, even in conditions of moderately heavy precipitation. The airborne CO2 and Ho:YAG lidar windshear detection systems analyzed can each give the pilot information about the line-of-sight component of windshear threat from his present position to a region extending 1 to 3 km in front of the aircraft. This constitutes a warning time of 15 to 45 s. The technology necessary to design, build and test such a brassboard 10.6-micron CO2 lidar is at hand. Author

N89-13125# National Weather Service, Garden City, NY.
TURB: TURBULENCE FORECASTING FOR SMALL/MEDIUM AND LARGE AIRCRAFT
STEVEN J. NAGLIC Jul. 1988 52 p
(PB88-246368; NOAA-NWS-ERCP-44) Avail: NTIS HC A04/MF A01 CSCL 04B

The program was developed to provide Center Weather Service Unit (CWSU) meteorologists and FAA flight service station personnel with a local product they can use to describe areas of significant turbulence. The program takes upper air data from any raob site, processes it, and generates a turbulence forcast for the areas within a 100 nm radius from the raob site. This information is quite valuable to the CWSU meteorologists as their forecasts, meteorological impact statements, and center weather advisories are used by the FAA for planning purposes and for the routing or rerouting of air traffic. The forecast product gives the layers analyzed in thousands of feet, the wind shear per thousand feet, and the turbulence forecast for small/medium aircraft and large aircraft. GRA

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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.

A89-13073
SOLUTION OF 2-D EULER EQUATIONS WITH A PARALLEL CODE
H. CAPDEVILA (DFVLR, Institut fuer Entwurfsaerodynamik, Brunswick, Federal Republic of Germany) (International SUPRENUM Colloquium, 2nd, Bonn, Federal Republic of Germany, Sept. 30-Oct. 2, 1987) Parallel Computing (ISSN 0167-8191), vol. 7, Sept. 1988, p. 451-460. refs

A parallel program for the simulation of inviscid fluid flow around airfoils, based on the solution of unsteady Euler equations, is presented. The concept of domain splitting and its connection with the selected parallelization strategy is outlined. Furthermore, the implementation of the algorithm within the SUPRENUM environment as well as the treatment given to interprocess communication are also discussed. Finally, code development, use of simulation systems, and preliminary validation tests are examined. Author

A89-13592*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
ACCURACY VERSUS CONVERGENCE RATES FOR A THREE DIMENSIONAL MULTISTAGE EULER CODE
ELI TURKEL (NASA, Langley Research Center, Hampton, VA; Tel Aviv University, Israel) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 892-897. Previously announced in STAR as N88-23519. refs

Using a central difference scheme, it is necessary to add an artificial viscosity in order to reach a steady state. This viscosity usually consists of a linear fourth difference to eliminate odd-even oscillations and a nonlinear second difference to suppress oscillations in the neighborhood of steep gradients. There are free constants in these differences. As one increases the artificial viscosity, the high modes are dissipated more and the scheme converges more rapidly. However, this higher level of viscosity smooths the shocks and eliminates other features of the flow. Thus, there is a conflict between the requirements of accuracy and efficiency. Examples are presented for a variety of three-dimensional inviscid solutions over isolated wings. Author

A89-13598*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
SENSITIVITY ANALYSIS AND MULTIDISCIPLINARY OPTIMIZATION FOR AIRCRAFT DESIGN - RECENT ADVANCES AND RESULTS
JAROSLAW SOBIESZCZANSKI-SOBIESKI (NASA, Langley Research Center, Hampton, VA) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 953-964. Previously announced in STAR as N88-23766. refs

Optimization by decomposition, complex system sensitivity analysis, and a rapid growth of disciplinary sensitivity analysis are some of the recent developments that hold promise of a quantum jump in the support engineers receive from computers in the quantitative aspects of design. Review of the salient points of these techniques is given and illustrated by examples from aircraft design as a process that combines the best of human intellect and computer power to manipulate data. Author

A89-13608#
TOWARDS A GENERAL THREE-DIMENSIONAL GRID GENERATION SYSTEM
L. G. TYSELL and S. G. HEDMAN (Flygtekniska Forsoksanstalten, Stockholm, Sweden) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 1048-1058. Research supported by the Styrelsen for Teknisk Utveckling. refs

The first version of a general purpose three-dimensional grid generation program system has been developed. The program is interactive and very user-friendly. It can be applied to two- or three-dimensional grids. The grid can be composed of a number of blocks, both patched and overlaid grids, where each block can have its own topology. The patched grid blocks can be either continuous or discontinuous at the block interfaces. The grid is generated by means of transfinite interpolation. A procedure for smoothing of the normal vectors to a surface is presented, as well as a procedure for smoothing of grids. Grid generation routines developed for special applications can be added to the program. The program can also be used to postprocess grids from, or preprocess grids to, other grid generation programs. An example with a grid around a wing-body configuration is given. Author

A89-13617#
THE DESIGN, DEVELOPMENT AND INTEGRATION OF THE COMPLEX AVIONICS SYSTEMS
P. SCHIRLE (Avions Marcel Dassault Breguet Aviation, Saint-Cloud, France) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 1155-1163.

An account is given of a major French military aircraft manufacturer's digital avionics development methodology; such avionics have of late reached a level of complexity at which they constitute half the cost of a fighter aircraft. Attention must be given to such factors as quality assurance in the design of software tools useful as development aids. The development method encompasses global definition of the avionics, a functional analysis of the system's architecture, detailed functional specifications, functional validation of the equipment, system verification on an integration bench, and system verification in a test aircraft. O.C.

A89-13623*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
NAS - THE FIRST YEAR
F. R. BAILEY and PAUL KUTLER (NASA, Ames Research Center, Moffett Field, CA) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 1210-1223. Previously announced in STAR as N88-25196. refs

Discussed are the capabilities of NASA's Numerical Aerodynamic Simulation (NAS) Program and its application as an

advanced supercomputing system for computational fluid dynamics (CFD) research. First, the paper describes the NAS computational system, called the NAS Processing System Network, and the advanced computational capabilities it offers as a consequence of carrying out the NAS Pathfinder objective. Second, it presents examples of pioneering CFD research accomplished during NAS's first operational year. Examples are included which illustrate CFD applications for predicting fluid phenomena, complementing and supplementing experimentation, and aiding in design. Finally, pacing elements and future directions for CFD and NAS are discussed.
Author

A89-13625#
MANAGING CFD IN INDUSTRY
R. H. WICKEMEYER (Boeing Commercial Airplane Co., Seattle, WA) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 1237-1243. refs

The evolution of CFD codes from research to application is discussed, and the roles played by the developer, the applications specialist, and the code user are identified. Several brief examples of successful CFD aerodynamics applications are included to illustrate the benefits achievable from a CFD analysis. Future requirements for CFD applications are discussed to point out the need for improved CFD management in the aerospace industry.
C.D.

A89-16155#
FAILURE DETECTION IN DYNAMIC SYSTEMS WITH MODELING ERRORS
DAN T. HORAK (Allied-Signal Aerospace Co., Columbia, MD) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 11, Nov.-Dec. 1988, p. 508-516. Previously cited in issue 22, p. 3640, Accession no. A87-50565. refs

A89-16511*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
AN INTERACTIVE GRID GENERATION TECHNIQUE FOR FIGHTER AIRCRAFT GEOMETRIES
ROBERT E. SMITH and ERIC L. EVERTON (NASA, Langley Research Center, Hampton, VA) International Conference on Numerical Grid Generation in Computational Fluid Dynamics, 2nd, Miami, FL, Dec. 5-8, 1988, Paper. 13 p. refs

This paper describes an interactive procedure to construct grids about fighter aircraft using a state-of-the-art workstation. The aircraft are characterized by a fuselage with an integrated canopy over the cockpit, an engine inlet, an area ruled midsection, canards, and highly-swept cranked delta wings or strakes integrated into the wings and tail surfaces. The grid topology, configuration surface grid, exterior grid computation, and computational interactive process are addressed.
C.D.

A89-16512*# Virginia Polytechnic Inst. and State Univ., Blacksburg.
APPLICATIONS OF AN ARCHITECTURE DESIGN AND ASSESSMENT SYSTEM (ADAS)
F. GAIL GRAY, LINDA S. DEBRUNNER, and TENNIS S. WHITE (Virginia Polytechnic Institute and State University, Blacksburg) 1988 Annual International Symposium on Computer Architecture, 15th, Honolulu, HI, May 30-June 2, 1988, Paper. 24 p. refs
(Contract NAS1-17964)

A new Architecture Design and Assessment System (ADAS) tool package is introduced, and a range of possible applications is illustrated. ADAS was used to evaluate the performance of an advanced fault-tolerant computer architecture in a modern flight control application. Bottlenecks were identified and possible solutions suggested. The tool was also used to inject faults into the architecture and evaluate the synchronization algorithm, and improvements are suggested. Finally, ADAS was used as a front end research tool to aid in the design of reconfiguration algorithms in a distributed array architecture.
C.D.

A89-16518* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
THE ROLE OF SPECIALIZED PROCESSORS IN THE NAS PROGRAM - RETROSPECTIVE/PROSPECTIVE
EUGENE LEVIN and FRANK PRESTON (NASA, Ames Research Center, Moffett Field, CA) IN: Multiprocessors and array processors. La Jolla, CA, Society for Computer Simulation, 1988, p. 47, 49-51. refs
(Contract NCC2-431)

The Numerical Aerodynamic Simulation (NAS) Program was initiated by NASA to establish a national resource for scientific research and engineering applications of computational fluid dynamics. This paper examines the changing views of the roles of general purpose and special purpose processors in this program in response to changes in technology as well as changes in perceived needs. The time period covered extends from more than 10 years ago, through the present, and concludes with some speculative concepts for the future roles of specialized processors in the advanced NAS system.
Author

N89-12231# Air Force Inst. of Tech., Wright-Patterson AFB, OH. School of Engineering.
APPLICATION OF LINEARIZED KALMAN FILTER-SMOOTHER TO AIRCRAFT TRAJECTORY ESTIMATION M.S. Thesis
JAMES M. RULEY Jun. 1988 161 p
(AD-A194362; AFIT/GAE/ENG/88J-1) Avail: NTIS HC A08/MF A01 CSCL 01C

The purpose of this study was to investigate the potential utility of the linearized Kalman filter-smoother as a tool for aircraft mishap investigations. The intention was to produce a computer analysis tool which could accurately reproduce the forcing functions required to generate a specified aircraft trajectory. This information is often of value to mishap investigation boards in determining probable pilot actions. The resulting algorithm was subjected to a noise strength sensitivity study, a measurement device precision study, and a study to determine the effects of multiple iterations of the algorithm. The evaluation showed that the algorithm performed well and generated useful results. However, limitations in the current implementation were discovered. As a result of these, the systematic generation of nominal trajectories and elimination of unrealistic output transients were identified as topics for further study.
GRA

N89-12234*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
A METHOD FOR MONITORING THE VARIABILITY IN NUCLEAR ABSORPTION CHARACTERISTICS OF AVIATION FUELS
DANNY R. SPRINKLE and CHIH-PING SHEN (Old Dominion Univ., Norfolk, Va.) 1988 28 p
(NASA-TM-4077; L-16497; NAS 1.15:4077) Avail: NTIS HC A03/MF A01 CSCL 09B

A technique for monitoring variability in the nuclear absorption characteristics of aviation fuels has been developed. It is based on a highly collimated low energy gamma radiation source and a sodium iodide counter. The source and the counter assembly are separated by a geometrically well-defined test fuel cell. A computer program for determining the mass attenuation coefficient of the test fuel sample, based on the data acquired for a preset counting period, has been developed and tested on several types of aviation fuel.
Author

N89-12238# National Aeronautical Lab., Bangalore (India). Systems Engineering Div.
ESTIMATION OF STATES OF AIRCRAFTS BY KALMAN FILTERING ALGORITHMS
V. PARAMESWARAN, U. C. NIRANJAN, and J. R. RAOL Jul. 1988 34 p
(PD-SE-8810) Avail: NTIS HC A03/MF A01

The theory of optimal estimation has applications to a broad range of problem areas. Given the system model and noisy measurements, with known statistical properties of the noise in system dynamics and measurement devices, and initial condition information, an optimal state estimation algorithm obtains minimal variance estimates of the states of a linear system. State estimation techniques find extensive use in many areas: chemical processes, nuclear reactors, telecommunications, and aerospace vehicles. The problem of estimation of states of aircrafts is addressed using both real and simulated data. The data used for state estimation pertained to both short period and phugoid longitudinal modes of the aircraft. The state model used in the filter algorithm makes use of the parameters determined from the simulated/real data by maximum likelihood estimation (MLE) algorithm. The state estimation becomes necessary in case of postflight data analysis. This is because the acquired data are contaminated by random noise, measurement errors and biases. In this context, it was felt necessary to develop and utilize Kalman filter type algorithms to serve the need as starting and complementary algorithms for obtaining complete analysis of postflight data. A recent algorithm based on the concept of modifiable nonlinearity has been employed to handle real flight data, not only to filter the states (prefiltering mode) but also to estimate stability and control derivatives of an aircraft (complementary mode to MLE). Author

N89-12309*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

AN EXPERT SYSTEM FOR RESTRUCTURABLE CONTROL

JONATHAN LITT 1988 9 p Prepared in cooperation with Army Aviation Research and Development Command, Cleveland, Ohio

(NASA-TM-101378; E-4433; NAS 1.15:101378; AVSCOM-TR-88-C-023) Avail: NTIS HC A02/MF A01 CSCL 09B

Work in progress on an expert system which restructures and tunes control systems on-line is presented. The expert system coordinates the different methods for redesigning and implementing the control strategies due to system changes. The research is directed toward aircraft and jet engine applications. The implementation is written in LISP and is currently running on a special purpose LISP machine. Author

N89-12335# National Aerospace Lab., Amsterdam (Netherlands). Informatics Div.

MULTIGRID METHODS IN BOUNDARY ELEMENT CALCULATIONS

H. SCHIPPERS 16 Apr. 1987 22 p Presented at the 9th International Conference on Boundary Element Methods in Engineering, Stuttgart, Fed. Republic of Germany, 31 Aug.-4 Sep. 1987

(NLR-MP-87025-U; B8807287; ETN-88-93393) Avail: NTIS HC A03/MF A01

Multigrid iterative methods are advocated for the fast solution of algebraic systems occurring in boundary element calculations. Multigrid methods combine relaxation schemes for reducing high-frequency errors and coarse grid corrections for diminishing low-frequency errors. The choice of the relaxation scheme is found to be essential to attain a fast convergent iterative process. Asymptotically, the multigrid method needs only two iterations to obtain a result of the order of the truncation error. The fast convergence, however, may break down if the relaxation scheme does not account for boundary singularities such as corners and edges. This is illustrated for the calculation of potential flow around an airfoil. 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.

A89-13351

EXPERIMENTAL INVESTIGATION OF THE CHARACTERISTICS OF THE INTERACTION BETWEEN GAS MOLECULES AND THE WALLS OF CYLINDRICAL CHANNELS IN THE CASE OF GRAZING INCIDENCE [EKSPERIMENTAL'NOE ISSLEDOVANIE KHARAKTERA VZAIMODEISTVIIA MOLEKUL GAZA SO STENKAMI TSILINDRICHESKIKH KANALOV PRI SKOL'ZIASHCHEM PADENII]

I. N. DUBROVSKAIA, B. B. STARIKOV, and A. A. SHMITT IN: The dynamics of homogeneous and inhomogeneous media. *Leningrad, Izdatel'stvo Leningradskogo Universiteta, 1987, p.* 172-176. In Russian.

The paper describes a hypersonic-flow facility for investigating the interaction between a gas and the walls of cylindrical channels in the case of grazing incidence. Based on the experimental data, the transit probability of molecules through the channel for different angles of attack is determined. A comparison between experimental results and theoretical relationships indicates that the specular-diffusion interaction scheme is inapplicable in this case. B.J.

A89-14988* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

A NEW DIAGNOSTIC METHOD FOR SEPARATING AIRBORNE AND STRUCTUREBORNE NOISE RADIATED BY PLATES WITH APPLICATIONS FOR PROPELLER DRIVEN AIRCRAFT

MICHAEL C. MCGARY (NASA, Langley Research Center, Hampton, VA) Acoustical Society of America, Journal (ISSN 0001-4966), vol. 84, Sept. 1988, p. 830-840. refs

The anticipated application of advanced turboprop propulsion systems is expected to increase the interior noise of future aircraft to unacceptably high levels. The absence of technically and economically feasible noise source-path diagnostic tools has been a prime obstacle in the development of efficient noise control treatments for propeller-driven aircraft. A new diagnostic method that permits the separation and prediction of the fully coherent airborne and structureborne components of the sound radiated by plates or thin shells has been developed. Analytical and experimental studies of the proposed method were performed on an aluminum plate. The results of the study indicate that the proposed method could be used in flight, and has fewer encumbrances than the other diagnostic tools currently available. Author

A89-15076

NOISE-CON 88 - NOISE CONTROL DESIGN: METHODS AND PRACTICE; PROCEEDINGS OF THE NATIONAL CONFERENCE ON NOISE CONTROL ENGINEERING, PURDUE UNIVERSITY, WEST LAFAYETTE, IN, JUNE 20-22, 1988

STUART J. BOLTON, ED. (*Purdue University, West Lafayette, IN*) Conference sponsored by Purdue University and Institute of Noise Control Engineering. Poughkeepsie, NY, Institute of Noise Control Engineering, 1988, 655 p. For individual items see A89-15077 to A89-15101.

Papers are presented on such topics as noise generation and control; noise control elements; and generation, transmission, isolation, and reduction of vibration. Consideration is given to methods of noise analysis, and to the physical aspects of environmental noise (multiple sources and paths). B.J.

A89-15081

CASCADE AEROACOUSTICS INCLUDING STEADY LOADING EFFECTS

HSIAO-WEI D. CHIANG and SANFORD FLEETER (Purdue

University, West Lafayette, IN) IN: NOISE-CON 88 - Noise control design: Methods and practice; Proceedings of the National Conference on Noise Control Engineering, West Lafayette, IN, June 20-22, 1988. Poughkeepsie, NY, Institute of Noise Control Engineering, 1988, p. 137-142.

A mathematical model is developed to analyze the effects of airfoil and cascade geometry, steady aerodynamic loading, and the characteristics of the unsteady flow field on the discrete frequency noise generation of a blade row in an incompressible flow. The unsteady lift which generates the noise is predicted with a complex first-order cascade convected gust analysis. This model was then applied to the Gostelow airfoil cascade and variations, demonstrating that steady loading, cascade solidity, and the gust direction are significant. Also, even at zero incidence, the classical flat plate cascade predictions are unacceptable.
Author

A89-15082
NONUNIFORM UPSTREAM AIRFOIL SPACING EFFECTS ON ROTOR BLADE NOISE GENERATION AND FORCED RESPONSE
JOHN R. FAGAN and SANFORD FLEETER (Purdue University, West Lafayette, IN) IN: NOISE-CON 88 - Noise control design: Methods and practice; Proceedings of the National Conference on Noise Control Engineering, West Lafayette, IN, June 20-22, 1988. Poughkeepsie, NY, Institute of Noise Control Engineering, 1988, p. 143-148. refs

A mathematical model is developed to investigate the influence of altering the harmonic content of the inlet flow field to a rotor blade row on noise generation and forced response. This is effected by periodic nonuniform circumnferential spacing of the airfoils in the upstream row. The beneficial effects of such spacing are demonstrated by applying this model to a modern compressor configuration and counterrotating turboprop geometry. B.J.

A89-15083* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
EFFECT OF AERODYNAMIC DETUNING ON SUPERSONIC ROTOR DISCRETE FREQUENCY NOISE GENERATION
D. HOYNIAK and SANFORD FLEETER (NASA, Lewis Research Center, Cleveland, OH) IN: NOISE-CON 88 - Noise control design: Methods and practice; Proceedings of the National Conference on Noise Control Engineering, West Lafayette, IN, June 20-22, 1988. Poughkeepsie, NY, Institute of Noise Control Engineering, 1988, p. 149-154.

A mathematical model was developed to predict the effect of alternate blade circumferential aerodynamic detuning on the discrete frequency noise generation of a supersonic rotor. Aerodynamic detuning was shown to have a small beneficial effect on the noise generation for reduced frequencies less than 3. For reduced frequencies greater than 3, however, the aerodynamic detuning either increased or decreased the noise generated, depending on the value of the reduced frequency. B.J.

A89-15084
A PARAMETRIC STUDY OF TRANSONIC BLADE-VORTEX INTERACTIONS
A. S. LYRINTZIS (Syracuse University, NY) and A. R. GEORGE (Cornell University, Ithaca, NY) IN: NOISE-CON 88 - Noise control design: Methods and practice; Proceedings of the National Conference on Noise Control Engineering, West Lafayette, IN, June 20-22, 1988. Poughkeepsie, NY, Institute of Noise Control Engineering, 1988, p. 155-160. Research supported by McDonnell Douglas Helicopter Co. refs

A novel Kirchhoff method of extending computed nonlinear two-dimensional near field aerodynamic results to the linear three-dimensional acoustic far field is developed. Good results were obtained on exact linear test cases and in matching Kirchhoff and numerically computed results in their regions of overlapping validity for transonic blade-vortex interactions (BVI). Explanations are presented for many of the factors involved in the origin of the propagating BVI waves. B.J.

A89-15085
TWO PHASE FLOW NOISE
WILLIAM K. BLAKE, HUGH HEMINGWAY, and THOMAS C. MATHEWS (David W. Taylor Naval Ship Research and Development Center, Bethesda, MD) IN: NOISE-CON 88 - Noise control design: Methods and practice; Proceedings of the National Conference on Noise Control Engineering, West Lafayette, IN, June 20-22, 1988. Poughkeepsie, NY, Institute of Noise Control Engineering, 1988, p. 167-172. refs

Research on cavitation and bubble noise is reviewed. In the case of cavitation, real fluid effects determine the inception as well as the details of the collapse dynamics that control the high-frequency sound. Noncavitating bubble noise is also dependent on the details of formation and splitting as determined by the liquid-phase dynamics. B.J.

A89-15088
SOUND TRANSMISSION INTO A FINITE, CLOSED, CYLINDRICAL SHELL HAVING AN ABSORBING LAYER ON ITS INNER SURFACE
L. R. KOVAL and C. D. LEE (Missouri-Rolla, University, Rolla) IN: NOISE-CON 88 - Noise control design: Methods and practice; Proceedings of the National Conference on Noise Control Engineering, West Lafayette, IN, June 20-22, 1988. Poughkeepsie, NY, Institute of Noise Control Engineering, 1988, p. 211-216. refs

A mathematical model for the noise reduction of a finite closed cylindrical shell with an absorptive layer on the inside surface of the shell wall is developed with allowance for the pressure contribution due to the pressure of the rigid end caps. The effect of the additional pressure due to the rigid end caps was shown to decrease the noise reduction of the cylindrical shell, as was expected. The results are pertinent to the transmission of airborne noise into an aircraft fuselage. B.J.

A89-15089* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
MECHANISMS OF NOISE CONTROL INSIDE A FINITE CYLINDER
H. C. LESTER (NASA, Langley Research Center, Hampton, VA) IN: NOISE-CON 88 - Noise control design: Methods and practice; Proceedings of the National Conference on Noise Control Engineering, West Lafayette, IN, June 20-22, 1988. Poughkeepsie, NY, Institute of Noise Control Engineering, 1988, p. 217-222. refs

Preliminary results are presented for a simple elastic cylinder/acoustic cavity model. The validity of the mode matching method, which was used to couple the shell vibrations to the interior acoustic response, has been validated by comparison with Junger's (1985) method. In addition, the importance of both structural and acoustic damping in the medium response was shown to be dramatic. B.J.

A89-15091* Lockheed Aeronautical Systems Co., Burbank, CA.
TRANSMISSION LOSS OF DOUBLE WALL PANELS CONTAINING HELMHOLTZ RESONATORS
R. A. PRYDZ, H. L. KUNTZ, D. L. MORROW, and L. S. WIRT (Lockheed Aeronautical Systems Co., Burbank, CA) IN: NOISE-CON 88 - Noise control design: Methods and practice; Proceedings of the National Conference on Noise Control Engineering, West Lafayette, IN, June 20-22, 1988. Poughkeepsie, NY, Institute of Noise Control Engineering, 1988, p. 243-248. (Contract NAS1-18036)

Data and an analysis are presented on the use of Helholtz resonators in double wall panels (i.e., aircraft sidewalls). Several wall materials and resonator configurations were tested, and the resonators were found to substantially increase the transmission loss of the double wall system at the tuning frequency. B.J.

A89-16107*# Syracuse Univ., NY.
AEROACOUSTICS OF SUPERSONIC JET FLOWS FROM A CONTOURED PLUG-NOZZLE
DARSHAN S. DOSANJH (Syracuse University, New York) and INDU

S. DAS (Pennsylvania State University, Sharon) AIAA Journal (ISSN 0001-1452), vol. 26, Aug. 1988, p. 924-931. Previously cited in issue 22, p. 3336, Accession no. A86-45433. refs
(Contract NAG1-129)

N89-12356# Air Force Inst. of Tech., Wright-Patterson AFB, OH.
STRUCTURAL OPTIMIZATION INCLUDING CENTRIFUGAL AND CORIOLIS EFFECTS Ph.D. Thesis
HOWARD D. GANS 1988 120 p
(AD-A196873; AFIT/CI/NR-88-19) Avail: NTIS HC A06/MF A01 CSCL 01A

Investigated are the effects of centrifugal and Coriolis forces on the mode shapes and frequencies of a rotating system. The rotational effects have a profound influence on the eigenfrequencies; this is important in optimal structural redesign where the frequencies must be adjusted. The structural matrices for the rotating system were obtained by examining the expression for the total system energy. This provides a differential stiffness matrix that models centrifugal force and provides velocity-dependent Coriolis matrix. By using a high-level programming language (Direct Matrix Abstraction Programming) a modal analysis solution sequence was modified to account for rotational effects in free vibration. Finite element models were then created for a typical compressor blade in a modern jet engine and for a cantilever beam rotating about the vertical axis. The optimal redesign was done by deriving complex nonlinear inverse perturbation equations for the problem involving both magnitude and phase components. The perturbation problem is solved by using nonlinear mathematical programming. Optimal redesign uses an underdetermined system, i.e., the feasible design must not be unique. This allows the application of an objective function, such as minimum structural weight or minimum change from the baseline design. Constraints, such as those on frequency, are applied. Optimal structural changes are obtained that meet the frequency goals to within three percent. GRA

N89-12363# National Aerospace Lab., Amsterdam (Netherlands). Fluid Dynamics Div.
THE ACOUSTICS OF A LINED DUCT WITH FLOW
S. W. RIENSTRA 5 Jan. 1987 72 p
(Contract NIVR-01605N)
(NLR-TR-87002-U; B8817851; ETN-88-93378; AD-B122238L)
Avail: NTIS HC A04/MF A01

A theory to calculate the sound propagation (including attenuation, reflection, radiation) through a three-sectioned cylindrical flow duct, modeling an aero-engine inlet is described. The flow is uniform apart from a thin boundary layer; two of the three sections are hard-walled, with an impedance-walled section in between. The modal amplitudes of the sound field in the duct are determined by an iterative technique allowing the modal expansions to include as many terms as required. The modal eigenvalues are found using a classification based on a distinction between acoustic modes and surface waves. Numerically, the main results are contour plots of constant attenuation, in the complex impedance plane. A dramatic effect of lining (via the occurrence of surface waves) on a sound field that is cut-off in a hard-walled duct is observed. The problems with a lining of constant impedance, and with a (necessarily variable) nonreflective impedance are considered. This problem is mainly relevant to an (acoustic) wind tunnel. It is shown that, for a given free field of the source, the solution describing this impedance distribution can be given analytically in closed form. ESA

N89-12364# National Aerospace Lab., Amsterdam (Netherlands). Fluid Dynamics Div.
A SPECTRAL METHOD FOR THE COMPUTATION OF PROPELLER ACOUSTICS
J. B. H. M. SCHULTEN 30 Oct. 1987 15 p Presented at the AIAA 11th Aeroacoustics Conference, Sunnyvale, Calif., 19-21 Oct. 1987
(Contract NIVR-03504N)
(NLR-MP-87038-U; B8815925; ETN-88-93396) Avail: NTIS HC A03/ A01

An analytical description of the acoustic field of a propeller in a uniform flow is derived. Instead of applying the usual Ffowcs Williams-Hawkings version of the acoustic analogy, sources are formulated on a surface enclosing the propeller and its adjacent nonlinear flow field. This approach, which avoids the laborious evaluation of quadrupole source terms, is to be considered as a generalization of the Kirchhoff-Helmholtz theorem of acoustics. By describing the fundamental solution as a spectral Fourier-Bessel decomposition, the resulting sound field is readily given the appropriate series of harmonic amplitudes. The method is validated by a comparison of numerical results with experimental data of a propeller in an acoustic wind tunnel. A good agreement in amplitude and phase is found between theory and experiment. ESA

N89-12471 Nottingham Univ. (England).
NUMERICAL OPTIMISATION TECHNIQUES APPLIED TO PROBLEMS IN CONTINUUM MECHANICS Ph.D. Thesis
RICHARD JONES 1987 345 p
Avail: Univ. Microfilms Order No. BRD-80502

Numerical optimization techniques are applied to problems in continuum mechanics. The problem of minimizing the loss in total pressure generated when a fluid is forced under pressure through a cascade of airfoils within a turbo-machine is examined. Only two-dimensional airfoil sections are considered and the loss in total pressure is assumed to occur only within the viscous boundary layers on the airfoil surfaces. An inverse approach was adopted whereby an optimized surface velocity distribution is found, from which the corresponding airfoil geometry is then calculated. The performance of different optimization methods were assessed, the most successful one for this particular problem proving to be the prototype method. Numerical optimization techniques were used to solve problems in finite elasticity. The deformations are large and hence the problems themselves become geometrically nonlinear as the stiffness of the deforming body changes. Using a finite element approximation to the appropriate variational principle, solutions to plane strain problems in which the material is compressible and isotropic are considered. Using linear triangular elements, the buckled and barrelled states of a plate under compression are investigated together with the indentation of a body by a flat-ended punch. Dissert. Abstr.

N89-13232 Virginia Polytechnic Inst. and State Univ., Blacksburg.
A STUDY OF ACTIVE CONTROL TECHNIQUES FOR NOISE REDUCTION IN AN AIRCRAFT FUSELAGE MODEL Ph.D. Thesis
JAMES D. JONES 1987 302 p
Avail: Univ. Microfilms Order No. DA8804408

A simplified cylindrical model is used to investigate the elementary mechanisms of control of sound transmission into aircraft cabins by two active control techniques: propeller synchrophasing and active vibration control. Propeller synchrophasing involves controlling the relative rotational phase of the engines to achieve maximum cabin noise reduction. Active vibration control involves structurally controlling the vibrational response of the cabin wall to reduce the important modes which transmit their energy into the cabin. Noise reductions for harmonic excitation at acoustic cavity resonance are shown to be in excess of 20 dB throughout most of the cavity whether synchrophasing or active vibration control is used. Off-resonance reductions are substantially less due to increase modal density requiring a larger number of actuators for effective control of the complex sound fields. Additional studies were performed using synchrophasing in conjunction with active vibration control to study their joint capabilities in controlling complex sound fields. The dual control system displayed improved control performance with noise reductions on the order of 25 to 35 dB and a more uniform sound field. An independent study was performed to identify the effects of a complex geometry on sound transmission into an aircraft fuselage model interior. This investigation identified the fundamental mechanisms of control of sound transmission into simplified models of aircraft fuselages by active control techniques. Dissert. Abstr.

N89-13256*# General Electric Co., Cincinnati, OH. Aircraft Engine Business Group.
FIBER OPTIC CONTROL SYSTEM INTEGRATION Final Report
G. L. POPPEL, W. M. GLASHEEN, and J. C. RUSSELL Feb. 1987 72 p
(Contract NAS3-24624)
(NASA-CR-179568; NAS 1.26:179568; R87AEB111) Avail: NTIS HC A04/MF A01 CSCL 20F

A total fiber optic, integrated propulsion/flight control system concept for advanced fighter aircraft is presented. Fiber optic technology pertaining to this system is identified and evaluated for application readiness. A fiber optic sensor vendor survey was completed, and the results are reported. The advantages of centralized/direct architecture are reviewed, and the concept of the protocol branch is explained. Preliminary protocol branch selections are made based on the F-18/F404 application. Concepts for new optical tools are described. Development plans for the optical technology and the described system are included. Author

N89-13295# Maryland Univ., College Park. Dept. of Aerospace Engineering.
ESTABLISHMENT OF CENTER FOR ROTORCRAFT EDUCATION AND RESEARCH Final Report, 22 Nov. 1982 - 31 Dec. 1987
ALFRED GESSOW 2 May 1988 25 p
(Contract DAAG29-83-K-0002)
(AD-A197141; ARO-19392.19-EG-RW) Avail: NTIS HC A03/MF A01 CSCL 01C

Under a five-year contract with the U.S. Army Research Office, a rotorcraft Center of Excellence was established in the Fall of 1982 at the University of Maryland. As one of the universities chosen for the program, Maryland had the responsibility to attract and involve a significant number of experienced faculty into the program; to develop and add to its graduate curriculum a number of specialized rotorcraft courses which cover the disciplines applicable to rotorcraft design; to attract the best and brightest students into the program and motivate them into rotorcraft as a career; to upgrade and develop experimental facilities which meet the specialized needs of rotorcraft research; to blend faculty, students and facilities into a research combination which concentrated on leading edge research areas; and finally, to disseminate widely the results of the research. The degree to which these responsibilities were met at the end of the contract period is summarized herein. GRA

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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.

A89-13597#
THE DESIGNER'S IMPACT ON COMMERCIAL AIRCRAFT ECONOMICS
A. L. JACOBSON and D. G. MURPHY (Douglas Aircraft Co., Long Beach, CA) IN: ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 946-952.

The engineer/designer has a powerful influence not only on the technical quality of the design but also on its economic feasibility. A commercial aircraft program involves the expenditure of large resources and produces an aircraft that must be price competitive and meet airline requirements. The designer uses trade studies and preliminary cost analyses to ensure that the selected design will be the best practical compromise between product quality, production costs, and operating costs. Author

A89-16538
RECENT DEVELOPMENTS IN AVIATION CASE LAW
JONATHAN M. HOFFMAN and LISA BRETT EGAN (Martin, Bischoff, Templeton, Ericsson and Langslet, Portland, OR) Journal of Air Law and Commerce (ISSN 0021-8642), vol. 54, Fall 1988, p. 1-121. refs

Cases in aviation law during the mid-1980s are reviewed. The cases discussed cover various topics, including jurisdiction, products liability, airports, contribution and indemnity, limitation of actions, insurance coverage, and damages. Cases relating to the Federal Tort Claims Act, the Hague Convention, the Warsaw Convention, and air carrier liability are examined. Other aspects of aviation law presented include FAA enforcement and local regulation, administrative law, negligence, antitrust, bankruptcy and FAA recordation, misrepresentation, and choice of law. R.B.

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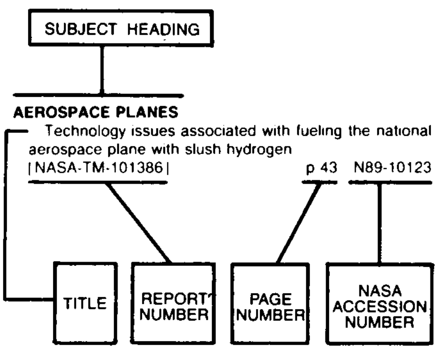

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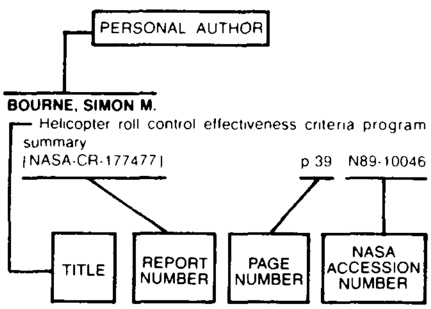

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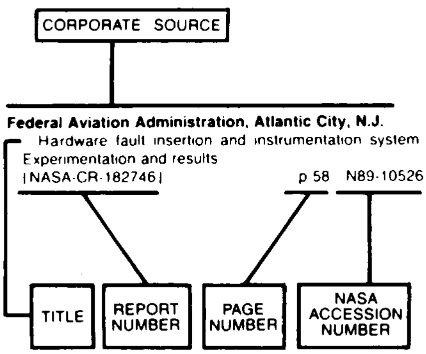

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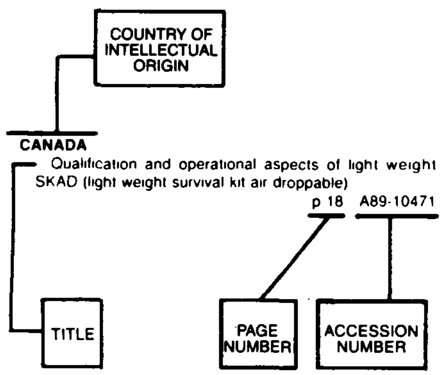

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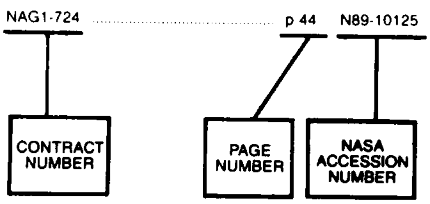

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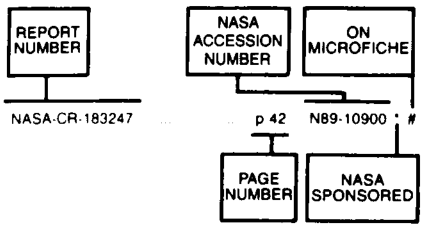

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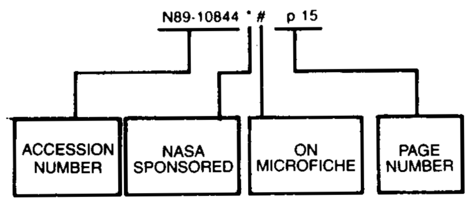

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