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August 1993

AERONAUTICAL ENGINEERING

A CONTINUING BIBLIOGRAPHY WITH INDEXES

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AERONAUTICAL ENGINEERING

A CONTINUING BIBLIOGRAPHY WITH INDEXES



National Aeronautics and Space Administration
Scientific and Technical Information Program
Washington, DC

1993

This publication was prepared by the NASA Center for Aerospace Information,
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INTRODUCTION

This issue of *Aeronautical Engineering — A Continuing Bibliography with Indexes* (NASA SP-7037) lists 590 reports, journal articles, and other documents recently announced in the NASA STI Database.

Accession numbers cited in this issue include:

Scientific and Technical Aerospace Reports (STAR) (N-10000 Series)

N93-26605 — N93-29046

International Aerospace Abstracts (IAA) (A-10000 Series)

A93-35701 — A93-39900

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 publication 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.

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

A cumulative index for 1993 will be published in early 1994.

Information on availability of documents listed, addresses of organizations, and CASI price schedules are located at the back of this issue.

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Category 12	Engineering Includes engineering (general); communications and radar; electronics and electri- cal engineering; fluid mechanics and heat transfer; instrumentation and photogra- phy; lasers and masers; mechanical engineering; quality assurance and reliability; and structural mechanics.	826

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TYPICAL REPORT CITATION AND ABSTRACT

NASA SPONSORED

↓ ON MICROFICHE

ACCESSION NUMBER → **N93-10098 * #** Old Dominion Univ., Norfolk, VA. Dept. of Mechanical Engineering and Mechanics. ← **CORPORATE SOURCE**

TITLE → **NAVIER-STOKES DYNAMICS AND AEROELASTIC COMPUTATIONS FOR VORTICAL FLOWS, BUFFET AND AEROELASTIC APPLICATIONS** Progress Report, 1 Oct. 1991 - 30 Sept. 1992

AUTHOR → OSAMA A. KANDIL Sep. 1992 38 p ← **PUBLICATION DATE**

CONTRACT NUMBER → (Contract NAG1-648)

REPORT NUMBER → (NASA-CR-190692; NAS 1.26:190692) Avail: CASI HC A03/MF A01 ← **AVAILABILITY AND PRICE CODE**

The accomplishments achieved during the period include conference and proceedings publications, journal papers, and abstracts which are either published, accepted for publication or under review. Conference presentations and NASA highlight publications are also included. Two of the conference proceedings publications are attached along with a Ph.D. dissertation abstract and table of contents. In the first publication, computational simulation of three-dimensional flows around a delta wing undergoing rock and roll-divergence motions is presented. In the second publication, the unsteady Euler equations and the Euler equations of rigid body motion, both written in the moving frame of reference, are sequentially solved to simulate the limit-cycle rock motion of slender delta wings. In the dissertation abstract, unsteady flows around rigid or flexible delta wings with and without oscillating leading-edge flaps are considered. L.R.R.

TYPICAL JOURNAL ARTICLE CITATION AND ABSTRACT

NASA SPONSORED

↓

ACCESSION NUMBER → **A93-12007 *** National Aeronautics and Space Administration. Langley Research Center, Hampton, VA. ← **CORPORATE SOURCE**

TITLE → **NUMERICAL SIMULATIONS OF HIGH-SPEED FLOWS ABOUT WAVERIDERS WITH SHARP LEADING EDGES**

AUTHORS → KEVIN D. JONES and F. C. DOUGHERTY (Colorado Univ., Boulder) ← **AUTHORS' AFFILIATION**

JOURNAL TITLE → Journal of Spacecraft and Rockets (ISSN 0022-4650) vol. 29, no. 5

PUBLICATION DATE → Sept.-Oct. 1992 p. 661-667. Research supported by Univ. of Colorado and DLR refs

CONTRACT NUMBER → (Contract NAG1-880)
Copyright

A procedure is developed for the numerical simulation of stagnation-free inviscid supersonic and hypersonic flows about waveriders with sharp leading edges. The numerical approach involves the development of a specialized grid generator (named HYGRID), an algebraic solution-adaptive grid scheme, and a modified flow solving method. A comparison of the results obtained for several waverider geometries with exact solutions, other numerical solutions, and experimental results demonstrated the ability of the new procedure to produce stagnation-free Euler solutions about sharp-edged configurations and to describe the physics of the flow in these regions. I.S.

AERONAUTICAL ENGINEERING

A Continuing Bibliography (Suppl. 294)

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01

AERONAUTICS (GENERAL)

A93-35901

AHS, ANNUAL FORUM, 48TH, WASHINGTON, JUNE 3-5, 1992, PROCEEDINGS. VOLS. 1 & 2

Alexandria, VA American Helicopter Society 1992 p. Vol. 1, 822 p.; vol. 2, 786 p. For individual items see A93-35902 to A93-36018

Copyright

Topics addressed include the development of the coupled rotor-fuselage model, maximum operational effectiveness on RAH-66 Comanche, advanced helicopter pilotage visual requirements, Navy success in modification installation management, improved static and dynamic performance of helicopter powerplant, Navier-Stokes correlations to fuselage wind tunnel test data, a Taguchi analysis of helicopter maneuverability and agility, and thermoplastic applications in helicopter components. Also discussed are Mi-26 autorotational landings, improvements in hover display dynamics for a combat helicopter, prediction of rotorcraft transmission noise, an optimal composite curing system, helicopter rotor blade flap vibratory loads, cost/weight savings for the V-22 wing stow, helicopter response to atmospheric turbulence, a hover performance analysis of advanced rotor blades, scaling of energy absorbing composite plates, an avionics troubleshooting system, and an integrated navigation system for tactical helicopters. AIAA

A93-35923

THE CRITICALNESS OF SPARES EFFECTIVITY CHECKS FOR AIRCRAFT CONFIGURATION CONTROL

ROBERT F. GOUCK (Boeing Defense & Space Group, Helicopters Div., Philadelphia, PA) *In* AHS, Annual Forum, 48th, Washington, June 3-5, 1992, Proceedings. Vol. 1 Alexandria, VA American Helicopter Society 1992 p. 305-307.

Copyright

The dissemination of configuration change information can suffer from delays and incomplete routing. Consequently, the operator of a rotorcraft may be working to out-of-date technical manuals and parts catalogs. However, an important configuration check acts as a safeguard for Boeing Helicopters' (BH) customers when they order spare parts. This paper addresses the decision-making process for configuration changes and obstacles to the dissemination of such change information. A description of the spares effectivity process at BH is given, together with examples of why it is critical to aircraft configuration control. Author

A93-35924

LOGISTIC SUPPORT ANALYSIS - AN INTEGRATED APPROACH TO CONFIGURATION MANAGEMENT

RICHARD S. BODZEK (Boeing Defense & Space Group, Philadelphia, PA) *In* AHS, Annual Forum, 48th, Washington, June 3-5, 1992, Proceedings. Vol. 1 Alexandria, VA American Helicopter Society 1992 p. 309-312.

Copyright

A discussion of the Logistic Support Analysis (LSA) process and its application in various phases in the acquisition process is presented. The emphasis is on the development of the Logistic Support Analysis Record (CSAR) rather than the up-front analyses associated with design influence. Configuration management is discussed briefly to afford some comparison to the LSA process. Similarities are highlighted and are the basis for the use of LSA in the configuration management process. An approach to better integrate LSA and configuration management by citing specific objectives and recommendations on how these objectives can be met is also presented. Author

A93-35927

CONTROLLING HAZARDOUS CONFIGURATIONS IN HELICOPTER SYSTEMS

EDWARD J. HOLLMAN and BRADLEY J. MEYER (U.S. Army, Aviation Systems Command, Saint Louis, MO) *In* AHS, Annual Forum, 48th, Washington, June 3-5, 1992, Proceedings. Vol. 1 Alexandria, VA American Helicopter Society 1992 p. 331-336. refs

Copyright

This paper is an overview of how the different armed services and commercial counterparts control hazardous configurations using safety communication on fielded helicopter systems. Specifically, it will provide information on how the U.S. Air Force, U.S. Army, Federal Aviation Administration (FAA) and U.S. Navy provide safety communication to the user of fielded helicopter systems. This paper will set forth procedures of each organization on how safety communication is developed, issued and distributed in accordance with each services applicable policies. Finally, a brief discussion of risk management challenges in today's helicopter community as it relates to safety communication will be provided. Author

A93-35944

A TAGUCHI ANALYSIS OF HELICOPTER MANEUVERABILITY AND AGILITY

SCOTT SWINSICK (McDonnell Douglas Helicopter Co., Mesa, AZ) *In* AHS, Annual Forum, 48th, Washington, June 3-5, 1992, Proceedings. Vol. 1 Alexandria, VA American Helicopter Society 1992 p. 543-553. refs

Copyright

The objective of the Rotorcraft Maneuverability and Agility Survivability Sensitivity Analysis (RMASSA) was to investigate rotorcraft survivability sensitivity to maneuverability and agility (M&A) variations. The goal was to identify those performance parameters (load factor, power available, roll rate, etc.) which contributed to improved M&A. Once identified, the performance parameters were related to specific design parameters (rotor diameter, blade solidity, engine size, etc.). The result was an investigation of nine derivative helicopter designs each having variations in M&A capabilities and design weight. The results of analytic combat simulations were used to examine the trade-offs between M&A, weight, and survivability. Author (revised)

A93-35971

IMPROVED AIRFRAME MANUFACTURING TECHNOLOGY

PETER B. LEONI (Sikorsky Aircraft, Stratford, CT) *In* AHS, Annual Forum, 48th, Washington, June 3-5, 1992, Proceedings.

01 AERONAUTICS (GENERAL)

Vol. 2 Alexandria, VA American Helicopter Society 1992 p. 949-954.

Copyright

The objective and the current status of the Improved Airframe Manufacturing Technology (IAMT) program, aimed at reducing the cost of building complex primary airframe structural composite assemblies, are discussed. The complex primary composite structure chosen for the IAMT program is the Keel Beam Torque Box Structure for the RAH-66 Comanche helicopter. The advanced technology selected for the IAMT program is the resin transfer molding (RTM) process, incorporating innovations in elastomeric tooling technology, advanced resin systems, automated preform development, and automated ply cutting and kitting. The advantages of the RTM technology are discussed, and results of the risk reduction work accomplished under Phase I are summarized. AIAA

A93-35973

NEW DEVELOPMENTS IN ORGANIZED WIRE SYSTEMS

JEANETTE HOLLIS (Sikorsky Aircraft, Stratford, CT) *In* AHS, Annual Forum, 48th, Washington, June 3-5, 1992, Proceedings. Vol. 2 Alexandria, VA American Helicopter Society 1992 p. 959-966.

Copyright

The concept of organized wire systems (OWS), introduced as an alternative to existing wire harnesses, is discussed. The OWS concept, which consists of arranging the wires in a planar array, addresses the weight and limited space constraints of the next generation aircraft, such as RAH-66 Comanche. In addition to design advantages, the OWS provides some manufacturing benefits. These include mass insulation stripping, computer programmed and controlled connector termination, and the routing of up to 20 wires at a time. The discussion also covers such enhancements as improved maintenance and supportability, elimination of wire coding, and improving EMI shielding by wrapping the cable bundles with foil instead of costly braided shields and braided protective coverings. AIAA

A93-39535

AVIONIC SYSTEMS/DESIGN AND MAINTENANCE; PROCEEDINGS OF THE CONFERENCE, HOUNSLOW, UNITED KINGDOM, APR. 22, 1993

London Royal Aeronautical Society 1993 102 p. For individual items see A93-39536 to A93-39542 (ISBN 1-85768-095-2) Copyright

The present conference on the design and maintenance of avionics equipment discusses the installation of electrical cable looms, the maintenance-optimized design of avionics software, on-board aids for avionics maintenance, and the skills and training required for future avionics maintenance engineers. Also discussed are the relationship of high-intensity radiated fields to lightning, development trends in aircraft antenna designs, and the state-of-the-art in aircraft cabin electronics. AIAA

A93-39536

INSTALLATION OF ELECTRICAL CABLE LOOMS

W. D. REES (British Aerospace Airbus, Ltd., Bristol, United Kingdom) *In* Avionic systems/design and maintenance; Proceedings of the Conference, Hounslow, United Kingdom, Apr. 22, 1993 London Royal Aeronautical Society 1993 p. 1.1-1.7.

Copyright

An overview is given of European Joint Airworthiness Regulations and U.S. Federal Airworthiness Regulations regarding design practices for the installation of electrical wiring aboard aircraft. 'Looms' of electrical cabling must be configured in ways that properly segregate and isolate incompatible and potentially destructively interacting materials; many of these have acquired great importance through the incorporation of fly-by-wire control systems. AIAA

A93-39538

ON-BOARD MAINTENANCE AIDS

J. P. P. DE MONTALK (Airbus Industrie, Blagnac, France) *In* Avionic systems/design and maintenance; Proceedings of the Conference, Hounslow, United Kingdom, Apr. 22, 1993 London Royal Aeronautical Society 1993 p. 3.1-3.6.

Copyright

The continuing decrease in the cost of electronic systems for condition monitoring has prompted design efforts toward their extensive incorporation in existing and prospective aircraft designs. Such Aircraft Condition Monitoring Systems (ACMSs) allow fault location and rectification by Centralized Fault Display Systems and Central Maintenance Systems (CMSs). CMSs help line mechanics to repair aircraft within scheduled turn-around times, and are especially helpful in the identification of faulty LRUs. AIAA

A93-39539

HIRF AND LIGHTNING

R. HATHAWAY (Civil Aviation Authority, Gatwick, United Kingdom) *In* Avionic systems/design and maintenance; Proceedings of the Conference, Hounslow, United Kingdom, Apr. 22, 1993 London Royal Aeronautical Society 1993 p. 5.1-5.21.

Copyright

High intensity radiated fields (HIRF) due to lightning discharges in the vicinity of aircraft pose an especially great threat at present, when there has been such extensive incorporation of electronic systems into aircraft. An account is presently given to the consequences of EMC criteria relevant to this problem for aircraft maintenance practices. Attention is given to the HIRF-related factors associated with nonmetallic aircraft structure components; these render the maintenance of protective filters and EM shielding a critical task of ground personnel. AIAA

A93-39540

ANTENNAS NOW AND FUTURE

F. R. WEBB (H.R. Smith Group of Companies, Leominster, United Kingdom) *In* Avionic systems/design and maintenance; Proceedings of the Conference, Hounslow, United Kingdom, Apr. 22, 1993 London Royal Aeronautical Society 1993 p. 6.1-6.5.

Copyright

A development status and development prospects evaluation is presented for current and future antenna designs concerned both with RF communications and microwave navigation systems. It is noted that while increasing use is made by aircraft designers of conformal antennas that are highly optimized for the design in question, more attention must also be given to commonality of such equipment in order to reduce costs; in addition, the advantage of high-reliability accruing to well-tested off-the-shelf equipment is forfeited. Increasingly, antennas will be required to support air-to-ground telephone links and GPS services. AIAA

N93-27056# Air Force Inst. of Tech., Wright-Patterson AFB, OH.

AVIATION PRODUCTION ENGINEERING: SELECTED ARTICLES

4 Feb. 1993 34 p Transl. into ENGLISH from unknown source (China), no. 102, Jun. 1991 p 25-31 (AD-A261231; FASTC-ID(RS)T-0626-92) Avail: CASI HC A03/MF A01

This article describes the guiding principles of management procedures and staffing of the Xian Aircraft Company Institute of Manufacturing Technology Research. The major role it plays in converting scientific and technical research achievements into productive forces are also presented. DTIC

N93-27166 Israel Society of Aeronautics and Astronautics, Tel Aviv.

COLLECTION OF PAPERS OF THE 31ST ISRAEL ANNUAL CONFERENCE ON AVIATION AND ASTRONAUTICS

20 Feb. 1992 503 p Conference held in Tel-Aviv, Israel, February 18-20, 1992 Sponsored by Technion - Israel Inst. of Tech.; Tel-Aviv Univ.; Ben Gurion Univ. of the Negev; Rafael Armament Development Authority; National Committee for Space Research;

Israel Space Agency; Israel Aircraft Industries Ltd.; El Al Israel Airlines Ltd.; Israel Military Industries; Society of Aerospace Engineers in Israel; and S. Neaman Inst. for Advanced Studies in Science and Technology
(ITN-93-85187) Copyright Avail: Israel Society of Aeronautics and Astronautics, c/o Faculty of Engineering, Tel-Aviv Univ., Ramat Aviv 69978, Israel

Subjects covered by the 56 papers include: hypersonics and advanced aircraft design; control systems design and evaluation; aircraft and spacecraft navigation; rocket ramjet and turbine engine design and development; development, evaluation and applications of synthetic materials; design and construction of space structures; missile guidance, control and avoidance; spacecraft, aircraft and missile propulsion; guidance systems; and aerodynamics.

ISA

N93-27405# Boeing Commercial Airplane Co., Seattle, WA.
WORLD JET AIRPLANE INVENTORY AT YEAR-END 1992

Mar. 1993 119 p See also PB90-207218
(PB93-174324) Avail: CASI HC A06/MF A02

The document contains data on the world commercial jet airplane fleet (including some military derivatives) and reflects the status of this fleet as accurately as possible as of December 31, 1992. Any fleet changes that have occurred since year-end 1992 will not be reflected in these data.

NTIS

N93-28576# Air Force Systems Command, Wright-Patterson AFB, OH. Foreign Aerospace Science and Technology Center.

INTERNATIONAL AVIATION (SELECTED ARTICLES)

18 Mar. 1993 75 p Transl. into ENGLISH from Guoji Hangkong (China), no. 7, 1989 p 6-20 LIMITED REPRODUCIBILITY: More than 20% of this document may be affected by microfiche quality (AD-A262566; FASTC-ID(RS)T-0625-92) Avail: Issuing Activity (Defense Technical Information Center (DTIC))

China's Aerodynamics Research and Development Center (hereafter called 'Center') is China's largest aerodynamics research and testing organ. It is located within Mianyang City in Sichuan Province. The Center is subordinate to the State Commission of Science, Technology, and Industry for National Defense. Its primary missions are to conduct experimental research, theoretical research, and applied research of aircraft and spacecraft and wind engineering; provide the results of their research to aircraft design organs and other state economic agencies; and to undertake the research and design of aerodynamic test equipment.

DTIC

02

AERODYNAMICS

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

A93-35935* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

A FINITE-VOLUME EULER SOLVER FOR COMPUTING ROTARY-WING AERODYNAMICS ON UNSTRUCTURED MESHES

ROGER C. STRAWN (U.S. Army, Aeroflightdynamics Directorate; NASA, Ames Research Center, Moffett Field, CA) and TIMOTHY J. BARTH (NASA, Ames Research Center, Moffett Field, CA) *In* AHS, Annual Forum, 48th, Washington, June 3-5, 1992, Proceedings. Vol. 1 Alexandria, VA American Helicopter Society 1992 p. 419-428. refs
Copyright

An unstructured-grid solver for the unsteady Euler equations has been developed for predicting the aerodynamics of helicopter rotor blades. This flow solver is a finite-volume scheme that computes flow quantities at the vertices of the mesh. Special treatments are used for the flux differencing and boundary conditions in order to compute rotary-wing flowfields, and these

are detailed in the paper. The unstructured-grid solver permits adaptive grid refinement in order to improve the resolution of flow features such as shocks, rotor wakes and acoustic waves. These capabilities are demonstrated in the paper. Example calculations are presented for two hovering rotors. In both cases, adaptive-grid refinement is used to resolve high gradients near the rotor surface and also to capture the vortical regions in the rotor wake. The computed results show good agreement with experimental results for surface airloads and wake geometry. Author

A93-35936* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

NUMERICAL SIMULATION OF A HOVERING ROTOR USING EMBEDDED GRIDS

EARL-PETER N. DUQUE (U.S. Army, Aeroflightdynamics Directorate; NASA, Ames Research Center, Moffett Field, CA) and GANAPATHI R. SRINIVASAN (JAI Associates, Inc.; NASA, Ames Research Center, Moffett Field, CA) *In* AHS, Annual Forum, 48th, Washington, June 3-5, 1992, Proceedings. Vol. 1 Alexandria, VA American Helicopter Society 1992 p. 429-445. refs
Copyright

The flow field for a rotor blade in hover was computed by numerically solving the compressible thin-layer Navier-Stokes equations on embedded grids. In this work, three embedded grids were used to discretize the flow field - one for the rotor blade and two to connect the rotor wake. The computations were performed at two hovering test conditions, for a two-bladed rectangular rotor of aspect ratio six. The results compare fairly with experiment and illustrates the use of embedded grids in solving helicopter type flow fields. Author

A93-35937

NAVIER-STOKES CORRELATIONS TO FUSELAGE WIND TUNNEL TEST DATA

J. C. NARRAMORE and A. G. BRAND (Bell Helicopter Textron, Inc., Fort Worth, TX) *In* AHS, Annual Forum, 48th, Washington, June 3-5, 1992, Proceedings. Vol. 1 Alexandria, VA American Helicopter Society 1992 p. 447-459. refs
Copyright

The results from a Navier-Stokes computation of the flow about the Bell Model 214ST helicopter fuselage have been compared to wind tunnel test data. Three cases were selected to test the code over a wide range of conditions. Comparisons include integrated forces and moments as well as pressure distributions. The ability of a 3D Navier-Stokes code to compute forces and moments that correlate well with M214ST fuselage wind tunnel test data is demonstrated. Author

A93-35938

HELICOPTER AERODYNAMICS RESEARCH TECHNIQUES AND ROTOR-FUSELAGE INTERACTION ANALYSIS

VIKTOR B. LETNIKOV (Moscow Helicopter Plant, Russia) *In* AHS, Annual Forum, 48th, Washington, June 3-5, 1992, Proceedings. Vol. 1 Alexandria, VA American Helicopter Society 1992 p. 461-473. refs
Copyright

Analysis techniques for the main helicopter rotor and the fuselage, and analysis of rotor-fuselage interaction at different flight regimes are discussed. The emphasis is placed on the development of comparatively fast-acting techniques of the aerodynamic analysis available for day-to-day use in engineering practice. To calculate the flow around the main rotor blades and the fuselage, a method based on the potential flow theory is used. A form of free vortex surfaces is considered as nonlinear. A computational algorithm for this form at axial regimes is presented, and an approximate method for its determination is given for the case of flight with horizontal speed. A level of flow turbulence under the rotor is estimated on the basis of experimental data. AIAA

A93-35939

VORTEX METHODS FOR THE COMPUTATIONAL ANALYSIS OF ROTOR/BODY INTERACTION

T. R. QUACKENBUSH, C.-M. G. LAM (Continuum Dynamics, Inc.,

02 AERODYNAMICS

Princeton, NJ), D. B. BLISS, and A. KATZ (Duke Univ., Durham, NC) *In* AHS, Annual Forum, 48th, Washington, June 3-5, 1992, Proceedings. Vol. 1 Alexandria, VA American Helicopter Society 1992 p. 475-488. Research supported by U.S. Army refs
Copyright

This paper describes the development and implementation of a unified model of rotorcraft interactional aerodynamics using advanced methods in vortex dynamics. The model incorporates several recently-developed tools for the analysis of vortex wake dynamics and vortex/surface interaction including: a Constant Vorticity Contour (CVC) full-span free wake model; a method for the prediction of surface pressures due to close vortex interactions based on Analytical Numerical Matching (ANM); and a new analytical asymptotic analysis of curved vortex interaction with curved surfaces. The development of each of these features of the analysis are described as is their coupling with a panel method analysis of the fuselage. Correlation studies with measured rotor velocity fields are presented, and model problems are also solved to demonstrate the ability of the ANM model to predict inviscid vortex/surface interactions accurately and with greater efficiency than traditional methods. In addition, fundamental studies of curved filament dynamics near curved surfaces are described, along with correlations of measured and predicted surface pressures. While considerable additional work is required to formulate a fully general analysis of rotorcraft interactional aerodynamics, the computational tools developed here provide a significant predictive capability for realistic wake/airframe interactions. Author

A93-35941

INTERACTIONAL AERODYNAMIC EFFECTS ON ROTOR PERFORMANCE IN HOVER AND FORWARD FLIGHT

G. L. CROUSE, JR. and J. G. LEISHMAN (Maryland Univ., College Park) *In* AHS, Annual Forum, 48th, Washington, June 3-5, 1992, Proceedings. Vol. 1 Alexandria, VA American Helicopter Society 1992 p. 513-523. refs
(Contract DAAL03-88-C-0002)
Copyright

A theoretical analysis has been conducted into the significance of rotor/body aerodynamic interactions on rotor performance and blade loads. Results from the analysis are compared with measurements from tests that were conducted on a rotor/body combination in hover and at advance ratios between 0.05 and 0.25. The experimental results showed significant changes in rotor thrust and power requirements with the introduction of a body to the flowfield. The theoretical analysis has been conducted to help explain the aerodynamic mechanisms involved. A fully unsteady potential flow model of the rotor and body was developed. The wake models consisted of a freewake methodology, as well as a standard prescribed wake, both coupled with a novel treatment of the rotor wake/body interaction process. These wake models were combined with the panel and rotor models to allow fully interactive trim calculations. The theoretical analysis has shown significant changes in the inflow distribution through the rotor disk, as well as large associated changes in the lift and inflow distribution due to the presence of the body, and these results can be used to explain the source of the measured effects on the rotor performance. Author

A93-35957* National Aeronautics and Space Administration, Langley Research Center, Hampton, VA.

A STUDY OF THE ROTOR WAKE OF A SMALL-SCALE ROTOR MODEL IN FORWARD FLIGHT USING LASER LIGHT SHEET FLOW VISUALIZATION WITH COMPARISONS TO ANALYTICAL MODELS

TERENCE A. GHEE (Analytical Services and Materials, Inc., Hampton, VA) and JOE W. ELLIOTT (U.S. Army, Aerostructures Directorate; NASA, Langley Research Center, Hampton, VA) *In* AHS, Annual Forum, 48th, Washington, June 3-5, 1992, Proceedings. Vol. 1 Alexandria, VA American Helicopter Society 1992 p. 697-719. refs
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An experimental investigation was conducted in the 14 by 22

ft subsonic tunnel at NASA Langley Research Center to quantify the rotor wake behind a scale model helicopter rotor in forward flight ($\mu = 0.15$ and 0.23) at one thrust level ($C_{sub T} = 0.0064$). The rotor system used in the present test consisted of a four-bladed, fully articulated hub and utilized blades of rectangular planform with a NACA-0012 airfoil section. A laser light sheet, seeded with propylene glycol smoke, was used to visualize the flow in planes parallel and perpendicular to the freestream flow. Quantitative measurements of vortex location, vertical skew angle, and vortex particle void radius were obtained for vortices in the flow; convective velocities were obtained for blade tip vortices. Comparisons were made between the experimental results and the wake geometry generated by computational predictions. The results of these comparisons show that the interaction between wake vortex structures is an important consideration for correctly predicting the wake geometry. Author (revised)

A93-35993

ROTOR BLADE AIRFOIL DESIGN BY NUMERICAL OPTIMIZATION AND UNSTEADY CALCULATIONS

HERVE BEZARD (ONERA, Chatillon, France) *In* AHS, Annual Forum, 48th, Washington, June 3-5, 1992, Proceedings. Vol. 2 Alexandria, VA American Helicopter Society 1992 p. 1283-1294. Research supported by DRET refs
(ONERA, TP NO. 1992-65) Copyright

This paper presents a new approach to the design of rotor blade airfoils by numerical optimization and unsteady calculations. The aerodynamic method associated to the minimization process is presented and the evaluation of the unsteady wave drag as well as of the viscous drag is described. Specific requirements to be prescribed in the unsteady case are discussed and applied in the case of outer blade sections for high speed configurations. Optimizations with several objectives are presented and show that significant improvements can be obtained in comparison with existing airfoils. Author

A93-35994

A 2-D NUMERICAL MODEL FOR PREDICTING THE AERODYNAMIC PERFORMANCE OF THE NOTAR SYSTEM TAILBOOM

RICHARD HOLZ, AHMED HASSAN (McDonnell Douglas Helicopter Co., Mesa, AZ), and HELEN REED (Arizona State Univ., Tempe) *In* AHS, Annual Forum, 48th, Washington, June 3-5, 1992, Proceedings. Vol. 2 Alexandria, VA American Helicopter Society 1992 p. 1295-1305. Research supported by McDonnell Douglas Helicopter Co. and Arizona State Univ refs
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---Current computational models for circulation-control (CC) flows have been applied, in most cases, to ellipse-shaped CC rotor blades having only one blowing slot (i.e., the X-wing). This paper describes the first Navier-Stokes solver which has been developed for modeling the external flowfield of the NOTAR system tailboom. In its original form, the Baldwin-Lomax algebraic turbulence model is shown to be inadequate for describing compound boundary layers such as those produced by the wall jet. A new turbulence model is therefore proposed. To account for the non-equilibrium production of turbulence at the slot exits and for its suppression due to wall curvature, two corrections to the turbulence model were implemented. A slanted slot exit boundary was used to reduce grid skewness without degrading solution accuracy. The current model has been validated for high Reynolds number/low Mach number flow over a circular cylinder with two jets. The model is shown to be valid over a wide range of slot flow conditions including stall. Some insight into wall jet separation is also presented. Author (revised)

A93-35995

DYNAMIC STALL OF SINUSOIDALLY OSCILLATING THREE-DIMENSIONAL SWEEP AND UNSWEEP WINGS IN COMPRESSIBLE FLOW

PETER F. LORBER (United Technologies Research Center, East Hartford, CT) *In* AHS, Annual Forum, 48th, Washington, June 3-5, 1992, Proceedings. Vol. 2 Alexandria, VA American

Helicopter Society 1992 p.1307-1322. refs
(Contract DAAL03-89-C-0013)
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Measurements have been made of the unsteady aerodynamic response of a three dimensional wing to sinusoidal pitching oscillations. The model scale and test conditions were selected to simulate the Reynolds number, airfoil section, Mach number, reduced frequency, angular range, and sweep angles of a full scale helicopter main rotor blade. Surface pressure measurements at five spanwise locations are used to identify the physical processes and characterize the resulting airloads. Qualitative agreement is found with data for constant pitch rate ramps, implying that previous observations regarding the details of the stall process remain valid for sinusoidal motions. The effects of the primary test parameters on the airloads during large amplitude sinusoids are described. Study of a series of moderate amplitude motions at varied mean angle of attack suggest that it is not feasible to achieve significant unsteady lift enhancements and stall delays without generating a strong dynamic stall vortex and thus an undesirable unsteady pitching moment. Author

A93-35996* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

SHADOWGRAPH FLOW VISUALIZATION OF ISOLATED TILTROTOR AND ROTOR/WING WAKES

ALEXANDRA A. SWANSON (Sterling Software, Inc., Moffett Field, CA) and JEFFREY S. LIGHT (NASA, Ames Research Center, Moffett Field, CA) /in AHS, Annual Forum, 48th, Washington, June 3-5, 1992, Proceedings. Vol. 2 Alexandria, VA American Helicopter Society 1992 p.1323-1344. refs
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Shadowgraph flow visualization images were acquired from a 0.184-scale tiltrotor and wing in hover. Measurements and details of the vortex core structure were examined as a function of thrust condition and wake age. Experimental data for the isolated rotor wake geometry and rotor wake interactions with a semi-span wing and image plane were acquired. Quantitative measurements and comparisons of wake geometry and distortion were made for three configurations: the isolated rotor, rotor/wing, and rotor/wing/image plane. Comparisons between tiltrotor and helicopter rotor wake geometry measurements were made. Experimental wake geometry data were also compared with two wake models. Suggestions for improvements to existing prescribed-wake and free-wake models are proposed. Author

**A93-35997
AERODYNAMIC AND WAKE METHODOLOGY EVALUATION USING MODEL UH-60A EXPERIMENTAL DATA**

MICHAEL S. TOROK and CHARLES R. BEREZIN (Sikorsky Aircraft, Stratford, CT) /in AHS, Annual Forum, 48th, Washington, June 3-5, 1992, Proceedings. Vol. 2 Alexandria, VA American Helicopter Society 1992 p.1345-1366. refs
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Several aerodynamic methodologies are evaluated using integrated blade loads, blade pressures, and blade strain data for a model UH-60A Black Hawk rotor. The methodologies examined include lifting line, lifting surface and CFD, and wake methodologies, as well as vortex lattice and constant vorticity contour models. The effect of blade dynamics on airload predictions is discussed. Experimental measurements of blade displacements are used to uncouple the aerodynamic analyses from their dynamic components in order to obtain unbiased evaluation. The predicted loads are compared with test data to isolate discrete effects. AIAA

A93-35998* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

HOVER PERFORMANCE ANALYSIS OF ADVANCED ROTOR BLADES

C. TUNG (U.S. Army, Aeroflightdynamics Directorate; NASA, Ames Research Center, Moffett Field, CA) and K. RAMACHANDRAN (Flow Analysis, Inc.; NASA, Ames Research Center, Moffett Field, CA) /in AHS, Annual Forum, 48th, Washington, June 3-5, 1992,

Proceedings. Vol. 2 Alexandria, VA American Helicopter Society 1992 p.1367-1384. refs
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This is an effort aimed at validating recent hover prediction methods. The experimental basis for this validation work is an extensive set of loads, wake and performance data, which were obtained from a pressure instrumented model UH-60 rotor tested at the Sikorsky hover test facility and at Duits-Nederlandse Windtunnel (DNW). This model was equipped with replaceable tips - including a tapered and a BERP-type tip - which permitted studies of the effects of rotor geometry. The central prediction method studied is a free-wake, vortex embedded, full-potential CFD method - called HELIX-I. It is found that the HELIX-I code produces very good comparisons with the data including wake, surface pressure and performance. Comparisons with the measured radial load distributions have permitted an improved understanding of the wake resolution modelling requirements of CFD methods. Since HELIX-I is a combined Eulerian/Lagrangian method, limited comparisons are also made with a Lagrangian boundary element code (called EHPIC) and an Eulerian Navier-Stokes code (called TURNS). In most cases all methods produce good comparisons with the data. It is found that the HELIX-I code provides a good compromise between the speed of boundary integral methods and the comprehensive nature of Navier-Stokes methods. Author

**A93-35999
INFLUENCE OF COUPLING INCIDENCE AND VELOCITY VARIATIONS ON THE AIRFOIL DYNAMIC STALL**

DANIEL FAVIER, JACQUES BELLEUDY, and CHRISTIAN MARESCA (Inst. de Mecanique des Fluides, Marseille, France) /in AHS, Annual Forum, 48th, Washington, June 3-5, 1992, Proceedings. Vol. 2 Alexandria, VA American Helicopter Society 1992 p.1385-1407. Research supported by Delegation Generale pour l'Armement refs
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The paper addresses the influence of coupling incidence and velocity variations on the unsteady aerodynamic behavior of a NACA 0012 airfoil oscillating through stall in a two-dimensional flow. The experimental simulation of the rotor blade sections environment is conducted by means of a combined translation-pitch motion, which produces periodic variation of velocity and incidence around the airfoil. The present experiments are focused on providing the airfoil response as a function of the different parameters of the combined motion, and more specifically as a function of the phase shift Theta between the periodic laws of incidence and velocity. Instantaneous measurements of airloads and chordwise pressure and skin friction distributions offer a detailed description of the airfoil unsteady behavior and a quantification of the effects associated to different stalling conditions, including light and deep stalls. The experimental data are then used to evaluate the prediction efficiency of the ONERA stall model extended and optimized to account for simultaneous incidence and velocity variations. Finally, from the present data base an empirical stall formulation is also proposed to represent the damped superposition of velocity and incidence effects generated by the combined motion. Author

A93-37378* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

MULTIBLOCK NAVIER-STOKES SOLUTIONS ABOUT THE F/A-18 WING-LEX-FUSELAGE CONFIGURATION

FARHAD GHAFARI, JAMES M. LUCKRING, JAMES L. THOMAS (NASA, Langley Research Center, Hampton, VA), BRENT L. BATES (Vigyan, Inc., Hampton, VA), and ROBERT T. BIEDRON (Analytical Services and Materials, Inc., Hampton, VA) Journal of Aircraft (ISSN 0021-8669) vol. 30, no. 3 May-June 1993 p. 293-303. AIAA Applied Aerodynamics Conference, 9th, Baltimore, MD, Sept. 23-25, 1991, Technical Papers. Vol. 2, p. 701-720. Previously cited in issue 23, p. 4003, Accession no. A91-53789 refs (Contract NAS1-18585; NAS1-19320)
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A93-37379

NONEQUILIBRIUM TURBULENCE MODELING STUDY ON LIGHT DYNAMIC STALL OF A NACA0012 AIRFOIL

MUSTAFA DINDAR, UNVER KAYNAK (TUSAS Aerospace Industries, Ankara, Turkey), and KOZO FUJII (Inst. of Space and Astronautical Science, Kanagawa, Japan) *Journal of Aircraft* (ISSN 0021-8669) vol. 30, no. 3 May-June 1993 p. 304-308. refs
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A computational study on the nonequilibrium turbulence modeling effects for the prediction of the light stall phenomenon has been done for the NACA0012 airfoil. For this, an unsteady thin-layer Navier-Stokes solver was developed that is capable of solving the flowfield around an airfoil undergoing unsteady harmonic motion. In the program, the Baldwin-Lomax and Cebeci-Smith turbulence models were used as baseline models, and the Johnson-King turbulence model was used to study the nonequilibrium effects. It was found that the nonequilibrium effects are important for the prediction of the light stall, and only the Johnson-King model yields light stall hysteresis loop that is similar to the experiment. It was also found that the wind-tunnel wall effects are important, and a mean angle-of-attack increase in the computation was necessary to yield a better agreement with the experiment. Author

A93-37381

VORTEX GENERATORS USED TO CONTROL LAMINAR SEPARATION BUBBLES

M. KERHO, S. HUTCHERSON, R. F. BLACKWELDER, and R. H. LIEBECK (Southern California Univ., Los Angeles, CA) *Journal of Aircraft* (ISSN 0021-8669) vol. 30, no. 3 May-June 1993 p. 315-319. AIAA, Aerospace Sciences Meeting, 28th, Reno, NV, Jan. 8-11, 1990, AIAA Paper 90-0051. Previously cited in issue 06, p. 753, Accession no. A90-19650 refs
(Contract N00014-89-J-1400)
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A93-37383* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

COMPUTATIONAL INVESTIGATION OF A PNEUMATIC FOREBODY FLOW CONTROL CONCEPT

KEN GEE (MCAT Inst., Moffett Field, CA), DOMINGO TAVELLA (Stanford Univ., CA), and LEWIS B. SCHIFF (NASA, Ames Research Center, Moffett Field, CA) *Journal of Aircraft* (ISSN 0021-8669) vol. 30, no. 3 May-June 1993 p. 326-333. AIAA Applied Aerodynamics Conference, 9th, Baltimore, MD, Sept. 23-25, 1991, Technical Papers. Vol. 1, p. 370-380. Previously cited in issue 23, p. 4000, Accession no. A91-53760 refs
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A93-37384* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

EFFECTS OF BLOWING ON DELTA WING VORTICES DURING DYNAMIC PITCHING

L. S. MILLER (Wichita State Univ., KS) and BRENDA E. GILE (NASA, Langley Research Center, Hampton, VA) *Journal of Aircraft* (ISSN 0021-8669) vol. 30, no. 3 May-June 1993 p. 334-339. AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992, AIAA Paper 92-0407. Previously cited in issue 09, p. 1352, Accession no. A92-26260 refs
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A93-37385

INDICIAL LIFT APPROXIMATIONS FOR TWO-DIMENSIONAL SUBSONIC FLOW AS OBTAINED FROM OSCILLATORY MEASUREMENTS

J. G. LEISHMAN (Maryland Univ., College Park) *Journal of Aircraft* (ISSN 0021-8669) vol. 30, no. 3 May-June 1993 p. 340-351. refs
(Contract DAAL03-88-C-002)
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An approach is described to obtain generalized approximations to the indicial lift response due to angle of attack and pitch rate in two-dimensional subsonic flow. Starting from an assumed

representation, the approximations are accomplished by means of a nongradient optimization algorithm in which the coefficients of the approximation are free parameters. The optimization is subject to prescribed constraints in terms of the known initial and asymptotic behavior of the indicial response, and by requiring the response duplicate the known exact (analytic) solutions at earlier values of time. The approach is applied to extract the intermediate forms of the indicial lift response, generalized in terms of Mach number and pitch axis location, from experimental measurements of the unsteady lift in the frequency domain. Author

A93-37386

SLENDER WING ROCK REVISITED

LARS E. ERICSSON (Lockheed Missiles & Space Co., Inc., Sunnyvale, CA) *Journal of Aircraft* (ISSN 0021-8669) vol. 30, no. 3 May-June 1993 p. 352-356. AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991, AIAA Paper 91-0417. Previously cited in issue 07, p. 972, Accession no. A91-21484 Research supported by Lockheed Missiles & Space Co., Inc refs
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A93-37387* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

COMPARISON OF TWO NAVIER-STOKES CODES FOR SIMULATING HIGH-INCIDENCE VORTICAL FLOW

NEAL M. CHADERJIAN (NASA, Ames Research Center, Moffett Field, CA) *Journal of Aircraft* (ISSN 0021-8669) vol. 30, no. 3 May-June 1993 p. 357-364. AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991, AIAA Paper 91-0175. Previously cited in issue 07, p. 970, Accession no. A91-21395 refs
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A93-37399

APPLICATION OF OSWATITSCH'S THEOREM TO SUPERCRITICAL AIRFOIL DRAG CALCULATION

G. R. INGER (Iowa State Univ. of Science and Technology, Ames) *Journal of Aircraft* (ISSN 0021-8669) vol. 30, no. 3 May-June 1993 p. 415, 416. AIAA, Applied Aerodynamics Conference, 9th, Baltimore, MD, Sept. 23-25, 1991, AIAA Paper 91-3210. Previously cited in issue 23, p. 4009, Accession no. A91-53884 refs
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A93-37400

THEODORSEN'S IDEAL PROPELLER PERFORMANCE WITH AMBIENT PRESSURE IN THE SLIPSTREAM

GERRIT SCHOUTEN (Delft Univ. of Technology, Netherlands) *Journal of Aircraft* (ISSN 0021-8669) vol. 30, no. 3 May-June 1993 p. 417-419. refs
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Theodorsen's propeller theory is briefly reviewed, and two deficiencies in this theory, namely, the high pressure in the slipstream and the underestimated required power, are identified. A modified version of the theory is proposed which remedies the deficiencies of the model and yields results that are more in agreement with physical reality. The thrust and power coefficients are recomputed based on the proposed modified theory. It is suggested that the proposed modifications be incorporated in a revised theory of propellers. AIAA

A93-37401

PERMEABLE AIRFOILS IN INCOMPRESSIBLE FLOW

VIRGIL M. MUSAT (Romanian Academy, Inst. of Applied Mathematics, Bucharest, Romania) *Journal of Aircraft* (ISSN 0021-8669) vol. 30, no. 3 May-June 1993 p. 419-421. refs
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The idea considered here is to use the effect of bubbles, generated in real flows, to improve the performance of airfoils, particularly at high incidences. In this manner, self-adaptive airfoils can be obtained, with the lift close to that observed in potential flows. In the potential flow, the 'provoked bubble' has three functions: (1) the diminution of the leading edge peak, (2) the

diminution of positive pressure gradient after peak, and (3) the increase of airfoil lift. It is expected that all these functions could enhance the boundary layer capability and therefore improve the behavior of the airfoil near stall. Theoretical results obtained for a NACA 0012 airfoil using a numerical code are in good agreement with experimental data. AIAA

A93-37404
MULTIPLE POLE RATIONAL-FUNCTION APPROXIMATIONS FOR UNSTEADY AERODYNAMICS

ASHISH TEWARI (National Aeronautical Lab., Bangalore, India) and JAN BRINK-SPALINK (Deutsche Airbus GmbH, Hamburg, Germany) *Journal of Aircraft* (ISSN 0021-8669) vol. 30, no. 3 May-June 1993 p. 426-428. refs
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The multiple-pole rational-function approximation (RFA) is examined from a mathematical standpoint. It is concluded that the multiple-pole RFA is dictated in the function space by the constrained optimization theory, thus validating the need for this approximation. AIAA

A93-37427*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

A FLUTTER INVESTIGATION OF ALL-MOVEABLE NASP-LIKE WINGS AT HYPERSONIC SPEEDS

CHARLES V. SPAIN, THOMAS A. ZEILER, ELLEN P. BULLOCK (Lockheed Engineering & Sciences Co., Hampton, VA), and JEFFREY S. HODGE (NASA, Langley Research Center, Hampton, VA) Apr. 1993 10 p. AIAA, ASME, ASCE, AHS, and ASC, Structures, Structural Dynamics and Materials Conference, 34th and AIAA and ASME, Adaptive Structures Forum, La Jolla, CA, Apr. 19-22, 1993 Research supported by NASA refs (AIAA PAPER 93-1315)

Six alternative all-moving wing configurations applicable to the NASP hypersonic/transatmospheric vehicle have undergone aeroelasticity testing in NASA-Langley's Mach-20-capable Helium Tunnel that yielded data for such parametric variations as airfoil profile and wing planform, wing-pivot flexure stiffness, and mass imbalance. While all wings fluttered at dynamic pressures lower than predicted by second-order piston-theory aerodynamics, this was of limited amplitude, suggesting nonlinear external-flow behavior. Slab airfoils were more stable than diamond-shaped ones; blunt leading edges enhance stability relative to sharp ones, and stiffer pivots exert a stabilizing influence. AIAA

A93-37933
ANALYSIS OF THERMAL IGNITION IN SUPERSONIC FLAT-PLATE BOUNDARY LAYERS

H. G. IM, J. K. BECHTOLD, and C. K. LAW (Princeton Univ., NJ) *Journal of Fluid Mechanics* (ISSN 0022-1120) vol. 249 April 1993 p. 99-120. Research supported by USAF refs
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The ignition of the supersonic boundary layer flow of a combustible mixture over a flat plate is studied through both direct numerical integration and activation energy asymptotics. Since ignition can be induced through either internally generated viscous heating or heat transfer from a hot wall, analyses are conducted for both an adiabatic wall and an isothermal wall whose temperature can be either higher or lower than the maximum frozen temperature in the flow. The analyses provide a description of the flow structure under various ignition situations, especially the extent of flow nonsimilarity and the interaction between the inner reaction region and the outer frozen regions. Explicit expressions for the ignition distance are obtained for all ignition situations, and the corresponding effects of the physical parameters on the ignition delay are also assessed. Specifically, it is demonstrated that, for low freestream Mach number M -infinity, the ignition distance increases linearly with M -infinity because of the decreased residence time, and for high M -infinity it decreases exponentially with M -infinity because of viscous heating. Results from the asymptotic analyses are found to compare well with those obtained from the direct numerical integration. Author (revised)

A93-37941
INVISCID INSTABILITY OF A SKEWED COMPRESSIBLE MIXING LAYER

GANYU LU and SANJIVA K. LELE (Stanford Univ., CA) *Journal of Fluid Mechanics* (ISSN 0022-1120) vol. 249 April 1993 p. 441-463. refs
 (Contract AF-AFOSR-91-0374)
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In this paper we study the inviscid instability of a skewed compressible mixing layer between streams of different velocity magnitude and direction. The mean flow is governed by the three-dimensional laminar boundary-layer equations and can be reduced to a sum of a uniform flow and a two-dimensional shear flow. In the stability analysis, the amplification direction is assumed to be normal to the homogeneous direction of the mean flow. The results show that skewing enhances the instability by a factor of three for the incompressible mixing layer with velocity ratio 0.5 and uniform temperature. Under compressible conditions, skewing still increases the maximum amplification rate for a medium convective Mach number, but the enhancement is smaller. A scaling of the skewing effect is introduced which quantitatively explains the linear stability behavior. Similarly, a suitably defined convective Mach number explains the compressibility effect. Author

A93-38130
THE APPLICATION OF CFD TO TURBOMACHINE DESIGN - PAST AND FUTURE

SUNAO AOKI (Mitsubishi Heavy Industries, Ltd., Takasago Machinery Works, Japan) *In Numerical Fluid Dynamics Symposium, 5th, Tokyo, Japan, Dec. 19-21, 1991, Proceedings Tokyo Numerical Fluid Dynamics Symposium Committee 1991* p. 25-32. In JAPANESE refs

This paper discusses the application of CFD to turbomachine design and development. It is based on the experience of the author in the use of CFD in designing turbomachines. Currently, 3D Euler codes are widely used in turbomachine manufacturers. Recently, 3D Navier-Stokes codes which can predict pressure losses have come into use. However, the codes need reducing CPU times and extensive verification studies. In near future, unsteady flow codes will be introduced to predict more realistic flow behavior. It is hoped that the CFD would make great contributions to the evolution of turbomachines. Author (revised)

A93-38146
VSL ANALYSIS OF NONEQUILIBRIUM FLOWS AROUND A HYPERSONIC BODY

YOSHITAKA SAKAMURA and MICHIO NISHIDA (Kyushu Univ., Fukuoka, Japan) *In Numerical Fluid Dynamics Symposium, 5th, Tokyo, Japan, Dec. 19-21, 1991, Proceedings Tokyo Numerical Fluid Dynamics Symposium Committee 1991* p. 171-174. In JAPANESE refs

Thermochemical nonequilibrium flows around a hypersonic reentry body have been studied using axisymmetric viscous shock-layer (VSL) equations. In order to take account of the effect of vibrational relaxation on the rate of chemical reactions, Park's two-temperature chemical reaction model is employed. The results show that the coupling of vibrational relaxation and reactions affects the flow fields and makes the shock stand-off distance, wall heat flux and hence wall temperature increase near the stagnation region. However, the increase in the wall heat flux and wall temperature is very small under a flight condition used in this analysis. Author (revised)

A93-38147
HYPERSONIC CHEMICALLY REACTING FLOW OF A REENTRY BODY

KEI-ICHI MURAKAMI and TOSHI FUJIWARA (Nagoya Univ., Japan) *In Numerical Fluid Dynamics Symposium, 5th, Tokyo, Japan, Dec. 19-21, 1991, Proceedings Tokyo Numerical Fluid Dynamics Symposium Committee 1991* p. 175-178. In JAPANESE refs

The body we treat is a 3D axisymmetric sphere-cone. Governing equations are the Navier-Stokes equations plus energy equation

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which couples with the species conservation equations. They are solved using a noniterative, approximately-factored implicit method of Beam and Warming. We set the flight Mach number 15 and 25, and the altitude 70 km. At first, we deal with a perfect gas to see approximate profiles of the density, pressure, and temperature in the base flow. In the next step, we use thermally perfect but calorically imperfect multicomponent gas mixtures. Five species (O₂, N₂, O, N, and NO) are considered where the five most important chemical reactions among these constituent species are allowed. Author (revised)

A93-38148 NUMERICAL ANALYSIS FOR CHEMICALLY NON-EQUILIBRIUM FLOW

ASAMI MATSUMOTO, NOBUYUKI SATOFUKA, and KOJI MORINISHI (Kyoto Inst. of Technology, Japan) *In* Numerical Fluid Dynamics Symposium, 5th, Tokyo, Japan, Dec. 19-21, 1991, Proceedings Tokyo Numerical Fluid Dynamics Symposium Committee 1991 p. 179-182. *In* JAPANESE refs

Numerical simulation of hypersonic, inviscid, chemically nonequilibrium gas flow is carried out. Park's five-species and three-reactions gas model is used as a real gas model. The 2D Euler equations in conservation law form are solved using a method of lines approach. In the method, the time integration and discretization of spatial derivatives are treated separately. The spatial derivatives are discretized by using the 2nd-order accurate upwind TVD scheme for good shock capturing. The resulting system of the ordinary differential equations in time is integrated by the rational Runge-Kutta scheme. Numerical results are shown for hypersonic inviscid flow past a double ellipse, and are compared with that of perfect gas flow. The differences between two flow fields, i.e., shock standoff distance, temperature distributions and so on, are investigated. Author (revised)

A93-38158 NUMERICAL CALCULATION OF SEPARATED FLOWS AROUND WING SECTION IN UNSTEADY MOTION BY USING INCOMPRESSIBLE NAVIER-STOKES EQUATIONS

SHIGERU ASO (Kyushu Univ., Fukuoka, Japan), ATSUHIRO SAKAMOTO (Nissan Motor Co., Ltd., Tokyo, Japan), and MASANORI HAYASHI (Nishinippon Inst. of Technology, Fukuoka, Japan) *In* Numerical Fluid Dynamics Symposium, 5th, Tokyo, Japan, Dec. 19-21, 1991, Proceedings Tokyo Numerical Fluid Dynamics Symposium Committee 1991 p. 251-254. *In* JAPANESE refs

Dynamic stall phenomena have been investigated numerically by solving incompressible Navier-Stokes equations by a third-order upwind scheme in order to reveal the flow structure and mechanism of dynamic stall. Separated flows around oscillating airfoil in pitch are calculated by using a moving mesh system. The flow conditions are selected from our experiments. The calculated separated region is small in pitching-up process and it becomes large in a pitching-down process. Quite different characteristics of flow patterns between in a pitching-up and pitching-down processes are obtained. The hysteresis curves of CL and CM in dynamic stall are also simulated in the present calculations. Author (revised)

A93-38162 NUMERICAL SOLUTION OF VISCOUS COMPRESSIBLE FLOWS USING ALGEBRAIC TURBULENCE MODELS

HIROYUKI KATO, NOBUYUKI SATOFUKA, and KOJI MORINISHI (Kyoto Inst. of Technology, Japan) *In* Numerical Fluid Dynamics Symposium, 5th, Tokyo, Japan, Dec. 19-21, 1991, Proceedings Tokyo Numerical Fluid Dynamics Symposium Committee 1991 p. 287-290. *In* JAPANESE refs

Three algebraic turbulence models; Baldwin-Lomax (B-L), Johnson-King (J-K) and Renormalization Group (RNG), are applied to viscous transonic flows over NACA0012 and RAE2822 airfoils. The 2D Reynolds averaged Navier-Stokes equations have been solved by using a method of lines approach. The spatial derivatives are discretized by means of the central finite differential approximation and the resulting system of the ordinary differential

equations in time is integrated by a rational Runge-Kutta (RRK) scheme. Computational results indicate that J-K and RNG models are in good agreement with experimental data. Author (revised)

A93-38187 ADAPTIVE GRID GENERATION USING OPTIMAL CONTROL THEORY

EITARO YAMADA and MAKOTO KOBAYAKAWA (Kyoto Univ., Japan) *In* Numerical Fluid Dynamics Symposium, 5th, Tokyo, Japan, Dec. 19-21, 1991, Proceedings Tokyo Numerical Fluid Dynamics Symposium Committee 1991 p. 451-454. *In* JAPANESE refs

New methods for the adaptive grid generation by using digital control theory are presented. In the first method, a 1D Poisson equation is transformed into a state-space form of linear control. Using the Thompson's weighting function, adaptation is performed along the xi-line. Since the correction of nodal positions and smoothing of grid lines are needed in the first method, the angular terms are introduced into the second method for automatic smoothing. The effectiveness of the present new method for adaptive grid generation is verified by numerical examples of high subsonic flow field around NACA-0012 airfoil. Author (revised)

A93-38193 UNSTEADY ANALYSIS OF HELICOPTER ROTOR

TAKASHI AOYAMA, KEIJI KAWACHI (Tokyo Univ., Japan), and SHIGERU SAITO (National Aerospace Lab., Chofu, Japan) *In* Numerical Fluid Dynamics Symposium, 5th, Tokyo, Japan, Dec. 19-21, 1991, Proceedings Tokyo Numerical Fluid Dynamics Symposium Committee 1991 p. 633-636. *In* JAPANESE refs

3D Euler equations in rotating Cartesian coordinate system are solved to analyze the flow field around helicopter rotors in forward flight. An implicit finite-difference method is used to solve the equations and the algebraic method is adopted to generate the grids. In order to analyze the unsteady phenomena the Newton-iterative method is applied. The pressure distributions on the blade-surface predicted by the present method are compared with experimental data, and the good correlation is obtained. Author (revised)

A93-38325 AN IMPLICIT FINITE-DIFFERENCE ALGORITHM FOR THE NUMERICAL SIMULATION OF SUPERSONIC FLOW OVER BLUNTED BODIES

S. A. EL-SEOUD (Sultan Qaboos Univ., Muscat, Oman) and W. TOERNIG (Darmstadt, Technische Hochschule, Germany) *Mathematical Methods in the Applied Sciences* (ISSN 0170-4214) vol. 16, no. 4 April 1993 p. 229-263. refs
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In order to compute axisymmetric laminar supersonic flow we use an unsteady implicit finite-difference scheme. This scheme solves numerically either the inviscid Euler equations or the 'thin-layer' Navier-Stokes equations. In both cases the scheme leads to large sparse nonlinear systems, which can be solved by a genuine iteration process. The convergence of this process is shown and numerical results are given. Author

A93-38434 NUMERICAL STUDY ON ATOM-MOLECULE RADIATION FLOWFIELD AROUND A HYPERSONIC BLUNT BODY

XIN-YU CHANG (Hiroshima Univ., Higashihiroshima, Japan), AKIHIRO SASOH (Tohoku Univ., Sendai, Japan), and TOSHI FUJIWARA (Nagoya Univ., Japan) *Japan Society for Aeronautical and Space Sciences, Transactions* (ISSN 0549-3811) vol. 35, no. 110 Feb. 1993 p. 177-186. refs

Equilibrium and nonequilibrium radiative heat transfer to a hypersonic reentry body is considered under the flow conditions at Mach number 25 and altitude 70 km. The gas around the body consists of seven chemical species including free electron. In order to treat nonequilibrium effect, a two-temperature model is used. In the radiative field, the absorption and emission coefficients are calculated with high spectral resolution and the radiation of each

species from each fluid element is computed. Furthermore, the radiative heat transfer to the body surface is calculated for practical purposes. The results show that the highest radiative heat flux to the body surface wall calculated here has amounted to 3.5 W/sq cm which is not negligible in designing a reentry-vehicle.

Author (revised)

A93-38573

VISCOUS NONEQUILIBRIUM FLOW CALCULATIONS

F. COQUEL, C. FLAMENT, V. JOLY, and C. MARMIGNON (ONERA, Chatillon, France) ONERA, TP no. 1992-89 1992 44 p. refs (ONERA, TP NO. 1992-89)

The purpose of this lecture is to present a numerical method capable to predict hypersonic flowfields by solving the conservation equations of chemical and vibrational nonequilibrium viscous flow. A fully coupled implicit finite volume method is presented in detail. The numerical approximation of the governing equations is derived using a second order upwind TVD scheme for the inviscid fluxes and a space centered scheme for the viscous fluxes. Numerical fluxes and source terms are fully coupled in the implicit step. Particular attention is paid on the physical models involved in this study. In order to illustrate the numerical method, quasi-1D Euler and axisymmetric internal Navier-Stokes results are presented. Results are also shown for 2D axisymmetric thermochemical nonequilibrium flows around a sphere-cylinder and a hyperboloid and for 2D plane chemical nonequilibrium flow around a double ellipse. The influence of physical models is studied and discussed.

Author (revised)

A93-38574

CALCULATIONS OF VISCOUS NONEQUILIBRIUM FLOWS IN NOZZLES [CALCULS D'ECOULEMENTS VISQUEUX EN DESEQUILIBRE DANS LES TUYERES]

C. MARMIGNON, V. JOLY, and F. COQUEL (ONERA, Chatillon, France) ONERA, TP no. 1992-91 1992 10 p. In FRENCH NATO, AGARD, Symposium on Theoretical and Experimental Methods in Hypersonic Flows, Turin, Italy, May 4-8, 1992 refs (ONERA, TP NO. 1992-91)

The paper presents an implicit finite-volume method for investigating viscous flows in a state of chemical and vibrational nonequilibrium in nozzles. The ideal-fluid flux terms are calculated by a decentered Roe-type scheme that is second order in space, and the viscous fluxes are determined using a centered scheme. The numerical fluxes and the sources terms are coupled completely at the implicit stage. The proposed method is illustrated by application to two flow configurations: (1) a test case from the Antibes Workshop on hypersonic flows and (2) a nozzle flow in the ONERA F4 wind tunnel.

AIAA

A93-38576

CONTRIBUTION OF VISUALIZATION TO THE STUDY OF UNSTEADY ASPECTS OF VORTEX BREAKDOWN [CONTRIBUTION DE LA VISUALISATION A L'ETUDE INSTATIONNAIRE DE L'ECLATEMENT TOURBILLONNAIRE]

JEAN-LOUIS SOLIGNAC and MARC GALLON (ONERA, Div. d'Aerodynamique Fondamentale, Chatillon, France) ONERA, TP no. 1992-93 1992 7 p. In FRENCH Colloque National de Visualisation et de Traitement d'Images en Mecanique des Fluides, 5th, Poitiers, France, June 26, 1992 refs (ONERA, TP NO. 1992-93)

Unsteady aspects of vortex breakdown at the apex of a delta wing were studied in a hydrodynamic tunnel using hydrogen bubbles created by electrolysis. Aspects of intermittency established between two vortices at high angle of attack were clarified. Then, the vortex structure in the breakdown regions was interpreted as being caused by the instability of rotational layers resulting from the original vortex.

AIAA

A93-38581

EXPERIMENTS ON SHOCK WAVE-BOUNDARY LAYER INTERACTION AT HIGH MACH NUMBER WITH ENTROPY LAYER EFFECT

MARIE-CLAIRE COET, JEAN DELERY, and BRUNO CHANETZ (ONERA, Chatillon, France) ONERA, TP no. 1992-101 1992 7 p. IUTAM, Symposium on Aerothermochemistry of Spacecraft and Associated Hypersonic Flow, Marseille, France, Sept. 1-4, 1992 Research supported by Dassault-Aviation refs (ONERA, TP NO. 1992-101)

The effect of an entropy layer on shock wave-boundary layer interactions occurring at Mach 10 has been investigated on 2D and 3D configurations. The presence of a blunt leading edge leads to a considerable decrease of heat transfer levels, compared to the sharp leading edge case. The phenomenon of spanwise variation of heat transfer in the reattachment region has been examined in more detail.

Author

A93-38588

SUPERSONIC VORTICAL FLOWS AROUND AN OGIVE-CYLINDER - LAMINAR AND TURBULENT COMPUTATIONS

M. BORREL, P. D'ESPINEY, and C. JOUET (ONERA, Chatillon, France) ONERA, TP no. 1992-111 1992 9 p. European Computational Fluid Dynamics Conference, 1st, Brussels, Belgium, Sept. 7-11, 1992 Research supported by DRET refs (ONERA, TP NO. 1992-111)

3D Navier-Stokes computations over an ogive cylinder configuration have been carried out at 10 deg and 20 deg of incidence for a flow at a freestream Mach number of two. The flow is either laminar or turbulent. The Baldwin-Lomax model has been chosen for turbulent cases. The numerical implementation of this model is carefully examined, with a particular attention to vortical 3D aspects. Comparisons with available experimental data are made.

Author (revised)

A93-38590

STRUCTURED GRID VARIATIONAL ADAPTION - REACHING THE LIMIT?

OLIVIER-PIERRE JACQUOTTE and GREGORY COUSSEMENT (ONERA, Chatillon, France) ONERA, TP no. 1992-114 1992 12 p. European Computational Fluid Dynamics Conference, 1st, Brussels, Belgium, Sept. 7-11, 1992 refs (ONERA, TP NO. 1992-114)

A variational method for the optimization and adaptation of structured grids is briefly reviewed. The method was tested for two cases, namely, the adaptation of a C-H mesh around the ONERA M6 wing and the adaptation to a flow in a relatively twisted compressor cascade. It is concluded that the method which uses mathematical and mechanical analysis produces satisfactory results in a large variety of cases. It is pointed out that there are certain difficulties caused by a combination of strong geometric constraints in areas of adaptation which indicates that scientists are reaching or at least getting close to the limit in structured grids with simple topologies.

AIAA

A93-38595

A NUMERICAL PROCEDURE FOR AERODYNAMIC OPTIMIZATION OF HELICOPTER ROTOR BLADES

J. ZIBI, G. DEFRESNE, and M. COSTES (ONERA, Chatillon, France) ONERA, TP no. 1992-121 1992 13 p. European Rotorcraft Forum, 18th, Avignon, France, Sept. 15-18, 1992 refs (ONERA, TP NO. 1992-121)

An aerodynamic optimization procedure is developed for rotor blade design, and is applied to define optimum airfoil characteristics in high speed forward flight. For that purpose, the CONMIN optimizer was coupled to a helicopter rotor performance code, R85 developed by Eurocopter France. The objective function to be minimized is the power necessary to drive the rotor, and constraints are imposed on aerodynamic and geometrical characteristics, among which the pitch-link loads are the most important. The airfoil tables for the profiles defining the blade are interpolated among a set of airfoil tables for existing or extrapolated airfoils, and the design variables are these interpolation coefficients. Numerical results show that significant improvements can be obtained on the rotor lift-to-drag ratio by thinning the blade, the

02 AERODYNAMICS

rotor performance at high lift being recovered by cambering the airfoils. Author

A93-38596

AERODYNAMIC ROTOR LOADS PREDICTION METHOD WITH FREE WAKE FOR LOW SPEED DESCENT FLIGHTS

B. MICHEA, A. DESOPPER, and M. COSTES (ONERA, Chatillon, France) ONERA, TP no. 1992-122 1992 13 p. European Rotorcraft Forum, 18th, Avignon, France, Sept. 15-18, 1992 Research supported by Service Technique des Programmes Aeronautiques refs (ONERA, TP NO. 1992-122)

A numerical method was developed to simulate a helicopter rotor at low speed and for descent flights. It consists of the coupling between a 3D unsteady full potential code, FP3D, and a new code derived from a lifting line method with vortex elements for the wake with prescribed geometry, METAR. This new code, MESIR, has a free wake analysis to get the capability to compute Blade-Vortex Interactions. Furthermore, the parts of the wake interacting with the blade are isolated and included in FP3D through a lifting surface approach. The method is validated with flight test results from the SA349 Gazelle helicopter and wind tunnel tests for the US Army OLS rotor in the DNW wind tunnel. Author

A93-38599

APPLICATION OF EUROPEAN CFD METHODS FOR HELICOPTER ROTORS IN FORWARD FLIGHT

M. COSTES (ONERA, Chatillon, France), R. HOUWINK (Nationaal Lucht- en Ruimtevaartlab., Amsterdam, Netherlands), A. KOKKALIS (Westland Helicopters, Ltd., Yeovil, United Kingdom), K. PAHLKE (DLR, Braunschweig, Germany), and A. SAPORITI (Agusta S.p.A., Cascina Costa di Samarate, Italy) ONERA, TP no. 1992-125 1992 13 p. European Rotorcraft Forum, 18th, Avignon, France, Sept. 15-18, 1992 Research supported by EEC refs (ONERA, TP NO. 1992-125)

Results are presented of computations performed for helicopter rotors in high-speed forward flight, using various European CFD codes for helicopter rotors. The methods using test cases dealing with rotors in high-speed forward flight cover a wide range of formulations, from a two-dimensional unsteady viscous TSP code to a three-dimensional quasi-steady and unsteady potential, with or without boundary layer corrections. The results show that the flow unsteadiness and three-dimensionality are important for describing correctly the transonic zone. AIAA

A93-38602

NUMERICAL CALCULATION OF HELICOPTER ROTOR EQUATIONS AND COMPARISON WITH EXPERIMENT

D. PETOT and J. BESSONE (ONERA, Chatillon, France) ONERA, TP no. 1992-128 1992 13 p. European Rotorcraft Forum, 18th, Avignon, France, Sept. 15-18, 1992 refs (ONERA, TP NO. 1992-128)

The numerical equations of the helicopter rotor structure are generalized by describing the rotor structure through an assembly of elementary units which often consist of only simple rotations or translations. The equations of the structure are written by describing the way all the dm elements move; the displacements of every point of the model are defined relative to any other point by the transformation that relates the two points. The equations of the model can be used for many purposes including determinations of the stability in hover, the forced periodic response in forward flight, and the rotor transient response through time integration. AIAA

A93-38605

DESIGNING NEW MULTI-PHASE INTERMETALLIC MATERIALS BASED ON PHASE COMPATIBILITY CONSIDERATIONS

SHIGEHISA NAKA and TASADDUQ KHAN (ONERA, Chatillon, France) ONERA, TP no. 1992-131 1992 10 p. ASM, Conference on Synthesis, Processing, and Modelling of Advanced Materials, Paris, France, Sept. 11-13, 1991 refs (ONERA, TP NO. 1992-131)

Inspired by the outstanding mechanical performance of nickel-base superalloys which results from an excellent phase compatibility between their constituent gamma and gamma-prime phases, we have tried to create a gamma-gamma-prime type microstructure in different alloy systems. The present paper describes the overall approach and the results of the experiments carried out essentially on both iron-base and niobium-base systems. In the pseudo-binary Fe-Ni2AlTi system and its derivatives, a microstructure which is very similar to that of nickel-base gamma-gamma-prime superalloys was observed, the constituent phases being A2 and L2(1). In the Nb-Ti2AlMo system, the second order order-disorder transition was observed, indicating the absence of a two-phase A2+B2 field, but the alloys of this system showed a high mechanical strength up to 950 C. Finally, the two-phase B2+A2 microstructure obtained most recently in a tantalum-base alloy is very encouraging for further effort directed to the development of new multiphase intermetallic materials.

Author (revised)

A93-38610

TRANSONIC AND SUPERSONIC FLOW CALCULATIONS AROUND AIRCRAFTS USING A MULTIDOMAIN EULER CODE

V. COUAILLIER, R. GRENON, and N. LIAMIS (ONERA, Chatillon, France) ONERA, TP no. 1992-137 1992 6 p. International Conference on Numerical Methods in Fluid Dynamics, 13th, Rome, Italy, July 6-10, 1992 refs (ONERA, TP NO. 1992-137)

A three-dimensional (3D) Euler numerical method is proposed, based on the explicit scheme of Ni (1982) combined with the implicit finite-volume method of Lerat et al. (1982). The method was implemented in a 3D code with multidomain approach and treatment of the boundary conditions based on the characteristic relations. Calculations performed using this method are presented of transonic and supersonic flows around a supersonic transport aircraft. AIAA

A93-38638

SOME SPECIAL PURPOSE PRECONDITIONERS FOR CONJUGATE GRADIENT-LIKE METHODS APPLIED TO CFD

J. STRIGBERGER, G. BARUZZI, W. HABASHI (Concordia Univ., Montreal, Canada), and M. FORTIN (Univ. Laval, Sainte-Foy, Canada) International Journal for Numerical Methods in Fluids (ISSN 0271-2091) vol. 16, no. 7 April 15, 1993 p. 581-596. refs

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Standard preconditioners such as incomplete LU decomposition perform well when used with conjugate gradient-like iterative solvers such as GMRES for the solution of elliptic problems. However, efficient computation of convection-dominated problems requires, in general, the use of preconditioners tuned to the particular class of fluid-flow problems at hand. This paper presents three such preconditioners. The first is applied to the finite element computation of inviscid (Euler equations) transonic and supersonic flows with shocks and uses incomplete LU decomposition applied to a matrix with extra artificial dissipation. The second preconditioner is applied to the finite difference computation of unsteady incompressible viscous flow; it uses incomplete LU decomposition applied to a matrix to which a pseudo-compressible term has been added. The third method and application are similar to the second, only the LU decomposition is replaced by Beam-warming approximate factorization. In all cases, the results are in very good agreement with other published results and the new algorithms are found to be competitive with others; it is anticipated that the efficiency and robustness of conjugate-gradient-like methods will render them the method of choice as the difficulty of the problems that they are applied to is increased. Author

A93-38695* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

CHARACTERISTICS OF THREE-DIMENSIONAL TURBULENT JETS IN CROSSFLOW

A. O. DEMUREN (NASA, Lewis Research Center, Cleveland, OH)

International Journal of Engineering Science (ISSN 0020-7225) vol. 31, no. 6 June 1993 p. 899-913. Previously announced in STAR as N91-22536 refs (Contract NASA ORDER C-99066-G) Copyright

Three-dimensional turbulent jets in crossflow at low to medium jet-to-crossflow velocity ratios are computed with a finite volume numerical procedure which utilizes a second-moment closure model to approximate the Reynolds stresses. A multigrid method is used to accelerate the convergence rate of the procedure. Comparison of the computations to measured data show good qualitative agreement. All trends are correctly predicted, though there is some uncertainty on the height of penetration of the jet. The evolution of the vorticity field is used to explore the jet-crossflow interaction. Author

A93-38728
LASER-VELOCIMETER STUDY OF VORTEX BREAKDOWN ON A 70-DEG SWEEPED DELTA WING IN INCOMPRESSIBLE FLOW [ETUDE AU VELOCIMETRE LASER DE L'ECLATEMENT D'UN TOURBILLON SUR UNE AILE DELTA DE 70 DEG DE FLECHE, EN ECOULEMENT INCOMPRESSIBLE]

PASCAL MOLTON and DIDIER AFCHAIN (ONERA, Chatillon, France) ONERA, TP no. 1992-147 1992 9 p. In FRENCH Congres Francophone de Velocimetrie Laser, 3rd, Toulouse, France, Sept. 21-24, 1992 refs (ONERA, TP NO. 1992-147)

Vortex-breakdown conditions on a delta wing at angle of attack were studied at an upstream velocity of 24 m/s. Laser visualizations made it possible to determine the breakdown point as a function of angle of attack for a 70-deg swept wing. A breakdown configuration was then analyzed on the basis of tridirectional laser velocimeter studies. Detailed velocity measurements have made possible a precise determination of the mean and turbulent flow structure. AIAA

A93-38729
ANALYSIS OF TURBULENCE IN SUPERSONIC FLOWS BY MEANS OF LASER VELOCIMETRY [SUR L'ANALYSE DE LA TURBULENCE PAR VELOCIMETRIE LASER DANS LES ECOULEMENTS SUPERSONIQUES]

ELISABETH BLIN, FRANCIS MICHELI, and LAURENT JACQUIN (ONERA, Chatillon, France) ONERA, TP no. 1992-148 1992 9 p. In FRENCH Congres Francophone de Velocimetrie Laser, 3rd, Toulouse, France, Sept. 21-24, 1992 refs (ONERA, TP NO. 1992-148)

The drag of the aerosol particles on laser-velometer measurements of the fluctuating velocity in flows interacting with a shock is investigated. A simplified calculation of the velocity of the particles through the shock is presented, which demonstrates the effects of the drag, associated with two significant factors: polydispersion and shock intermittency. Also considered are uncertainties of laser measurements in supersonic mixing layers. This problem is analyzed on the basis of sounding results obtained by different methods on a coaxial jet. AIAA

A93-38734
TESTING TECHNIQUES FOR STRAIGHT TRANSONIC AND SUPERSONIC CASCADES

J. HOORELBEKE, R. GAILLARD, and G. LOSFELD (ONERA, Chatillon, France) ONERA, TP no. 1992-155 1992 11 p. refs (ONERA, TP NO. 1992-155) Copyright

The paper describes the S5Ch wind tunnel at the Meudon test center of ONERA, designed for transonic and supersonic cascade testing. Particular attention is given to the cascade testing equipment, the stator cascade test fixture, the supersonic cascade test fixture, and the test techniques. Experimental results of tests conducted in two experiments were compared with those obtained by inviscid fluid computations, and it was found that good agreement could be achieved in supersonic flows if boundary layers were taken into account by measurements and by computations using integral methods. AIAA

A93-38741
DEFINITION AND EVALUATION OF NEW HELICOPTER ROTOR BLADE TIPS [DEFINITION ET EVALUATION DE NOUVELLES EXTREMITES DE PALES DE ROTORS D'HELICOPTERE]

J. J. PHILIPPE (ONERA, Chatillon, France) ONERA, TP no. 1992-179 1992 21 p. In FRENCH SFEN, Journees Techniques sur l'Approche Qualite en Nucleaire et Aerospatial - Divergences et Convergences, Paris, France, Oct. 21, 22, 1992 Research supported by Ministere de la Defense refs (ONERA, TP NO. 1992-179)

From 1975 to 1992 ONERA conducted a series of studies with the aim of defining and evaluating new helicopter rotor blade tips. The various phases of theoretical and experimental studies conducted within the framework of this research are described. Both simple and sophisticated blade tips have been considered. The research has had as its objectives the development of calculation codes and the realization of wind tunnel tests in an effort to understand the complex phenomena involved and to evaluate the local and global performance of different types of blade tips. Flight tests were carried out on Aerospatiale aircraft. AIAA

A93-38743
SHOCK/BOUNDARY LAYER INTERACTION IN A HYPERSONIC FLOW IN THE PRESENCE OF AN ENTROPY LAYER [INTERACTION ONDE DE CHOC/COUCHE LIMITE EN ECOULEMENT HYPERSONIQUE EN PRESENCE D'UNE COUCHE D'ENTROPIE]

M.-C. COET, B. CHANETZ, and J. DELERY (ONERA, Chatillon, France) ONERA, TP no. 1992-181 1992 9 p. In FRENCH Colloque sur les Ecoulements Hypersoniques, Garchy, France, Oct. 5-7, 1992 Research supported by Dassault Aviation refs (ONERA, TP NO. 1992-181)

An experimental study of shock/boundary layer interaction phenomena at large Mach numbers was carried out in simple 2D and 3D geometries in the framework of the Hermes project. Experiments were performed in the R3Ch wind tunnel at a Mach number of 10. The interactions studied are probably transitional. In the 2D flow the presence of an entropy layer leads to a ten-fold reduction in the flux levels achieved at reattachment. Transverse variations of the heat flux were observed for both sharp and rounded leading edges. Values of maximum heat flux on the obstacle were also determined for 3D flow. AIAA

A93-38744
SHOCK WAVE/BOUNDARY LAYER INTERACTION IN A TWO-DIMENSIONAL LAMINAR HYPERSONIC FLOW [INTERACTION ONDE DE CHOC-COUCHE LIMITE EN ECOULEMENT HYPERSONIQUE LAMINAIRE BIDIMENSIONNEL]

B. CHANETZ, M.-C. COET, D. NICOUT, and T. POT (ONERA, Chatillon, France) ONERA, TP no. 1992-182 1992 9 p. In FRENCH Colloque sur les Ecoulements Hypersoniques, Garchy, France, Oct. 5-7, 1992 refs (ONERA, TP NO. 1992-182)

The paper presents an investigation of the interaction between a shock wave and a laminary boundary layer induced by a 2D ramp in the R5 wind tunnel at a Mach number of 10. Two models were studied which led to interactions without separation (ramp angle of 15 deg) and with extended separation (ramp angle of 25 deg). Separation at 25 deg was investigated on the basis of temperature and mass measurements using multibeam CARS. The interaction was also studied using a calculation code to solve the Navier-Stokes equations. Good agreement was found between calculations and experimental results. AIAA

A93-38745

A VISCOUS-INVISCID SOLVER FOR HIGH-LIFT INCOMPRESSIBLE FLOWS OVER MULTI-ELEMENT AIRFOILS AT DEEP SEPARATION CONDITIONS [UNE METHODE D'INTERACTION VISQUEUX NON-VISQUEUX POUR ECOULEMENTS INCOMPRESSIBLES HYPERSUSTENTES SUR PROFILS MULTI-CORPS EN REGIME DE DECOLLEMENT PROFOND]

J. C. LE BALLEUR and M. NERON (ONERA, Chatillon, France) ONERA, TP no. 1992-183 1992 13 p. In FRENCH NATO, AGARD, Symposium on High-Lift Aerodynamics, Banff, Canada, Oct. 5-8, 1992 refs (ONERA, TP NO. 1992-183)

A viscous-inviscid interaction numerical method for incompressible flows over multi-elements airfoils, which is an extension of the numerical method previously suggested for compressible attached or separated or even stalled flows over airfoils, is presented. The robust algorithms of the method are capable now to converge as well for attached flows or massively separated flows, such as induced by slope discontinuities of airfoils or slats, or such as induced by stall. The viscous-inviscid approach introduces a self-adaptative viscous grid in both normal and streamwise directions along the displacement surfaces, with everywhere a streamwise grid-resolution of the same order as the separating boundary layer thicknesses, even at slat apexes, which is believed to eliminate any aleatory effect of numerical viscosity. The method is validated with respect to ONERA experiments, on the three-element RA16SCI high-lift device, with the severe AMD slat-geometry. A realistic non-uniqueness of the separated flow solutions has been exhibited by the calculation method. A satisfactory agreement between theory and experiment is obtained, with the suggested 2 equation turbulence model.

Author (revised)

A93-38746

VISCOUS-INVISCID CALCULATION OF HIGH-LIFT SEPARATED COMPRESSIBLE FLOWS OVER AIRFOILS AND WINGS [CALCUL PAR INTERACTION VISQUEUX NON-VISQUEUX DES ECOULEMENTS COMPRESSIBLES FORTEMENT DECOLLES AUX GRANDES PORTANCES SUR PROFILS D'AILES ET VOILURES]

J. C. LE BALLEUR (ONERA, Chatillon, France) ONERA, TP no. 1992-184 1992 19 p. In FRENCH NATO, AGARD, Symposium on High-Lift Aerodynamics, Banff, Canada, Oct. 5-8, 1992 Research supported by Service Technique des Programmes Aeronautiques refs (ONERA, TP NO. 1992-184)

The viscous-inviscid interaction transonic numerical method previously defined by the author for computing attached or separated flows over airfoils, including the deeply stalled flows is extended into a new three-dimensional method for strongly separated flows over wings at high-lift and compressible speeds. The numerical non-linearly implicit boundary layer technique (direct/inverse), the turbulent models, the grid generation and grid-adaption, the coupling and wake-equilibration algorithms, the inviscid full-potential schemes, are extended in three-dimension, with approximation on the viscous equations (2.75D-local). New theoretical results are given on the singularities and characteristic cones of the fully three-dimensional boundary layer in inverse mode. A new 'Massive-separation 2.75D' extension of the 'Semi-inverse' algorithm of Le Balleur for coupling is given and detailed, together with its stability-theory. Results are shown for 2D-stall, and for 3D separated flows over rectangular or swept wings, with satisfactory agreement between theory and experiment. A self-adaptation technique of the grid to the viscous effects is displayed. The results demonstrate that the viscous-inviscid interaction methods give a full access to the calculation of three-dimensional separation.

Author (revised)

A93-38755

PHENOMENOLOGY AND SIMPLIFIED MODELING OF A VORTEX WAKE GENERATED BY A TRANSVERSE JET [PHENOMENOLOGIE ET MODELISATION SIMPLIFIEE DU SILLAGE TOURBILLONNAIRE ENGENDRE PAR UN JET TRANSVERSAL]

L. JACQUIN (ONERA, Chatillon, France) ONERA, TP no. 1992-194 1992 36 p. In FRENCH Colloque d'Aerodynamique Appliquee, 28th, Saint Louis, France, Oct. 21-23, 1991 refs (ONERA, TP NO. 1992-194)

The main mechanisms associated with the development of an incompressible transverse jet are first examined. Aspects of the modeling of vortex wakes are then considered; equations of mass and momentum conservation are presented for a pair of counterrotating vortices. Comparison is made with subsonic experiments, and the application to supersonic jets is discussed. The application of the simplified modeling approach discussed here to a problem of missile guidance is considered. AIAA

A93-38777

THEORETICAL AND EXPERIMENTAL STUDY OF THE BEHAVIOR OF PARTICLES PASSING THROUGH A SHOCK WAVE [ETUDE THEORIQUE ET EXPERIMENTALE DU COMPORTEMENT DES PARTICULES A LA TRAVERSEE D'UNE ONDE DE CHOC]

O. LEUCHTER, K. AMRAM (ONERA, Chatillon, France), and P. THOMAS (DLR, Goettingen, Germany) ONERA, TP no. 1992-233 1992 9 p. In FRENCH Congres Francophone de Velocimetrie Laser, 3rd, Toulouse, France, Sept. 21-24, 1992 refs (ONERA, TP NO. 1992-233)

A numerical method has been developed to analyze experimental data obtained jointly by ONERA and DLR on the behavior of aerosol in an oblique shock wave. Considering the particle size distribution made it possible to demonstrate the existence of a parasitic turbulence peak below the shock as a result of polydispersion. The results are of interest in connection with the use of aerosol particles to study flows via laser velocimetry. AIAA

A93-39115

A ONE-DIMENSIONAL THEORY FOR SUPERSONIC GAS JETS ABOVE THE CRITICAL PRESSURE [ODNOMERNAIA TEORIJA SVERKHZVUKOVYKH NERASCHETNYKH STRUI GAZA]

F. I. LUKHTURA Rossiiskaia Akademiia Nauk, Izvestiia, Mekhanika Zhidkosti i Gaza (ISSN 0568-5281) no. 1 Jan.-Feb. 1993 p. 48-56. In RUSSIAN refs

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A method is proposed, based on a quasi-one-dimensional study of a supersonic jet above the critical pressure, for calculations of the parameters of such a jet. The method is used to compute the jet parameters at the section of its adaptation to the ambient conditions, directly adjacent to the exhaust nozzle exit section. The features of the jet which determine the jet structure and its attenuation behavior are examined. AIAA

A93-39116

AERODYNAMIC RESISTANCE OF THREE-DIMENSIONAL BODIES WITH A STARLIKE CROSS SECTION AT SUPERSONIC VELOCITIES, AND PROBLEMS OF ITS CALCULATION [AERODINAMICHESKOE SOPROTVIENIE PROSTRANSTVENNYKH TEL SO ZVEZDOBRIZNYM POPERECHNYM SECHENIEM PRI SVERKHZVUKOVYKH SKOROSTIAKH I PROBLEMY EGO RASCHETA]

N. A. OSTAPENKO (Moskovskii Gosudarstvennyi Univ., Moscow, Russia) Rossiiskaia Akademiia Nauk, Izvestiia, Mekhanika Zhidkosti i Gaza (ISSN 0568-5281) no. 1 Jan.-Feb. 1993 p. 57-69. In RUSSIAN refs

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The effects of the viscosity of the gas mass amount to a three-dimensional pyramidal body with a starlike cross section, the width of the displaced boundary layer, and its separation under the effect of internal shock waves on the aerodynamic resistance

of the body were investigated. It is shown that resistance models for starlike bodies that do not take into account the width of the displaced layer can be used only in unperturbed flows with freestream-Mach values of 3 or less. A new model for calculating the displacement width of the boundary layer is proposed. The model was validated in experiments with pyramidal bodies of varying parameters, exposed to hypersonic and supersonic gas flows.

AIAA

A93-39118

SUPERSONIC FLOW OF A GAS OVER A SEMIINFINITE PLATE WITH SMALL-SCALE HARMONIC SPANWISE OSCILLATIONS [OBTEKANIE SVERKHZVUKOVYM POTOKOM GAZA POLUBESKONECHNOI PLASTINY S MALYMI GARMONICHESKIMI VOZMUSHCHENIAMI PO RAZMAKHU]

V. A. BASHKIN and V. N. SHABANOV Rossiiskaia Akademiia Nauk, Izvestiia, Mekhanika Zhidkosti i Gaza (ISSN 0568-5281) no. 1 Jan.-Feb. 1993 p. 146-156. In RUSSIAN refs

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The problem of supersonic flow of an ideal gas over a semiinfinite plate with lengthwise fins is investigated using the method of combined external and internal factorization. The solution is obtained for a problem involving four expansion terms. It is shown that the calculated effect of the crosswise surface perturbations on the local resistance coefficients agrees with experimental data and with calculations based on Navier-Stokes equations.

AIAA

A93-39119

FLOW PAST THREE-DIMENSIONAL IRREGULARITIES IN A HYPERSONIC BOUNDARY LAYER ON A COOLED BODY [OBTEKANIE TREKHMERNYKH NEROVNSTEII V GIPERZVUKOVOM POGRANICHNOM SLOE NA OKHLAZHDENNOM TELE]

T. V. KONOTOP and V. N. TRIGUB Rossiiskaia Akademiia Nauk, Izvestiia, Mekhanika Zhidkosti i Gaza (ISSN 0568-5281) no. 1 Jan.-Feb. 1993 p. 157-165. In RUSSIAN refs

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Calculations are presented of the characteristics of flow of a hypersonic gas over a small three-dimensional irregularity on the surface of a cooled body, at the bottom of the boundary layer. The solution obtained for a wedgelike irregularity yields parameters determining the physical characteristics of the flow in the viscous layer next to the body surface, demonstrating qualitatively the effect of three-dimensionality.

AIAA

A93-39120

INTERFERENCE OF AN OBLIQUE SHOCK WITH A SHOCK LAYER ON A BLUNT EDGE FOR SMALL REYNOLDS NUMBERS [INTERFERENTSIIA NAKLONNOGO SKACHKA S UDARNYM SLOEM NA ZATUPLENNOI KROMKE PRI MALYKH CHISLAKH REINOL'DSA]

A. V. BOTIN Rossiiskaia Akademiia Nauk, Izvestiia, Mekhanika Zhidkosti i Gaza (ISSN 0568-5281) no. 1 Jan.-Feb. 1993 p. 166-171. In RUSSIAN refs

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Results are presented of experimental and numerical investigations of the interference of an oblique plane shock with a shock layer on a cylinder, simulating the leading edge of an air intake, for a Reynolds number $Re(0)$ equal to 32. Experiments were carried out in a vacuum tunnel, using direct visualization of the flow and data on local heat transfer in the presence of interference. Results are used to derive basic laws for the distribution of the flow characteristics at this Reynolds number for various types of interference.

AIAA

A93-39123

UNDEREXPANDED BOUNDARY JET IN A WAKE FLOW [PRISTENOCHNAIA NEDORASSHIRENNAIA STRUIA V SPUTNOM POTOKE]

E. G. ZAITSEV Rossiiskaia Akademiia Nauk, Izvestiia, Mekhanika Zhidkosti i Gaza (ISSN 0568-5281) no. 1 Jan.-Feb. 1993 p.

196-199. In RUSSIAN refs

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The flow characteristics of a planar underexpanded boundary jet discharged from an acoustic nozzle along the channel wall was experimentally investigated. A relationship is obtained between the magnitude of the first pulsation of the jet and the pressure differential. It is shown that, as the jet flows along the channel, a substantial axial gradient is formed in the initial section of the wake flow, resulting in a significantly changed geometry of the boundary jet.

AIAA

A93-39124

A NUMERICAL INVESTIGATION OF SUPERSONIC FLOW OF A VISCOUS GAS OVER LONG BLUNT CONES, TAKING INTO ACCOUNT EQUILIBRIUM PHYSICO-CHEMICAL TRANSFORMATIONS [CHISLENNOE ISSLEDOVANIE SVERKHZVUKOVOGO OBTEKANIIA ZATUPLENNYKH KONUSOV BOL'SHOI DLINY POTOKOM VIAZKOGO GAZA S UCHEMOM RAVNOVESNYKH FIZIKO-KHIMICHESKIKH PREVRASHCHENII]

S. V. UTIUZHNIKOV Rossiiskaia Akademiia Nauk, Izvestiia, Mekhanika Zhidkosti i Gaza (ISSN 0568-5281) no. 1 Jan.-Feb. 1993 p. 202-205. In RUSSIAN refs

Copyright

A numerical study was made of supersonic axisymmetrical flow of a viscous heat-conducting gas past a spherically blunted elongated cone at high Reynolds numbers, using a high-efficiency method based on global iterations to solve the equations of the viscous shock layer. Results elucidate the overall effect of a second approximation of the boundary layer theory and the effect of equilibrium physicochemical transitions on the thermal load on elongated cones.

AIAA

A93-39126

PROBLEMS IN PHYSICAL GAS DYNAMICS [PROBLEMY FIZICHESKOI GAZOVOI DINAMIKI]

V. IA. NEILAND, ED., V. M. KUZNETSOV, ED., and T. S. SHADRINA, ED. Moscow Izdatel'skii Otdel TsAGI (TsAGI, Trudy, No. 2424) 1990 338 p. In RUSSIAN For individual items see A93-39127 to A93-39152

Copyright

The papers contained in this volume are concerned with fundamental and applied research in the field of physical gas dynamics. A series of papers are presented which deal with the study of polyatomic gases and gas mixtures using asymptotic methods based on the kinetic theory of gases. Particular attention is given to studies of nonequilibrium flows of gases and low-temperature plasma using analytical methods and methods of computational physics, including studies of the structure of polyphase flows and gas flows with condensation. Consideration is also given to the aerophysical experiment, including papers on heterogeneous recombination in materials with varying catalytic properties, electron temperature diagnostics in strong shock waves, and characteristics of flow in gasdynamic shock tubes.

AIAA

A93-39130

KINETIC THEORY OF HYPERSONIC FLOWS OF A VISCOUS GAS [O KINETICHESKOI TEORII PREDEL'NYKH GIPERZVUKOVYKH TECHENII VIAZKOGO GAZA]

M. M. KUZNETSOV and V. S. NIKOL'SKII In Problems in physical gas dynamics Moscow Izdatel'skii Otdel TsAGI 1990 p. 74-99. In RUSSIAN refs

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Hypersonic flows are analyzed in the viscous layer regime using the Boltzmann equation. More general macroscopic analogs of equations of a thin viscous shock layer are obtained. These follow from Navier-Stokes and Barnett relaxation equations and from moment equations with a Newtonian limit process.

AIAA

02 AERODYNAMICS

A93-39131

ASYMPTOTIC STRUCTURE OF A LIMITING HYPERSONIC FLOW IN A SHOCK WAVE [ASIMPTOTICHESKAI A STRUKTURA PREDEL'NOGO GIPERZVUKOVOGO TECHENIIA V UDARNOI VOLNE]

M. M. KUZNETSOV and V. S. NIKOL'SKII *In* Problems in physical gas dynamics Moscow Izdatel'skii Otdel TsAGI 1990 p. 100-110. *In* RUSSIAN refs
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A limiting hypersonic flow of a gas with a large number of degrees of freedom is analyzed within the framework of the kinetic theory of gases. The scales of shock wave 'swelling' with the decreasing characteristic Reynolds number are estimated. It is shown that the asymptotic structure of the limiting flow in a shock wave includes supersonic, transonic, and subsonic flow zones of different scales. AIAA

A93-39132

THE PROBLEM OF TWO COULOMB CENTERS AND ITS APPLICATIONS IN PHYSICAL AERODYNAMICS [ZADACHA DVUKH KULONOVSKIKH TSENTROV I EE PRILOZHENIIA V FIZICHESKOI AERODINAMIKE]

A. D. NADEZHIN *In* Problems in physical gas dynamics Moscow Izdatel'skii Otdel TsAGI 1990 p. 111-121. *In* RUSSIAN refs
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A method is presented for the numerical solution of the quantum mechanical problem of two Coulomb centers, which can be used to model elementary physicochemical processes in high-velocity gas flows and radio wave transmission through a plasma layer. Photoionization with electron level excitation of a simple molecule and electron scattering by polar molecules are investigated to illustrate applications of the method. New oscillation patterns in effective cross sections are obtained. AIAA

A93-39133

NONEQUILIBRIUM LIMITING HYPERSONIC FLOW OF A GAS PAST THREE-DIMENSIONAL TAPERED BODIES WITH A SEPARATED SHOCK [NERAVNOVESNOE OBTEKANIE TREKHMERNYKH ZAOSTRENNYKH TEL S OTOSHEDSHIM SKACHKOM PREDEL'NYM GIPERZVUKOVYM POTOKOM GAZA]

M. M. KUZNETSOV *In* Problems in physical gas dynamics Moscow Izdatel'skii Otdel TsAGI 1990 p. 122-142. *In* RUSSIAN refs
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The asymptotic form of equations of a hypersonic three-dimensional thin shock layer is examined in the case of a limiting process with respect to one or several characteristic small parameters. It is shown that nonequilibrium flow in a three-dimensional wall layer depends on a number of new dimensionless criteria which have a substantial effect on the pressure at the body surface and heat transfer characteristics. For steady state nonequilibrium flow past a slender wing, an approximate method is proposed for solving the inverse problem. Attention is also given to the effect of an anomalous pressure drop near the trailing edge. AIAA

A93-39134

AN APPROXIMATE METHOD FOR CALCULATING NONEQUILIBRIUM FLOWS NEAR BLUNT BODIES [OB ODNOM Priblizhennom Metode Rascheta Neravnovesnykh Tehenii Okolo ZATuplennykh Tel]

O. IU. POLIANSKII *In* Problems in physical gas dynamics Moscow Izdatel'skii Otdel TsAGI 1990 p. 143-149. *In* RUSSIAN refs
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A sufficiently accurate engineering method is proposed for determining shock wave separation and nonequilibrium nonviscous hypersonic flow parameters at a critical flow line near a spherical nose for an arbitrary kinetic model of a gas. For a simple thermokinetic model, an analytical solution is obtained, and parametric calculations are carried out. The solution is used to

explain some characteristics of flow past models in wind tunnels in the presence of real gas effects, such as flow of Freon-14 CF4. AIAA

A93-39135

HYPERSONIC LIMITING FLOWS OF A RELAXING GAS WITH PRESSURE CHANGES IN THE MAIN APPROXIMATION [O GIPERZVUKOVYKH PREDEL'NYKH TECHENIIAKH RELAKSIRUIUSHCHEGO GAZA S IZMENENIEM DAVLENNIA V GLAVNOM Priblizhenii]

M. M. KUZNETSOV and O. IU. POLIANSKII *In* Problems in physical gas dynamics Moscow Izdatel'skii Otdel TsAGI 1990 p. 150-164. *In* RUSSIAN refs
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Some compression and rarefaction flows of a relaxing gas, in which the effect of flow nonequilibrium on the pressure is significant even in the main Newtonian approximation, are examined within the framework of a thin shock layer. It is shown that, when calculating aerodynamic characteristics (e.g., drag and lift coefficients and pressure center shifts), this phenomenon, which is not typical of nonequilibrium flows, sometimes becomes a determining factor. AIAA

A93-39136

EFFECT OF THE THERMODYNAMIC AIR MODEL ON THE AERODYNAMIC CHARACTERISTICS OF PROFILES WITH BENDS [VLIANIE TERMODINAMICHESKOI MODELI VOZDUKHA NA AERODINAMICHESKIE KHARAKTERISTIKI PROFILEI S IZLOMAMI]

V. L. MEN'SHIKOVA *In* Problems in physical gas dynamics Moscow Izdatel'skii Otdel TsAGI 1990 p. 165-175. *In* RUSSIAN refs
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By considering nonviscous hypersonic flow past a blunt plate with a bend, simulating an airfoil with a flap, as an example, a study is made of the effect of the thermodynamic air model on pressure distribution over the surface, aerodynamic coefficients, and pressure center position as a function of the airfoil geometry, angle of attack, and flap angle. These parameters are calculated and compared for flows of an ideal gas, equilibrium air, and chemically nonequilibrium air past a plate. AIAA

A93-39141

CALCULATION OF THE EFFECT OF THE SHOCK WAVE OF A DELTA WING ON A SECOND WING AT SUPERSONIC VELOCITIES [RASCHET VOZDEISTVIA UDARNOI VOLNY TREUGOL'NOGO KRYLA NA VTOROE KRYLO PRI SVERKHZVUKOVOI SKOROSTI]

A. N. MINAILOS *In* Problems in physical gas dynamics Moscow Izdatel'skii Otdel TsAGI 1990 p. 213-219. *In* RUSSIAN refs
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The objective of the study was to investigate the possibility of using McCormack's finite difference scheme for solving the problem of flow field interference near a wing with an incident shock wave. The problem considered here deals with the reflection of a shock wave, generated by a delta wing, from another wing. The problem is formulated in such a way as to reduce the dimensionality to three, maintaining only two-dimensional files in computer memory. It is shown that the numerical approach used here makes it possible to investigate flow field and shock wave interference in supersonic flow past lifting surfaces both qualitatively and quantitatively. AIAA

A93-39142

CALCULATION OF THE EFFECT OF FLOW CONICITY IN A HYPERSONIC NOZZLE ON THE AERODYNAMICS OF A FLIGHT VEHICLE MODEL [RASCHET VLIANIIA KONICHNOSTI POTOKA V GIPERZVUKOVOM SOPLE NA AERODINAMIKU MODELI LETATEL'NOGO APPARATA]

A. N. MINAILOS *In* Problems in physical gas dynamics Moscow Izdatel'skii Otdel TsAGI 1990 p. 220-228. *In*

RUSSIAN refs
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Flow past a delta wing with a sweep of 65 deg in the field of a conical stream from a supersonic nozzle at Mach close to 8 and 13 and angles of attack of 10-30 deg is investigated numerically using McCormack's finite difference scheme. The differences between the aerodynamic characteristics and the characteristics corresponding to steady incoming flow are determined as a function of the wing span and the height of its position within the test section of the tunnel. AIAA

A93-39143

NUMERICAL STUDY OF SPONTANEOUS NITROGEN CONDENSATION IN THE AXISYMMETRIC HYPERSONIC NOZZLES OF WIND TUNNELS [CHISLENNOE ISSLEDOVANIE SPONTANNOI KONDENSATSII AZOTA V OSESIMMETRICHNYKH GIPERZVUKOVYKH SOPLAKH AERODINAMICHESKIKH TRUB]

A. V. CHIRIKHIN *In* Problems in physical gas dynamics Moscow Izdatel'skii Otdel TsAGI 1990 p. 229-243. In RUSSIAN refs
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Parametric calculations of spontaneous nitrogen condensation in axisymmetric nozzles with a rated Mach number of 14 are presented. The results indicate significant mutual influence of flow two-dimensionality and phase transition in profiled nozzles with overexpansion. This effect is much less pronounced in conical nozzles. AIAA

A93-39145

NONEQUILIBRIUM HEAT TRANSFER NEAR THE CRITICAL POINT OF BLUNT BODIES [NERAVNOVESNAIA TEPLOPEREDACHA V OKRESTNOSTI KRITICHESKOI TOCHKI ZATUPLENNYKH TEL]

I. V. EGOROV, M. M. KUZNETSOV, and V. IA. NEILAND *In* Problems in physical gas dynamics Moscow Izdatel'skii Otdel TsAGI 1990 p. 254-268. In RUSSIAN refs
Copyright

The effect of chemical relaxation processes and catalytic surface properties on specific heat flow at the critical point of blunt bodies is investigated using the similarity theory for hypersonic flows and exact numerical calculations of a nonequilibrium thin viscous shock layer. The heat transfer coefficients are expressed as functions of the governing parameters over a wide range of parameter changes. For gliding bodies, the similarity parameters are determined, as are the corresponding universal relations which determine maximum heat flows at the thermally stressed section of the flight. AIAA

A93-39150

AN EXPERIMENTAL STUDY OF THE THREE-DIMENSIONAL INTERACTION OF A TRANSVERSE JET WITH HYPERSONIC FLOW [EKSPERIMENTAL'NOE ISSLEDOVANIE TREKHMERNOGO VZAIMODEISTVIA POPERECHNOI STRUI S GIPERZVUKOVYM POTOKOM]

A. S. KOROLEV *In* Problems in physical gas dynamics Moscow Izdatel'skii Otdel TsAGI 1990 p. 309-319. In RUSSIAN refs
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The interaction of a transverse gas jet injected from the cone of a surface with hypersonic incoming flow is investigated experimentally at Mach 10-14, $Re = (3.5-20) \times 10^6$, and angles of attack of 0-30 deg. Data on the flow structure, jet penetration depth in the external flow, and separation zone extension are obtained over a wide range of injection intensities. AIAA

A93-39152

MODELING OF FLOW IN A PULSED SHOCK TUNNEL [O MODELIROVANII TECHENIIA V IMPUL'SNOI AERODINAMICHESKOI UDARNOI TRUBE]

V. IA. BEZMENOV and V. V. OSIPOV *In* Problems in physical

gas dynamics Moscow Izdatel'skii Otdel TsAGI 1990 p. 329-335. In RUSSIAN refs
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Results of a study of gas flow in a pulsed shock tunnel are presented. A parameter is defined which determines pressure changes in the test chamber and in the exhaust volume of the tunnel. A method for calculating a high-pressure tunnel with allowance for intermolecular interaction forces is proposed. AIAA

A93-39196

EXPERIENCE IN THE DESIGN OF SUPERCRITICAL CASCADES FOR THE FLOW STRAIGHTENER OF A TRANSONIC FAN [OPYT PROEKTIROVANIA SUPERKINETICHESKIKH RESHETOK SPRIAMLIAUSHCHEGO APPARATA TRANZVUKOVOGO VENTILIATORA]

L. G. BOIKO, V. N. ERSHOV, A. E. DEMIN, and D. V. KALIAMIN *Aviatsionnaia Tekhnika* (ISSN 0579-2975) no. 4 1992 p. 82-85. In RUSSIAN refs
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By using the basic principles of the design of supersonic cascades, an airfoil cascade providing for shock free flow deceleration in supersonic flow regimes is designed using several approximations. It is shown that the cascade design proposed here has a sufficiently wide range of operating regimes with respect to impingement angles and Mach numbers of the incoming flow. Mach number distributions in the cascade are presented in graphic form. AIAA

A93-39254* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

HYPERSONIC SINGLE EXPANSION RAMP NOZZLE SIMULATIONS

STEPHEN M. RUFFIN (NASA, Ames Research Center, Moffett Field, CA), ETHIRAJ VENKATAPATHY, EARL R. KEENER (Eloret Inst., Palo Alto, CA), and FRANK W. SPAID (McDonnell Douglas Research Labs., Saint Louis, MO) *Journal of Spacecraft and Rockets* (ISSN 0022-4650) vol. 29, no. 6 Nov.-Dec. 1992 p. 749-755. AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992, AIAA Paper 92-0387. Previously cited in issue 09, p. 1351, Accession no. A92-26243 refs (Contract NCC2-420; NCC2-553)
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A93-39255

ENGINEERING METHOD FOR CALCULATING SURFACE PRESSURES AND HEATING RATES ON VEHICLES WITH EMBEDDED SHOCKS

D. B. LANDRUM, FRED R. DEJARNETTE (North Carolina State Univ., Raleigh), and BRET L. BOMAN (McDonnell Aircraft Co., Saint Louis, MO) *Journal of Spacecraft and Rockets* (ISSN 0022-4650) vol. 29, no. 6 Nov.-Dec. 1992 p. 756-764. AIAA, International Aerospace Planes Conference, 3rd, Orlando, FL, Dec. 3-5, 1991, AIAA Paper 91-5060. Previously cited in issue 05, p. 674, Accession no. A92-17842 refs (Contract F33615-87-C-3402)
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A93-39257* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

COMPUTATIONAL FLOW PREDICTIONS FOR HYPERSONIC DRAG DEVICES

SUSAN TOKARCIK and ETHIRAJ VENKATAPATHY (Eloret Inst., Palo Alto, CA) *Journal of Spacecraft and Rockets* (ISSN 0022-4650) vol. 29, no. 6 Nov.-Dec. 1992 p. 773-779. AIAA, Applied Aerodynamics Conference, 9th, Baltimore, MD, Sept. 23-25, 1991, AIAA Paper 91-3303. Previously cited in issue 23, p. 4008, Accession no. A91-53861 refs (Contract NCC2-420)

02 AERODYNAMICS

A93-39258* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

SHOCK INTERFERENCE PREDICTION USING DIRECT SIMULATION MONTE CARLO

ANN B. CARLSON and RICHARD G. WILMOTH (NASA, Langley Research Center, Hampton, VA) *Journal of Spacecraft and Rockets* (ISSN 0022-4650) vol. 29, no. 6 Nov.-Dec. 1992 p. 780-785. AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992, AIAA Paper 92-0492. Previously cited in issue 09, p. 1354, Accession no. A92-26322 refs
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A93-39259* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

ENERGETICS OF GAS-SURFACE INTERACTIONS IN TRANSITIONAL FLOWS AT ENTRY VELOCITIES

R. G. WILMOTH (NASA, Langley Research Center, Hampton, VA), V. K. DOGRA (Vigyan Research Associates, Inc., Hampton, VA), and J. N. MOSS (NASA, Langley Research Center, Hampton, VA) *Journal of Spacecraft and Rockets* (ISSN 0022-4650) vol. 29, no. 6 Nov.-Dec. 1992 p. 786-793. AIAA, Thermophysics Conference, 26th, Honolulu, HI, June 24-26, 1991, AIAA Paper 91-1338. Previously cited in issue 18, p. 3050, Accession no. A91-43407 refs
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A93-39260

NAVIER-STOKES STALL PREDICTIONS USING AN ALGEBRAIC REYNOLDS-STRESS MODEL

LARS DAVIDSON (Chalmers Univ. of Technology, Goteborg, Sweden) and ARTHUR RIZZI (Aeronautical Research Inst. of Sweden, Bromma) *Journal of Spacecraft and Rockets* (ISSN 0022-4650) vol. 29, no. 6 Nov.-Dec. 1992 p. 794-800. refs
Copyright

The paper presents results of a computational study of low-speed flow over an airfoil in stall. The code that solves the mean-flow equations is a rather standard explicit Runge-Kutta time-marching cell-centered finite volume technique using central differencing. The Baldwin-Lomax model failed to predict stall, and a standard k-epsilon transport model underpredicted the separation region in comparison with experiment. Only an algebraic Reynolds-stress model produced good agreement with the observed stall. The numerical treatment of the turbulent transport equations is novel. The k and epsilon equations are calculated implicitly using hybrid central/upwind differencing. A tridiagonal matrix procedure solves the resulting discretized linearized equations in both coordinate directions. This method for solving k and epsilon has proved to be very efficient and much more stable than the explicit solver used for the mean-flow equations. The combined approach therefore is semiimplicit. The influence of the explicit adding of the fourth-order numerical dissipation in the mean-flow equations is investigated, and it is shown that it has negligible effects on the calculated results. Author (revised)

A93-39401

AERODYNAMICS OF MANEUVERING SLENDER WINGS WITH LEADING-EDGE SEPARATION

T. S. TAVARES (USAF, Wright Lab., Wright-Patterson AFB, OH) and JAMES E. MCCUNE (MIT, Cambridge, MA) *AIAA Journal* (ISSN 0001-1452) vol. 31, no. 6 June 1993 p. 977-986. refs

(Contract AF-AFOSR-86-0157)

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A nonlinear theoretical technique is presented for treating the unsteady aerodynamics of low-aspect-ratio wings with leading-edge separation in incompressible flow. Cases are treated for wings in steady flight and for those undergoing severe unsteady maneuver. The treatment extends classical slender wing theory to allow for large-scale motion along with possibly asymmetric wake development. Calculated results are presented for a variety of cases and are compared with related analyses and experiments. Examples studied include wings of delta and clipped-delta planform. Flight conditions and maneuvers treated included sideslip, sudden

plunge, and rapid constant-rate roll at zero angle of attack. New results are interpreted in the light of wake history effects, a framework which provides a simplified means of interpreting the aerodynamic response in the severe maneuver case. The ability of the calculations to reproduce observed phenomena under a wide variety of conditions supports the practical usefulness of the extended slender wing treatment as a tool for gaining increased insight into the unsteady interaction between low-aspect-ratio wings and their wakes. Author

A93-39402

LIFTING LINE THEORY FOR SUPERSONIC FLOW APPLICATIONS

I. JADIC (Inst. of Applied Mathematics, Bucharest, Romania) and V. N. CONSTANTINESCU (Polytechnic Inst., Bucharest, Romania) *AIAA Journal* (ISSN 0001-1452) vol. 31, no. 6 June 1993 p. 987-994. AIAA, International Aerospace Planes Conference, 3rd, Orlando, FL, Dec. 3-5, 1991, AIAA Paper 91-5058. Previously cited in issue 05, p. 674, Accession no. A92-17841 refs
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A93-39403

VELOCITY AND VORTICITY DISTRIBUTIONS OVER AN OSCILLATING AIRFOIL UNDER COMPRESSIBLE DYNAMIC STALL

M. S. CHANDRASEKHARA (U.S. Naval Postgraduate School, Monterey, CA) and S. AHMED (MCAT Inst., San Jose, CA) *AIAA Journal* (ISSN 0001-1452) vol. 31, no. 6 June 1993 p. 995, 996. Abridged. AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 22nd, Honolulu, HI, June 24-26, 1991, AIAA Paper 91-1799. Previously cited in issue 18, p. 3059, Accession no. A91-43648 Research supported by U.S. Army refs
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A93-39409* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

FLIP-FLOP JET NOZZLE EXTENDED TO SUPERSONIC FLOWS

GANESH RAMAN (Sverdrup Technology, Inc., Brook Park, OH), MICHAEL HAILYE (Michigan Univ., Ann Arbor), and EDWARD J. RICE (NASA, Lewis Research Center, Cleveland, OH) *AIAA Journal* (ISSN 0001-1452) vol. 31, no. 6 June 1993 p. 1028-1035. AIAA Applied Aerodynamics Conference, 10th, Palo Alto, CA, June 22-24, 1992, Technical Papers. Pt. 2, p. 928-951. Previously cited in issue 19, p. 3252, Accession no. A92-45561 refs

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A93-39410

STABILIZATION OF THE BURNETT EQUATIONS AND APPLICATION TO HYPERSONIC FLOWS

XIAOLIN ZHONG, ROBERT W. MACCORMACK, and DEAN R. CHAPMAN (Stanford Univ., CA) *AIAA Journal* (ISSN 0001-1452) vol. 31, no. 6 June 1993 p. 1036-1043. AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991, AIAA Paper 91-0770. Previously cited in issue 06, p. 803, Accession no. A91-19460 refs

(Contract DAAL03-86-K-0139; DAAL03-90-G-0031-P00002; AF-AFOSR 91-0005)

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A93-39412 National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

UNSTEADY TRANSONIC TWO-DIMENSIONAL EULER SOLUTIONS USING FINITE ELEMENTS

GARY A. DAVIS and ODDVAR O. BENDIKSEN (California Univ., Los Angeles) *AIAA Journal* (ISSN 0001-1452) vol. 31, no. 6 June 1993 p. 1051-1059. AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics and Materials Conference, 33rd, Dallas, TX, Apr. 13-15, 1992, Technical Papers. Pt. 4, p. 2203-2213. Previously cited in issue 13, p. 2089, Accession no. A92-34499 refs

(Contract NCC2-374; NAS3-26064)

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A93-39428

INSTANTANEOUS STRUCTURE OF VORTEX BREAKDOWN ON A DELTA WING VIA PARTICLE IMAGE VELOCIMETRY

J. TOWFIGHI and D. ROCKWELL (Lehigh Univ., Bethlehem, PA) AIAA Journal (ISSN 0001-1452) vol. 31, no. 6 June 1993 p. 1160-1162. Research supported by USAF refs
Copyright

High density particle image velocimetry was used to characterize the instantaneous structure of vortex breakdown over an entire plane of the flow. Emphasis is placed on determination of the instantaneous contours of azimuthal vorticity and sectional streamline patterns over a plane passing through the centerline of the leading-edge vortex on a delta wing. The flow structure is characterized as a function of time after the wing is abruptly brought to a stationary position following a transient pitching motion.

AIAA

A93-39721

DEVELOPMENT OF A TRANSONIC EULER METHOD FOR COMPLETE AIRCRAFT CONFIGURATIONS

F. KAFYEKE, P. PIPERNI, F. MOKHTARIAN (Bombardier, Inc., Canadair Group, Montreal, Canada), and N. DJILALI (Bombardier, Inc., Canadair Group, Montreal; Victoria Univ., Canada) Canadian Aeronautics and Space Journal (ISSN 0008-2821) vol. 39, no. 1 March 1993 p. 3-15. Research supported by DND refs

A three-dimensional multi-block Euler method for complete aircraft configurations was developed at Canadair as part of an ongoing joint project with the Defence Industrial Research program (D.I.R.). As part of the project, new methods were developed to model the aircraft surface geometry, to generate three-dimensional body-fitted grids and to solve the Euler equations in a flow domain decomposed into several blocks. The paper discusses each one of these aspects of the project and includes a presentation of the computing facilities and of the pre- and post-processing software that were acquired in order to satisfy the requirements of the new codes.

Author

N93-26899*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

DEVELOPMENT OF A LARGE-SCALE, OUTDOOR, GROUND-BASED TEST CAPABILITY FOR EVALUATING THE EFFECT OF RAIN ON AIRFOIL LIFT

GAUDY M. BEZOS and BRYAN A. CAMPBELL Washington Apr. 1993 68 p

(Contract RTOP 505-68-01-02)

(NASA-TM-4420; L-17004; NAS 1.15:4420) Avail: CASI HC A04/MF A01

A large-scale, outdoor, ground-based test capability for acquiring aerodynamic data in a simulated rain environment was developed at the Langley Aircraft Landing Dynamics Facility (ALDF) to assess the effect of heavy rain on airfoil performance. The ALDF test carriage was modified to transport a 10-ft-chord NACA 64210 wing section along a 3000-ft track at full-scale aircraft approach speeds. An overhead rain simulation system was constructed along a 525-ft section of the track with the capability of producing simulated rain fields of 2, 10, 30, and 40 in/hr. The facility modifications, the aerodynamic testing and rain simulation capability, the design and calibration of the rain simulation system, and the operational procedures developed to minimize the effect of wind on the simulated rain field and aerodynamic data are described in detail. The data acquisition and reduction processes are also presented along with sample force data illustrating the environmental effects on data accuracy and repeatability for the 'rain-off' test condition.

Author (revised)

N93-27004*# Institute for Computer Applications in Science and Engineering, Hampton, VA.

SENSITIVITY CALCULATIONS FOR A 2D, INVISCID, SUPERSONIC FOREBODY PROBLEM Final Report

JEFF BORGGAARD (Virginia Polytechnic Inst., Blacksburg.), JOHN A. BURNS (Virginia Polytechnic Inst., Blacksburg.), EUGENE CLIFF (Virginia Polytechnic Inst., Blacksburg.), and MAX GUNZBURGER (Virginia Polytechnic Inst., Blacksburg.) Washington Mar. 1993

14 p Submitted for publication

(Contract NAS1-19480; F49620-92-J-0078; AF-AFOSR-0179-90; NSF INT-89-22490) (NASA-CR-191444; NAS 1.26:191444; ICASE-93-13) Avail: CASI HC A03/MF A01

The use of a sensitivity equation method to computer derivatives for optimization based design algorithms are discussed. The problem of designing an optimal forebody simulator is used to motivate the algorithm and to illustrate the basic ideas. Finally, how an existing computational fluid dynamics (CFD) code can be modified to compute sensitivities and a numerical example is presented.

Author (revised)

N93-27005*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

ASSESSMENT OF A FLOW-THROUGH BALANCE FOR HYPERSONIC WIND TUNNEL MODELS WITH SCRAMJET EXHAUST FLOW SIMULATION

LAWRENCE D. HUEBNER, MARC W. KNISKERN (North Carolina State Univ., Raleigh.), and WILLIAM J. MONTA Washington May 1993 50 p

(Contract RTOP 505-59-40-03)

(NASA-TM-4441; L-17088; NAS 1.15:4441) Avail: CASI HC A03/MF A01

The purpose of this investigation were twofold: first, to determine whether accurate force and moment data could be obtained during hypersonic wind tunnel tests of a model with a scramjet exhaust flow simulation that uses a representative nonwatercooled, flow-through balance; second, to analyze temperature time histories on various parts of the balance to address thermal effects on force and moment data. The tests were conducted in the NASA Langley Research Center 20-Inch Mach 6 Wind Tunnel at free-stream Reynolds numbers ranging from 0.5 to 7.4 x 10⁶/ft and nominal angles of attack of -3.5 deg, 0 deg, and 5 deg. The simulant exhaust gases were cold air, hot air, and a mixture of 50 percent Argon and 50 percent Freon by volume, which reached stagnation temperatures within the balance of 111, 214, and 283 F, respectively. All force and moment values were unaffected by the balance thermal response from exhaust gas simulation and external aerodynamic heating except for axial-force measurements, which were significantly affected by balance heating. This investigation showed that for this model at the conditions tested, a nonwatercooled, flow-through balance is not suitable for axial-force measurements during scramjet exhaust flow simulation tests at hypersonic speeds. In general, heated exhaust gas may produce unacceptable force and moment uncertainties when used with thermally sensitive balances.

Author (revised)

N93-27032*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

TRANSITION AERODYNAMICS FOR 20-PERCENT-SCALE VTOL UNMANNED AERIAL VEHICLE

KEVIN J. KJERSTAD and JOHN W. PAULSON, JR. Washington Apr. 1993 51 p Original contains color illustrations

(Contract RTOP 505-59-30-02)

(NASA-TM-4419; L-17112; NAS 1.15:4419) Avail: CASI HC A04/MF A01; 2 functional color pages

An investigation was conducted in the Langley 14- by 22-Foot Subsonic Tunnel to establish a transition data base for an unmanned aerial vehicle utilizing a powered-lift ejector system and to evaluate alterations to the ejector system for improved vehicle performance. The model used in this investigation was a 20-percent-scale, blended-body, arrow-wing configuration with integrated twin rectangular ejectors. The test was conducted from hover through transition conditions with variations in angle of attack, angle of sideslip, free-stream dynamic pressure, nozzle pressure ratio, and model ground height. Force and moment data along with extensive surface pressure data were obtained. A laser velocimeter technique for measuring inlet flow velocities was demonstrated at a single flow condition, and also a low order panel method was successfully used to numerically simulate the ejector inlet flow.

Author

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N93-27067*# Vigyan Research Associates, Inc., Hampton, VA.
**UNSTRUCTURED VISCOUS GRID GENERATION BY
ADVANCING-FRONT METHOD**
SHAHYAR PIRZADEH Apr. 1993 26 p
(Contract NAS1-19672; RTOP 505-59-53-05)
(NASA-CR-191449; NAS 1.26:191449) Avail: CASI HC A03/MF
A01

A new method of generating unstructured triangular/tetrahedral grids with high-aspect-ratio cells is proposed. The method is based on new grid-marching strategy referred to as 'advancing-layers' for construction of highly stretched cells in the boundary layer and the conventional advancing-front technique for generation of regular, equilateral cells in the inviscid-flow region. Unlike the existing semi-structured viscous grid generation techniques, the new procedure relies on a totally unstructured advancing-front grid strategy resulting in a substantially enhanced grid flexibility and efficiency. The method is conceptually simple but powerful, capable of producing high quality viscous grids for complex configurations with ease. A number of two-dimensional, triangular grids are presented to demonstrate the methodology. The basic elements of the method, however, have been primarily designed with three-dimensional problems in mind, making it extendible for tetrahedral, viscous grid generation. Author

N93-27084*# Stanford Univ., CA. Dept. of Aeronautics and
Astronautics.
**HYPERSONIC PANEL FLUTTER IN A RAREFIED
ATMOSPHERE**
HUGO B. RESENDE Washington May 1993 116 p
(Contract NGL-05-020-243; RTOP 505-63-50)
(NASA-CR-4514; NAS 1.26:4514; SUDAAR-614) Avail: CASI HC
A06/MF A02

Panel flutter is a form of dynamic aeroelastic instability resulting from the interaction between motion of an aircraft structural panel and the aerodynamic loads exerted on that panel by air flowing past one of the faces. It differs from lifting surface flutter in the sense that it is not usually catastrophic, the panel's motion being limited by nonlinear membrane stresses produced by the transverse displacement. Above some critical airflow condition, the linear instability grows to a limit cycle. The present investigation studies panel flutter in an aerodynamic regime known as 'free molecule flow', wherein intermolecular collisions can be neglected and loads are caused by interactions between individual molecules and the bounding surface. After collision with the panel, molecules may be reflected specularly or reemitted in diffuse fashion. Two parameters characterize this process: the 'momentum accommodation coefficient', which is the fraction of the specularly reflected molecules; and the ratio between the panel temperature and that of the free airstream. This model is relevant to the case of hypersonic flight vehicles traveling at very high altitudes and especially for panels oriented parallel to the airstream or in the vehicle's lee. Under these conditions the aerodynamic shear stress turns out to be considerably larger than the surface pressures, and shear effects must be included in the model. This is accomplished by means of distributed longitudinal and bending loads. The former can cause the panel to buckle. In the example of a simply-supported panel, it turns out that the second mode of free vibration tends to dominate the flutter solution, which is carried out by a Galerkin analysis. Several parametric studies are presented. They include the effects of (1) temperature ratio; (2) momentum accommodation coefficient; (3) spring parameters, which are associated with how the panel is connected to adjacent structures; (4) a parameter which relates compressive end load to its value which would cause classical column buckling; (5) a parameter proportional to the pressure differential between the front and back faces; and (6) initial curvature. The research is completed by an investigation into the possibility of accounting for molecular collisions, which proves to be infeasible given the speeds of current mainframe supercomputers. Author (revised)

N93-27090*# Institute for Computer Applications in Science
and Engineering, Hampton, VA.
**GODUNOV-TYPE SCHEMES APPLIED TO DETONATION
FLOWS Final Report**
JAMES J. QUIRK Washington NASA Apr. 1993 21 p
Presented at the 2nd ICASE/NASA LaRC Combustion Workshop,
12-14 Oct. 1992
(Contract NAS1-19480; RTOP 505-90-52-01)
(NASA-CR-191447; NAS 1.26:191447; ICASE-93-15) Avail: CASI
HC A03/MF A01

Over recent years, a variety of shock-capturing schemes have been developed for the Euler equations of gas dynamics. During this period, it has emerged that one of the more successful strategies is to follow Godunov's lead and utilize a nonlinear building block known as a Riemann problem. Now, although Riemann solver technology is often thought of as being mature, there are in fact several circumstances for which Godunov-type schemes are found wanting. Indeed, one inherent deficiency is so severe that if left unaddressed, could preclude such schemes from being used to capture detonation fronts in simulations of complex flow phenomena. In this paper, we highlight this particular deficiency along with some other little known weaknesses of Godunov-type schemes, and we outline one strategy that we have used to good effect in order to produce reliable high resolution simulations of both reactive and nonreactive shock wave phenomena. In particular, we present results for simulations of so-called galloping instabilities and detonation cell phenomena. Author

N93-27093*# California Polytechnic State Univ., San Luis
Obispo.
**AERODYNAMIC ANALYSIS OF HYPERSONIC WAVERIDER
AIRCRAFT Final Report, 1 Oct. 1991 - 30 Sep. 1993**
DORAL R. SANDLIN and DAVID N. PESSIN Apr. 1993 103 p
(Contract NAG2-766)
(NASA-CR-192981; NAS 1.26:192981) Avail: CASI HC A06/MF
A02

The purpose of this study is to validate two existing codes used by the Systems Analysis Branch at NASA ARC, and to modify the codes so they can be used to generate and analyze waverider aircraft at on-design and off-design conditions. To generate waverider configurations and perform the on-design analysis, the appropriately named Waverider code is used. The Waverider code is based on the Taylor-Maccoll equations. Validation is accomplished via a comparison with previously published results. The Waverider code is modified to incorporate a fairing to close off the base area of the waverider configuration. This creates a more realistic waverider. The Hypersonic Aircraft Vehicle Optimization Code (HAVOC) is used to perform the off-design analysis of waverider configurations generated by the Waverider code. Various approximate analysis methods are used by HAVOC to predict the aerodynamic characteristics, which are validated via a comparison with experimental results from a hypersonic test model. Author (revised)

N93-27096*# High Technology Corp., Hampton, VA.
**ROUGHNESS-INDUCED GENERATION OF CROSSFLOW
VORTICES IN THREE-DIMENSIONAL BOUNDARY LAYERS**
MEELAN CHOUDHARI Washington May 1993 62 p
(Contract NAS1-19299; RTOP 537-03-23-03)
(NASA-CR-4505; NAS 1.26:4505) Avail: CASI HC A04/MF A01

The receptivity theory of Goldstein and Ruban is extended within the nonasymptotic (quasi-parallel) framework of Zavol'skii et al to predict the roughness-induced generation of stationary and nonstationary instability waves in three-dimensional, incompressible boundary layers. The influence of acoustic-wave orientation, as well as that of different types of roughness geometries, including isolated roughness elements, periodic arrays, and two-dimensional lattices of compact roughness shapes, as well as random, but spatially homogeneous roughness distributions, is examined. The parametric study for the Falkner-Skan-Cooke family of boundary layers supports our earlier conjecture that the initial amplitudes of roughness-induced stationary vortices are likely to be significantly larger than the amplitudes of similarly induced

nonstationary vortices in the presence of acoustic disturbances in the free stream. Maximum unsteady receptivity occurs when the acoustic velocity fluctuation is aligned with the wavenumber vector of the unsteady vortex mode. On the other hand, roughness arrays that are oriented somewhere close to the group velocity direction are likely to produce higher instability amplitudes. Limitations of the nonasymptotic theory are discussed, and future work is suggested. Author

N93-27097*# Sverdrup Technology, Inc., Cleveland, OH.
**NUMERICAL SIMULATION OF FREE SHEAR FLOWS:
 TOWARDS A PREDICTIVE COMPUTATIONAL
 AEROACOUSTICS CAPABILITY**

W. Y. SOH Apr. 1993 26 p
 (Contract NAS3-25266; RTOP 505-62-52)
 (NASA-CR-191015; E-7821; NAS 1.26:191015) Avail: CASI HC
 A03/MF A01

Implicit and explicit spatial differencing techniques with fourth order accuracy have been developed. The implicit technique is based on the Pade compact scheme. A Dispersion Relation Preserving concept has been incorporated into both of the numerical schemes. Two dimensional Euler computation of a spatially-developing free shear flow, with and without external excitation, has been performed to demonstrate the capability of numerical schemes developed. Results are in good agreement with theory and experimental observation regarding the growth rate of fluctuating velocity, the convective velocity, and the vortex-pairing process. Author

N93-27126*# Texas Univ., Austin.
**THE CENTER OF EXCELLENCE FOR HYPERSONICS
 TRAINING AND RESEARCH AT THE UNIVERSITY OF TEXAS
 AT AUSTIN Final Report**

DAVID S. DOLLING Apr. 1993 15 p
 (Contract NAGW-964)
 (NASA-CR-193070; NAS 1.26:193070) Avail: CASI HC A03/MF
 A01

Over the period of this grant (1986-92), 23 graduate students were supported by the Center and received education and training in hypersonics through MS and Ph.D. programs. An additional 8 Ph.D. candidates and 2 MS candidates, with their own fellowship support, were attracted to The University of Texas and were recruited into the hypersonics program because of the Center. Their research, supervised by the 10 faculty involved in the Center, resulted in approximately 50 publications and presentations in journals and at national and international technical conferences. To provide broad-based training, a new hypersonics curriculum was created, enabling students to take 8 core classes in theoretical, computational, and experimental hypersonics, and other option classes over a two to four semester period. The Center also developed an active continuing education program. The Hypersonics Short Course was taught 3 times, twice in the USA and once in Europe. Approximately 300 persons were attracted to hear lectures by more than 25 of the leading experts in the field. In addition, a hypersonic aerodynamics short course was offered through AIAA, as well as short courses on computational fluid dynamics (CFD) and advanced CFD. The existence of the Center also enabled faculty to leverage a substantial volume of additional funds from other agencies, for research and graduate student training. Overall, this was a highly successful and highly visible program. Author

N93-27150*# Stanford Univ., CA. Dept. of Aeronautics and
 Astronautics.

**AN AERODYNAMIC MODEL FOR ONE AND TWO DEGREE OF
 FREEDOM WING ROCK OF SLENDER DELTA WINGS**

JOHN HONG May 1993 52 p Sponsored by NASA. Ames
 Research Center
 (NASA-CR-193130; NAS 1.26:193130; JIAA-TR-109) Avail: CASI
 HC A04/MF A01

The unsteady aerodynamic effects due to the separated flow around slender delta wings in motion were analyzed. By combining the unsteady flow field solution with the rigid body Euler equations

of motion, self-induced wing rock motion is simulated. The aerodynamic model successfully captures the qualitative characteristics of wing rock observed in experiments. For the one degree of freedom in roll case, the model is used to look into the mechanisms of wing rock and to investigate the effects of various parameters, like angle of attack, yaw angle, displacement of the separation point, and wing inertia. To investigate the roll and yaw coupling for the delta wing, an additional degree of freedom is added. However, no limit cycle was observed in the two degree of freedom case. Nonetheless, the model can be used to apply various control laws to actively control wing rock using, for example, the displacement of the leading edge vortex separation point by inboard span wise blowing. Author (revised)

N93-27167 Princeton Univ., NJ. Dept. of Mechanical and
 Aerospace Engineering.

HYPERSONICS REVISITED

SEYMOUR M. BOGDONOFF *In* Israel Society of Aeronautics
 and Astronautics, 32nd Annual Conference on Aviation and
 Astronautics p 1-9 20 Feb. 1992

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 c/o Faculty of Engineering, Tel-Aviv Univ., Ramat Aviv 69978,
 Israel

A brief review of the first era of hypersonics is followed by a discussion of the present status of the field. The challenges of the future in hypersonics are outlined, as well as the integrated efforts required for practical solutions. ISA

N93-27212 Rafael Armament Development Authority, Haifa
 (Israel).

AIRFOIL STABILITY IN TURBULENT FLOW

A. STERNBERG *In* Israel Society of Aeronautics and Astronautics,
 32nd Annual Conference on Aviation and Astronautics p 385-391
 20 Feb. 1992

Copyright Avail: Israel Society of Aeronautics and Astronautics,
 c/o Faculty of Engineering, Tel-Aviv Univ., Ramat Aviv 69978,
 Israel

Oscillatory instability of an aircraft's wing (flutter) depends on both the wing's structure and the flow conditions. A fighting aircraft in a common low-level flight mission will most likely encounter boundary layer turbulence, typical to the specific area of activity. The turbulence is considered as a wide-band random excitation, due to its high convective speed and in spite of its long characteristic length, relative to the wing width. The lowest eigenfrequency of a modern wing may be as low as 7 Hz (e.g., the F-16). Under these circumstances, turbulence may also affect the wing stability. Velocity perturbations are included in the parameters of the governing differential equations (DE), thus rendering them random-time-variant and also parametrically excited. The second-order DE's are converted into a set of first-order DE's, for which the state vector is assumed to be a Markov vector. Stability of the first and second statistical moments is considered. For the sake of simplicity, the model includes two degrees of freedom, in torsion and flexure, the flow is incompressible, and the wing is uniform with $AR = \infty$. Numerical results for two wings all indicate that turbulence delays instability as long as it is at a very low spectral density level. However, beyond a specific level for each case, higher turbulence would lower the critical speed. It is impossible to draw general conclusions though, since the phenomenon can only be explained hypothetically. ISA

N93-27214 Tel-Aviv Univ. (Israel).

**TOWARDS AN ANALYTICAL TREATMENT OF THE
 AEROLASTIC PROBLEM OF A CIRCULAR WING**

A. HAUPTMAN and T. MILOH *In* Israel Society of Aeronautics
 and Astronautics, 32nd Annual Conference on Aviation and
 Astronautics p 398-403 20 Feb. 1992

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 Israel

An idealized model of a thin wing of circular planform is used to analyze the aerolastic behavior of a low-aspect-ratio wing. A closed-form solution for the steady aerodynamic lifting problem is

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presented, based on expanding the acceleration potential of the incompressible flowfield about the wing into a series of appropriately selected ellipsoidal harmonics. The aerostatic problem is formulated, and the possibility of obtaining analytical solutions is discussed. ISA

N93-27218 Technion - Israel Inst. of Tech., Haifa. Faculty of Aerospace Engineering.

LEADING EDGE VORTICES IN A CHORDWISE PERIODIC FLOW

M. AMITAY, J. ER-AL, and A. SEGNER *In* Israel Society of Aeronautics and Astronautics, 32nd Annual Conference on Aviation and Astronautics p 427-438 20 Feb. 1992
Copyright Avail: Israel Society of Aeronautics and Astronautics, c/o Faculty of Engineering, Tel-Aviv Univ., Ramat Aviv 69978, Israel

The flow over a slender delta wing in a periodically changing free-stream is investigated, theoretically and experimentally. The theoretical model assumes the wings to be slender and infinitesimally thin with straight spanwise cross-sections. The amplitudes and frequencies of the periodic motion are assumed to be very small so that the flow is governed by the steady two-dimensional Laplace equation. Time dependence is introduced through the boundary condition. The theoretical model was validated by the visualization of the flow over a delta wing in a periodic translational motion in a water tunnel. The vortical flow field over the wing was visualized by the hydrogen-bubbles technique. The spatial trajectories of the leading edge vortices as a function of several parameters, were found from the flow visualization results. Good agreement between the theoretical and the experimental results was obtained, as long as the small-perturbations assumption was justified. The results also show that the effects of a periodic flow are comparable with those of a periodically translating wing, under these assumptions and Galilei transformation. ISA

N93-27220 National Research Council of Canada, Ottawa (Ontario). Inst. for Aerospace Research.

EFFECT OF VORTEX BEHAVIOR ON LOADS ACTING ON A 65 DEG DELTA WING OSCILLATING IN ROLL AT HIGH INCIDENCE

E. S. HANFF and X. Z. HUANG *In* Israel Society of Aeronautics and Astronautics, 32nd Annual Conference on Aviation and Astronautics p 446-458 20 Feb. 1992
Copyright Avail: Israel Society of Aeronautics and Astronautics, c/o Faculty of Engineering, Tel-Aviv Univ., Ramat Aviv 69978, Israel

Wind-tunnel experiments conducted on a 65-degree delta wing subjected to large-amplitude high-rate oscillations in roll at high incidence have revealed the presence of nonlinear, time-dependent loads in both the longitudinal and lateral planes. Correlations between these loads and surface pressure measurements and high-speed flow visualization data indicate that the instantaneous loads are largely determined by the position of the leading edge vortex breakdown points. ISA

N93-27221 Technion - Israel Inst. of Tech., Haifa. Faculty of Aerospace Engineering.

ANALYSIS OF WIND-TUNNEL DATA FOR ELLIPTIC CROSS-SECTIONED FOREBODIES AT MACH NUMBERS 0.4 TO 5.0

ASHER SIGAL and GAVRIEL AVITAL *In* Israel Society of Aeronautics and Astronautics, 32nd Annual Conference on Aviation and Astronautics p 459-466 20 Feb. 1992
Copyright Avail: Israel Society of Aeronautics and Astronautics, c/o Faculty of Engineering, Tel-Aviv Univ., Ramat Aviv 69978, Israel

A pre-existing database for elliptic cross-sectioned forebodies was analyzed by identifying the linear aerodynamic characteristics at small angles of attack, and by fitting a model for the vortex-induced normal-force coefficient. The parameters in the model strongly depend on Mach numbers. An attempt to predict

the amplitude parameter of the model, by an extended version of the crossflow method, yielded results that underpredict the experimentally obtained values. ISA

N93-27274# Defence Research Agency, Farnborough (England). Aerospace Division.

THE EXPERIMENTAL STUDY OF TRANSITION AND LEADING EDGE CONTAMINATION OF SWEEP WINGS [ETUDE DE LA TRANSITION ET DE LA CONTAMINATION DE BORD D'ATTAQUE SUR ALLES EN FLECHE]

D. ARNAL, J. C. JUILLEN, and C. BETTS, ed. Mar. 1992 24 p
Presented at a conference, 1988 Original language document was announced as N90-10362
(LIB-TRANS-2197) Copyright Avail: CASI HC A03/MF A01

The transition mechanisms in an incompressible laminar boundary layer developing on swept wings is investigated experimentally. The transition is detected by using hot films glued on the model. Two series of experiments are presented. In the first one, the sensors are placed along the chord, and the instantaneous signals allow us to analyze the problems of streamwise instability, crossflow instability, and leading edge contamination. In the second series of experiments, hot films are glued along the span direction, close to the leading edge. The leading edge contamination is studied in detail, and the possibilities of relaminarization are examined. CASI

N93-27282*# Brown Univ., Providence, RI. Div. of Engineering.

PARAMETER IDENTIFICATION FOR NONLINEAR AERODYNAMIC SYSTEMS Final Technical Report, 23 Oct. 1989 - 28 Feb. 1993

ALLAN E. PEARSON May 1993 16 p
(Contract NAG1-1065)

(NASA-CR-193072; NAS 1.26:193072) Avail: CASI HC A03/MF A01

This final technical report covers a three and one-half year period preceding February 28, 1993 during which support was provided under NASA Grant NAG-1-1065. Following a general description of the system identification problem and a brief survey of methods to attack it, the basic ideas behind the approach taken in this research effort are presented. The results obtained are described with reference to the published work, including the five semiannual progress reports previously submitted and two interim technical reports. Derived from text

N93-27413# Draper (Charles Stark) Lab., Inc., Cambridge, MA. **AERODYNAMIC FORCES ON MAGLEV VEHICLES Final Report, Jul. 1991 - Nov. 1992**

T. BARROWS, D. MCCULLUM, S. MARK, and R. C. CASTELLINO Dec. 1992 188 p Sponsored by National Maglev Initiative (FRA), Washington, DC LIMITED REPRODUCIBILITY: More than 20% of this document may be affected by microfiche quality
(Contract DTFR53-91-C-00072)

(PB93-154813; CSDL-R-2463; DOT/FRA/NMI-92/21) Avail: Issuing Activity (National Technical Information Service (NTIS))

The results of four separate tasks are documented: (1) minimization of front-end drag, (2) effect of fineness ratio (ratio of length to diameter) on drag, (3) design of aerofurfaces for control purposes, and (4) control and dynamics of maglev vehicles with aerodynamic control surfaces. Task 1 examines the flow disturbances near the nose of a high speed channel vehicle which cause vortices to form near the tops of the guidewalls. These vortices are a major source of drag. The nose of the train can be idealized as a source flow, and the walls of the channel guideway are represented as two vertical flat plates. A numerical solution of the two-dimensional unsteady problem is presented. Using a representative design example, the nose shape which provides the minimum drag is derived from this solution. Under task 2, drag data is presented from the automotive industry, the Japanese National Railway, Krauss-Maffei, and Tracked Hovercraft Limited. An empirical formula is used to estimate the drag of vehicles designed for channel and box beam guideways. The optimum width for these cases is derived. Under task 3, a simple numerical scheme

is described for computing the lift and drag on an aerosurface with a control flap operating in close proximity to a guideway surface. It is shown that large variations in lift can be produced using very small flap angles. Task 4 examines the improvement in ride quality (or conversely the increase in allowable guideway roughness for a given ride quality) which is possible through the use of aerodynamic control surfaces. Comparisons are made between vehicles with active and passive secondary suspensions with aerodynamic control surfaces mounted on the vehicle body or control flaps on the vehicle bodies. NTIS

N93-27427*# California State Univ., Long Beach.
THE FIFTH SYMPOSIUM ON NUMERICAL AND PHYSICAL ASPECTS OF AERODYNAMIC FLOWS Final Report
 1992 437 p Symposium held in Long Beach, CA, 13-15 Jan. 1992 Sponsored in part by ONR and Army Research Center (Contract NAG2-726)
 (NASA-CR-193000; NAS 1.26:193000) Avail: CASI HC A19/MF A04

This volume contains the papers presented at the Fifth Symposium on Numerical and Physical Aspects of Aerodynamic Flows, held at the California State University, Long Beach, from 13 to 15 January 1992. The symposium, like its immediate predecessors, considers the calculation of flows of relevance to aircraft, ships, and missiles with emphasis on the solution of two-dimensional unsteady and three-dimensional equations.

N93-27428*# Stanford Univ., CA. Dept. of Mechanical Engineering.
TURBULENCE: THE CHIEF OUTSTANDING DIFFICULTY OF OUR SUBJECT
 PETER BRADSHAW *In* California State Univ., The Fifth Symposium on Numerical and Physical Aspects of Aerodynamic Flows 11 p 1992
 Avail: CASI HC A03/MF A04

A review of interesting current topics in turbulence research is decorated with examples of popular fallacies about the behavior of turbulence. Topics include the status of the Law of the Wall, especially in compressible flow; analogies between the effects of Reynolds numbers, pressure gradient, unsteadiness and roughness change; the status of Kolmogorov's universal equilibrium theory and local isotropy of the small eddies; turbulence modelling, with reference to universality, pressure-strain modelling and the dissipation equation; and chaos. Fallacies include the mixing-length concept; the effect of pressure gradient on Reynolds shear stress; the separability of time and space derivatives; models of the dissipation equation; and chaos. Author

N93-27429*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
THE TRANSITION PREDICTION TOOLKIT: LST, SIT, PSE, DNS, AND LES
 THOMAS A. ZANG, CHAU-LYAN CHANG (High Technology Corp., Hampton, VA.), and LIAN L. NG (Analytical Services and Materials, Inc., Hampton, VA.) *In* California State Univ., The Fifth Symposium on Numerical and Physical Aspects of Aerodynamic Flows 13 p 1992
 (Contract NAS1-18240; NAS1-18599)
 Avail: CASI HC A03/MF A04

The $e(\sup N)$ method for predicting transition onset is an amplitude ratio criterion that is on the verge of full maturation for three-dimensional, compressible, real gas flows. Many of the components for a more sophisticated, absolute amplitude criterion are now emerging: receptivity theory, secondary instability theory, parabolized stability equations approaches, direct numerical simulation and large-eddy simulation. This paper will provide a description of each of these new theoretical tools and provide indications of their current status. Author

N93-27431*# Centre d'Etudes et de Recherches, Toulouse (France).

THREE-DIMENSIONAL COMPRESSIBLE STABILITY-TRANSITION CALCULATIONS USING THE SPATIAL THEORY

R. NIETHAMMER (Ludwig-Maximilians-Univ., Munich, Germany.), D. ARNAL, V. DELAHARPE (California State Univ., Long Beach.), H. H. CHEN (California State Univ., Long Beach.), and T. CEBECI (California State Univ., Long Beach.) *In* California State Univ., The Fifth Symposium on Numerical and Physical Aspects of Aerodynamic Flows 12 p 1992
 Avail: CASI HC A03/MF A04

The $e(\exp n)$ -method is employed with the spatial amplification theory to compute the onset of transition on a swept wing tested in transonic cryogenic flow conditions. Two separate eigenvalue formulations are used. One uses the saddle-point method and the other assumes that the amplification vector is normal to the leading edge. Comparisons of calculated results with experimental data show that both formulations give similar results and indicate that the wall temperature has a rather strong effect on the value of the n factor. Author

N93-27432*# DCW Industries, La Canada, CA.
THE REMARKABLE ABILITY OF TURBULENCE MODEL EQUATIONS TO DESCRIBE TRANSITION
 DAVID C. WILCOX *In* California State Univ., The Fifth Symposium on Numerical and Physical Aspects of Aerodynamic Flows 7 p 1992
 (Contract DAAL03-89-C-0032)
 Avail: CASI HC A02/MF A04

This paper demonstrates how well the k - ω turbulence model describes the nonlinear growth of flow instabilities from laminar flow into the turbulent flow regime. Viscous modifications are proposed for the k - ω model that yield close agreement with measurements and with Direct Numerical Simulation results for channel and pipe flow. These modifications permit prediction of subtle sublayer details such as maximum dissipation at the surface, k approximately $y(\exp 2)$ as y approaches 0, and the sharp peak value of k near the surface. With two transition specific closure coefficients, the model equations accurately predict transition for an incompressible flat-plate boundary layer. The analysis also shows why the k - ϵ model is so difficult to use for predicting transition. Author

N93-27436*# Technische Univ., Berlin (Germany). Inst. fuer Stromungstechnik.
STABILITY INVESTIGATIONS OF AIRFOIL FLOW BY GLOBAL ANALYSIS
 MAREK MORZYNSKI and FRANK THIELE (Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Berlin, Germany.) *In* California State Univ., The Fifth Symposium on Numerical and Physical Aspects of Aerodynamic Flows 10 p 1992
 Avail: CASI HC A02/MF A04

As the result of global, non-parallel flow stability analysis the single value of the disturbance growth-rate and respective frequency is obtained. This complex value characterizes the stability of the whole flow configuration and is not referred to any particular flow pattern. The global analysis assures that all the flow elements (wake, boundary and shear layer) are taken into account. The physical phenomena connected with the wake instability are properly reproduced by the global analysis. This enhances the investigations of instability of any 2-D flows, including ones in which the boundary layer instability effects are known to be of dominating importance. Assuming fully 2-D disturbance form, the global linear stability problem is formulated. The system of partial differential equations is solved for the eigenvalues and eigenvectors. The equations, written in the pure stream function formulation, are discretized via FDM using a curvilinear coordinate system. The complex eigenvalues and corresponding eigenvectors are evaluated by an iterative method. The investigations performed for various Reynolds numbers emphasize that the wake instability develops into the Karman vortex street. This phenomenon is shown to be connected with the first mode obtained from the non-parallel

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flow stability analysis. The higher modes are reflecting different physical phenomena as for example Tollmien-Schlichting waves, originating in the boundary layer and having the tendency to emerge as instabilities for the growing Reynolds number. The investigations are carried out for a circular cylinder, oblong ellipsoid and airfoil. It is shown that the onset of the wake instability, the waves in the boundary layer, the shear layer instability are different solutions of the same eigenvalue problem, formulated using the non-parallel theory. The analysis offers large potential possibilities as the generalization of methods used till now for the stability analysis.

Author

N93-27437*# Illinois Univ., Urbana-Champaign. Dept. of Aeronautical and Astronautical Engineering.

AERODYNAMICS OF A FINITE WING WITH SIMULATED ICE

M. B. BRAGG, A. KHODADOUST, and M. KERHO *In* California State Univ., The Fifth Symposium on Numerical and Physical Aspects of Aerodynamic Flows 10 p 1992 Sponsored by NASA, Lewis Research Center

Avail: CASI HC A02/MF A04

The effect of a simulated glaze ice accretion on the aerodynamic performance of a three-dimensional wing is studied experimentally. Results are reviewed from earlier two-dimensional tests which show the character of the large leading-edge separation bubbles caused by the simulated ice accretion. The 2-D bubbles are found to closely resemble well known airfoil laminar separation bubbles. For the 3-D experiments a semispan wing of effective aspect ratio five was mounted from the sidewall of the UIUC subsonic wind tunnel. The model uses a NACA 0012 airfoil section on a rectangular planform with interchangeable tip and root sections to allow for 0- and 30-degree sweep. A three-component sidewall balance was used to measure lift, drag and pitching moment on the clean and iced model. Fluorescent oil flow visualization has been performed on the iced model and reveals extensive spanwise and vortical flow in the separation bubble aft of the upper surface horn. Sidewall interaction and spanwise nonuniformity are also seen on the unswept model. Comparisons to the computed flow fields are shown. Results are also shown for roughness effects on the straight wing. Sand grain roughness on the ice shape is seen to have a different effect than isolated 3-D roughness elements.

Author

N93-27439*# California State Univ., Long Beach. Dept. of Aerospace Engineering.

A COMPOSITE STRUCTURED/UNSTRUCTURED-MESH EULER METHOD FOR COMPLEX AIRFOIL SHAPES

H. HEFAZI and L. T. CHEN (Douglas Aircraft Co., Inc., Long Beach, CA.) *In its* The Fifth Symposium on Numerical and Physical Aspects of Aerodynamic Flows 6 p 1992

Avail: CASI HC A02/MF A04

A general two-dimensional Euler zonal method has been developed for computing flows about complex airfoil geometries such as multielement and iced airfoils. The method utilizes a composite structured and unstructured grid generated using conformal mapping and Delaunay triangulation, respectively. The finite-volume Euler method is then modified to couple solutions in the zones with structured and unstructured grids. Solutions about an iced airfoil and a multielement airfoil are given as examples of applications of the scheme.

Author

N93-27440*# National Aeronautics and Space Administration, Lewis Research Center, Cleveland, OH.

EXPERIMENTAL AND COMPUTATIONAL ICE SHAPES AND RESULTING DRAG INCREASE FOR A NACA 0012 AIRFOIL

JAIWON SHIN and THOMAS H. BOND *In* California State Univ., The Fifth Symposium on Numerical and Physical Aspects of Aerodynamic Flows 10 p 1992 Previously announced as N92-28674

Avail: CASI HC A02/MF A04

Tests were conducted in the Icing Research Tunnel (IRT) at the NASA Lewis Research Center to document the repeatability of the ice shape over the range of temperatures varying from -15 F to 28 F. Measurements of drag increase due to the ice accretion

were also made. The ice shape and drag coefficient data, with varying total temperatures at two different airspeeds, were compared with the computational predictions. The calculations were made with the 2D LEWICE/IBL code which is a combined code of LEWICE and the interactive boundary layer method developed for iced airfoils. Comparisons show good agreement with the experimental data in ice shapes. The calculations show the ability of the code to predict drag increases as the ice shape changes from a rime shape to a glaze shape.

Author

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RECENT PROGRESS IN THE ANALYSIS OF ICED AIRFOILS AND WINGS

TUNCER CEBECI, HSUN H. CHEN, KALLE KAUPS, and SUE SCHIMKE *In its* The Fifth Symposium on Numerical and Physical Aspects of Aerodynamic Flows 10 p 1992

Avail: CASI HC A02/MF A04

Recent work on the analysis of iced airfoils and wings is described. Ice shapes for multielement airfoils and wings are computed using an extension of the LEWICE code that was developed for single airfoils. The aerodynamic properties of the iced wing are determined with an interactive scheme in which the solutions of the inviscid flow equations are obtained from a panel method and the solutions of the viscous flow equations are obtained from an inverse three-dimensional finite-difference boundary-layer method. A new interaction law is used to couple the inviscid and viscous flow solutions. The newly developed LEWICE multielement code is amplified to a high-lift configuration to calculate the ice shapes on the slat and on the main airfoil and on a four-element airfoil. The application of the LEWICE wing code to the calculation of ice shapes on a MS-317 swept wing shows good agreement with measurements. The interactive boundary-layer method is applied to a tapered iced wing in order to study the effect of icing on the aerodynamic properties of the wing at several angles of attack.

Author

N93-27442*# National Aeronautics and Space Administration, Ames Research Center, Moffett Field, CA.

HIGH-LIFT AERODYNAMICS: PROSPECTS AND PLANS

Abstract Only

LAWRENCE E. OLSON *In* California State Univ., The Fifth Symposium on Numerical and Physical Aspects of Aerodynamic Flows 1 p 1992

Avail: CASI HC A01/MF A04

The emergence of high-lift aerodynamics is reviewed as one of the key technologies to the development of future subsonic transport aircraft. Airport congestion, community noise, economic competitiveness, and safety - the drivers that make high-lift an important technology - are discussed. Attention is given to the potentially synergistic integration of high-lift aerodynamics with two other advanced technologies: ultra-high bypass ratio turbofan engines and hybrid laminar flow control. A brief review of the ongoing high-lift research program at Ames Research Center is presented. Suggestions for future research directions are made with particular emphasis on the development and validation of computational codes and design methods. It is concluded that the technology of high-lift aerodynamics analysis and design should move boldly into the realm of high Reynolds number, three-dimensional flows.

Author

N93-27443*# National Aeronautics and Space Administration, Ames Research Center, Moffett Field, CA.

EFFICIENT SIMULATION OF INCOMPRESSIBLE VISCOUS FLOW OVER MULTI-ELEMENT AIRFOILS

STUART E. ROGERS, N. LYN WILTBERGER, and DOCHAN KWAK *In* California State Univ., The Fifth Symposium on Numerical and Physical Aspects of Aerodynamic Flows 10 p 1992

Previously announced in IAA as A92-26258

Avail: CASI HC A02/MF A04

The incompressible, viscous, turbulent flow over single and multi-element airfoils is numerically simulated in an efficient manner by solving the incompressible Navier-Stokes equations. The

computer code uses the method of pseudo-compressibility with an upwind-differencing scheme for the convective fluxes and an implicit line-relaxation solution algorithm. The motivation for this work includes interest in studying the high-lift take-off and landing configurations of various aircraft. In particular, accurate computation of lift and drag at various angles of attack, up to stall, is desired. Two different turbulence models are tested in computing the flow over an NACA 4412 airfoil; an accurate prediction of stall is obtained. The approach used for multi-element airfoils involves the use of multiple zones of structured grids fitted to each element. Two different approaches are compared: a patched system of grids, and an overlaid Chimera system of grids. Computational results are presented for two-element, three-element, and four-element airfoil configurations. Excellent agreement with experimental surface pressure coefficients is seen. The code converges in less than 200 iterations, requiring on the order of one minute of CPU time (on a CRAY YMP) per element in the airfoil configuration. Author (revised)

N93-27444*# Institute for Computer Application Research and Utilization in Science, Inc., Boston, MA.

UNSTRUCTURED MESH ALGORITHMS FOR AERODYNAMIC CALCULATIONS

D. J. MAVRIPLIS /In California State Univ., The Fifth Symposium on Numerical and Physical Aspects of Aerodynamic Flows 12 p 1992

Avail: CASI HC A03/MF A04

The use of unstructured mesh techniques for solving complex aerodynamic flows is discussed. The principle advantages of unstructured mesh strategies, as they relate to complex geometries, adaptive meshing capabilities, and parallel processing are emphasized. The various aspects required for the efficient and accurate solution of aerodynamic flows are addressed. These include mesh generation, mesh adaptivity, solution algorithms, convergence acceleration, and turbulence modeling. Computations of viscous turbulent two-dimensional flows and inviscid three-dimensional flows about complex configurations are demonstrated. Remaining obstacles and directions for future research are also outlined. Author (revised)

N93-27445*# California State Univ., Long Beach. Dept. of Aerospace Engineering.

AN INTERACTIVE BOUNDARY-LAYER APPROACH TO MULTIELEMENT AIRFOILS AT HIGH LIFT

TUNCER CEBECI /In its The Fifth Symposium on Numerical and Physical Aspects of Aerodynamic Flows 12 p 1992

Avail: CASI HC A03/MF A04

A calculation method based on an interactive boundary-layer approach to multielement airfoils is described and is applied to three types of airfoil configurations with and without flap-wells in order to demonstrate the applicability of the method to general high-lift configurations. This method, well tested for single airfoils as a function of shape, angle of attack, and Reynolds number, is here shown to apply equally well to two-element airfoils and their wakes, to a flap-well region, and to a three-element arrangement which includes the effects of co-flowing regions, a flap well, and the wake of the elements. In addition to providing accurate representation of these flows, the method is general so that its extension to three-dimensional arrangements is likely to provide a practical, accurate and efficient tool to assist the design process. Author (revised)

N93-27446*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

REYNOLDS AND MACH NUMBER EFFECTS ON MULTIELEMENT AIRFOILS

WALTER O. VALAREZO (Douglas Aircraft Co., Inc., Long Beach, CA.), CHET J. DOMINIK (Douglas Aircraft Co., Inc., Long Beach, CA.), and ROBERT J. MCGHEE /In California State Univ., The Fifth Symposium on Numerical and Physical Aspects of Aerodynamic Flows 13 p 1992

Avail: CASI HC A03/MF A04

Experimental studies were conducted to assess Reynolds and

Mach number effects on a supercritical multielement airfoil. The airfoil is representative of the stall-critical station of an advanced transport wing design. The experimental work was conducted as part of a cooperative program between the Douglas Aircraft Company and the NASA LaRC to improve current knowledge of high-lift flows and to develop a validation database with practical geometries/conditions for emerging computational methods. This paper describes results obtained for both landing and takeoff multielement airfoils (four and three-element configurations) for a variety of Mach/Reynolds number combinations up to flight conditions. Effects on maximum lift are considered for the landing configurations and effects on both lift and drag are reported for the takeoff geometry. The present test results revealed considerable maximum lift effects on the three-element landing configuration for Reynolds number variations and significant Mach number effects on the four-element airfoil. Author (revised)

N93-27447*# Boeing Commercial Airplane Co., Seattle, WA. Aerodynamics Engineering.

QUANTITATIVE THREE-DIMENSIONAL LOW-SPEED WAKE SURVEYS

G. W. BRUNE /In California State Univ., The Fifth Symposium on Numerical and Physical Aspects of Aerodynamic Flows 13 p 1992

Avail: CASI HC A03/MF A04

Theoretical and practical aspects of conducting three-dimensional wake measurements in large wind tunnels are reviewed with emphasis on applications in low-speed aerodynamics. Such quantitative wake surveys furnish separate values for the components of drag, such as profile drag and induced drag, but also measure lift without the use of a balance. In addition to global data, details of the wake flowfield as well as spanwise distributions of lift and drag are obtained. The paper demonstrates the value of this measurement technique using data from wake measurements conducted by Boeing on a variety of low-speed configurations including the complex high-lift system of a transport aircraft. Author (revised)

N93-27448*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

FLOW PREDICTION OVER A TRANSPORT MULTI-ELEMENT HIGH-LIFT SYSTEM AND COMPARISON WITH FLIGHT MEASUREMENTS Abstract Only

P. M. H. W. VIJGEN (High Technology Corp., Hampton, VA.), J. D. HARDIN (North Carolina State Univ., Raleigh.), and L. P. YIP /In California State Univ., The Fifth Symposium on Numerical and Physical Aspects of Aerodynamic Flows 1 p 1992

Avail: CASI HC A01/MF A04

Accurate prediction of surface-pressure distributions, merging boundary-layers, and separated-flow regions over multi-element high-lift airfoils is required to design advanced high-lift systems for efficient subsonic transport aircraft. The availability of detailed measurements of pressure distributions and both averaged and time-dependent boundary-layer flow parameters at flight Reynolds numbers is critical to evaluate computational methods and to model the turbulence structure for closure of the flow equations. Several detailed wind-tunnel measurements at subscale Reynolds numbers were conducted to obtain detailed flow information including the Reynolds-stress component. As part of a subsonic-transport high-lift research program, flight experiments are conducted using the NASA-Langley B737-100 research aircraft to obtain detailed flow characteristics for support of computational and wind-tunnel efforts. Planned flight measurements include pressure distributions at several spanwise locations, boundary-layer transition and separation locations, surface skin friction, as well as boundary-layer profiles and Reynolds stresses in adverse pressure-gradient flow. Author (revised)

N93-27449*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

ASSESSMENT OF COMPUTATIONAL ISSUES ASSOCIATED WITH ANALYSIS OF HIGH-LIFT SYSTEMS

R. BALASUBRAMANIAN (Spectrex Corp., Inc., Gloucester, VA.),

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KENNETH M. JONES, and EDGAR G. WAGGONER *In* California State Univ., The Fifth Symposium on Numerical and Physical Aspects of Aerodynamic Flows 27 p 1992
Avail: CASI HC A03/MF A04

Thin-layer Navier-Stokes calculations for wing-fuselage configurations from subsonic to hypersonic flow regimes are now possible. However, efficient, accurate solutions for using these codes for two- and three-dimensional high-lift systems have yet to be realized. A brief overview of salient experimental and computational research is presented. An assessment of the state-of-the-art relative to high-lift system analysis and identification of issues related to grid generation and flow physics which are crucial for computational success in this area are also provided. Research in support of the high-lift elements of NASA's High Speed Research and Advanced Subsonic Transport Programs which addresses some of the computational issues is presented. Finally, fruitful areas of concentrated research are identified to accelerate overall progress for high lift system analysis and design.

Author (revised)

N93-27452*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

SOME RECENT APPLICATIONS OF NAVIER-STOKES CODES TO ROTORCRAFT

W. J. MCCROSKEY *In* California State Univ., The Fifth Symposium on Numerical and Physical Aspects of Aerodynamic Flows 15 p 1992 Prepared in cooperation with Army Aviation Systems Command, Cleveland, OH
Avail: CASI HC A03/MF A04

Many operational limitations of helicopters and other rotary-wing aircraft are due to nonlinear aerodynamic phenomena including unsteady, three-dimensional transonic and separated flow near the surfaces and highly vortical flow in the wakes of rotating blades. Modern computational fluid dynamics (CFD) technology offers new tools to study and simulate these complex flows. However, existing Euler and Navier-Stokes codes have to be modified significantly for rotorcraft applications, and the enormous computational requirements presently limit their use in routine design applications. Nevertheless, the Euler/Navier-Stokes technology is progressing in anticipation of future supercomputers that will enable meaningful calculations to be made for complete rotorcraft configurations.

Author (revised)

N93-27453*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

DYNAMIC AIRFOIL STALL INVESTIGATIONS

M. F. PLATZER (Naval Postgraduate School, Monterey, CA.), M. S. CHANDRASEKHARA (Naval Postgraduate School, Monterey, CA.), J. A. EKATERINARIS (Naval Postgraduate School, Monterey, CA.), and L. W. CARR (Army Aviation Systems Command, Cleveland, OH.) *In* California State Univ., The Fifth Symposium on Numerical and Physical Aspects of Aerodynamic Flows 11 p 1992
Avail: CASI HC A03/MF A04

Experimental and computational investigations of the dynamic stall phenomenon continue to attract the attention of various research groups in the major aeronautical research laboratories. There are two reasons for this continued research interest. First, the occurrence of dynamic stall on the retreating blade of helicopters imposes a severe performance limitation and thus suggests to search for ways to delay the onset of dynamic stall. Second, the lift enhancement prior to dynamic stall presents an opportunity to achieve enhanced maneuverability of fighter aircraft. A description of the major parameters affecting dynamic stall and lift and an evaluation of research efforts prior to 1988 has been given by Carr. In this paper the authors' recent progress in the development of experimental and computational methods to analyze the dynamic stall phenomena occurring on NACA 0112 airfoils is reviewed. First, the major experimental and computational approaches and results are summarized. This is followed by an assessment of our results and an outlook toward the future.

Author (revised)

N93-27454*# David Taylor Research Center, Bethesda, MD.
SIMULTANEOUS MAPPING OF THE UNSTEADY FLOW FIELDS BY PARTICLE DISPLACEMENT VELOCIMETRY (PDV) Abstract Only

THOMAS T. HUANG, DAVID J. FRY, HAN-LIEH LIU, JOSEPH KATZ (Johns Hopkins Univ., Baltimore, MD.), and THOMAS C. FU (Johns Hopkins Univ., Baltimore, MD.) *In* California State Univ., The Fifth Symposium on Numerical and Physical Aspects of Aerodynamic Flows 1 p 1992
Avail: CASI HC A01/MF A04

Current experimental and computational techniques must be improved in order to advance the prediction capability of the longitudinal vortical flows shed by underwater vehicles. The generation, development, and breakdown mechanisms of the shed vortices at high Reynolds numbers are not fully understood. The ability to measure hull separated vortices associated with vehicle maneuvering does not exist at present. The existing point-by-point measurement techniques can only capture approximately the large 'mean' eddies but fail to meet the dynamics of small vortices during the initial stage of generation. A new technique, which offers a previously unavailable capability to measure the unsteady cross-flow distribution in the plane of the laser light sheet, is called Particle Displacement Velocimetry (PDV). PDV consists of illuminating a thin section of the flowfield with a pulsed laser. The water is seeded with microscopic, neutrally buoyant particles containing imbedded fluorescing dye which responds with intense spontaneous fluorescence with the illuminated section. The seeded particles in the vortical flow structure shed by the underwater vehicle are illuminated by the pulse laser and the corresponding particle traces are recorded in a single photographic frame. Two distinct approaches were utilized for determining the velocity distribution from the particle traces. The first method is based on matching the traces of the same particle and measuring the distance between them. The direction of the flow can be identified by keeping one of the pulses longer than the other. The second method is based on selecting a small window within the image and finding the mean shift of all the particles within that region. The computation of the auto-correlation of the intensity distribution within the selected sample window is used to determine the mean displacement of particles. The direction of the flow is identified by varying the intensity of the laser light between pulses. Considerable computational resources are required to compute the auto-correction of the intensity distribution. Parallel processing will be employed to speed up the data reduction. A few examples of measured unsteady vortical flow structures shed by the underwater vehicles will be presented.

Author (revised)

N93-27455*# Office National d'Etudes et de Recherches Aeronautiques, Paris (France).

CALCULATION OF FULLY THREE-DIMENSIONAL SEPARATED FLOW WITH AN UNSTEADY VISCOUS-INVISCID INTERACTION METHOD Abstract Only

J. C. LEBALLEUR and P. GIROUDROUX-LAVIGNE *In* California State Univ., The Fifth Symposium on Numerical and Physical Aspects of Aerodynamic Flows 1 p 1992
Avail: CASI HC A01/MF A04

Three previous papers have shown that the viscous inviscid numerical methods were capable of calculating separated turbulent flows. The 'Semi-inverse method' and the models of the first author allow the computation of massive separations, stalled flows, and shock wave-boundary layer interactions, in two-dimensional or quasi-three-dimensional conditions, from low speeds to supersonic speeds. The 'Semi-implicit' method for time-consistent coupling allows for the computation of time-accurate transonic separated flow and buffer computations in two-dimensions. The present paper shows that the viscous-inviscid interaction approach is also able to compute the fully three-dimensional flow separation phenomena. The method is based on a thin-layer approximation of the theory of 'Defect-Formulation' that provides the viscous-inviscid splitting of the Navier-Stokes equations. A parametric analytical modelling of the 3D-turbulent velocity profiles is involved. Numerically, the 3D-velocity profiles are discretized in the normal z-direction and driven by parametric integral 3D-equations in direct or inverse

modes in the x-direction. The viscous-inviscid coupling is fully 3D and solved the time-consistency problem with an extension of the 'Semi-implicit' method previously suggested in two-dimensions. A 3D inviscid subroutine with TSP approximation is used. Results are obtained for transonic steady flows over wings with shock-induced transonic separation. The method provides results for highly three-dimensional flow separations, such as induced by a three-dimensional through at the wall of a flat plate. The 3D viscous-inviscid coupling and the 3D model of the velocity field provide three-dimensional instantaneous skin-friction lines whose patterns exhibit the same complex topology as Navier-Stokes solvers, with foci, nodes, and saddle-points. Author (revised)

N93-27456*# Korea Advanced Inst. of Science and Technology, Seoul (Republic of Korea).

PREDICTION OF AIRFOIL STALL USING NAVIER-STOKES EQUATIONS IN STREAMLINE COORDINATES

D. H. CHOI, C. H. SOHN, and C. S. OH *In* California State Univ., The Fifth Symposium on Numerical and Physical Aspects of Aerodynamic Flows 9 p 1992
Avail: CASI HC A02/MF A04

A Navier-Stokes procedure to calculate the flow about an airfoil at incidence was developed. The parabolized equations are solved in the streamline coordinates generated for an arbitrary airfoil shape using conformal mapping. A modified k-epsilon turbulence model is applied in the entire domain, but the eddy viscosity in the laminar region is suppressed artificially to simulate the region correctly. The procedure was applied to airfoils at various angles of attack, and the results are quite satisfactory for both laminar and turbulent flows. It is shown that the present choice of the coordinate system reduces the error due to numerical diffusion, and that the lift is accurately predicted for a wide range of incidence.

Author (revised)

N93-27457*# Korea Advanced Inst. of Science and Technology, Seoul (Republic of Korea). Dept. of Mechanical Engineering.

DISCRETE-VORTEX SIMULATION OF PULSATING FLOW ON A TURBULENT LEADING-EDGE SEPARATION BUBBLE

HYUNG JIN SUNG, JAE WOOK RHIM, and MASARU KIYA (Hokkaido Univ., Sapporo, Japan.) *In* California State Univ., The Fifth Symposium on Numerical and Physical Aspects of Aerodynamic Flows 9 p 1992
Avail: CASI HC A02/MF A04

Studies are made of the turbulent separation bubble in a two-dimensional semi-infinite blunt plate aligned to a uniform free stream with a pulsating component. The discrete-vortex method is applied to simulate this flow situation because this approach is effective for representing the unsteady motions of the turbulent shear layer and the effect of viscosity near the solid surface. The numerical simulation provides reasonable predictions when compared with the experimental results. A particular frequency with a minimum reattachment is related to the drag reduction. The most effective frequency is dependent on the amplified shedding frequency. The turbulent flow structure is scrutinized. This includes the time-mean and fluctuations of the velocity and the surface pressure, together with correlations between the fluctuating components. A comparison between the pulsating flow and the non-pulsating flow at the particular frequency of the minimum reattachment length of the separation bubble suggests that the large-scale vortical structure is associated with the shedding frequency and the flow instabilities. Author (revised)

N93-27459*# McDonnell Aircraft Co., Saint Louis, MO.

PREDICTION OF VORTEX BREAKDOWN ON A DELTA WING

S. AGRAWAL, B. A. ROBINSON, and R. M. BARNETT *In* California State Univ., The Fifth Symposium on Numerical and Physical Aspects of Aerodynamic Flows 8 p 1992
Avail: CASI HC A02/MF A04

Recent studies of leading-edge vortex flows with computational fluid dynamics codes using Euler or Navier-Stokes formulations have shown fair agreement with experimental data. These studies have concentrated on simulating the flowfields associated with a sharp-edged flat plate 70 deg delta wing at angles of attack where

vortex breakdown or burst is observed over the wing. There are, however, a number of discrepancies between the experimental data and the computed flowfields. The location of vortex breakdown in the computational solutions is seen to differ from the experimental data and to vary with changes in the computational grid and freestream Mach number. There also remain issues as to the validity of steady-state computations for cases which contain regions of unsteady flow, such as in the post-breakdown regions. As a partial response to these questions, a number of laminar Navier-Stokes solutions were examined for the 70 deg delta wing. The computed solutions are compared with an experimental database obtained at low subsonic speeds. The convergence of forces, moments and vortex breakdown locations are also analyzed to determine if the computed flowfields actually reach steady-state conditions. Author (revised)

N93-27460*# Cranfield Inst. of Tech., Bedford (England). Coll. of Aeronautics.

PLUME EFFECTS ON THE FLOW AROUND A BLUNTED CONE AT HYPERSONIC SPEEDS

P. ATCLIFFE, D. KUMAR, and J. L. STOLLERY *In* California State Univ., The Fifth Symposium on Numerical and Physical Aspects of Aerodynamic Flows 7 p 1992
(Contract SLS42B/590)

Avail: CASI HC A02/MF A04

Tests at $M = 8.2$ show that a simulated rocket plume at the base of a blunted cone can cause large areas of separated flow, with dramatic effects on the heat transfer rate distribution. The plume was simulated by solid discs of varying sizes or by an annular jet of gas. Flow over the cone without a plume is fully laminar and attached. Using a large disc, the boundary layer is laminar at separation at the test Reynolds number. Transition occurs along the separated shear layer and the boundary layer quickly becomes turbulent. The reduction in heat transfer associated with a laminar separated region is followed by rising values as transition occurs and the heat transfer rates towards the rear of the cone substantially exceed the values obtained without a plume. With the annular jet or a small disc, separation occurs much further aft, so that heat transfer rates at the front of the cone are comparable with those found without a plume. Downstream of separation the shear layer now remains laminar and the heat transfer rates to the surface are significantly lower than the attached flow values. Author (revised)

N93-27462*# Centre d'Etudes et de Recherches, Toulouse (France). Dept. Aerothermodynamique.

INVESTIGATIONS ON ENTROPY LAYER ALONG HYPERSONIC HYPERBOLOIDS USING A DEFECT BOUNDARY LAYER

J. P. BRAZIER, B. AUPOIX, and J. COUSTEIX *In* California State Univ., The Fifth Symposium on Numerical and Physical Aspects of Aerodynamic Flows 12 p 1992
Avail: CASI HC A03/MF A04

A defect approach coupled with matched asymptotic expansions is used to derive a new set of boundary layer equations. This method ensures a smooth matching of the boundary layer with the inviscid solution. These equations are solved to calculate boundary layers over hypersonic blunt bodies involving the entropy gradient effect. Systematic comparisons are made for both axisymmetric and plane flows in several cases with different Mach and Reynolds numbers. After a brief survey of the entropy layer characteristics, the defect boundary layer results are compared with standard boundary layer and full Navier-Stokes solutions. The entropy gradient effects are found to be more important in the axisymmetric case than in the plane one. The wall temperature has a great influence on the results through the displacement effect. Good predictions can be obtained with the defect approach over a cold wall in the nose region, with a first order solution. However, the defect approach gives less accurate results far from the nose on axisymmetric bodies because of the thinning of the entropy layer. Author

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N93-27464*# Naval Oceanographic Office, Bay Saint Louis, MS.

ADAPTIVE EAGLE DYNAMIC SOLUTION ADAPTATION AND GRID QUALITY ENHANCEMENT

PHU VINH LUONG, J. F. THOMPSON (Mississippi State Univ., Mississippi State.), B. GATLIN (Mississippi State Univ., Mississippi State.), C. W. MASTIN (Mississippi State Univ., Mississippi State.), and H. J. KIM (Mississippi State Univ., Mississippi State.) *In* California State Univ., The Fifth Symposium on Numerical and Physical Aspects of Aerodynamic Flows 13 p 1992 (Contract NAS8-36949; F08635-89-C-0209)
Avail: CASI HC A03/MF A04

In the effort described here, the elliptic grid generation procedure in the EAGLE grid code was separated from the main code into a subroutine, and a new subroutine which evaluates several grid quality measures at each grid point was added. The elliptic grid routine can now be called, either by a computational fluid dynamics (CFD) code to generate a new adaptive grid based on flow variables and quality measures through multiple adaptation, or by the EAGLE main code to generate a grid based on quality measure variables through static adaptation. Arrays of flow variables can be read into the EAGLE grid code for use in static adaptation as well. These major changes in the EAGLE adaptive grid system make it easier to convert any CFD code that operates on a block-structured grid (or single-block grid) into a multiple adaptive code. Author (revised)

N93-27955# Army Research Lab., Adelphi, MD.

NAVIER-STOKES SIMULATION OF VISCOUS, SEPARATED, SUPERSONIC FLOW OVER A PROJECTILE ROTATING BAND Final Report, Nov. 1989 - Nov. 1991

BERNARD J. GUIDOS and JAMES E. DANBERG Mar. 1993
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(Contract DA PROJ. 1L1-62618-AH-80)
(AD-A263073; ARL-TR-102) Avail: CASI HC A04/MF A01

A numerical simulation is made of the separated, turbulent flow over the rotating band of a projectile-like body at Mach numbers 2.5, 3.0, and 3.5. The simulation is made by solving the thin-layer, compressible, mass-averaged, Navier-Stokes equations using an implicit numerical procedure. Numerical solutions are generated on a body-conforming computational grid which is constructed by adapting the boundary conditions of a grid generation scheme which solves the two-dimensional Poisson equations. The computed surface pressure distributions are compared to existing supersonic wind tunnel measurements. An evaluation is made of the accuracy and suitability of the numerical approach, and recommendations are made for the direction of future investigation. DTIC

N93-28070*# National Aeronautics and Space Administration, Langley Research Center, Hampton, VA.

EFFECT OF PYLON CROSS-SECTIONAL GEOMETRIES ON PROPULSION INTEGRATION FOR A LOW-WING TRANSPORT

ANTHONY M. INGRALDI, DINESH A. NAIK (Vigyan Research Associates, Inc., Hampton, VA.), and ODIS C. PENDERGRAFT, JR. Washington Jun. 1993 66 p

(Contract RTOP 535-03-10-01)
(NASA-TP-3333; L-17149; NAS 1.60:3333) Avail: CASI HC A04/MF A01

An experimental program was conducted in the Langley 16-Foot Transonic Tunnel to evaluate the performance effects of various types of pylons on a 1/17th-scale, low-wing transport model. The model wing was designed for cruise at a Mach number of 0.77 and a lift coefficient of 0.55. The pylons were tested at two wing semispan locations over a range of toe-in angles. The effects of toe-in angle were found to be minimal, but the variation in geometry had a more pronounced effect on the lift characteristics of the model. A pylon whose maximum thickness occurred at the wing trailing edge, known as a compression pylon, proved to be the best choice in terms of retaining the flow characteristics of the wing without pylons. Practical considerations such as structural viability may necessitate modification of the compression pylon

concept in order to take advantage of its apparent benefits.

Author

N93-28078 Michigan Univ., Ann Arbor.

AXISYMMETRIC VORTEX SHEET ROLL-UP Ph.D. Thesis MONIKA NITSCHKE 1992 89 p

Avail: Univ. Microfilms Order No. DA9308412

This thesis presents a numerical study of axisymmetric vortex sheet roll-up applied to vortex ring formation. The calculations are performed using a vortex blob method which resolves spiral vortex sheet roll-up. A convergence study with respect to the smoothing parameter is performed, and detailed information about the vortex sheet is obtained. The first problem studied is the evolution of an initially flat circular vortex sheet obtained by giving a disk immersed in ideal fluid an impulse and then removing it from the fluid. For a short time, the computed axisymmetric vortex sheet rolls up and obeys 2-d similarity theory in a moving frame of reference. For longer times, the computed solution approximates a steady propagating vortex ring with vorticity concentrated in a core, in good agreement with a symmetric core model proposed by an earlier researcher. A slight asymmetry in the computed vorticity distribution is responsible for a small deviation of the vortex ring radius and translation velocity from the theoretical results of others. The second problem studied is vortex ring formation at the edge of a circular tube due to the motion of a piston which ejects fluid from the tube. An earlier experiment is simulated numerically using a vortex blob model which incorporates vortex sheet separation at a sharp edge. Good agreement between computation and experiment is found for the sheet shape and the vortex ring trajectory. Except in an initial time period, during which viscous effects, are dominant in the experiment, the computed and experimental circulation shedding rates agree reasonably well. Experiments show that the vortex ring trajectory does not obey 2-d similarity theory predictions over long times. The present computations confirm this experimental observation and clarify previous explanations proposed for the absence of self-similarity.

Dissert. Abstr.

N93-28251 Boston Univ., MA.

THE ONSET OF VORTEX TURBULENCE Ph.D. Thesis

GREG HUBER 1993 110 p

Avail: Univ. Microfilms Order No. DA9309755

The onset of turbulence in two-dimensional, excitable media close to a global Hopf bifurcation is investigated. There one finds that the turbulence is associated with the appearance of topological point defects (vortices). A discrete form of the complex Ginzburg-Landau equation is used to explore the dynamics. Linear stability analysis of the complex Ginzburg-Landau equation indicates in what regions of parameter space the global, homogeneous solution is stable. However, in general the system does not asymptotically settle into this homogeneous state, rather it finds a many-vortex state. This can be either a 'frozen' state of stationary vortices, or a highly turbulent state with vortex-antivortex creation and annihilation. These states are related to the dynamics of the vortex statistics, as computed numerically. A phase diagram, based on the numerical simulations, is presented. Transient turbulence, near the transition line that separates the frozen states and the turbulent states, is discovered. These transients are identified as metastable states having a well-defined vortex density. Just below the transition to turbulence, the metastable states break down through the nucleation and growth of single-vortex droplets, leading to a finite-density frozen state. The lifetime of the metastable state is found to depend on the distance to the transition line. A relation between the nucleation time and droplet radius is derived, and their dependence on the distance to the turbulence transition is found. Dissert. Abstr.

N93-28440# Institut National de Recherche d'Informatique et d'Automatique, Valbonne (France). Programme 4: Robotique, Image et Vision.

HOMENTHALPIC-FLOW APPROACH FOR HYPERSONIC INVISCID NON-EQUILIBRIUM FLOWS

MARIE-CLAUDE CICCOLI and JEAN-ANTOINE DESIDERI Apr.

1992 36 p

(ISSN 0249-6399)

(INRIA-RR-1652; ETN-93-93899) Avail: CASI HC A03/MF A01

Two different methods for the numerical simulation of steady, inviscid, nonequilibrium reactive flow governed by Euler equations augmented by a five species seventeen reaction finite rate dissociation model are studied. The employed approximations are based on a conservative mixed finite volume/finite element upwind formulation. The study concentrates on the efficiency of the pseudo time integration methods as iterative algorithms. The iterative properties of the basic method are demonstrated by various computations of the flow fields around blunt bodies. In particular, the effect of varying the global Damkholer number (i.e. the size of geometry) is illustrated. A variant of the basic method is proposed. For steady (external) flows with uniform free stream, the total enthalpy is known to be constant throughout the domain. Hence, an algorithm which conserves this quantity was implemented in which the energy equation (in differential form) is not solved but replaced by its (algebraic) first integral. The extension of existing Flux Vector Splittings (FVS) to this context where one less partial differential equation is solved and one algebraic constraint is enforced, is examined. The FVS is demonstrated to be proper, and the efficiency of the proposed approach is assessed by numerical experiments for first and second order approximation schemes. ESA

N93-28449* West Virginia Univ., Morgantown. Dept. of Mechanical and Aerospace Engineering.

THE GROUND VORTEX FLOW FIELD ASSOCIATED WITH A JET IN A CROSS FLOW IMPINGING ON A GROUND PLANE FOR UNIFORM AND ANNULAR TURBULENT AXISYMMETRIC JETS M.S. Thesis

WILLIAM M. CAVAGE and JOHN M. KUHLMAN Washington May 1993 162 p

(Contract NAG1-1245; RTOP 505-59-30-02)

(NASA-CR-4513; NAS 1.26:4513) Avail: CASI HC A08/MF A02

An experimental study was conducted of the impingement of a single circular jet on a ground plane in a cross flow. This geometry is a simplified model of the interaction of propulsive jet exhaust from a V/STOL aircraft with the ground in forward flight. Jets were oriented normal to the cross flow and ground plane. Jet size, cross flow-to-jet velocity ratio, ground plane-to-jet board spacing, and jet exit turbulence level and mean velocity profile shape were all varied to determine their effects on the size of the ground vortex interaction region which forms on the ground plane, using smoke injection into the jet. Three component laser Doppler velocimeter measurements were made with a commercial three color system for the case of a uniform jet with exit spacing equal to 5.5 diameters and cross flow-to-jet velocity ratio equal to 0.11. The flow visualization data compared well for equivalent runs of the same nondimensional jet exit spacing and the same velocity ratio for different diameter nozzles, except at very low velocity ratios and for the larger nozzle, where tunnel blockage became significant. Variation of observed ground vortex size with cross flow-to-jet velocity ratio was consistent with previous studies. Observed effects of jet size and ground plane-to-jet board spacing were relatively small. Jet exit turbulence level effects were also small. However, an annular jet with a low velocity central core was found to have a significantly smaller ground vortex than an equivalent uniform jet at the same values of cross flow-to-jet velocity ratio and jet exit-to-ground plane spacing. This may suggest a means of altering ground vortex behavior somewhat, and points out the importance of proper simulation of jet exit velocity conditions. LV data indicated unsteady turbulence levels in the ground vortex in excess of 70 percent. Author (revised)

N93-28493* Air Force Systems Command, Wright-Patterson AFB, OH. Foreign Aerospace Science and Technology Center.

EFFECT OF CANARD WING POSITIONS ON AERODYNAMIC CHARACTERISTICS OF SWEEP-FORWARD WING

ZHANG BINQIAN and B. LASCHKA 25 Feb. 1993 17 p Transl. into ENGLISH from Kongqidonglixue Xuebao (China), v. 8, no. 4,

Dec. 1990 p 404-408

(AD-A262373; FASTC-ID(RS)T-0825-92) Avail: CASI HC A03/MF A01

Based on force measurements, oil flow observations, and eddy measurements in low air-speed wind tunnels, the paper studies the mechanism underlying the effect of canard wing positions on the aerodynamic characteristics of swept-forward canard wing configurations. As shown in studies, canard wing positions play the most significant role with respect to aerodynamic characteristics. Improvements in characteristics through a large incident angle in the swept-forward canard wing configuration depends on the relative position and the mutual control of the eddy at the leading edge of main wing. Based on the experimental results of an assembly with swept-forward and swept-back canard wing as well as the main wing, the paper presents the two-dimensional shapes of the canard and main wings, as well as their relative positions when adopting canard configuration. In addition, the authors express some of their views on the configuration of dual swept forward wings. DTIC

N93-28662# Pacific Northwest Lab., Richland, WA.

A DEMONSTRATION OF SIMPLE AIRFOILS: STRUCTURAL DESIGN AND MATERIALS CHOICES

L. ROY BUNNELL and STEVE W. PIIPPO (Richland School District, WA.) Jan. 1993 10 p Presented at the National Educator's Workshop, Oak Ridge, TN, 11-13 Nov. 1992

(Contract DE-AC06-76RL-01830)

(DE93-007882; PNL-SA-21578; CONF-9211178-3) Avail: CASI HC A02/MF A01

An educational unit is presented for building and evaluating simple wing structures, in order to learn about materials choice and lightweight construction. This unit is appropriate for a high school materials science class or lower-division college courses in structural engineering, materials science, or aeronautical engineering. DOE

N93-29005# Royal Inst. of Tech., Stockholm (Sweden). Dept. of Numerical Analysis and Computing Science.

THE NUMERICAL SOLUTION OF LOW MACH NUMBER FLOW IN CONFINED REGIONS BY RICHARDSON EXTRAPOLATION

B. CHRISTER V. JOHANSSON 25 Mar. 1992 40 p (Contract N00014-83-K-0422; NUTEK-726-91-01071; TFR-91-402) (TRITA-NA-9207) Avail: CASI HC A03/MF A01

We use artificial compressibility together with Richardson extrapolation in the Mach number M as a method for solving the time dependent Navier-Stokes equation for very low Mach number flow and for incompressible flow. The question of what boundary conditions one should use for low Mach number flow, especially at inflow and outflow boundaries, is investigated theoretically, and boundary layer suppressing boundary conditions are derived. For the case of linearization around a constant flow we show that the low Mach number solution will converge with the rate $O(M^2)$ to the true incompressible solution, provided that we choose the boundary conditions correctly. However, if the boundary conditions are chosen incorrectly, it might happen that the low Mach number solution converges to an incompressible solution that looks physical, even though the difference between the true incompressible solution and the limit solution derived as M^2 approaches 0 is $O(1)$. The reason is that the limit solution in this case does not satisfy the boundary conditions. The results of numerical calculations for the time dependent, nonlinear equations and for flow situations with time dependent inflow velocity profiles are presented. The convergence rate M^2 to incompressible solution is numerically confirmed. It is also shown that using Richardson extrapolation to $M^2 = 0$ in order to derive a solution with very small divergence can with good result be carried through with M^2 as large as 0.1 and 0.05. As the time step in numerical methods must be chosen approximately such that $\Delta t \times (1/M \Delta x + \nu/\Delta x^2)$ is in the stability region of the time stepping method, and as $M^2 = 0.05$ is sufficiently small to yield good results, the restriction on the time step due to the Mach number is not serious. Therefore the equations can be integrated very fast by explicit time stepping

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methods. This method for solving very low Mach number flow and incompressible flow is well suited to parallel processing.

Author (revised)

N93-29006# Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, Goettingen (Germany). Abt. Stabilitaet und Antwort. **TRANSONIC FLOWS ON AN OSCILLATING AIRFOIL AND THEIR EFFECT ON THE FLUTTER-BOUNDARY** Ph.D. Thesis - Technische Univ. Munich [TRANSSONISCHE STROEMUNGEN AN EINEM SCHWINGENDEN PROFIL UND DEREN EINFLUSS AUF DIE FLATTERGRENZE]

LORENZ TICHY May 1992 145 p In GERMAN (ISSN 0939-2963)

(DLR-FB-92-08; ETN-93-93733) Avail: CASI HC A07/MF A02; DLR, VB-PL-DO, Postfach 90 60 58, 5000 Cologne, Germany, HC

A mount system for experiments on a two dimensional airfoil in a transonic wind tunnel is described. The system permits the measurement of static and dynamic pressure distributions and forces as well as flutter experiments. The study is based on results for the NACA 0012 airfoil oscillating in plunging and pitching modes. Different types of pressure fluctuations for weak and strong shocks and for shock induced separation are detailed. Flutter calculations based on measured unsteady aerodynamic derivatives show the effect of these pressure fluctuations on the flutter boundary in transonic flow. ESA

N93-29035# Sandia National Labs., Albuquerque, NM. **THE DEVELOPMENT OF A PARACHUTE SYSTEM FOR AERIAL DELIVERY FROM HIGH SPEED CARGO AIRCRAFT**

V. L. BEHR 1992 11 p Presented at the 12th Royal Aeronautical Society/AIAA Aerodynamic Decelerator Systems Technical Conference, London, England, 10 May 1993

(Contract DE-AC04-76DP-00789)

(DE93-008339; SAND-92-1889C; CONF-930580-2) Avail: CASI HC A03/MF A01

Supply of military personnel on the ground with cargo has long been accomplished with parachute delivery systems from aircraft. Structural limits of aircraft have typically limited these operations to no more than 150 KCAS. A desire for increased survivability of cargo delivery aircraft has led to the development and fielding of aircraft capable of delivering cargo at substantially higher speeds. This paper describes efforts undertaken to design develop and test a cargo delivery system for use at speeds compatible with those high speed cargo aircraft. DOE

03

AIR TRANSPORTATION AND SAFETY

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

A93-39541

CRITICAL DISPATCH - A PILOT'S VIEW

D. B. A. FLEMING (British Airways, PLC, Hounslow, United Kingdom) *In* Avionic systems/design and maintenance; Proceedings of the Conference, Hounslow, United Kingdom, Apr. 22, 1993 London Royal Aeronautical Society 1993 p. 7.1-7.3.

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A structured approach to critical dispatch is now an acceptable philosophy to both Airlines and regulators. What was once an arbitrary procedure with individual interpretation critical dispatch is a set of criteria that permits safe flight with known defects to aircraft systems. The paper describes the various categories of allowable defects with associated constraints on the operation. The Minimum Equipment List is now well established and may be electrically incorporated in the aircraft system on the next generation of aircraft. Author

N93-27033# National Transportation Safety Board, Washington, DC. Office of Research and Engineering.

ANNUAL REVIEW OF AIRCRAFT ACCIDENT DATA: US GENERAL AVIATION CALENDAR YEAR 1989

1989 87 p

(PB93-160687; NTSB/ARG-93/01) Avail: CASI HC A05/MF A01

A statistical compilation and review of general aviation accidents which occurred in 1989 in the United States, its territories and possessions, and in international waters is 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 five sections covered are: all accidents; fatal accidents; serious injury accidents; property damage accidents; and midair collision accidents. Several tables present accident parameters for 1989 accidents only, and each section includes tabulations which present comparative statistics for 1989 and for the five-year period 1984-1988.

Author (revised)

N93-27034# National Transportation Safety Board, Washington, DC.

AIRCRAFT ACCIDENT REPORT: TAKEOFF STALL IN ICING CONDITIONS. USAIR FLIGHT 405 FOKKER F-28, N485US, LAGUARDIA AIRPORT, FLUSHING, NEW YORK, 22 MARCH 1992

17 Feb. 1993 129 p

(PB93-910402; NTSB/AAR-93/02) Avail: CASI HC A07/MF A02

The crash of USAir flight 405, a Fokker 28-4000, after an attempted takeoff from runway 13 at LaGuardia Airport, Flushing, New York, on March 22, 1992 is explained. The safety issues focus on the weather, USAir's deicing procedures, industry airframe deicing practices, air traffic control aspects of the flight, USAir's takeoff and preflight procedures, and flightcrew qualifications and training. The airplane's impact with the ground, postaccident survivability, and crash/fire/rescue activities are also discussed. Safety recommendations concerning these issues are addressed to the Federal Aviation Administration, the Port Authority of New York and New Jersey, the Department of Transportation, and the New York City Health and Hospitals Corporation.

Author (revised)

N93-27035# National Transportation Safety Board, Washington, DC.

AIRCRAFT ACCIDENT REPORT: CONTROLLED COLLISION WITH TERRAIN GP EXPRESS AIRLINES, INC., FLIGHT 861, A BEECHCRAFT C99, N118GP, ANNISTON, ALABAMA, 8 JUNE 1992

2 Mar. 1993 79 p

(PB93-910403; NTSB/AAR-93/03) Avail: CASI HC A05/MF A01

The controlled collision into terrain of GP Express flight 861, a Beechcraft C99, N118GP, in Anniston, Alabama, on June 8, 1992 is described. The safety issues discussed are, for aircraft operating under 14 CFR Part 135, the importance of adequate preparation and experience of newly hired captains, available approach charts for each pilot, and adherence to specific stabilized approach criteria. The importance of adequate cockpit resource management is also discussed. Recommendations concerning these issues were made to the Federal Aviation Administration. Author (revised)

N93-27076*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

AUTOGENIC-FEEDBACK TRAINING IMPROVES PILOT PERFORMANCE DURING EMERGENCY FLYING CONDITIONS

MICHAEL A. KELLAR (Tripler Army Medical Center, Honolulu, HI.), RAYMOND A. FOLEN (Tripler Army Medical Center, Honolulu, HI.), PATRICIA S. COWINGS, WILLIAM B. TOSCANO (California Univ., San Francisco.), and GLEN L. HISERT (Coast Guard, Barbers Point, HI.) Mar. 1993 12 p

(Contract RTOP 199-70-12-14)

(NASA-TM-104005; A-93046; NAS 1.15:104005) Avail: CASI HC A03/MF A01

Studies have shown that autonomous mode behavior is one cause of aircraft fatalities due to pilot error. In such cases, the

pilot is in a high state of psychological and physiological arousal and tends to focus on one problem, while ignoring more critical information. The effect of training in physiological self-recognition and regulation, as a means of improving crew cockpit performance was examined. Seventeen pilots were assigned to the treatment and control groups matched for accumulated flight hours. The treatment group comprised four pilots of HC-130 Hercules aircraft and four HH-65 Dolphin helicopter pilots; the control group comprised three pilots of HC-130's and six Dolphin helicopter pilots. During an initial flight physiological data were recorded for each crewmember and individual crew performance and rated by an instructor pilot. Eight crewmembers were then taught to regulate their own physiological response levels using Autogenic-Feedback Training (AFT). The remaining subjects received no training. During a second flight, treatment subjects showed significant improvement in performance, while controls did not improve. The results indicate that AFT management of high states of physiological arousal may improve pilot performance during emergency flying conditions.

Author (revised)

N93-27252# Illinois Univ., Urbana-Champaign. Dept. of Aeronautical and Astronautical Engineering.

EFFECT OF UNDERWING FROST ON TRANSPORT AIRCRAFT TAKEOFF PERFORMANCE

MICHAEL B. BRAGG and DOUGLAS C. HEINRICH Feb. 1993 97 p

(Contract DTA03-92-C-00013)

(DOT/FAA/CT-TN93/9) Avail: CASI HC A05/MF A02

The effect of underwing frost on transport aircraft takeoff and climb performance was studied. Underwing frost occurs when the lower surface of the wing is cooled by cold-soaked fuel in the wing tanks and frost accretes prior to takeoff. A two-dimensional test was performed in the NASA Langley Low Turbulence Pressure Tunnel on a typical high-lift airfoil with leading-edge slats and trailing-edge flaps. Frost was simulated on the lower surface using distributed roughness particles. The test was conducted at a Mach number of 0.2 and chord Reynolds numbers from 5 to 16 million. The effects of the frost were generally small with the largest effects occurring for the slat open case with the frost starting at 12 percent chord. In this situation the frost actually contaminated the upper surface boundary layer. The 2-D data were extrapolated to 3-D for a typical twin-jet and four-jet aircraft. Drag increases were converted into weight penalties to maintain clean aircraft climb angles, and maximum lift penalties were presented as stall speed changes or weight penalties to maintain clean aircraft stall speeds. The largest weight penalties were incurred to maintain the clean stall speed, but all effects were small considering the conservative assumptions made in the analysis.

Author (revised)

N93-27267*# Boeing Defense and Space Group, Seattle, WA. Military Airplanes Div.

THREE-DIMENSIONAL WATER DROPLET TRAJECTORY CODE VALIDATION USING AN ECS INLET GEOMETRY Final Report

MARLIN D. BREER and MARK P. GOODMAN May 1993 325 p

(Contract NAS3-25820; RTOP 505-62-00)

(NASA-CR-191097; E-7853; NAS 1.26:191097) Avail: CASI HC A14/MF A03

A task was completed under NASA contract, the purpose of which was to validate a three-dimensional particle trajectory code with existing test data obtained from the Icing Research Tunnel at NASA-LeRC. The geometry analyzed was a flush-mounted environmental control system (ECS) inlet. Results of the study indicated good overall agreement between analytical predictions and wind tunnel test results at most flight conditions. Difficulties were encountered when predicting impingement characteristics of the droplets less than or equal to 13.5 microns in diameter. This difficulty was corrected to some degree by modifications to a module of the particle trajectory code; however, additional modifications will be required to accurately predict impingement characteristics of smaller droplets.

Author (revised)

N93-27269# Galaxy Scientific Corp., Pleasantville, NJ. **AIRCRAFT ICE DETECTORS AND RELATED TECHNOLOGIES FOR ONGROUND AND INFLIGHT APPLICATIONS Final Report**

GREGORY A. HOOVER Apr. 1993 52 p

(Contract DTFA03-89-C-00043)

(DOT/FAA/CT-92/27) Avail: CASI HC A04/MF A01

This report describes a number of ice detection systems and identifies companies which produce ice detection systems. Twenty-two companies were contacted for this report. Of these companies, 16 satisfied the criteria for inclusion in the report. Systems described in this report include inflight, onground, combined inflight and onground, and related technologies. Each technology category features a 'Promising Technologies' section. In these sections, future ice detections systems are discussed.

Author (revised)

N93-28055# Federal Aviation Administration, Atlantic City, NJ. **VENTILATION EFFECTS ON SMOKE AND TEMPERATURE IN AN AIRCRAFT CABIN QUARTER-SCALE MODEL Final Report**

ALLAN ABRAMOWITZ and FRANKLIN FANN Mar. 1993 35 p

(DOT/FAA/CT-89/25) Avail: CASI HC A03/MF A01

Fire tests were conducted on a quarter-scale model of an aircraft cabin to determine ventilation effects on temperature and smoke. The ventilation rates were varied between 1 1/4 and 2 1/2 minutes of time for an air exchange (quarter scale). The data indicate that there were no significant changes in the cabin temperatures and in the quantity of heat being removed from the cabin by changing ventilation rates. The increased flows tended to redistribute small quantities of smoke within the cabin and out the exhaust.

Author (revised)

N93-28206# Technische Univ., Brunswick (Germany). Fakultät fuer Maschinenbau und Elektrotechnik.

PROTECTION OF TAXIING TRAFFIC IN AIRPORTS THROUGH MODE S SECONDARY RADAR TECHNOLOGY Ph.D. Thesis [SICHERUNG DES ROLLVERKEHRS AUF FLUGHAEFEN DURCH MODE S SEKUNDAERRADARTECHNIKEN]

WOLFGANG DETLEFSEN 1992 154 p In GERMAN

(ETN-93-93455) Avail: CASI HC A08/MF A02

The implementation possibilities of taxiing traffic protection systems are examined with particular consideration to a system based on mode S. Mode S was chosen because of the opportunity of data identification and transfer with tools corresponding to IACO (International Civil Aviation Organization) standards. It was proposed to build a locating and identification system by phase difference detection. An experimental mode S installation was developed for allowing phase and transmission measurements on airports and to be later used as an experimental localization system according to the trilateration process. Signal processing capability was tested in Frankfurt Airport (Germany), and the whole system was tested in Hanover Airport. It is remarked that pilot orientation on the runway can be improved by graphical information such as runway maps. Influence of perturbations on location and data transfer was studied, such as multichannel signal propagation and radio emissions.

ESA

N93-28571# Lawrence Livermore National Lab., CA.

WORLD COMMERCIAL AIRCRAFT ACCIDENTS

C. Y. KIMURA Jan. 1993 517 p

(Contract W-7405-ENG-48)

(DE93-010892; UCRL-ID-112905) Avail: CASI HC A22/MF A04

This report is a compilation of all accidents world-wide involving aircraft in commercial service which resulted in the loss of the airframe or one or more fatality, or both. This information has been gathered in order to present a complete inventory of commercial aircraft accidents. Events involving military action, sabotage, terrorist bombings, hijackings, suicides, and industrial ground accidents are included within this list. Included are the following topics: accidents involving world commercial jet aircraft, world commercial turboprop aircraft, world commercial pistonprop aircraft with four or more engines, and world commercial pistonprop aircraft with two or three engines from 1946 to 1992. Each accident is presented with information in the following categories: date of

04 AIRCRAFT COMMUNICATIONS AND NAVIGATION

the accident, airline and its flight numbers, type of flight, type of aircraft, aircraft registration number, construction number/manufacturers serial number, aircraft damage, accident flight phase, accident location, number of fatalities, number of occupants, cause, remarks, or description (brief) of the accident, and finally references used. The sixth chapter presents a summary of the world commercial aircraft accidents by major aircraft class (e.g. jet, turboprop, and pistonprop) and by flight phase. The seventh chapter presents several special studies including a list of world commercial aircraft accidents for all aircraft types with 100 or more fatalities in order of decreasing number of fatalities, a list of collision accidents involving commercial aircrafts, and a list of world commercial aircraft accidents for all aircraft types involving military action, sabotage, terrorist bombings, and hijackings. DOE

04

AIRCRAFT COMMUNICATIONS AND NAVIGATION

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

A93-36502

RELATIVE SENSITIVITY OF LORAN-C PHASE TRACKING AND CYCLE SELECTION TO CWI

Y. BIAN and D. LAST (Univ. of Wales, Bangor, United Kingdom) Electronics Letters (ISSN 0013-5194) vol. 29, no. 4 Feb. 18, 1993 p. 332-334. refs
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Novel results of an investigation of the relative sensitivity to CWI of the phase-tracking and cycle-selection operations of Loran-C receivers are presented. The results are shown to be dependent on the bandwidth of the bandpass filter, the zero crossing chosen for timing measurement, and the error limit set for each operation. In practice, it is the phase-tracking operation which demands the greater SIR because the dominant interferers are generally close to 100 kHz. It is also demonstrated that the wider the bandpass filters or the earlier the zero crossing chosen, the safer the cycle selection relative to phase tracking. AIAA

A93-37068

SYNTHETIC VISION - A VIEW IN THE FOG

MALCOM A. BURGESS (FAA, Research and Development Service, Washington) and ROBERT D. HAYES IEEE Aerospace and Electronic Systems Magazine (ISSN 0885-8985) vol. 8, no. 3 March 1993 p. 6-13. refs
Copyright

The joint efforts of the FAA, industry, and DOD to evaluate and demonstrate technologies permitting aircraft to land in very low visibilities over a wide range of airports, called the Synthetic Vision System Technology Demonstration Program, are examined. The system concept provides an electronic image of the runway to the pilot on a head-up display with an overlay on the display of symbology providing all the navigation and performance information required to fly and land the aircraft. Theoretical performance of the system concept at 35 GHz is calculated and compared to the actual performance of the 35 GHz experimental demonstration system for typical approach and runway intrusion detection conditions. There is excellent correlation between the two. With the experimental system pilots are routinely able to fly to CAT IIIa minimums on the Type I ILS facilities used in the program to date using the millimeter wave sensor. AIAA

A93-37090

A SELF-STEERING ARRAY FOR THE SHARP MICROWAVE-POWERED AIRCRAFT

THOMAS W. R. EAST (Tom East Engineering Services, Waterloo, Canada) IEEE Transactions on Antennas and Propagation (ISSN

0018-926X) vol. 40, no. 12 Dec. 1992 p. 1565-1567. refs
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SHARP is a proposed airborne platform consisting of a light aircraft powered by microwave energy beamed to it from the ground. This paper describes a novel design for a phased array which automatically tracks the aircraft as it flies on station. It uses a feedback link through the transmitted beam. Computer simulations are presented. Author

A93-38203

GPS AUTOLAND CONSIDERATIONS

ALFRED R. LOPEZ (ARL Associates, Inc., Commack, NY) IEEE Aerospace and Electronic Systems Magazine (ISSN 0885-8985) vol. 8, no. 4 April 1993 p. 37-40. refs
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The Global Navigation Satellite System (GNSS) will play a significant role in aircraft navigation, including approach and landing. A key issue is the capability for fully automatic hands-off landing (autoland). The resolution of this issue will impact the deployment of the Microwave Landing System (MLS). The GNSS will evolve from GPS. The GPS literature indicates that currently a Differential GPS/Inertial Reference Unit/Radar Altimeter (DGPS/IRU/RA) combination has the required accuracy for autoland. This paper points out that autoland capability for commercial aircraft has not been demonstrated. It indicates that ground multipath errors limit the vertical positioning accuracy of a DGPS/IRU/RA autoland system. The achievable vertical positioning accuracy is 1/10 that of MLS. A new system architecture, 'Tunnel Concept', for approach and landing is evolving which utilizes integrated sensors such as a DGPS/IRU/RA combination. It is argued that the precise velocity information available can substantially reduce the vertical accuracy requirement for autoland. This remains to be demonstrated. Author

A93-38564

TRANSITION TO A SEAMLESS COMMUNICATIONS SYSTEM REQUIRES MUCH EXPERIMENTATION

DANIEL B. SCHWARTZ (Aeronautical Radio, Inc., Annapolis, MD) ICAO Journal (ISSN 0018-8778) vol. 48, no. 2 March 1993 p. 15-18.
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An aeronautical telecommunication network (ATN) concept aimed at achieving a seamless, interoperable communications systems is presented. The ATN is an architecture of defined communications protocols and routing procedures that allow both air and ground end systems to communicate through a wide variety of media. A practical approach is proposed to devise and execute a stepwise migration path from today's collection of separately developed, incompatible systems to the future ATN system. An optimal first step for this migration to ATN is considered to be air traffic services communications between aircraft in oceanic airspace and ground end systems. AIAA

A93-39204

THE NAVIGATION AND FLYING EQUIPMENT OF THE YAK-42 AIRCRAFT [NAVIGATSIONNO-PILOTAZHNYI KOMPLEKS SAMOLETA YAK-42]

ANATOLII P. ZUBRILOV Riga Rizhskii Aviatzionnyi Universitet 1992 126 p. In RUSSIAN refs
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The general design, layout, operation, and the main components of the navigation and flying equipment of Yak-42 aircraft are examined. Attention is given to the methodological principles of solving various navigation and flying problems. Methods are also presented for testing the navigation and flying equipment for proper operation in accordance with the standard technical specifications. AIAA

N93-27017# Federal Aviation Administration, Atlantic City, NJ. THE ILS MATHEMATICAL MODELING STUDY OF THE RUNWAY 10 ILS LOCALIZER AT LUIS MUNOZ MARIN INTERNATIONAL AIRPORT, SAN JUAN, PUERTO RICO

JAMES D. RAMBONE Apr. 1993 23 p

(Contract FAA-T0603-S)

(DOT/FAA/CT-TN93/10) Avail: CASI HC A03/MF A01

This Technical Note describes the Instrument Landing System (ILS) math modeling performed by the Federal Aviation Administration (FAA) Technical Center at the request of the Southern Region. Computed localizer data are presented showing the effects of several structures on the performance of an ILS localizer serving runway 10 at the Luis Munoz Marin International Airport. The facility currently employs an 8-element log periodic dipole (LPD) antenna array which has been restricted and unusable from the middle marker inbound. A 14-element, self-clearing, LPD and a 14/6, dual-frequency, LPD localizer antenna system were modeled at the localizer site as possible replacement antennas. Modeled course structure results indicate that Category 1 localizer performance should be obtained with either of these antenna systems installed at the existing localizer site. Computed clearance orbit results for both replacement antenna systems indicate satisfactory linearity, course crossover, and signal clearance levels. Author

N93-27178 Rafael Armament Development Authority, Haifa (Israel).

INFORMATION-BASED CRITERIA OF TERRAIN NAVIGABILITY. PART 1: DATA-BASE ANALYSIS

S. FAIBISH and A. YAVNAI /n Israel Society of Aeronautics and Astronautics, 32nd Annual Conference on Aviation and Astronautics p 98-106 20 Feb. 1992

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A novel approach for terrain-aided navigability analysis is presented. This approach is based on evaluating the information content of the terrain spatial spectra, as related to the problem of minimizing the location error, given a pattern of terrain elevations. A set of information theoretic criteria has been developed and used. The criteria developed have been found to be a useful tool for navigability analysis and for optimal (in the sense of minimum navigation error) route planning. It is shown that the greater the spatial variance, the lower the entropy and the higher the navigability of the terrain. Part 1 of the work concentrates on terrain data-base analysis. ISA

N93-27925# Operational Test and Evaluation Force, Norfolk, VA.

FOLLOW-ON OPERATIONAL TEST AND EVALUATION OF THE NAVSTAR GLOBAL POSITIONING SYSTEM AIR INTEGRATION/INSTALLATION PROGRAM

TONY BOEX 22 Feb. 1993 8 p

(AD-A263067; OPNAV-3960-12) Avail: CASI HC A02/MF A01

This is a report of COMOPTEVFOR's first phase of follow-on operational test and evaluation of the Global Positioning System (GPS) as installed in the ES-3A. The purpose of the evaluation was to determine the reliability, maintainability, and availability of the AN/ARN-151 GPS User Equipment, as installed in the ES-3A, in an aircraft carrier environment. The GPS user equipment (UE) is determined to be operationally suitable. Approval for extension of application to platforms which require catapult launches and arrested landings is recommended. DTIC

N93-28625# Federal Aviation Administration, Atlantic City, NJ.

RESULTS OF DATAS INVESTIGATION OF ATCRBS ENVIRONMENT AT THE LOS ANGELES INTERNATIONAL AIRPORT Final Report, 14 Dec. 1992 - 15 Jan. 1993

LEO WAPELHORST, THOMAS PAGANO, and JOHN VANDONGEN Apr. 1993 37 p

(Contract FAA-T1101-F)

(DOT/FAA/CT-93/6) Avail: CASI HC A03/MF A01

The deployment of the Data Link Test and Analysis System (DATAS) as a Traffic Alert and Collision Avoidance System (TCAS) monitor at the Los Angeles International Airport (LAX) is documented. The purpose was to identify aircraft which were reporting illegal Mode Select ID's. Data were also taken on the

downlink portion of the environment in order to characterize the environment after the implementation of TCAS. The project was conducted by the Airborne Collision and Data Link Systems branch of the Federal Aviation Administration (FAA) Technical Center.

Author (revised)

N93-28936*# California Polytechnic State Univ., San Luis Obispo.

HELICOPTER APPROACH CAPABILITY USING THE DIFFERENTIAL GLOBAL POSITIONING SYSTEM M.S. Thesis

DAVID N. KAUFMANN Jun. 1993 56 p

(Contract NCC2-775)

(NASA-CR-193183; NAS 1.26:193183) Avail: CASI HC A04/MF A01

The results of flight tests to determine the feasibility of using the Global Positioning System (GPS) in the differential mode (DGPS) to provide high accuracy, precision navigation, and guidance for helicopter approaches to landing are presented. The airborne DGPS receiver and associated equipment is installed in a NASA UH-60 Black Hawk helicopter. The ground-based DGPS reference receiver is located at a surveyed test site and is equipped with a real-time VHF data link to transmit correction information to the airborne DGPS receiver. The corrected airborne DGPS information, together with the preset approach geometry, is used to calculate guidance commands which are sent to the aircraft's approach guidance instruments. The use of DGPS derived guidance for helicopter approaches to landing is evaluated by comparing the DGPS data with the laser tracker truth data. Both standard (3 deg) and steep (6 deg and 9 deg) glideslope straight-in approaches were flown. DGPS positioning accuracy based on a time history analysis of the entire approach was 0.2 m (mean) +/- 1.8 m (2 sigma) laterally and -2.0 m (mean) +/- 3.5 m (2 sigma) vertically for 3 deg glideslope approaches, -0.1 m (mean) +/- 1.5 m (2 sigma) laterally and -1.1 m (mean) +/- 3.5 m (2 sigma) vertically for 6 deg glideslope approaches and 0.2 m (mean) +/- 1.3 m (2 sigma) laterally and -1.0 m (mean) +/- 2.8 m (2 sigma) vertically for 9 deg glideslope approaches. DGPS positioning accuracy at the 200 ft decision height (DH) on a standard 3 deg slideslope approach was 0.3 m (mean) +/- 1.5 m (2 sigma) laterally and -2.3 m (mean) +/- 1.6 m (2 sigma) vertically. These errors indicate that the helicopter position based on DGPS guidance satisfies the International Civil Aviation Organization (ICAO) Category 1 (CAT 1) lateral and vertical navigational accuracy requirements.

Author (revised)

N93-28990# Naval Command, Control and Ocean Surveillance Center, San Diego, CA.

ADVANCED UNMANNED SEARCH SYSTEM (AUSS) SUPERVISORY COMMAND, CONTROL AND NAVIGATION Final Report

H. B. MCCracken Nov. 1992 85 p

(Contract NR PROJ. S03-97)

(AD-A263171; NRAD-TR-1533) Avail: CASI HC A05/MF A01

This document summarizes three major facets of Advanced Unmanned Search System (AUSS) vehicle operation. It describes the AUSS vehicle system's four command groups: the basic vehicle mode commands, which alter the vehicle's basic mode of operation; movement commands, which move the vehicle around; search commands, which control the vehicle's search sensors; and informational and miscellaneous commands, which provide information to surface operators. The document details the operation of individual basic vehicle mode, movement, and search commands. The document discusses the two types of AUSS vehicle navigation: dead reckoning and Doppler navigation. It describes the main computer system and the sensor computer group that comprise the AUSS vehicle's basic computer architecture, and it summarizes AUSS vehicle computer system components and their specific functions. DTIC

AIRCRAFT DESIGN, TESTING AND PERFORMANCE

Includes aircraft simulation technology.

A93-35902

EFFECTS OF DYNAMIC STALL AND STRUCTURAL MODELING ON AEROELASTIC STABILITY OF ELASTIC BENDING AND TORSION OF HINGELESS ROTOR BLADES WITH EXPERIMENTAL CORRELATION

DINESH BARWEY and GOPAL H. GAONKAR (Florida Atlantic Univ., Boca Raton) *In* AHS, Annual Forum, 48th, Washington, June 3-5, 1992, Proceedings. Vol. 1 Alexandria, VA American Helicopter Society 1992 p. 13-31. refs

(Contract DAAL03-87-K-0037; DAAL03-91-G-0007)

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The effects of blade and root-flexure elasticity and dynamic stall on aeroelastic stability of hingeless rotor blades are investigated. The dynamic stall description is based on the ONERA models of lift, drag and pitching moment. The structural analysis is based on three blade models that range from a rigid flap-lag model to two elastic flap-lag-torsion models, which differ in representing root-flexure elasticity. The predictions are correlated with the measured lag damping of two experimental isolated rotors: a two-blade rotor in hover and a three-blade rotor in hover and forward flight. The operating conditions range from near-zero thrust in hover to highly stalled, high-thrust conditions in forward flight. The correlations show increasing sensitivity of lag damping to structural refinements in blade and root-flexure modeling, and this sensitivity increases with increasing control pitch angle for the three-blade rotor. The study also shows that the root-flexure elasticity has considerable impact on the stability of the three-blade rotor, for which the root-flexure is soft in comparison to the blade. For the data in high advance-ratio and high-thrust conditions, inclusion of dynamic stall generally improves the correlation.

Author

A93-35903

THE DEVELOPMENT OF THE COUPLED ROTOR-FUSELAGE MODEL (CRFM)

ROBERT E. HANSFORD (Westland Helicopters, Ltd., Yeovil, United Kingdom) *In* AHS, Annual Forum, 48th, Washington, June 3-5, 1992, Proceedings. Vol. 1 Alexandria, VA American Helicopter Society 1992 p. 33-56. refs

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A coupled rotor-fuselage model (CRFM) developed under a collaborative program between Westland Helicopters Ltd. and the Defense Research Agency is described. The model takes into account the effects of hub motion on rotor load and vibration prediction by coupling the dynamic systems of the rotor and fuselage using complex rotor modes. CRFM is capable of simulating maneuvering flight conditions by mimicking the pilot control logic to fly maneuvers and incorporates a new wake model to address the first order implications of maneuvers on wake geometry. A new modal curve fitting technique is used to provide improved accuracy and efficiency when determining loads using the force integration procedure. It is concluded that CRFM provides versatility in computation and application to multiple rotor and wing combinations of different aircraft configurations.

AIAA

A93-35904* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

AEROMECHANICAL STABILITY OF HELICOPTERS WITH COMPOSITE ROTOR BLADES IN FORWARD FLIGHT

EDWARD C. SMITH and INDERJIT CHOPRA (Maryland Univ., College Park) *In* AHS, Annual Forum, 48th, Washington, June 3-5, 1992, Proceedings. Vol. 1 Alexandria, VA American Helicopter Society 1992 p. 57-73. refs

(Contract NAG1-1253; DAAL03-88-C-0002)

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The aeromechanical stability, including air resonance in hover, air resonance in forward flight, and ground resonance, of a helicopter with elastically tailored composite rotor blades is investigated. Five soft-inplane hingeless rotor configurations, featuring elastic pitch-lag, pitch-flap and extension-torsion couplings, are analyzed. Elastic couplings introduced through tailored composite blade spars can have a powerful effect on both air and ground resonance behavior. Elastic pitch-flap couplings (positive and negative) strongly affect body, rotor and dynamic inflow modes. Air resonance stability is diminished by elastic pitch-flap couplings in hover and forward flight. Negative pitch-lag elastic coupling has a stabilizing effect on the regressive lag mode in hover and forward flight. The negative pitch-lag coupling has a detrimental effect on ground resonance stability. Extension-torsion elastic coupling (blade pitch decreases due to tension) decreases regressive lag mode stability in both airborne and ground contact conditions. Increasing thrust levels has a beneficial influence on ground resonance stability for rotors with pitch-flap and extension-torsion coupling and is only marginally effective in improving stability of rotors with pitch-lag coupling.

Author

A93-35906

ON THE EFFECT OF PITCH/MAST-BENDING COUPLING ON WHIRL-MODE STABILITY

DONALD L. KUNZ (McDonnell Douglas Helicopter Co., Mesa, AZ) *In* AHS, Annual Forum, 48th, Washington, June 3-5, 1992, Proceedings. Vol. 1 Alexandria, VA American Helicopter Society 1992 p. 87-93. refs

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The influence of pitch/mast-bending coupling on whirl-mode instabilities is investigated using a simplified, linear model of a 4-bladed helicopter rotor and a nonrotating hub/mast support. An explanation of the proper procedure for modeling this coupling is given, and its rationale explained. Results using this model show that pitch/mast-bending coupling is usually destabilizing, and that the flap coupling component is more powerful than the pitch component. Since optimizing the pitch/mast-bending coupling may be difficult, or impractical, several methods for improving the stability characteristics are proposed.

Author

A93-35907

OVERVIEW OF TIGER DYNAMICS VALIDATION PROGRAM

GERHARD SEITZ (Eurocopter Deutschland, Munich, Germany) and TOMASZ KRYSINSKI (Eurocopter France, Marignane) *In* AHS, Annual Forum, 48th, Washington, June 3-5, 1992, Proceedings. Vol. 1 Alexandria, VA American Helicopter Society 1992 p. 95-107. refs

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A dynamic validation program of the French-German Tiger helicopter is described. Component and shake tests are compared with theoretical results to summarize various aspects of rotor dynamics, vibration control, aeroelastic stability, and response characteristics. It is concluded that both main and tail rotors were designed as soft inplane rotors whose aeromechanical stability margins were adequately predicted using whirl tower and shake test results. The analytically predicted 4/rev vibration level of less than 0.1 g was substantiated by flight tests confirming the effectiveness of the SARIB system for vibration control.

AIAA

A93-35908

DESIGN OF THE VARIABLE PITCH FAN FOR THE MCDONNELL DOUGLAS MD 520N HELICOPTER EQUIPPED WITH THE NOTAR SYSTEM

DANIEL NYHUS and CARLO RAO (McDonnell Douglas Helicopter Co., Mesa, AZ) *In* AHS, Annual Forum, 48th, Washington, June 3-5, 1992, Proceedings. Vol. 1 Alexandria, VA American Helicopter Society 1992 p. 111-120.

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A simple lightweight device is designed to improve operational characteristics of the NOTAR fan. It is concluded that the MD 520N NOTAR fan has proven to be an effective solution to the

unique technical challenges associated with such a device. The system is quiet and efficient and requires very low control force to operate. AIAA

A93-35909

PDT APPROACH FOR DEVELOPING RAH-66 COMANCHE AIRFRAME SYSTEMS

BRUCE F. KAY (Sikorsky Aircraft, Trumbull, CT) *In* AHS, Annual Forum, 48th, Washington, June 3-5, 1992, Proceedings. Vol. 1 Alexandria, VA American Helicopter Society 1992 p. 121-131.

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Boeing-Sikorsky is using a Product Development Team approach to meet the challenging weight, cost, supportability and military requirements of the Comanche helicopter. This paper will describe how the airframe system teams are organized and how they operate. The First Team is also making extensive use of advanced engineering tools such as three-dimensional CATIA electronic mockups as part of the design process. The Electronic mockups not only benefit Engineering but greatly facilitate development of manufacturing plans and MANPRINT evaluations. Several exemplary cases of how concurrent engineering, as embedded in the PDT process, are used to accomplish otherwise difficult tasks will also be discussed. Author

A93-35912

ANTITORQUE SAFETY AND THE RAH-66 FANTAIL

MICHAEL G. CLEMMONS (Boeing Defense & Space Group, Philadelphia, PA) *In* AHS, Annual Forum, 48th, Washington, June 3-5, 1992, Proceedings. Vol. 1 Alexandria, VA American Helicopter Society 1992 p. 169-175. refs

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The Comanche Fantail shrouded tail rotor designed by Boeing Sikorsky to improve overall aircraft safety is described. The Fantail shroud is an essential component in preventing tail rotor strikes and a contributing factor in antitorque thrust performance. Other safety features were developed to be used in conjunction with the Fantail shroud and duct which make it possible to reduce the probability that other tail rotor-related mishaps will occur or to provide redundancy in the event of failure of primary systems. AIAA

A93-35916

CONCEPT FEASIBILITY DEMONSTRATION FOR THE ARMY COCKPIT DELETHALIZATION PROGRAM

RICKY L. GRETH, W. B. SHOPE, MARK S. PLAFF (LME, Inc., Warminster, PA), and KENT F. SMITH (USAF, Aviation Applied Technology Directorate, Fort Eustis, VA) *In* AHS, Annual Forum, 48th, Washington, June 3-5, 1992, Proceedings. Vol. 1 Alexandria, VA American Helicopter Society 1992 p. 223-231. refs

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Research performed by LME, Incorporated, under a contract with the Aviation Applied Technology Directorate, aimed at development of active and passive crew protection designs for helicopter or light aircraft applications is reviewed. Protective concepts were evaluated using a series of computer simulations and dynamic tests based on a replication of an advanced attack helicopter crewstation interior with a stroking crewseat. Results indicate that significant improvement was achieved in reduction of head and neck accelerations and forward displacement when compared to a baseline conventional restraint. AIAA

A93-35932* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

RESULTS OF A LOW POWER ICE PROTECTION SYSTEM TEST AND A NEW METHOD OF IMAGING DATA ANALYSIS

JAIWON SHIN, THOMAS H. BOND (NASA, Lewis Research Center, Cleveland, OH), and GEERT A. MESANDER (USAF, Air Logistics Center, Tinker AFB, OK) *In* AHS, Annual Forum, 48th, Washington, June 3-5, 1992, Proceedings. Vol. 1 Alexandria, VA American Helicopter Society 1992 p. 375-390. Previously announced in STAR as N92-28696 refs

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Tests were conducted on a BF Goodrich De-Icing System's Pneumatic Impulse Ice Protection (PIIP) system in the NASA Lewis Icing Research Tunnel (IRT). Characterization studies were done on shed ice particle size by changing the input pressure and cycling time of the PIIP de-icer. The shed ice particle size was quantified using a newly developed image software package. The tests were conducted on a 1.83 m (6 ft) span, 0.53 m (221 in) chord NACA 0012 airfoil operated at a 4 degree angle of attack. The IRT test conditions were a -6.7 C (20 F) glaze ice, and a -20 C (-4 F) rime ice. The ice shedding events were recorded with a high speed video system. A detailed description of the image processing package and the results generated from this analytical tool are presented. Author

A93-35940* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

THREE-DIMENSIONAL CALCULATIONS OF ROTOR-AIRFRAME INTERACTION IN FORWARD FLIGHT

LAITH A. J. ZORI, SANJAY R. MATHUR, and R. G. RAJAGOPALAN (Iowa State Univ. of Science and Technology, Ames) *In* AHS, Annual Forum, 48th, Washington, June 3-5, 1992, Proceedings. Vol. 1 Alexandria, VA American Helicopter Society 1992 p. 489-512. refs

(Contract NAG1-1267)

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A method for analyzing the mutual aerodynamic interaction between a rotor and an airframe model has been developed. This technique models the rotor implicitly through the source terms of the momentum equations. A three-dimensional, incompressible, laminar, Navier-Stokes solver in cylindrical coordinates was developed for analyzing the rotor/airframe problem. The calculations are performed on a simplified model at an advance ratio of 0.1. The airframe surface pressure predictions are found to be in good agreement with wind tunnel test data. Results are presented for velocity and pressure field distributions in the wake of the rotor. Author

A93-35948

CRACK GROWTH/DAMAGE TOLERANCE ANALYSIS METHODS AS APPLIED TO V-22 FUSELAGE AND EMPENNAGE

RON W. ASKIN (Boeing Defense & Space Group, Helicopters Div., Philadelphia, PA) *In* AHS, Annual Forum, 48th, Washington, June 3-5, 1992, Proceedings. Vol. 1 Alexandria, VA American Helicopter Society 1992 p. 593-601. refs

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During the design phase of the V-22 tiltrotor aircraft both fatigue and fracture mechanics analyses were conducted on the metallic structure. As crack initiation, not crack growth, was the primary criterion and since the fuselage/empennage is designed with fail-safe principals, a less rigorous approach to fracture mechanics was required than would be expected for single load path parts (i.e., dynamic components). An analysis which provides an assessment of remaining life and residual strength after initiation and propagation of a crack was required for all flight critical components. In addition to the typical discrete maneuver type spectrum, the V-22 airframe experiences continuous high frequency oscillatory loads due to 3/rev loads and tail buffeting. In order to realistically evaluate crack growth under this type of loading it was necessary to define a buffet/vibratory load spectrum. This paper details analysis methods (spectrum development, stress intensity factor solutions, residual strength calculations) used on the V-22 fuselage and empennage and provides results of analysis by way of crack growth curves, critical crack sizes, and residual strength margins. Author

A93-35949

APPLICATION OF GENERALIZED FORCE DETERMINATION TO A FULL SCALE LOW CYCLE FATIGUE TEST OF THE SH-2G HELICOPTER

C. A. TOMASHOFSKI, E. J. NAGY, and P. E. KEARY (Kaman Aerospace Corp., Bloomfield, CT) *In* AHS, Annual Forum, 48th,

05 AIRCRAFT DESIGN, TESTING AND PERFORMANCE

Washington, June 3-5, 1992, Proceedings. Vol. 1 Alexandria, VA American Helicopter Society 1992 p. 603-616. refs
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As part of an overall Structural Life Assessment Program, a full scale low cycle fatigue test is currently being performed on a representative SH-2G airframe. This test is designed to reproduce the loads and mass/inertial responses that are imposed on the fuselage from various flight and landing conditions which the aircraft experiences throughout its service life. The test is performed for a period of 2 lifetimes using a flight spectrum representative of the fleet of SH-2 helicopters. Presented here is the methodology which was developed for conducting this type of full scale ground flying test. A process referred to as Generalized Force Determination (GFD) is used to quickly and reliably design the test set-up and load magnitudes which most closely represent the desired flight conditions. Measured flight test data of strains, internal loads, and accelerations along with pre-test calibration measurements are used by GFD to develop ground test requirements. In addition, GFD is shown to provide a means of improving the test configuration within the constraints of the user's available hardware. Author

A93-35951

EFFECTS ON LOAD DISTRIBUTION IN A HELICOPTER ROTOR SUPPORT STRUCTURE ASSOCIATED WITH VARIOUS BOUNDARY CONFIGURATIONS

MARK H. MORTON and ALLYNE KAIZOJI (McDonnell Douglas Helicopter Co., Mesa, AZ) *In* AHS, Annual Forum, 48th, Washington, June 3-5, 1992, Proceedings. Vol. 1 Alexandria, VA American Helicopter Society 1992 p. 629-634. refs
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A methodology used to assess the structural integrity and optimize the design of a new-generation commercial helicopter rotor support structure is described. All analyses employ a detailed FEM of the rotor support structure and MSC/NASTRAN to determine internal loads and stresses. Results indicate that the structure will exceed material allowables under ultimate flight and control loads. Fuselage stiffness is incorporated into the FEM of the rotor support structure via a 'general' finite element and the consequent redistribution of the load examined. Inertia relief is employed to obtain a better representation of the load redistribution due to flight load imbalances. Nonlinear analysis is also used to examine the redistribution of the load due to yielding. AIAA

A93-35952

THERMOPLASTIC APPLICATIONS IN HELICOPTER COMPONENTS

JOANNE G. HUTCHINS (Bell Helicopter Textron, Inc., Fort Worth, TX) *In* AHS, Annual Forum, 48th, Washington, June 3-5, 1992, Proceedings. Vol. 1 Alexandria, VA American Helicopter Society 1992 p. 635-645. refs
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This paper addresses the concept of using advanced thermoplastics in helicopter applications, presenting an overview of current thermoplastic applications being investigated at Bell Helicopter Textron Inc. The primary objectives of these programs are to reduce weight, reduce cost, and decrease manufacturing cycle time, while improving maintainability and reliability. Thermoplastic applications are broken into three classifications: (1) fiber-reinforced thermoplastic airframe composite structures; (2) injection-molded thermoplastic components; and (3) composite fasteners for joining composite and metal structure. Development of these various programs is described, including material and processing information and test procedures. The continuous-fiber-reinforced structures and the injection-molded components are currently going through final testing prior to flight test on aircraft. The composite fasteners have already been successfully flown in secondary structural components. Author

A93-35954

EH 101 SHIP INTERFACE TRIALS

R. LONGOBARDI, G. VISMARA, and B. PAGGI (Agusta S.p.A., Cascina Costa di Samarate, Italy) *In* AHS, Annual Forum, 48th,

Washington, June 3-5, 1992, Proceedings. Vol. 1 Alexandria, VA American Helicopter Society 1992 p. 663-669.
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The study describes the status of the EH 101 integrated development flight test program covering four variants: naval, civil passenger, civil and military utility. Attention is given to: on-shore assessment of handling qualities and performance in the low-speed region; handling quality assessment during operation in the proximity of a ship, during the final approach phase; deck landing and takeoff for a preliminary identification of deck motion limits and wind envelope; assessment of the deck landing technique; assessment of the aircraft landing on the deck, rotor folding, refuelling, armament loading, taxiing, tie-down, etc.; and assessment of the maintainability characteristics of the EH 101 in limited space. For each topic, the relevant results, collected during ship trials carried out in July 1990 and October 1991, are presented. AIAA

A93-35956

SIDE-BY-SIDE HOVER PERFORMANCE COMPARISON OF MDHC 500 NOTAR AND TAIL ROTOR ANTI-TORQUE SYSTEMS

RANDALL E. BREGGER and SETH DAWSON (McDonnell Douglas Helicopter Co., Mesa, AZ) *In* AHS, Annual Forum, 48th, Washington, June 3-5, 1992, Proceedings. Vol. 1 Alexandria, VA American Helicopter Society 1992 p. 689-695. refs
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A flight test of a 530N 'first generation-production' prototype NOTAR helicopter and a 530FF tail rotor equipped helicopter was performed to study and compare the hover performance of the two helicopters. The purpose of this test program was to accurately compare the anti-torque and total system performances of both helicopters. Results from the flight test show the two helicopters require the same power to hover in-ground-effect at 36 inch skid height, and to hover-out-of-ground-effect. The NOTAR-equipped 530N used less main rotor power per pound of gross weight as compared to the 530FF. However, the 530N required a higher percentage of anti-torque power versus total power than the 530FF. Improvements have been identified that can improve the efficiency of the next generation of NOTAR systems which would reduce the total hover power required to below that of tail rotor equipped helicopters. Author

A93-35975

AN INVESTIGATION OF HELICOPTER ROTOR BLADE FLAP VIBRATORY LOADS

WILLIAM G. BOUSMAN and THOMAS H. MAIER (U.S. Army, Aeroflightdynamics Directorate, Moffett Field, CA) *In* AHS, Annual Forum, 48th, Washington, June 3-5, 1992, Proceedings. Vol. 2 Alexandria, VA American Helicopter Society 1992 p. 977-999. refs
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The analysis CAMRAD/JA is used to model two aircraft, a Puma with a swept-tip blade, and a UH-60A Black Hawk. The accuracy of the analysis to predict the blade vibratory flap bending moments is assessed by comparing the predicted moments with measurements from flight test. The influence of assumptions in the analytical model is examined by varying model parameters, reducing the degrees of freedom, and so forth and comparing the predicted results to baseline values for the vibratory loads. In general, the analysis underpredicts the 3/rev and 4/rev flap bending moments in the blade, both at low and high speeds. The qualitative prediction of the loads, however, is quite good for the research Puma, but less satisfactory for the Black Hawk. The examination of modeling assumptions demonstrates the importance of the vortex wake at low speed and the importance of the airload distribution dictated by roll moment balance at high speed. Author

A93-35976

APPLICATION OF COMPONENT MODE SYNTHESIS TO MODELING THE DYNAMIC RESPONSE OF BEARINGLESS MAIN ROTORS

ROBERT SOPHER and SHYI-YAUNG CHEN (Sikorsky Aircraft, Stratford, CT) *In* AHS, Annual Forum, 48th, Washington, June 3-5, 1992, Proceedings. Vol. 2 Alexandria, VA American Helicopter Society 1992 p. 1001-1019. refs
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The paper describes an approach which uses component mode synthesis and an existing set of coding assets to model a Bearingless Main Rotor and shows that the resulting tool is practical and versatile. Comparisons are given between dual and single load path models to illustrate the scope of applicability and inadequacies of the single load path approximation. It was found that inclusion of the torque tube was necessary for vibratory loads predictions at the blade passage frequency for the case studied. Solutions based on single load path models were shown to be adequate for hover stability predictions in comparisons with the dual load path solution and test data for a 1/6th Froude scale model BMR. Run time efficiency was found to be satisfactory.

Author

A93-35977

COUPLED ROTOR FUSELAGE MODE SHAPES - A TOOL IN UNDERSTANDING HELICOPTER RESPONSE

PHILIP T. W. JUGGINS (Westland Helicopters, Ltd., Yeovil, United Kingdom) *In* AHS, Annual Forum, 48th, Washington, June 3-5, 1992, Proceedings. Vol. 2 Alexandria, VA American Helicopter Society 1992 p. 1021-1038. Research supported by Ministry of Defence Procurement Executive refs
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The Westland Coupled Rotor-Fuselage Model (CRFM) is under development, in a collaborative project with the UK Defence Research Agency (DRA), to provide a prediction tool for rotor loads and fuselage vibration in both level and maneuvering flight, as well as application to stability, performance and handling qualities. Modal degrees of freedom for CRFM are generated in the form of complex coupled rotor-fuselage (CRF) mode shapes, with associated natural frequencies, by the CRFD (Coupled Rotor-Fuselage Dynamics) program. The definition of CRF mode shapes is described, and the method of their application within a response analysis. The requirement for explicit modal orthogonality is examined, and a method is presented for enabling orthogonality conditions to be extracted from the transfer matrix form of the CRFD analysis by re-casting into a dynamic stiffness matrix form. The role of CRF mode shapes as a tool in not only calculation but enhancement of understanding of the rotor-fuselage system response and stability is considered with examples of calculated mode shapes and their significant characteristics. Results from a correlation exercise are given, for CRF modes calculated by CRFD compared with those from a method using blade modes as intermediate degrees of freedom.

Author

A93-35979* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

FLAP-LAG DAMPING IN HOVER AND FORWARD FLIGHT WITH A THREE-DIMENSIONAL WAKE

A. R. MANJUNATH (Indian Inst. of Science, Bangalore, India), J. HAGABHUSHANAM, GOPAL H. GAONKAR (Florida Atlantic Univ., Boca Raton), DAVID A. PETERS (Washington Univ., Saint Louis, MO), and AY SU (Yuan-Ze Inst. of Technology, Taiwan) *In* AHS, Annual Forum, 48th, Washington, June 3-5, 1992, Proceedings. Vol. 2 Alexandria, VA American Helicopter Society 1992 p. 1061-1077. refs
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Prediction of lag damping is difficult owing to the delicate balance of drag, induced drag and Coriolis forces in the in-plane direction. Moreover, induced drag is sensitive to dynamic wake, both shed and trailing components, and thus its prediction requires adequate unsteady-wake representation. Accordingly, rigid-blade flap-lag equations are coupled with a three-dimensional finite-state wake model; three isolated rotor configurations with three, four and five blades are treated over a range of thrust levels, Lock numbers, lag frequencies and advance ratios. The investigation includes convergence characteristics of damping with respect to

the number of shape functions and harmonics of the wake model for multiblade modes of low frequency (less than 1/rev.) to high frequency (greater than 1/rev.). Predicted flap and lag damping levels are then compared with similar predictions with (1) rigid wake (no unsteady induced flow), (2) Loewy lift deficiency, and (3) dynamic inflow.
Author (revised)

A93-35980* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

INTRODUCTION OF THE M-85 HIGH-SPEED ROTORCRAFT CONCEPT

ROBERT H. STROUB (NASA, Ames Research Center, Moffett Field, CA) *In* AHS, Annual Forum, 48th, Washington, June 3-5, 1992, Proceedings. Vol. 2 Alexandria, VA American Helicopter Society 1992 p. 1081-1104. Previously announced in STAR as N91-19078 refs
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As a result of studying possible requirements for high-speed rotorcraft and studying many high-speed concepts, a new high-speed rotorcraft concept, designated as M-85, was derived. The M-85 is a helicopter that is reconfigured to a fixed-wing aircraft for high-speed cruise. The concept was derived as an approach to enable smooth, stable conversion between fixed-wing and rotary-wing while retaining hover and low-speed flight characteristics of a low disk loading helicopter. The name, M-85, reflects the high-speed goals of 0.85 Mach number at high altitude. For a high-speed rotorcraft, it is expected that a viable concept must be a cruise-efficient, fixed-wing aircraft so it may be attractive for a multiplicity of missions. It is also expected that a viable high-speed rotorcraft concept must be cruise efficient first and secondly, efficient in hover. What makes the M-85 unique is the large circular hub fairing that is large enough to support the aircraft during conversion between rotary-wing and fixed-wing modes. With the aircraft supported by this hub fairing, the rotor blades can be unloaded during the 100 percent change in rotor rpm. With the blades unloaded, the potential for vibratory loads would be lessened. In cruise, the large circular hub fairing would be part of the lifting system with additional lifting panels deployed for better cruise efficiency. In hover, the circular hub fairing would slightly reduce lift potential and/or decrease hover efficiency of the rotor.

Author

A93-35981

COST/WEIGHT SAVINGS FOR THE V-22 WING STOW

THOMAS G. BAROTH and WILLIAM E. RUMBERGER (Boeing Defense & Space Group, Philadelphia, PA) *In* AHS, Annual Forum, 48th, Washington, June 3-5, 1992, Proceedings. Vol. 2 Alexandria, VA American Helicopter Society 1992 p. 1107-1114.
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Two redesign investigations aimed at achieving cost-weight savings for the V-22 Tiltrotor wing stow system are discussed. One is a weight reduction/produciibility study with a limited conceptual departure; the other is an ongoing initiative with a radical conceptual departure and a potential for greater rewards. The weight reduction/produciibility study focuses on the stow ring, primary flight fittings, ring secondary fittings, and wing rotation actuator. The second study employs the 'flexring' principle, whereby the stow wing is attached to, and rotates with, the wing rather than being fixed to the fuselage. The stages of design development are described; the philosophy and objectives of demonstration and verification are addressed.

AIAA

A93-35982

ADVANCING TILTROTOR STATE-OF-THE-ART WITH VARIABLE DIAMETER ROTORS

EVAN A. FRADENBURGH and DAVID G. MATUSKA (Sikorsky Aircraft, Stratford, CT) *In* AHS, Annual Forum, 48th, Washington, June 3-5, 1992, Proceedings. Vol. 2 Alexandria, VA American Helicopter Society 1992 p. 1115-1135. refs
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Results of an evaluation of a conventional tiltrotor and several variations of the variable diameter tiltrotor are summarized. The

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variable diameter tiltrotor has the potential to reduce disk loadings to desirable values, to match the rotor to both hover and cruise requirements, and to provide significantly better Category A performance, greater operational flexibility, and superior growth capability. It also has the potential to reduce external and internal noise, to improve passenger comfort, and to increase the design cruise speed. Progress summaries of full-scale aeroelastic analyses and planned wind tunnel tests are presented. AIAA

A93-35983 DESIGN AND MANUFACTURING CONCEPTS OF EUROFAR MODEL NO. 2 BLADES

VITTORIO CARAMASCHI and GIANCARLO MAFFIOLI (Agusta S.p.A., Cascina Costa di Samarate, Italy) /In AHS, Annual Forum, 48th, Washington, June 3-5, 1992, Proceedings. Vol. 2 Alexandria, VA American Helicopter Society 1992 p. 1137-1155. refs
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The objectives and the current status of the Model 2 phase of the Eurofar tiltrotor program are briefly reviewed. The main objectives of the Model 2 program include experimental validation of the aerodynamic design and performances of the full-scale baseline rotor blade geometry, setting up a European tiltrotor data base, and enhancing a complete rotor pre-design and suitable blade technology. Results of the structural and dynamic testing of the Model 2 blades are summarized. AIAA

A93-35984 FAIL SAFETY ASPECTS OF THE V-22 PYLON CONVERSION ACTUATOR

DUANE HICKS and ART SHORT (Bell Helicopter Textron, Inc., Fort Worth, TX) /In AHS, Annual Forum, 48th, Washington, June 3-5, 1992, Proceedings. Vol. 2 Alexandria, VA American Helicopter Society 1992 p. 1157-1165.
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The Bell-Boeing V-22 Osprey pylons are converted between helicopter and airplane modes by a linear actuator at each nacelle. The pylon conversion actuator is a telescoping ballscrew assembly powered to two hydraulic motors, with an electric motor backup mode. The actuator design is such that the ballscrew can be operated by driving the ball nut while grounding the screw, or driving the ballscrew while grounding the ball nut. This provides a totally separate backup drive system. Since the telescoping ballscrew is essentially two ballscrews in series, each providing half travel, the failure of one ballscrew will not preclude the other from providing at least one-half nacelle conversion. Partial conversion can position the rotors for a safe run-on landing. The primary power source is the two hydraulic motors, acting in parallel to rotate the ball nut located in the wing-mounted actuator housing. The backup electric power is applied to the ballscrew at the output end, or pylon attachment. Redundant load paths are used throughout the design. Author

A93-35985 OPTIMUM DESIGN OF HIGH SPEED PROP-ROTORS USING A MULTIDISCIPLINARY APPROACH

ADITI CHATTOPADHYAY (Arizona State Univ., Tempe) and JOHNNY R. NARAYAN (MCAT Inst., San Jose, CA) /In AHS, Annual Forum, 48th, Washington, June 3-5, 1992, Proceedings. Vol. 2 Alexandria, VA American Helicopter Society 1992 p. 1167-1177. refs
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The design of advanced high speed prop-rotor aircraft is addressed using a formal multidisciplinary optimization procedure. The optimization problem is formulated with aerodynamic performance, dynamics, aeroelastic stability and structural design requirements. Both high speed cruise and hover flight conditions are addressed. The analysis is performed at a cruise speed of 400 knots. The efficiency in cruise is maximized without deteriorating hover performance. A wide selection of structural and aerodynamic design variables are used. The optimization is performed using a nonlinear programming procedure and an approximate analysis technique. Significant improvements are

obtained in the overall rotor performance using the optimization procedure. Author

A93-35986 A PARAMETRIC STUDY OF REAL TIME MATHEMATICAL MODELING INCORPORATING DYNAMIC WAKE AND ELASTIC BLADES

CHENGJIAN HE and WILLIAM D. LEWIS (Georgia Inst. of Technology, Atlanta) /In AHS, Annual Forum, 48th, Washington, June 3-5, 1992, Proceedings. Vol. 2 Alexandria, VA American Helicopter Society 1992 p. 1181-1196. Research supported by U.S. Army refs
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In this paper, a finite-state dynamic wake theory is combined with blade element model for rotor modeling in helicopter real time flight simulation. A parametric study of the effects of incorporating dynamic wake and elastic blades to a real time rotorcraft mathematical model is discussed. The representation of the wake dynamics is a closed-form, first-order, ordinary differential equation in time. In this application, the induced flow modeling up to a second harmonic variation is implemented. Results for rigid and elastic blade models, while varying induced flow degree of freedom are presented. Correlation of the results with flight test data is provided to assess the inflow dynamics and rotor blade dynamics modeling effects. Author

A93-35989 EVALUATION OF TILT ROTOR AIRCRAFT DESIGN UTILIZING A REALTIME INTERACTIVE SIMULATION

FRANK M. WARBURTON (Sikorsky Aircraft, Stratford, CT) and H. C. CURTISS (Princeton Univ., NJ) /In AHS, Annual Forum, 48th, Washington, June 3-5, 1992, Proceedings. Vol. 2 Alexandria, VA American Helicopter Society 1992 p. 1225-1235. refs
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A workstation based interactive real time simulation was used to evaluate the external noise signatures, level flight performance, and one-engine-inoperative takeoff performance characteristics of six tilt rotor aircraft designs including both conventional and variable diameter configurations. Both the simulation visual display and flight mechanics model computations were performed in real time on a workstation computer. The non-linear tilt rotor dynamic model utilized six body axis plus other aircraft system degrees of freedom, and input derivatives to the flight mechanics model defined the tilt rotor configuration being evaluated. The tilt rotor configurations that were used in the evaluation were developed with preliminary design analysis. The ROTONET acoustic prediction system was used to generate the external noise signatures that were integrated into a flight sequence replay facility of the simulation. Category A vertical takeoff procedure guidelines were used for the interactive simulation of one-engine-inoperative departure flight profiles. Author

A93-35990* - National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

INVESTIGATION OF THE FLIGHT MECHANICS SIMULATION OF A HOVERING HELICOPTER

M. CHAIMOVICH, A. ROSEN, O. RAND (Technion - Israel Inst. of Technology, Haifa), M. H. MANSUR, and M. B. TISCHLER (U.S. Army, Aeroflightdynamics Directorate; NASA, Ames Research Center, Moffett Field, CA) /In AHS, Annual Forum, 48th, Washington, June 3-5, 1992, Proceedings. Vol. 2 Alexandria, VA American Helicopter Society 1992 p. 1237-1256. refs
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The flight mechanics simulation of a hovering helicopter is investigated by comparing the results of two different numerical models with flight test data for a hovering AH-64 Apache. The two models are the U.S. Army BEMAP and the Technion model. These nonlinear models are linearized by applying a numerical linearization procedure. The results of the linear models are compared with identification results in terms of eigenvalues, stability and control derivatives, and frequency responses. Detailed time histories of the responses of the complete nonlinear models, as a result of various pilots' inputs, are compared with flight test results.

In addition the sensitivity of the models to various effects are also investigated. The results are discussed and problematic aspects of the simulation are identified. Author

A93-35991
HELICOPTER ROTOR DISK AND BLADE ELEMENT COMPARISON

HAMID RAFATI, RONALD W. DU VAL, and OFER BRUHIS (Advanced Rotorcraft Technology, Inc., Mountain View, CA) *In* AHS, Annual Forum, 48th, Washington, June 3-5, 1992, Proceedings. Vol. 2 Alexandria, VA American Helicopter Society 1992 p. 1257-1265. refs (Contract N00421-91-C-0045)
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Modern computer technology offers the capability to perform real-time processing of mathematical models far more sophisticated than those currently being utilized in training applications. The capability to cost effectively implement Blade Element rotor models in real time using multiprocessor architectures and RISC technology processors has been demonstrated. In order to effectively utilize this new computational capability it is necessary to assess the trade-offs between increased fidelity and the cost associated with added sophistication in rotorcraft mathematical modeling. The objective of this study is to perform off-line comparisons of Blade Element and Rotor Map models under otherwise identical conditions to assess the significance of this increased sophistication to simulation fidelity and to weigh it against the additional cost associated with the increased computational requirements. The comparison was conducted using the FLIGHTLAB system to provide a modular approach to replacing only the rotor model in a configured simulation. A Blade Element model was compared with an equivalent Rotor Map model for the Main Rotor of a UH-60 Black Hawk. Comparisons of trim, static stability, transient response and frequency response were used to evaluate the models. Author

A93-35992
DEVELOPMENT AND VALIDATION OF A COMPREHENSIVE REAL TIME AH-64 APACHE SIMULATION MODEL

SELWYN H. STURISKY, WILLIAM D. LEWIS, DANIEL P. SCHRAGE, and J. V. R. PRASAD (Georgia Inst. of Technology, Atlanta) *In* AHS, Annual Forum, 48th, Washington, June 3-5, 1992, Proceedings. Vol. 2 Alexandria, VA American Helicopter Society 1992 p. 1267-1280. Research supported by U.S. Army refs
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A recently developed software tool specifically designed to support interactive modeling and analysis of dynamic systems was used to formulate a real-time AH-64 Apache simulation model. The model is comprehensive in that it is based on a sophisticated blade element rotor model which permits real-time modeling of elastic blades and dynamic inflow. Major component modules were independently verified for trends. Preliminary results were then obtained for static trims at various airspeeds, and dynamic response at specific flight conditions. The model used for these validation checks used a constant speed rotor, rigid blade dynamics and unsteady uniform inflow. The results obtained show a relatively good correlation with flight test data. Future work will include a full system identification validation of the model incorporating elastic blades with dynamic inflow. Author

A93-36001
THE DEVELOPMENT OF A CRASHWORTHY COMPOSITE FUSELAGE AND LANDING GEAR

H. BARQUET and P. SARLIN (Eurocopter France, Marignane) *In* AHS, Annual Forum, 48th, Washington, June 3-5, 1992, Proceedings. Vol. 2 Alexandria, VA American Helicopter Society 1992 p. 1421-1430. refs
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The results of a research effort aimed at the development of a composite landing gear and a composite central section of a 20,000-lb gross weight helicopter are summarized. The selection of the protection levels is discussed, including impact conditions

and required criteria for survivability, such as human tolerance, residual volume for occupants, and postcrash fire. The general design of the landing gear and the central section are described, and drop test results are reported. AIAA

A93-36004
A NONLINEAR ANALYSIS METHODOLOGY FOR THE DESIGN OF SKID LANDING GEARS

LISA C. WILLIAMS and AKIF O. BOLUKBASI (McDonnell Douglas Helicopter Co., Mesa, AZ) *In* AHS, Annual Forum, 48th, Washington, June 3-5, 1992, Proceedings. Vol. 2 Alexandria, VA American Helicopter Society 1992 p. 1451-1456. refs
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This paper describes a nonlinear analysis methodology for the design of helicopter skid landing gears. The methodology emphasizes the dynamic behavior of the skid landing gears using their energy absorption capability under all design landing conditions. The methodology employs nonlinear finite element analyses to determine the landing gear cross-tube load-deflection characteristics. The cross-tubes are then modeled as nonlinear springs in a rigid body dynamic analysis of the helicopter for the design landing conditions. A series of static and dynamic design support tests were performed to validate the methodology. These test results are presented and compared with the analytical predictions. Author

A93-36019
THE CABRI TWO-SEAT HELICOPTER - DESIGN AND FIRST FLIGHTS

BRUNO GUIMBAL (Eurocopter France, Marignane) Jun. 1992 8 p. AHS, Annual Forum, 48th, Washington, June 3-5, 1992, Paper

The Cabri two-seat civil helicopter, which is powered by a 150-hp, four-cylinder aircraft engine, is able to have a design gross weight of only 550 kg due to the use of carbon/glass-fiber/Nomex monocoque shell construction. The three-bladed main rotor achieves a great simplification for state-of-the-art technology, as well as high inertia in order to allow full autorotation-descent training. Attention is given to the Cabri's primary-rotor drivetrain and hub structure, shrouded tail rotor, and cockpit controls. AIAA

A93-36020* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

ADVANCED TECHNOLOGY BLADE TESTING ON THE XV-15 TILT ROTOR RESEARCH AIRCRAFT

BRENT WELLMAN (NASA, Ames Research Center, Moffett Field, CA) Jun. 1992 10 p. AHS, Annual Forum, 48th, Washington, June 3-5, 1992, Paper refs

The XV-15 Tilt Rotor Research Aircraft has just completed the first series of flight tests with the Advanced Technology Blade (ATB) rotor system. The ATB are designed specifically for flight research and provide the ability to alter blade sweep and tip shape. A number of problems were encountered from first installation through envelope expansion to airplane mode flight that required innovative solutions to establish a suitable flight envelope. Prior to operation, the blade retention hardware had to be requalified to a higher rated centrifugal load, because the blade weight was higher than expected. Early flights in the helicopter mode revealed unacceptably high vibratory control system loads which required a temporary modification of the rotor controls to achieve higher speed flight and conversion to airplane mode. The airspeed in airplane mode was limited, however, because of large static control loads. Furthermore, analyses based on refined ATB blade mass and inertia properties indicated a previously unknown high-speed blade mode instability, also requiring airplane-mode maximum airspeed to be restricted. Most recently, a structural failure of an ATB cuff (root fairing) assembly retention structure required a redesign of the assembly. All problems have been addressed and satisfactory solutions have been found to allow continued productive flight research of the emerging tilt rotor concept. Author

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A93-36021

V-22 TILTROTOR FLIGHT TEST DEVELOPMENT

PHILIP J. DUNFORD, KEN LUNN (Boeing Defense & Space Group, Helicopters Div., Philadelphia, PA), RONALD A. MAGNUSON, and ROGER L. MARR (Bell Helicopter Textron, Inc., Fort Worth, TX) Jun. 1992 14 p. AHS, Annual Forum, 48th, Washington, June 3-5, 1992, Paper refs

The V-22 Osprey Flight Test Development program has been ongoing since 1989. This paper provides details of the flight test program conducted to date on the four development aircraft. A summary of the accomplishments shows that a significant portion of the flight envelope has been evaluated. A discussion of the classical development tests and evaluations highlights the approach used to efficiently assess the V-22 tiltrotor's characteristics throughout its flight envelope. Shortcomings identified in flight test are discussed along with the approach used to effectively provide a specification-compliant aircraft. Lessons learned throughout the flight test program are discussed, including a mishap which resulted in extensive damage to the No. 5 flight test aircraft during its initial flight. A summary of the results of Government operational-type evaluations, which verify the mission potential of the V-22 Osprey, is included for completeness. Finally, ongoing development testing, to be accomplished during 1992/93, is discussed. Author

A93-36023* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

PILOTED SIMULATOR INVESTIGATIONS OF A CIVIL TILT-ROTOR AIRCRAFT ON STEEP INSTRUMENT APPROACHES

WILLIAM A. DECKER (NASA, Ames Research Center, Moffett Field, CA) Jun. 1992 18 p. AHS, Annual Forum, 48th, Washington, June 3-5, 1992, Paper refs

NASA-Ames has used its Vertical Motion Simulator to investigate steep-glideslope instrument approaches for a civil transport tilt-rotor aircraft in two different cases: (1) where pilots used raw glideslope and localized error data for 6-25 deg slopes, terminating in slow roll-on landings, and (2) where a flight director commanded manual conversion from fixed-wing to helicopter modes and a deceleration on the glideslope led to a vertical landing on a small urban helipad. In the former, there occurred control problems directly ascribable to the slow approach speed; in the latter, the four-cue flight director's cockpit augmentation furnished adequate pilot ratings up to 15-deg glideslope. AIAA

A93-36025

BLADE TWIST-DESIGN OF EXPERIMENT

P. N. FLETCHER (Bell Helicopter Textron, Inc., Fort Worth, TX) Jun. 1992 14 p. AHS, Annual Forum, 48th, Washington, June 3-5, 1992, Paper

A Model 406 composite main rotor blade for the OH58D has, by design, a relatively low torsional stiffness when compared to a V-22, 214ST, or 222 blade. An unacceptable blade twist rejection was being experienced during blade manufacture. After initiating SPC on blade components and conducting cure cycle tests, it was determined that there was a direct correlation between cure cycle and blade twist in a blade with this degree of torsional stiffness. This case study, a design of experiment, is designed to optimize the cure cycle, and discuss the events leading up to and execution of the Taguchi-style (L8) design of experiment using a 48-blade population. The paper also contains a discussion of noise factors that were monitored during the experiment and the improved results achieved. Author

A93-36026

THE V-22 FOR SOF

THOMAS A. SWERTFAGER (USAF, Naval Air Systems Command, Washington), STANLEY MARTIN, JR., and ROSS D. CLARK (Bell-Boeing Joint Program Office, Arlington, VA) Jun. 1992 11 p. AHS, Annual Forum, 48th, Washington, June 3-5, 1992, Paper refs

A review of special operations infiltration/exfiltration requirements forms the basis of an investigation of a

SOF-configured V-22. Mission radius was determined as limited by midmission hover OGE and maximum takeoff gross weight. It was found that the V-22 can fly a radius of 755 nautical miles, sufficient to meet 70 percent of the anticipated SOF missions. With air-to-air refueling, it could perform SOF missions extending out beyond a 1000-mile radius. The high V-22 average cruise speed, up to 262 knots depending on altitude, ensures completion of even the 1000-mile radius SOF mission under cover of darkness, assumed to be nominally 8 hours. Because of recent occurrences in the Middle East, the V-22 performance in a Special Operations role was superimposed on a map showing typical locations of U.S. aircraft carriers and major bases in Saudi Arabia. It was found that the V-22, carrying a 12-man SOF team, could reach all areas of Iraq and Kuwait. A qualitative assessment of V-22-survivability, including protection against chemical warfare agents, is also given. Author (revised)

A93-36330

EFFECTS OF PYLON YAW AND LATERAL STIFFNESS ON THE FLUTTER OF A DELTA WING WITH EXTERNAL STORE

ZHICHUN YANG, LINGCHENG ZHAO, LING LI, and HONGJUN LIU (Northwestern Polytechnical Univ., Xian, China) Journal of Vibration Engineering (ISSN 1004-4523) vol. 5, no. 2 June 1992 p. 168-172. In Chinese. refs

Both theoretical analysis and wind tunnel tests are performed for a model delta wing with external store to investigate the effects of pylon yaw and lateral stiffness on the flutter properties of the wing/store system. The theoretical results agree well with the experimental data. Some conclusions are presented. Author (revised)

A93-36339

INVESTIGATION OF SUBHARMONIC RESPONSE OF LIMIT CYCLE FLUTTER OF WING-STORE SYSTEM

YIREN YANG (Southwest Jiaotong Univ., Chengdu, China) and LINGCHENG ZHAO (Northwestern Polytechnical Univ., Xian, China) Journal of Vibration Engineering (ISSN 1004-4523) vol. 5, no. 4 Dec. 1992 p. 296-305. In Chinese. refs

The subharmonic response of limit cycle flutter of a wing with a store system is investigated theoretically and experimentally. Under the condition of stable limit cycle flutter of a nonlinear aeroelastic system, a relatively simple method, which can predict the regions of subharmonic response of limit cycle flutter of a wing-store system, is developed by means of the subharmonic bifurcation condition of a single degree of freedom oscillator. The results of numerical integration and wind-tunnel tests support the prediction. Author (revised)

A93-36342

THE INVESTIGATION OF LIMIT CYCLE AMPLITUDE OF NONLINEAR NOSE GEAR

XUEJUN WANG and XIN QIAO (Nanjing Aeronautical Inst., China) Journal of Vibration Engineering (ISSN 1004-4523) vol. 5, no. 4 Dec. 1992 p. 384-390. In Chinese. refs

The nonlinear nose gear shimmy is complicated by self-excited vibration coupled with lateral oscillation and torsional oscillation around the centerline of the strut. The nose wheel will oscillate and diverge to a limit cycle produced by the integrated influence of nonlinear terms in the strut when the taxiing speed of aircraft exceeds a critical speed. This paper investigates the limit cycle amplitude of a nonlinear shimmy system with nonlinear damping and with five degrees of freedom by describing the function method and by the perturbation method in the case where the taxiing speed exceeds the critical speed. The results from the above methods are verified by a numerical method. It is shown that the nose wheel shimmy with greater amplitude is prevented by greater nonlinear damping. A correlation analysis of the three methods is given. Author (revised)

A93-36784

A STUDY OF THE ORIGIN OF RESIDUAL STRESSES AND STRAINS IN THE TRANSPARENCIES OF SUPERSONIC AIRCRAFT [ISSLEDOVANIE PRICHIN VOZNIKNOVENIIA OSTATOCHNYKH NAPRIAZHENII I DEFORMATSII V OSTEKLENNIAKH SVERKHZVUKOVYKH SAMOLETOV]

V. F. VOROB'EV, V. I. MERKUR'EV, and S. E. POSTNOV *In* Stress-strain analysis and optimal design of aircraft structures Moscow Izdatel'skii Otdel TsAGI 1992 p. 21-28. *In* Russian. refs
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Results of an analysis of the service data for supersonic aircraft are reviewed with a view to establishing the factors responsible for the generation of residual stresses and strains in the aircraft transparencies. These data as well as results of bench tests indicate that the residual stresses and strains result from creep and stress relaxation processes and increase gradually with service time and with the number of loading cycles during testing. Particularly high residual stresses and strains are generated in organic glasses in the case where the outer surface temperature during the supersonic flight exceeds the glass transition temperature. The use of a more thermally stable glass eliminates crack formation. Good results are also obtained by replacing solid glass with laminated composite transparencies. AIAA

A93-36785

METHODOLOGY FOR STUDYING THE FRACTURE OF AIRCRAFT STRUCTURES IN STATIC TESTS [METODOLOGIIA ISSLEDOVANIYA RAZRUSHENII AVIATSIONNYKH KONSTRUKTSII PRI STATICHESKIKH ISPYTANIYAKH]

V. F. KUT'INOV, G. N. ZAMULA, V. F. MOKHOV, K. M. IERUSALIMSKII, and V. P. FOMIN *In* Stress-strain analysis and optimal design of aircraft structures Moscow Izdatel'skii Otdel TsAGI 1992 p. 29-39. *In* Russian. refs
Copyright

A methodology is presented for the statistical analysis of the existing data base on the fracture of aircraft structures in static tests. Examples of the processing of test results are presented, and the use of application software for the extraction, classification, and organization of fracture data is described. A procedure is also presented for determining the additional safety coefficients for structures that have not passed static tests. AIAA

A93-36794

LOAD-BEARING CAPACITY OF AN AIRCRAFT WING BASED ON THE CONDITION OF COMPRESSED SURFACE FRACTURE [NESUSHCHAIA SPOSOBNOST' KRYLA SAMOLETA PO USLOVIU RAZRUSHENIIA SZHATOI POVERKHNOSTI]

V. F. GALKIN *In* Stress-strain analysis and optimal design of aircraft structures Moscow Izdatel'skii Otdel TsAGI 1992 p. 105-110. *In* Russian. refs
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A simple physically meaningful method is proposed which makes it possible to determine the fracture-causing bending moment in the cross section of a wing and the safety margin with sufficiently high accuracy without the use of a computer. The method is based on a fracture condition for a surface under compressive loading. The validity of the fracture criterion proposed here is demonstrated experimentally for an H-beam of D16T alloy. Calculations for a compressed wing section of V95pchT2 alloy are found to be in good agreement with static test results. AIAA

A93-36795

EFFICIENCY OF USING LONGITUDINAL AND CIRCUMFERENTIAL BANDS IN THE STRUCTURES OF AN AIRTIGHT FUSELAGE [EFFEKTIVNOST' ISPOL'ZOVANIYA V KONSTRUKTSII GERMETICHESKOGO FIUZELIAZHA PRODOL'NYKH I KOL'TSEVYKH LENT]

I. A. KOVAL' *In* Stress-strain analysis and optimal design of aircraft structures Moscow Izdatel'skii Otdel TsAGI 1992 p. 111-121. *In* Russian. refs
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The problem of determining the stress-strain state and the

critical stresses of the local buckling of the cylindrical shell of an airtight fuselage reinforced by longitudinal and circumferential bands, in addition to stringers and frames, is solved by the finite element method. It is shown that the weight penalty resulting from the use of the bands can be compensated by reducing the initial thickness of the shell without any loss in its strength. AIAA

A93-36797

NUMERICAL MODELING OF THE IMPACT OF A BIRD AGAINST AIRCRAFT TRANSPARENCIES [CHISLENNOE MODELIROVANIE SOUDARENIIA PTITSY S OSTEKLENIEM LETATEL'NOGO APPARATA]

IU. V. SHENK *In* Stress-strain analysis and optimal design of aircraft structures Moscow Izdatel'skii Otdel TsAGI 1992 p. 140-144. *In* Russian. refs
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The impact of a fluid volume against a rigid surface is simulated on a computer. The density of the fluid and the curvature of its surface in the contact zone correspond to those of a bird. The boundary pressures and the time dependence of the total force are obtained for the initial stages of impact, when the effects resulting from the compressibility of the fluid dominate. AIAA

A93-36798

A STUDY OF THE EFFECT OF THE STATIC AEROELASTICITY OF A SWEEP WING ON ITS WEIGHT RESPONSE [ISSLEDOVANIE VLIANIYA STATICHESKOI AEROUPRUGOSTI STRELOVIDNOGO KRYLA NA EGO VESOVUIU OTDACHU]

V. A. BELOUS and V. I. BIRIUK *In* Stress-strain analysis and optimal design of aircraft structures Moscow Izdatel'skii Otdel TsAGI 1992 p. 145-149. *In* Russian.
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A methodology is presented for solving the problem of determining the effect of elasticity on the mass characteristics of a swept wing at the design stage. The methodology is implemented in a set of software which includes a finite element optimization program, a program for calculating pressures in terms of wing surface deformations, a program for preparing initial data using the finite element method, and a program for processing the output data. Calculations of the mass of the load-bearing elements of a swept wing in relation to its aerodynamic characteristics are presented as an example. AIAA

A93-37174

DESIGN DEVELOPMENTS FOR ADVANCED GENERAL AVIATION AIRCRAFT. I

Aerospace Engineering (ISSN 0736-2536) vol. 13, no. 4 April 1993 p. 7-11.
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An account is given of methodologies applicable to the preliminary design of advanced single-engined six-passenger general aviation aircraft, presently exemplified by a pusher-propeller and a tractor-propeller configuration. Both configurations, which have maximum takeoff weight of 13,224 lb, employ a high aspect ratio sweptforward wing. Attention is given to cabin layouts, advanced guidance and display technologies employed, and the detailed dimensions and other geometric specifications of the lifting surfaces of each configuration. AIAA

A93-37175

SPOILER ACTUATOR - A PROBLEM INVESTIGATION

Aerospace Engineering (ISSN 0736-2536) vol. 13, no. 4 April 1993 p. 23-28.
Copyright

Between early 1989 and mid-1990, reports were received by Boeing from operators which described a rolling tendency during flap deployment in 757 aircraft. An investigation was accordingly conducted of the 757 design's Spoiler Control Module and of each spoiler's Power Control Actuator (PCA). In due course, it was determined that failure had occurred within the PCAs, and further investigation established that the type of seal used in the spoiler actuator trunnion lacks vents that would allow hydraulic

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pressure to reach the area below a capstan; this prompts it to stick to a seal-retaining flange, forcing a capstrip and O-ring down in such a way as to allow hydraulic fluid leakage. This reduced the actuator's capacity and allowed the spoiler panel to float.

AIAA

A93-37376

FUNDAMENTALS OF LOW RADAR CROSS-SECTIONAL AIRCRAFT DESIGN

ALAN C. BROWN (Lockheed Corp., Calabasas, CA) Journal of Aircraft (ISSN 0021-8669) vol. 30, no. 3 May-June 1993 p. 289, 290.

Copyright

There are two basic approaches to passive radar cross-sectional reduction, shaping to minimize backscatter, and coating for energy absorption and cancellation. Both of these approaches have to be used coherently to achieve required levels over the appropriate frequency range. Design details are extremely important. a.

A93-37377

OPTIMAL TAKEOFF PROCEDURES FOR A TRANSPORT CATEGORY TILTROTOR

YOSHINORI OKUNO (National Aerospace Lab., Tokyo, Japan) and KEIJI KAWACHI (Tokyo Univ., Japan) Journal of Aircraft (ISSN 0021-8669) vol. 30, no. 3 May-June 1993 p. 291, 292. refs

Copyright

Tiltrotor aircraft are capable of performing running takeoffs similar to an airplane, whereas they use vertical and short takeoffs when operating as a helicopter. A method is presented to determine optimal takeoff procedures according to the available field length such that the takeoff weight is maximized while also complying with the transport category regulations. Author

A93-37390

DAMAGE TOLERANCE ASSESSMENT OF THE FIGHTER AIRCRAFT 37 VIGGEN MAIN WING ATTACHMENT

BJORN PALMBERG, MATS-OLOF OLSSON, PER-OLOF BOMAN, and ANDERS F. BLOM (Aeronautical Research Inst. of Sweden, Bromma) Journal of Aircraft (ISSN 0021-8669) vol. 30, no. 3 May-June 1993 p. 377-381. refs

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The Swedish fighter aircraft 37 Viggen, designed some 25 yr ago on a safe life basis, has been reassessed in terms of a damage tolerance evaluation. The aim was to ensure structural safety and to investigate the possibilities for extending the service life of the aircraft. This article deals with the reassessment of the newest wing attachment frame for the fighter version of the aircraft. The purpose of this article is to briefly show the extent and complexity of the assessment. Because of the original safe life design, resulting in rather high stresses, very extensive finite-element analyses were necessary in order to obtain accurate stress distributions and three-dimensional stress intensity factors in critical sections. Also, high demands have been placed on the accuracy of the crack growth predictions. Hence, extensive validation of the crack growth prediction technique was required. Structural testing, including artificial flaws, was carried out with the aim of obtaining crack growth data for correlation to the prediction technique. It is concluded that the state-of-the-art methodology used was successfully verified. Furthermore, damage tolerance of the considered parts were analytically proven and experimentally verified. Finally, extension of the original design life may be possible following further considerations. Author

A93-37391

EXTENDED RANGE OPERATIONS OF TWO AND THREE TURBOFAN ENGINED AIRPLANES

RODRIGO MARTINEZ-VAL and EMILIO PEREZ (Madrid, Univ. Politecnica, Spain) Journal of Aircraft (ISSN 0021-8669) vol. 30, no. 3 May-June 1993 p. 382-386. ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 2, p. 1479-1484. Previously cited in issue 09, p. 1323, Accession no. A91-24452 refs

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A93-37394

OPTIMAL CRUISE PERFORMANCE

L. E. MILLER (Dayton Univ., OH) Journal of Aircraft (ISSN 0021-8669) vol. 30, no. 3 May-June 1993 p. 403-405. refs

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The optimal cruise conditions are determined analytically for constant cruise altitude and cruise climb. It is demonstrated that the optimal cruise speed is in the drag rise region if sufficient thrust is available. The best cruise altitude corresponds to the altitude where drag is a global minimum. AIAA

A93-37997* National Aeronautics and Space Administration, Langley Research Center, Hampton, VA.

THE STRAKE - A SIMPLE MEANS FOR DIRECTIONAL CONTROL IMPROVEMENT

JOHN C. WILSON and HENRY L. KELLEY (U.S. Army; NASA, Langley Research Center, Hampton, VA) Vertiflite (ISSN 0042-4455) vol. 39, no. 2 Mar.-Apr. 1993 p. 29-31. refs

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On the basis of several flight test programs conducted to date, a directional control margin improvement of at least 5 percent is obtainable for right-sideward flight through the use of flow pattern separation-controlling tail-boom strakes. The enhanced directional control margin is critically important in low speed maneuvers, where high airloads are experienced by the tailboom. Numerous European helicopters have incorporated the strake on their tailbooms. AIAA

A93-38565

ADVANCED TUPOLEV TWINJET COMBINES RUSSIAN AND WESTERN TECHNOLOGIES

MARTIN JOHNSON (Rolls-Royce, PLC, London, United Kingdom) ICAO Journal (ISSN 0018-8778) vol. 48, no. 2 March 1993 p. 21-23.

Copyright

The Tupolev Tu-204, a Russian aircraft designed to carry 178 to 214 passengers over distances up to 6,500 km, is described. The Tu-204 is designed in two versions, with Russian Perm PS-90A engines and with the Rolls-Royce RB211-535E4-B engines, and is being produced using parallel production lines. It is concluded that the Tu-204 is based on an advanced airliner design at economic cost and is equipped with proven and fuel-efficient engines. AIAA

A93-38570

MODAL IDENTIFICATION OF AIRCRAFT STRUCTURES - ONERA METHODS [IDENTIFICATION MODALE DES STRUCTURES AERONAUTIQUES - METHODES DE L'ONERA]

ALAIN GRAVELLE (ONERA, Chatillon, France) ONERA, TP no. 1992-86 1992 7 p. In FRENCH Colloque Europeen ASTELAB, Paris, France, June 16-18, 1992 refs

(ONERA, TP NO. 1992-86)
Dynamic identification of large transport aircraft and light aircraft by ONERA is discussed. The appropriation method is examined along with some improvements that have been made in it. Finally, identification by nonappropriated excitations such as the use of flight control surfaces is addressed. AIAA

A93-38597

VALIDATION OF R85/METAR ON THE PUMA RAE FLIGHT TESTS

G. ARNAUD (Eurocopter France, Marignane) and P. BEAUMIER (ONERA, Chatillon, France) ONERA, TP no. 1992-123 1992 11 p. European Rotorcraft Forum, 18th, Avignon, France, Sept. 15-18, 1992 Research supported by DRET refs

(ONERA, TP NO. 1992-123)
The R85/METAR code, which belongs to codes using a lifting line theory, was validated by the results of flight tests performed at RAE Bedford on an Aerospatiale AS330 Puma helicopter using a rotor equipped with four swept tip blades, one of which was instrumented with pressure transducers on the suction side and on the lower side and another was instrumented with strain gauges.

Good correlations between the R85/METAR code and the measurements could be obtained using certain improvements outlined in the paper. AIAA

A93-38598

STUDY OF SOFT-IN-TORSION BLADES - ROSOH OPERATION
P. BEAUMIER (ONERA, Chatillon, France) and E. BERTON (Marseille, Inst. de Mecanique de Fluides, France) ONERA, TP no. 1992-124 1992 13 p. European Rotorcraft Forum, 18th, Avignon, France, Sept. 15-18, 1992 refs (ONERA, TP NO. 1992-124)

The operation of the ROSOH (Soft Rotor for Helicopters) is described. Experimental results obtained in the ONERA S2CH wind tunnel on a soft and a rigid rotor are analyzed, and the effects of the tab deflection, the advance ratio, and the lift coefficient on the global performance (torque) and the local coefficients are investigated. A comparison of experimental results with computations made with the R85/METAR code showed good agreement. It was found that the deflection of the tabs has an important effect on torsion but was detrimental to performance, particularly for the soft rotor. AIAA

A93-38731**ACTIVITIES OF THE GARTEUR HIGH LIFT RESEARCH PROGRAM [ACTIVITES DU GROUPE GARTEUR SUR L'HYPERSTUSTENTATION]**

J. J. THIBERT ONERA, TP no. 1992-152 1992 28 p. In FRENCH AAAF, Colloque d'Aerodynamique Appliquee, 29th, Biscarrosse, France, Sept. 21-23, 1992 (ONERA, TP NO. 1992-152)

Activities of the GARTEUR (Group for Aeronautical Research and Technology in Europe) high lift research program are described, and results are presented. A half-model of the A310 Airbus was used to support 3D tests, with 2D tests also being carried out. Tests performed in the principal European low-speed wind tunnels were complemented by flight tests performed by Airbus Industrie. A large range of Reynolds and Mach numbers was covered, and a complete and detailed set of results was obtained. This paper presents an analysis of the Reynolds and Mach number effects in 2D and 3D, airfoil and wing comparison results, and wind tunnel/flight test comparisons. AIAA

A93-38763**A FRENCH LOOK AT THE FUTURE SUPERSONIC TRANSPORT**

PH. POISSON-QUINTON (ONERA, Chatillon, France) ONERA, TP no. 1992-209 1992 29 p. International Aerospace Symposium, Nagoya, Japan, Dec. 2, 1992 refs (ONERA, TP NO. 1992-209)

A comprehensive evaluation is presented of the technological readiness and commercial viability of a new SST able to carry 250 passengers over 6500 n.mi. at Mach 2.2. The feasibility of such an aircraft's development is noted to critically depend on environmental-impact considerations, encompassing both upper-atmosphere pollution and near-airport noise levels. Attention is given to promising propulsion systems alternatives, structural techniques, and potential route structures over both the Atlantic and Pacific. AIAA

A93-38837**THE WHALE WITH A TAIL**

WILLIAM A. HAUPRICH (Thunderbird Aviation, Inc., Phoenix, AZ) and L. G. PEARSON *In 1992 report to the aerospace profession; SETP Symposium, 36th, Beverly Hills, CA, Sept. 24-26, 1992, Proceedings Lancaster, CA Society of Experimental Test Pilots 1992 p. 19-43.*

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Recent modification of the A-3D Thunderbird aircraft are discussed. Structural analysis of supports and housings for two antennas to be installed on Thunderbird Aviations's TA-3B aircraft. Equipment racks being installed in the aircraft's cabin are analyzed. The results of flight tests are reviewed. AIAA

A93-38838**DEVELOPMENT STATUS OF THE RAH-66 COMANCHE**

LORREN STILES (Sikorsky Aircraft, Stratford, CT) *In 1992 report to the aerospace profession; SETP Symposium, 36th, Beverly Hills, CA, Sept. 24-26, 1992, Proceedings Lancaster, CA Society of Experimental Test Pilots 1992 p. 44-62. refs* Copyright

This paper provides a historical perspective and the current status of the Army's new armed reconnaissance helicopter program, the RAH-66 Comanche. Preliminary design has been completed and detailed design is well underway for a first flight scheduled for August 1995. This unique aircraft is being developed using a novel product development team organizational approach with an emphasis upon mission requirements such as low observables, high maneuverability, night pilotage, target acquisition, weapons, and crew interface. Simulation and surrogate aircraft are being used to support design of the fly-by-wire control system. Pilot inputs (both contractor and military) are being used to highlight and assess attributes of the aircraft's design which enhance the mission of Army aviation. An aggressive prototype flight test program will be used to validate aircraft and mission effectiveness. Author (revised)

A93-38839**F/A-18 CONTROLS RELEASED DEPARTURE RECOVERY - FLIGHT TEST EVALUATION**

DAVID L. PRATER, MARC G. STEVENS, and JAMES B. LACKEY (U.S. Navy, Naval Air Warfare Center, Patuxent River, MD) *In 1992 report to the aerospace profession; SETP Symposium, 36th, Beverly Hills, CA, Sept. 24-26, 1992, Proceedings Lancaster, CA Society of Experimental Test Pilots 1992 p. 77-96. Previously announced in STAR as N93-15396 refs* Copyright

The F/A-18 has had a history of numerous departures from controlled flight during operational fleet use, several of which have resulted in mishaps. Many F/A-18 departures are characterized by high lateral forces making it difficult to maintain neutral longitudinal and lateral control stick position. The Naval Air Warfare Center Aircraft Division was tasked by Naval Air Systems Command to determine if releasing the control stick during departure recovery would result in any airplane induced control inputs that would delay recovery. Additionally, from the desire to improve departure awareness of all F/A-18 pilots, an assessment was made of the suitability of the test maneuvers for inclusion into an airborne departure recognition and out-of-control flight training syllabus. Testing was conducted using a fleet representative F/A-18D which did not incorporate any nonproduction emergency recovery devices (i.e., no spin recovery chute). Test maneuvers included both high and low angle of attack departures up to 0.80 IMN. Author (revised)

A93-38840**F-14D FLIGHT DIRECTOR DEVELOPMENT, TEST, AND EVALUATION**

R. W. HUFF, G. K. KESSLER, D. E. MUSSER, and O. P. HONORS (U.S. Navy, Naval Air Warfare Center, Patuxent River, MD) *In 1992 report to the aerospace profession; SETP Symposium, 36th, Beverly Hills, CA, Sept. 24-26, 1992, Proceedings Lancaster, CA Society of Experimental Test Pilots 1992 p. 100-110. refs* Copyright

The results are presented of simulations and flight tests to develop a flight director display in the F-14D aircraft for both shore-based and shipboard operations. Criteria used to optimize the flight director display, the selection of the display symbology, and the tradeoffs made in optimizing the control program are discussed. Comparisons are made with shore-based and shipboard flight test results. The paper recommends that the flight director be developed for all carrier aircraft and incorporated immediately. AIAA

A93-38844**B-2 FLIGHT TEST UPDATE**

FRANK T. BIRK (USAF, Washington) and C. W. STALEY (Northrop

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Corp., B-2 Div., Pico Rivera, CA) /n 1992 report to the aerospace profession; SETP Symposium, 36th, Beverly Hills, CA, Sept. 24-26, 1992, Proceedings Lancaster, CA Society of Experimental Test Pilots 1992 p. 174-187.

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A review is presented of recent flight tests and test results of the B-2 aircraft. The air data system, flight test schedule, flying qualities of the aircraft are examined. System testing is addressed, including avionics, weapons, and low observables (stealth), and logistics. Lessons learned for the tests as regards the value of good simulation, cockpit displays, avionics, low observables, and logistics are discussed. AIAA

A93-38846* National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.

X-29 VORTEX FLOW CONTROL TESTS

REGIS HANCOCK (USAF, Test Center, Edwards AFB, CA) and GORDON FULLERTON (NASA, Flight Research Center, Edwards, CA) /n 1992 report to the aerospace profession; SETP Symposium, 36th, Beverly Hills, CA, Sept. 24-26, 1992, Proceedings Lancaster, CA Society of Experimental Test Pilots 1992 p. 209-219.

Copyright

A joint Air Force/NASA X-29 aircraft program to improve yaw control at high angle of attack using vortex flow control (VFC) is described. Directional VFC blowing proved to be a powerful yaw moment generator and was very effective in overriding natural asymmetries, but was essentially ineffective in suppressing wing rock. Symmetric aft blowing also had little effect on suppressing wing rock. AIAA

A93-38847

THE SAAB 2000 INITIAL FLIGHT TEST - STATUS REPORT

GIDEON SINGER (SAAB Aircraft, AB, Linkoping, Sweden) /n 1992 report to the aerospace profession; SETP Symposium, 36th, Beverly Hills, CA, Sept. 24-26, 1992, Proceedings Lancaster, CA Society of Experimental Test Pilots 1992 p. 220-228.

Copyright

The SAAB 2000 turboprop airliner is described. The flight controls, development flight oscillator, and test rigs are addressed. The flight control development is examined, including the optimization of the system for control of rudder, roll, and pitch. AIAA

A93-39188

USING CURRENT NUMERICAL METHODS IN A MATHEMATICAL MODEL OF FLIGHT VEHICLE SYNTHESIS [OSOBENNOSTI ISPOL'ZOVANIYA SOVREMENNYKH CHISLENNYKH METODOV V MATEMATICHESKOI MODELI SINTEZA LETATEL'NOGO APPARATA]

A. M. BUTOV, V. P. GONCHARENKO, and A. I. ZHUKOVSKII Aviatsonnaia Tekhnika (ISSN 0579-2975) no. 4 1992 p. 56-59. In RUSSIAN refs

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A procedure is presented for using the Newton method for solving a system of nonlinear algebraic equations in a mathematical model for configuring a flight vehicle. Some problems associated with the use of the approach proposed here are examined. It is shown that the use of a modified version of the Newton method makes it possible to significantly reduce the time required for theoretical and analytical research involved in flight vehicle synthesis. AIAA

A93-39189

OPTIMIZATION OF THE PARAMETERS OF THE LIFT-AUGMENTATION DEVICES OF THE WING OF A MANEUVERABLE AIRCRAFT EQUIPPED WITH AN ACTIVE LOAD-REDUCTION SYSTEM [OPTIMIZATSIIA PARAMETROV MEKHAZITSII KRYLA MANEVRENNOGO SAMOLETA, OSNASHCHENNOGO AKTIVNOI SISTEMOI SNIZHENIIA NAGRUZOK]

V. P. SURIN and N. S. NIKOLAENKO Aviatsonnaia Tekhnika

(ISSN 0579-2975) no. 4 1992 p. 59-62. In RUSSIAN refs
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The paper is concerned with the static problem of determining the parameters of the lift-augmentation devices of a maneuverable aircraft wing (the tailless scheme) equipped by an automatic load-reduction system. The problem of optimizing the parameters of the lift-augmentation devices is formulated as a mathematical programming problem. The solution of the problem is illustrated for a hypothetical tailless aircraft with a takeoff weight of 50,000 kg. AIAA

A93-39203

MAINTENANCE OF THE LIQUID AND GAS SYSTEMS OF THE IL-76 AIRCRAFT [TEKHNICHESKAIA EKSPLOATATSIYA ZHIDKOSTNO-GAZOVYKH SISTEM SAMOLETA IL-76]

EVGENII S. BARYSHEV, NIKOLAI T. DOMOTENKO, and VALERII N. MUKHIN Riga Rzhskii Aviatsonnyi Universitet 1992 103 p. In RUSSIAN refs

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The design, operation, and maintenance of the fuel, lubrication, fire prevention, and deicing systems of the Il-76 aircraft are examined. Attention is also given to the starting systems of the D-ZOKP engine and of the auxiliary powerplant TA-6A. The main functional components of these systems are described, as are the basic maintenance procedures. AIAA

A93-39498* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

RESEARCH IN UNSTEADY AERODYNAMICS AND COMPUTATIONAL AEROELASTICITY AT THE NASA LANGLEY RESEARCH CENTER

WOODROW WHITLOW, JR. (NASA, Langley Research Center, Hampton, VA) May 1993 13 p. International Forum on Aeroelasticity and Structural Dynamics, Strasbourg, France, May 24-26, 1993, Paper refs

This paper presents recent results in the unsteady aerodynamics and computational aeroelasticity research programs at the NASA Langley Research Center. These programs include development of two types of computational methods: methods that use structured computational meshes and those that use unstructured meshes. Results show that an aeroelastic analysis method that uses unsteady transonic small disturbance (TSD) potential aerodynamics and structured, Cartesian meshes is capable of accurate analysis of complex aircraft configurations. The paper describes recent enhancements to the TSD method that allow analysis of vehicles with swept, flexible vertical surfaces and flexible fuselages and presents selected results that verify the accuracy of the new capabilities. Modifications to a structured-mesh Euler/Navier-Stokes method to allow aeroelastic analysis are described, and a wing flutter analysis using the resulting method is presented. Advantages of using unstructured meshes for the analysis of complex configurations are discussed. The paper presents development of unstructured-mesh Euler/Navier-Stokes methods for unsteady aerodynamics and aeroelastic analysis. Spatial and temporal adaption methods on unstructured meshes are described, and selected results are presented. Author

A93-39542

NEW CABIN ELECTRONICS

IVOR G. COWLEY (British Airways, PLC, Hounslow, United Kingdom) /n Avionic systems/design and maintenance; Proceedings of the Conference, Hounslow, United Kingdom, Apr. 22, 1993 London Royal Aeronautical Society 1993 p. 8.1-8.16.

Copyright

A development status evaluation is presented for electronic components intended for the passenger cabins of current and prospective commercial aircraft. These components will furnish individual passengers such services as communications, entertainment, and data retrieval and processing, as well as overall cabin diagnostics and management for airline personnel. Attention is given to the likely configuration and supporting technologies for video and telephony services under development. AIAA

A93-39599

C-17 SHOULD FULFILL USAF AIRLIFT MISSION

DAVID M. NORTH Aviation Week & Space Technology (ISSN 0005-2175) vol. 138, no. 19 May 10, 1993 p. 42, 43, 45-47.

Copyright

The development of the C-17 aircraft is discussed. The aircraft is expected to meet the Air Force's requirements for combined long-range strategic and short-range tactical airlift roles. Technical problems in the development program and cost overruns are described. Aircraft specifications and expected performance characteristics are listed. The experiences of one of the first pilots to fly the aircraft are presented and evaluations of the aircraft's performance and the technical problems experienced are given.

AIAA

A93-39600

VERSATILITY, AUTOMATION KEY TO C-17 CARGO OPERATIONS

MICHAEL A. DORNHEIM Aviation Week & Space Technology (ISSN 0005-2175) vol. 138, no. 19 May 10, 1993 p. 48, 49.

Copyright

The design of the C-17 aircraft and its cargo systems is reviewed. The versatility of the aircraft is provided by the standard equipment carried. The payload range and the automated cargo system are discussed.

AIAA

N93-27089*# Virginia Polytechnic Inst. and State Univ., Blacksburg. Dept. of Aerospace and Ocean Engineering.

ADJOINT METHODS FOR AERODYNAMIC WING DESIGN**Semiannual Progress Report**

BERNARD GROSSMAN May 1993 18 p

(Contract NAG1-1466)

(NASA-CR-193086; NAS 1.26:193086; NLPN92-737) Avail: CASI HC A03/MF A01

A model inverse design problem is used to investigate the effect of flow discontinuities on the optimization process. The optimization involves finding the cross-sectional area distribution of a duct that produces velocities that closely match a targeted velocity distribution. Quasi-one-dimensional flow theory is used, and the target is chosen to have a shock wave in its distribution. The objective function which quantifies the difference between the targeted and calculated velocity distributions may become non-smooth due to the interaction between the shock and the discretization of the flowfield. This paper offers two techniques to resolve the resulting problems for the optimization algorithms. The first, shock-fitting, involves careful integration of the objective function through the shock wave. The second, coordinate straining with shock penalty, uses a coordinate transformation to align the calculated shock with the target and then adds a penalty proportional to the square of the distance between the shocks. The techniques are tested using several popular sensitivity and optimization methods, including finite-differences, and direct and adjoint discrete sensitivity methods. Two optimization strategies, Gauss-Newton and sequential quadratic programming (SQP), are used to drive the objective function to a minimum. Author

N93-27168 Lockheed Advanced Development Co., Sunland, CA. **THE DEVELOPMENT OF AIRCRAFT IN THE LOCKHEED SKUNK WORKS FROM 1954 TO 1991**

BEN R. RICH In Israel Society of Aeronautics and Astronautics, 32nd Annual Conference on Aviation and Astronautics p 10-14 20 Feb. 1992

Copyright Avail: Israel Society of Aeronautics and Astronautics, c/o Faculty of Engineering, Tel-Aviv Univ., Ramat Aviv 69978, Israel

Some past projects of the Lockheed Advanced Development Co are briefly reviewed. Among successful programs have been the U-2 and SR-71 series of reconnaissance aircraft, the F-117 stealthy attack aircraft and the YF-22 fighter prototype. The success of the company depends on close cooperation between designers and constructors through all stages of a project. ISA

N93-27173 Lockheed Advanced Development Co., Burbank, CA.

YF-22A PROTOTYPE ADVANCED TACTICAL FIGHTER DEMONSTRATION/VALIDATION FLIGHT TEST PROGRAM OVERVIEW

DAVID L. FERGUSON In Israel Society of Aeronautics and Astronautics, 32nd Annual Conference on Aviation and Astronautics p 43-56 20 Feb. 1992

Copyright Avail: Israel Society of Aeronautics and Astronautics, c/o Faculty of Engineering, Tel-Aviv Univ., Ramat Aviv 69978, Israel

The Lockheed Aeronautical Systems Company, teamed with the General Dynamics Fort Worth Division and Boeing Military Airplanes Company, designed, built and flight tested two YF-22A Advanced Tactical Fighter (ATF) prototypes which were powered by new prototype high-thrust-to-weight ratio engines. The YF-22A design optimized the blend of low observability, maneuverability and supersonic performance. These design goals were achieved with the incorporation of many new and innovative technologies, including thrust vectoring, integrated flight and propulsion control, internal weapons carriage, and composite materials. An advanced cockpit with colored liquid crystal displays, finger-on-glass controls and advanced avionics architecture was also incorporated in the prototypes. The YF-22A Demonstration/Validation (Dem/Val) flight test program was completed on the 28th of December 1990. Seventy-four flights for a total of 91.6 flight hours were accumulated on both prototypes. The first flight of YF-22A no. 1 was made on 29 September 1990; the second prototype flew on 30 October 1990. The primary objective of the Dem/Val flight test program was to demonstrate the airplane's capabilities. This approach, which prioritized the use of the aircraft as demonstrators over their use as development tools, was considered to be the most efficient method of generating the test data required for the Engineering and Manufacturing Development (EMD) proposal. The purpose of this paper is briefly to describe some of the YF-22A's unique design features and flight instruments. ISA

N93-27241*# California Polytechnic State Univ., San Luis Obispo.

ROBUST CROSSFEED DESIGN FOR HOVERING ROTORCRAFT M.S. Thesis

DAVID R. CATAPANG Apr. 1993 70 p

(Contract NCC2-751)

(NASA-CR-193107; NAS 1.26:193107) Avail: CASI HC A04/MF A01

Control law design for rotorcraft fly-by-wire systems normally attempts to decouple angular responses using fixed-gain crossfeeds. This approach can lead to poor decoupling over the frequency range of pilot inputs and increase the load on the feedback loops. In order to improve the decoupling performance, dynamic crossfeeds may be adopted. Moreover, because of the large changes that occur in rotorcraft dynamics due to small changes about the nominal design condition, especially for near-hovering flight, the crossfeed design must be 'robust.' A new low-order matching method is presented here to design robust crossfeed compensators for multi-input, multi-output (MIMO) systems. The technique identifies degrees-of-freedom that can be decoupled using crossfeeds, given an anticipated set of parameter variations for the range of flight conditions of concern. Cross-coupling is then reduced for degrees-of-freedom that can use crossfeed compensation by minimizing off-axis response magnitude average and variance. Results are presented for the analysis of pitch, roll, yaw, and heave coupling of the UH-60 Black Hawk helicopter in near-hovering flight. Robust crossfeeds are designed that show significant improvement in decoupling performance and robustness over nominal, single design point, compensators. The design method and results are presented in an easily-used graphical format that lends significant physical insight to the design procedure. This plant pre-compensation technique is an appropriate preliminary step to the design of robust feedback control laws for rotorcraft. Author (revised)

05 AIRCRAFT DESIGN, TESTING AND PERFORMANCE

N93-27258*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

MULTIDISCIPLINARY DESIGN OPTIMIZATION: AN EMERGING NEW ENGINEERING DISCIPLINE

JAROSLAW SOBIESZCZANSKI-SOBIESKI May 1993 13 p
Prepared for presentation at the World Congress on Optimal Design of Structural Systems, Rio De Janeiro, Brazil, 2-6 Aug. 1993
(Contract RTOP 505-63-50)
(NASA-TM-107761; NAS 1.15:107761) Avail: CASI HC A03/MF A01

This paper defines the Multidisciplinary Design Optimization (MDO) as a new field of research endeavor and as an aid in the design of engineering systems. It examines the MDO conceptual components in relation to each other and defines their functions.

Author

N93-27547# Naval Postgraduate School, Monterey, CA. **TESTING A WHEELED LANDING GEAR SYSTEM FOR THE TH-57 HELICOPTER M.S. Thesis**

NANCY L. HECKMAN Dec. 1992 173 p
(AD-A262152) Avail: CASI HC A08/MF A02

Using the main gear from a Cessna 182 and the nose gear from a Grumman AAI-B, (patent pending) a comparison with the skid gear currently installed on the TH-57 helicopters was conducted. The initial comparison was done using a structural analysis program, GIFTS, to simultaneously analyze and compare the gear systems. Experimental data was used to verify program results. Experimental testing was conducted for further code validation and analysis of each system's advantages and disadvantages. While the benefits of a wheeled system merit further study, the system analyzed requires modification to eliminate premature failure of the nose wheel attachment tube.

DTIC

N93-27692# Army Research Lab., Aberdeen Proving Ground, MD.

ANALYSIS OF THE STATIC AND DYNAMIC RESPONSE OF A T-38 WING AND COMPARISON WITH EXPERIMENTAL DATA Final Report, Aug. 1990 - Nov. 1991

JONG-HO WOO Mar. 1993 105 p
(Contract DA PROJ. 1L1-62618-AH-80)
(AD-A262363; ARL-TR-99) Avail: CASI HC A06/MF A02

This report documents the investigation of a three-dimensional finite element model for calculating the static displacement and dynamic structural response of a T-38 wing and comparison of the analytical results with T-38 wing experimental data. The wing structure is modeled by rod and bar (beam), quadrilateral plate, triangular plate, and shear panel finite elements. The general structural analysis programs MSC/NASTRAN and MSC/PAL2 are used to calculate deflections, natural frequencies, and mode shapes. The wing finite element model yielded excellent agreement between calculated and experimental results for the eight loading conditions studied. The methodology developed in this study is expected to provide a valuable tool for the static aeroelastic response and dynamic analysis of wing structures in conjunction with aircraft ballistic vulnerability assessments.

DTIC

N93-27694# Air Force Systems Command, Wright-Patterson AFB, OH. Foreign Aerospace Science and Technology Center.

COMPUTATIONAL METHOD IN OPTIMAL BENDING-TWISTING COMPREHENSIVE DESIGN OF WINGS OF SUBSONIC AND SUPERSONIC AIRCRAFT

LIU DEHUA and HUANG CHANGYOU 25 Feb. 1993 19 p
Transl. into ENGLISH from Kongqidonglixue Xuebao (China), vol. 7, no. 2, Jun. 1989 p 192-198
(AD-A262374; FASTC-ID(RS)T-0826-92) Avail: CASI HC A03/MF A01

The paper presents a computational method for the optimal bending-twisting design of wings of subsonic and supersonic aircraft; a method for obtaining the finite fundamental solution is applied. By selecting a specific design point (M number and C(sub L)), the design of wings to withstand bending and twisting can be carried out. The goal is to reduce lift-related drag. On this technical basis, the aerodynamic features of these two design points for

subsonic and supersonic aircraft are noted in addition to the feasibility of other aircraft performance values applied to its structure. The paper presents the computational results of the optimal bending-twisting design for subsonic and supersonic aircraft, as well as the comprehensive design. As analysis showed, the computational results are rational.

DTIC

N93-28586# Aurora Flight Sciences Corp., Manassas, VA.

DEVELOPMENT AND TESTING OF THE PERSEUS PROOF-OF-CONCEPT AIRCRAFT

JOHN S. LANGFORD 26 Feb. 1993 68 p Prepared in cooperation with National Inst. for Global Environmental Change, Davis, CA

(Contract DE-FC03-90ER-61010)

(DE93-010121; DOE/ER-61010/002; AR-9301) Avail: CASI HC A04/MF A01

Many areas of global climate change research could benefit from a flexible, affordable, and near-term platform that could provide in situ measurements in the upper troposphere and lower stratosphere. To provide such a capability, the Perseus unmanned science research aircraft was proposed in 1989. As a first step toward the development of Perseus, a proof-of-concept (POC) demonstrator was constructed and tested during 1990 and 1991. The POC was a full scale Perseus airframe intended to validate the structural, aerodynamic, and flight control technologies for the Perseus within a total budget of about \$1.5 million. Advanced propulsion systems needed for the operational Perseus were not covered in the POC program due to funding limitations. This report documents the design, development, and testing of the Perseus POC.

DOE

N93-28693*# Texas A&M Univ., College Station. Aerospace Engineering Div.

PRELIMINARY DESIGN OF AN INTERMITTENT SMOKE FLOW VISUALIZATION SYSTEM

DONALD T. WARD and JAMES H. MYATT Jun. 1993 65 p
(Contract NAG2-651; RTOP 533-02-35)
(NASA-CR-186027; H-1917; NAS 1.26:186027;
TEES-AERO-TR-91-1) Avail: CASI HC A04/MF A01

A prototype intermittent flow visualization system that was designed to study vortex flow field dynamics has been constructed and tested through its ground test phase. It produces discrete pulses of dense white smoke consisting of particles of terephthalic acid by the pulsing action of a fast-acting three-way valve. The trajectories of the smoke pulses can be tracked by a video imaging system without intruding in the flow around in flight. Two methods of pulsing the smoke were examined. The simplest and safest approach is to simply divert the smoke between the two outlet ports on the valve; this approach should be particularly effective if it were desired to inject smoke at two locations during the same test event. The second approach involves closing off one of the outlet ports to momentarily block the flow. The second approach requires careful control of valve dwell times to avoid excessive pressure buildup within the cartridge container. This method also increases the velocity of the smoke injected into the flow. The flow of the smoke has been blocked for periods ranging from 30 to 80 milliseconds, depending on the system volume and the length of time the valve is allowed to remain open between valve closings.

Author (revised)

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AIRCRAFT INSTRUMENTATION

Includes cockpit and cabin display devices; and flight instruments.

A93-35921* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

VISUAL AUGMENTATION FOR NIGHT FLIGHT OVER FEATURELESS TERRAIN

MARY K. KAISER, WALTER W. JOHNSON, LYN MOWAFY (NASA, Ames Research Center, Moffett Field, CA), ROBERT T. HENNESSY, and JOY A. MATSUMOTO (Monterey Technologies, Inc., CA) *In* AHS, Annual Forum, 48th, Washington, June 3-5, 1992, Proceedings. Vol. 1 Alexandria, VA American Helicopter Society 1992 p. 275-280.

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Visual augmentation technique based on infrared cueing lights which project from the aircraft to the terrain is proposed to mitigate the problems associated with night flight over regions with featureless terrains. A series of simulation studies evaluated the effectiveness of several cueing light configurations. Results indicate that certain relatively low-cost cueing light configurations can be effectively used as pseudo-flight directors without impairing the pilot's use of available natural cues in the scene. Pilots prefer configurations which provide multiple samples of the forward terrain. Providing several 'look-aheads' helps to resolve potential vehicle/terrain state ambiguities. It is concluded that cueing lights are capable of creating visual patterns which are readily interpreted and translated to control commands, thus providing pilots with intuitive, low-workload decision aids. AIAA

A93-36018

SOME CONSIDERATIONS ON INDICATION MEANS FOR HELICOPTER PILOT VISION SYSTEMS

EVGENII V. IABLONSKII (Moscow Helicopter Plant, Russia) *In* AHS, Annual Forum, 48th, Washington, June 3-5, 1992, Proceedings. Vol. 2 Alexandria, VA American Helicopter Society 1992 p. 1587-1598.

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Possible approaches to the design of indication means for a round-the-clock helicopter vision system are examined. It is demonstrated that the TV display is preferable to a helmet mounted display (HMD). In an optimal system, the instantaneous field of view should be selectable within the range of 13 x 18 to 21 x 28 degrees; the scale of the image presented on the screen should be natural (i.e., equal to 1). A narrower field of view provides an advantage in terms of the time required for maneuvering. Alpha-numeric flight information (e.g., horizon position, flight height, airspeed, and distance to obstacles) is superimposed on the TV display screen. AIAA

A93-37071

MULTIPLE FUNCTION SENSORS FOR ENHANCED VISION APPLICATION

WALTER W. PATTERSON (Westinghouse Electronic Systems Group, Baltimore, MD) *IEEE Aerospace and Electronic Systems Magazine* (ISSN 0885-8985) vol. 8, no. 3 March 1993 p. 27-30.

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Enhanced Vision, a system which includes sensors capable of supporting the means for safe operation in a low-visibility (fog) environment, is discussed. A case is made to place EVS in perspective as part of a nested capability to provide seamless, safe, and efficient gate-to-gate operation, in any environment. EVS sensor selection criteria must support functional integration with other avionics. Its architecture must support evolutionary assimilation not only of the EVS capability, but that of the other Enhanced Situation Awareness System functions as well. A modularly architected, Multiple Function Sensor approach to cost-effective EVS capability is described. AIAA

A93-37074

A FAULT-TOLERANT AIR DATA/INERTIAL REFERENCE UNIT

MICHAEL L. SHEFFELS (Honeywell Corp., Flight Systems Div., Minneapolis, MN) *IEEE Aerospace and Electronic Systems Magazine* (ISSN 0885-8985) vol. 8, no. 3 March 1993 p. 48-52. refs

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A fault-tolerant Air Data Inertial Reference Unit (ADIRU) is described herein. The ADIRU is a key part of a fault-tolerant Air Data/Inertial Reference System (ADIRS). The ADIRS is designed to be the inertial and air data reference for the ARINC 651

Integrated Modular Avionics (IMA) distributed architecture. The ADIRU has been designed to meet the commercial aviation market demands for low life cycle cost and high reliability using simple, reliable methods to provide high integrity fault detection, fault isolation, and redundancy management. The ADIRU's internal redundant resources provide quad channel redundancy that is one level higher than conventional triple redundant systems. This allows the ADIRU to provide deferred maintenance capability. Robust partitioning, simple serial internal interfaces, and simple voting planes assure internal redundant components are properly utilized to provide high integrity system outputs. This relieves using systems from having to perform their own redundancy management of the air data and inertial outputs from multiple sources required by conventional systems. Author

A93-37407

COMMENT ON 'IN-FLIGHT MEASUREMENT OF STATIC PRESSURES'

DENNIS G. MABEY (Imperial College of Science, Technology, and Medicine, London, United Kingdom) *Journal of Aircraft* (ISSN 0021-8669) vol. 30, no. 3 May-June 1993 p. 432; Author's Reply, p. 432. refs

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It is argued that the paper in question, which includes some measurements of the steady and fluctuating trailing-edge pressures on an A310-200 aircraft at high speeds, contains two remarks that may mislead some readers. The remarks relate to buffet frequencies. In his reply, the author of the original paper points out that the characteristics of unsteady transonic flow and buffeting criteria that are based mainly on NACA 6 sections and generic three-dimensional models with rectangular winds may have to be modified for modern transonic wings. AIAA

A93-37699

A TECHNIQUE TO CORRECT AIRBORNE DOPPLER DATA FOR COORDINATE TRANSFORMATION ERRORS USING SURFACE CLUTTER

JACQUES TESTUD (Centre de Recherches en Physique de l'Environnement Terrestre et Planetaire, Issy-les-Moulineaux, France) and PETER H. HILDEBRAND (NCAR, Boulder, CO) *In* International Conference on Radar Meteorology, 25th, Paris, France, June 24-28, 1991, Preprints Boston, MA American Meteorological Society 1991 p. 493-496. refs

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A technique of using aircraft radar measurements of the ground echo to evaluate and correct coordinate transformation errors is presented. Attention is given to the correction of radial velocities for aircraft motion, an evaluation of residual velocity errors, and the correction of single scans of data. It is shown that the present technique agrees quite well with ground radar data. AIAA

A93-37737 National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, MD.

UPDATE ON THE NASA ER-2 DOPPLER RADAR SYSTEM (EDOP)

GERALD M. HEYMSFIELD, LOUIS R. DOD (NASA, Goddard Space Flight Center, Greenbelt, MD), LEE MILLER (Clemson Univ., SC), MICHAEL CRANER (Ressler Associates, Inc., Laurel, MD), and DOUGLAS VANDEMARK (NASA, Wallops Flight Facility, Wallops Island, VA) *In* International Conference on Radar Meteorology, 25th, Paris, France, June 24-28, 1991, Preprints Boston, MA American Meteorological Society 1991 p. 855-858. refs

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An update on the development status of EDOP, a dual-beam Doppler weather radar to be flown on the NASA ER-2 aircraft, is presented. The EDOP system is an X-band Doppler radar with a dual-beam configuration in the ER-2 nose, such that one beam is nadir pointing and the other at an angle of 35 deg forward of the nadir. The dual beams, as used on ELDORA, directed at, e.g., 20 deg fore and aft of the normal to the fuselage, require only a linear rather than L-shaped flight pattern to compute air motions. On the ER-2, EDOP will essentially map out high-resolution time-height sections of reflectivity and vertical hydrometeor velocity

06 AIRCRAFT INSTRUMENTATION

from the nadir beam. Flying EDOP with other ground-based and airborne radars will also provide a more complete picture of the overall 3D precipitation and hydrometeor structure of storms.

AIAA

A93-37853

SYSTEM STATUS - THE DIAGNOSTIC EDGE OF THE PILOT'S ASSOCIATE

JOHN W. BALL, SR. (Lockheed Aeronautical Systems Co., Marietta, GA) *In* International Instrumentation Symposium, 38th, Las Vegas, NV, Apr. 26-30, 1992, Proceedings Research Triangle Park, NC Instrument Society of America 1992 p. 19-29. refs
Copyright

Attention is given to System Status, one of several modules that comprise the Lockheed Pilot's Associate (PA). The System Status subsystem objectives include detecting faults, supplying operating limits of the aircraft, and providing corrective actions that are monitored to determine their effectiveness. The PA and pilot aiding functions supported, technical approach employed, and determinations deduced during the development of the System Status subsystem are discussed.

AIAA

A93-37882

A DATA SYSTEM FOR THE OBSERVATION OF FLOW CONDITIONS ON AN AIRCRAFT WING

HERMAN R. GELBACH (Boeing Co., Seattle, WA) *In* International Instrumentation Symposium, 38th, Las Vegas, NV, Apr. 26-30, 1992, Proceedings Research Triangle Park, NC Instrument Society of America 1992 p. 657-669. refs
Copyright

A system for determining flow conditions (laminar, transitional, or turbulent) and displaying them to the experimenter is described. The system employs hot film sensors and signal conditioning to achieve this as well as making the data available for archiving. Under certain conditions the laminar area is found to exceed 65 percent of the wing chord.

AIAA

A93-37885

FLIGHT DEFLECTION MEASUREMENT SYSTEM

ROBERT FODALE and HERBERT HAMPTON (Grumman Corp., Calverton, NY) *In* International Instrumentation Symposium, 38th, Las Vegas, NV, Apr. 26-30, 1992, Proceedings Research Triangle Park, NC Instrument Society of America 1992 p. 725-740. refs
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An electrooptical displacement measurement system, the Flight Deflection Measurement System (FDMS), developed to measure in-flight quasi-static aircraft structural deformations providing previously unavailable real-time data for processing and analysis is presented. Excellent in-flight wing/canard displacement data were consistently obtained and collaborated during operation in very harsh environments. Offering real-time analysis while using low data transmission bandwidth makes the FDMS compatible with existing telemetry test bandwidth allocations not offered by video camera techniques that are heavy users of precious test bandwidth. Application of the FDMS to real-time data acquisition of aircraft store separation data is expected to prove very cost-effective in the reduction of flight time, schedule, and data processing.

AIAA

A93-38841

AFTI/F-16 NIGHT CLOSE AIR SUPPORT SYSTEM TESTING

DANA D. PURIFOY and PETER F. DEMITRY (USAF, Edwards AFB, CA) *In* 1992 report to the aerospace profession; SETP Symposium, 36th, Beverly Hills, CA, Sept. 24-26, 1992, Proceedings Lancaster, CA Society of Experimental Test Pilots 1992 p. 111-121.

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A progress report is presented on the continuing development of automated round collision avoidance automated terrain, following, and automated threat avoidance in the AFTI/F-16 program. The technologies examined include a digital terrain

database system, a pilot-activated unusual attitude recovery system, and a dual line-of-sight head-steered FLIR.

AIAA

N93-27169 General Dynamics Corp., Fort Worth, TX.

AVIONICS SYSTEMS ARCHITECTURES

JAMES D. ENGELLAND *In* Israel Society of Aeronautics and Astronautics, 32nd Annual Conference on Aviation and Astronautics p 15-25 20 Feb. 1992

Copyright Avail: Israel Society of Aeronautics and Astronautics, c/o Faculty of Engineering, Tel-Aviv Univ., Ramat Aviv 69978, Israel

This paper looks at some underlying concepts of architecture in digital avionics systems, discusses how and why these have changed, where we are today in avionics systems integration technology, and introduces some of the issues and considerations associated with next generation systems. The paper includes discussion of centralized versus distributed systems, architectural concepts for growth, structuring for graceful element failures, and system wide integrity concepts. It also takes a brief look at the impact of the new U.S. Air Force Avionics Integrity Program requirements and the Joint Integrated Avionics Working Group standards on architecture and functional partitioning.

ISA

N93-28418*# Pennsylvania State Univ., University Park. Dept. of Electrical and Computer Engineering.

A MODEL-BASED APPROACH FOR DETECTION OF OBJECTS IN LOW RESOLUTION PASSIVE MILLIMETER WAVE IMAGES

Interim Report, 24 Jan. 1992 - 23 Jan. 1993

RANGACHAR KASTURI, YUAN-LIANG TANG, and SADASHIVA DEVADIGA 1993 26 p

(Contract NAG1-1371)

(NASA-CR-193161; NAS 1.26:193161) Avail: CASI HC A03/MF

A01

A model-based vision system to assist the pilots in landing maneuvers under restricted visibility conditions is described. The system was designed to analyze image sequences obtained from a Passive Millimeter Wave (PMMW) imaging system mounted on the aircraft to delineate runways/taxiways, buildings, and other objects on or near runways. PMMW sensors have good response in a foggy atmosphere, but their spatial resolution is very low. However, additional data such as airport model and approximate position and orientation of aircraft are available. These data are exploited to guide our model-based system to locate objects in the low resolution image and generate warning signals to alert the pilots. Also analytical expressions were derived from the accuracy of the camera position estimate obtained by detecting the position of known objects in the image.

Author (revised)

N93-28621*# Computer Sciences Corp., Hampton, VA.

ADVANCED TRANSPORT OPERATING SYSTEM (ATOPS)

FLIGHT MANAGEMENT/FLIGHT CONTROLS (FM/FC)

SOFTWARE DESCRIPTION Report, Jan. 1989 - Feb. 1991

DAVID A. WOLVERTON, RICHARD W. DICKSON, WINSTON C. CLINEDINST, and CHRISTOPHER J. SLOMINSKI Apr. 1993 370 p

(Contract NAS1-19038; RTOP 505-64-13)

(NASA-CR-191457; NAS 1.26:191457) Avail: CASI HC A16/MF A03

The flight software developed for the Flight Management/Flight Controls (FM/FC) MicroVAX computer used on the Transport Systems Research Vehicle for Advanced Transport Operating Systems (ATOPS) research is described. The FM/FC software computes navigation position estimates, guidance commands, and those commands issued to the control surfaces to direct the aircraft in flight. Various modes of flight are provided for, ranging from computer assisted manual modes to fully automatic modes including automatic landing. A high-level system overview as well as a description of each software module comprising the system is provided. Digital systems diagrams are included for each major flight control component and selected flight management functions.

Author (revised)

N93-29004# Industrial Coll. of the Armed Forces, Washington, DC.

STANDARDIZATION OF AUTOMATIC TEST EQUIPMENT IN THE US AIR FORCE Research Report, Aug. 1991 - Apr. 1992

ARTHUR J. ROONEY, JR. Apr. 1992 31 p
(AD-A262076; NDU-ICAF-92-S79) Avail: CASI HC A03/MF A01

The USAF has failed to standardize automatic test equipment (ATE) used to support aircraft avionics systems. Although the savings from standardization are difficult to estimate, studies indicate the Air Force could save over \$200M through standardization of ATE. Aside from the monetary savings, other benefits such as reduced training requirements and provisioning fewer items could be realized through standardization. This paper will focus on three areas. First, we will look at standardization from definition through highlighting the importance of standard ATE. Next, a review of the impediments to achieving commonality of ATE within the Air Force. Finally, an actual example of acquiring common ATE for the Special Operations Forces will be examined. The paper concludes with recommendations to achieve greater commonality of ATE within the Air Force. DTIC

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.

A93-35928**IMPROVED STATIC AND DYNAMIC PERFORMANCE OF HELICOPTER POWERPLANT**

GERMAN N. LEONOV (Moscow Helicopter Plant, Russia) *In* AHS, Annual Forum, 48th, Washington, June 3-5, 1992, Proceedings. Vol. 1 Alexandria, VA American Helicopter Society 1992 p. 339-345. refs
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Features inherent in the helicopter as an aircraft, as well as operating conditions of its powerplant, and the influence of the latter on the static and dynamic performance of engines and the helicopter as a whole in accordance with the laws limiting the maximum engine parameters are presented. The takeoff power limitation is optimized in accordance with engine parameters, and recommendations leading to improved helicopter takeoff and hovering safety as well as improved powerplant static and dynamic performance and stabilized engine parameters in flight in turbulent air are developed. Results of spectrum analysis of the thermal effect produced by reingestion of the exhaust gases into the compressor inlet are presented. Data from investigations of the turbine engine takeoff power augmentation by injecting water into the compressor inlet and limiting simultaneously the maximum gas temperature at this power rating are given. AIAA

A93-35929**T55 ENGINE - THE CHALLENGE OF TORQUE MEASUREMENT**

ALAN DUBROW, JAMES MATHEWS, and JOHN HEWITT (Textron Lycoming, Stratford, CT) *In* AHS, Annual Forum, 48th, Washington, June 3-5, 1992, Proceedings. Vol. 1 Alexandria, VA American Helicopter Society 1992 p. 347-353. refs
Copyright

This paper describes the design, development, and testing of an Improved Magnetostrictive Torquemeter (IMT) for the T55 engine family. The goals of the IMT are to improve accuracy, reliability, and maintainability, while preserving low weight and cost. This must be achieved without major redesign of the engine and its short, torsionally stiff output shaft. The approach taken to achieve these goals includes choice of a magnetostrictive material having a more linear transfer curve, and use of ratiometric signal processing, which eliminates errors resulting from variations in common mode voltage. Development of a procedure which enables

field replacement of the torquemeter junction box provides a substantial maintainability improvement over previous T55 magnetostrictive torquemeters. Author

A93-35933**AN ADVANCED METHOD FOR PREDICTING THE PERFORMANCE OF HELICOPTER PROPULSION SYSTEM EJECTORS**

CACHE C. FOLKMAN (McDonnell Douglas Helicopter Co., Mesa, AZ) *In* AHS, Annual Forum, 48th, Washington, June 3-5, 1992, Proceedings. Vol. 1 Alexandria, VA American Helicopter Society 1992 p. 391-398. refs
Copyright

A new analytical technique for predicting ejector throat static pressure while predicting ejector mass flow ratio is presented. Ejector modeling was performed using integral forms of the governing conservation equations for compressible flow. A new correction factor, named the secondary flow correction factor, was devised to balance the pressure forces on the ejector control volume while accounting for real ejector system losses. Excellent agreement was obtained when results of high and low pressure ratio ejector tests were compared to theory using the secondary flow correction factor. Author

A93-35934* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

IDENTIFICATION OF THE OPEN LOOP DYNAMICS OF THE T700 TURBOSHAFT ENGINE

AHMET DUYAR, ZHEN GU (Florida Atlantic Univ., Boca Raton), and JONATHAN S. LITT (U.S. Army, Aviation Systems Command; NASA, Lewis Research Center, Cleveland, OH) *In* AHS, Annual Forum, 48th, Washington, June 3-5, 1992, Proceedings. Vol. 1 Alexandria, VA American Helicopter Society 1992 p. 399-416. refs
(Contract NAG3-1198)
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A simplified model of the T700 turboshaft engine open loop dynamics valid within the normal operating range of the engine is developed. This model is obtained by linking the linearized point models obtained at five different operating conditions of the engine. The simplified model may be used with a model-based real time diagnostic scheme for fault detection and diagnostics, as well as for open loop engine dynamics studies and closed loop control analysis utilizing a user generated control law. Author

A93-36268**A NEW RESONANT LINK AIRCRAFT POWER GENERATING SYSTEM**

THOMAS M. JAHNS (GE Corporate Research and Development Center, Schenectady, NY) and MIGUEL A. MALDONADO (USAF, Aero Propulsion Lab., Wright-Patterson AFB, OH) IEEE Transactions on Aerospace and Electronic Systems (ISSN 0018-9251) vol. 29, no. 1 Jan. 1993 p. 206-214. refs
(Contract F33615-87-C-2806)
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A new 400 Hz aircraft power generating system is introduced which has been designed to achieve significant improvements in power density and reliability compared with conventional systems now in use. Design targets for this exploratory development program include system (generator-plus-converter) power density of 1 kVA/lb and mean-time-between-failure (MTBF) of 5000 h. At the heart of the new variable-speed constant-frequency (VSCF) configuration is a high-frequency resonant link inverter designed so that all inverter switching occurs under zero-voltage conditions. Advantages include minimization of switching losses and significant reductions in power device switching stresses and electromagnetic interference (EMI) generation. Inverter losses are further reduced by using metal-oxide-semiconductor (MOS)-controlled thyristors (MCTs) as the power switches in order to take advantage of the low forward voltage drop of the MCT. A 60 kVA breadboard version of the new generating system has been constructed, and test results are presented which confirm its key performance characteristics. Author

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A93-37389* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

UNSTEADY BLADE PRESSURES ON A PROPFAN AT TAKEOFF - EULER ANALYSIS AND FLIGHT DATA

M. NALLASAMY (Sverdrup Technology, Inc., Brook Park; NASA, Lewis Research Center, Cleveland, OH) *Journal of Aircraft* (ISSN 0021-8669) vol. 30, no. 3 May-June 1993 p. 372-376. AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992, AIAA Paper 92-0376. Previously cited in issue 09, p. 1361, Accession no. A92-26234 refs (Contract NAS3-25266)

A93-37398

METHOD FOR ASSESSING THE ELECTRIC POWER SYSTEM RELIABILITY OF MULTIPLE-ENGINE AIRCRAFT

HSING-JUIN LEE (National Chung-Hsing Univ., Taichung, Taiwan) and HSING-WEI LEE (Chung-Cheng Inst. of Technology, Taoyuan, Taiwan) *Journal of Aircraft* (ISSN 0021-8669) vol. 30, no. 3 May-June 1993 p. 413, 414. refs Copyright

A combinational pivotal decomposition method (CPDM) is proposed for assessing the system reliability of the aircraft electricity generating system. The method makes use of the pivotal decomposition technique to assess system reliability in an efficient and systematic manner by considering all possible combinational top cases as the pivotal events. The combinational reliability of each case then can be easily calculated by using the binominal distribution. Ultimately, the system reliability is determined by using the theorem of total probability. Some typical examples are examined. AIAA

A93-37446*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

AEROELASTIC DYNAMICS OF MISTUNED BLADE ASSEMBLIES WITH CLOSELY SPACED BLADE MODES

CHRISTOPHE PIERRE (Michigan Univ., Ann Arbor) and DURBHA V. MURTHY (NASA, Lewis Research Center, Cleveland; Toledo Univ., OH) Apr. 1993 13 p. AIAA, ASME, ASCE, AHS, and ASC, Structures, Structural Dynamics and Materials Conference, 34th and AIAA and ASME, Adaptive Structures Forum, La Jolla, CA, Apr. 19-22, 1993 refs (Contract NAG3-1163) (AIAA PAPER 93-1628) Copyright

The aeroelastic characteristics of tuned and randomly mistuned blade assemblies which possess two blade-alone natural modes with close frequencies are studied. Modal interactions among the two blade modes are shown to be come extremely significant for small-frequency separation. The two distinct loci of the aeroelastic eigenvalues, which characterize an assembly with well separated modes, fully merge into a single root locus as the blade-mode frequency separation vanishes. Also, while in the case of well separated blade modes the introduction of random mistuning into one blade mode affects only the assembly modes which are predominantly of that blade-mode type, mistuning results in the localization of all the assembly modes when the blade-alone natural frequencies are close. Results indicate that in the case of closely-spaced blade modes a single-degree of freedom blade model yields qualitatively erroneous results and that an N-blade assembly with two close blade modes behaves like an equivalent 2Nb-blade assembly with a single blade mode. Author

A93-38181

A NUMERICAL SIMULATION OF A SCRAM JET COMBUSTOR FLOW

M. SAMEJIMA and C. ARAKAWA (Tokyo Univ., Japan) *In Numerical Fluid Dynamics Symposium, 5th, Tokyo, Japan, Dec. 19-21, 1991, Proceedings Tokyo Numerical Fluid Dynamics Symposium Committee 1991* p. 417, 418. In JAPANESE refs

A numerical analysis was carried out to test a ram combustor flow composed of a constant area combustion duct and a flame holder, using the Baldwin-Lomax turbulent model. The solution algorithm used is an approximate factorization method and resultant

matrices are efficiently solved by LU-ADI method. A third-order accurate upwind differenced TVD scheme is applied to the convective term. Author (revised)

A93-38701

GE90 PROGRAM MOVES INTO HIGH GEAR

STANLEY W. KANDEBO *Aviation Week & Space Technology* (ISSN 0005-2175) vol. 138, no. 16 April 19, 1993 p. 42, 43. Copyright

An account is given of the development status and test/certification program milestones of the GE90 high-bypass turbofan, whose output has in one static test been shown to reach 105,400 lbs. of thrust. A total of seven engines is undergoing component performance tests; a B747 aircraft has been selected as a flight testbed. AIAA

A93-39028

A STUDY OF THE STABILITY OF THE ACCELERATION CIRCUIT OF THE HYDROMECHANICAL AUTOMATIC CONTROL SYSTEM OF AN AVIATION GAS TURBINE ENGINE [ISSLEDOVANIE USTOICHIVOSTI KONTURA PRIEMISTOSTI GIDROMEKHANICHESKOI SAU AVIATSIONNOGO GTD]

A. N. KRIUCHKOV and I. V. SHABUROV *In Dynamic processes in the powerplants and power-generating equipment of flight vehicles Kuibyshev, Russia Kuibyshevskii Aviatsionnyi Institut 1990* p. 3-9. In RUSSIAN refs Copyright

A nonlinear dynamic model is developed which describes the operation of the acceleration circuit of the automatic control system of an aviation gas turbine engine. The model allows for the nonlinearity of the circuit elements and for the presence of air bubbles in the system cavities. The stability of a system based on an analog computer is investigated, and recommendations are given concerning possible methods of enhancing the system stability. AIAA

A93-39033

ABSOLUTE STABILITY OF AN AUTOMATIC CONTROL SYSTEM FOR GAS TURBINE ENGINES [ABSOLIUTNAIA USTOICHIVOST' SISTEMY AVTOMATICHESKOGO REGULIROVANIYA GTD]

N. P. SHUMSKII *In Dynamic processes in the powerplants and power-generating equipment of flight vehicles Kuibyshev, Russia Kuibyshevskii Aviatsionnyi Institut 1990* p. 52-63. In RUSSIAN refs Copyright

The paper is concerned with the absolute stability problem for nonlinear systems up to the fifth order inclusive in a plane of two generalized parameters. A simple method is developed for isolating a class of nonlinear systems in the general sense which are similar to stable linear systems. The analysis is based on stability criteria and diagrams developed by the author. AIAA

A93-39034

THE REQUIRED DAMPING AND CONTROL PROCESS QUALITY IN A FUEL PRESSURE REGULATOR [TREBUEMOE DEMPFIROVANIE I KACHESTVO PROTSESSA REGULIROVANIYA V REGULATORE DAVLENIIA TOPLIVA]

IU. S. ANISIMKIN *In Dynamic processes in the powerplants and power-generating equipment of flight vehicles Kuibyshev, Russia Kuibyshevskii Aviatsionnyi Institut 1990* p. 64-69. In RUSSIAN refs Copyright

An equation of motion for the control system of a fuel pressure regulator is obtained on the basis of a simplified computational model of the regulator. An analysis is made of the effect of operation and design parameters on the required damping of the moving elements of the fuel pressure regulator and the quality of the transition processes of the control system. A condition for the stability and specified quality of the control system is obtained which is consistent with experimental data for specific operating conditions. AIAA

A93-39037

A STUDY OF THE EFFECT OF THE WORKING MEDIUM ON THE START-UP CHARACTERISTIC OF AN AVIATION GAS TURBINE ENGINE [ISSLEDOVANIIE VLIANIIA KOLEBANI RABOCHEI SREDY NA KHARAKTERISTIKU ZAPUSKA AVIATIONNOGO GTD]

A. G. GIMADIEV, A. N. KRUICHKOV, I. V. SHABUROV, and V. P. SHORIN *In* Dynamic processes in the powerplants and power-generating equipment of flight vehicles Kuibyshev, Russia Kuibyshevskii Aviatsionnyi Institut 1990 p. 87-96. In RUSSIAN refs
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A method, an algorithm, and a computer program have been developed for calculating the characteristics of the fuel delivery system of an aviation gas turbine engine with allowance for the fluctuations of the working medium. The developed procedure makes it possible to adjust the parameters of the fuel delivery system so as to ensure the stable startup of the engine. Calculations for the automatic control system of the D18T engine are presented as an example. AIAA

A93-39072

ENHANCING THE PERFORMANCE OF AIRCRAFT ENGINE BLADES BY SURFACE HARDENING [POVYSHENIE RABOTOSPOSOBNOSTI LOPATOK AVIATIONNYKH DVIGATELEI POVERKHNOSTNYM UPROCHNIENIEM]

D. D. PAPSHEV and P. V. RIABIKOV (Politekhnicheskii Inst., Samara, Russia) *In* Quality of the surface layer and operating properties of aircraft engine components Yaroslavl, Russia Rybinskii Aviatsionnyi Tekhnologicheskii Institut 1990 p. 67-75. In RUSSIAN
Copyright

A surface plastic working technique using rotating mechanical brushes is investigated as a method for the repeat local surface hardening of blades during their manufacture and repair. The method makes it possible to harden those areas of critical parts that are not accessible with traditional surface hardening treatments. The use of the method for treating the end surfaces of gas turbine engine blades has resulted in a 18-percent increase of their fatigue strength. AIAA

A93-39073

EFFECT OF ION TREATMENTS ON THE FATIGUE STRENGTH OF BLADES [VLIANIE IONNYKH METODOV OBRABOTKI NA USTALOSTNUIU PROCHNOST' LOPATOK]

L. A. KHVOROSTUKHIN and I. S. DEMIDOVICH (Moskovskii Aviatsionnyi Tekhnologicheskii Inst., Moscow, Russia) *In* Quality of the surface layer and operating properties of aircraft engine components Yaroslavl, Russia Rybinskii Aviatsionnyi Tekhnologicheskii Institut 1990 p. 75-79. In RUSSIAN refs
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With a view to developing an optimal process for increasing the erosion wear resistance of blades, compressor blades of VT-18 alloy were subjected to two different ion treatments. On some of the blades, antierosion coatings, 1, 10, and 20 microns thick, were deposited by the ion bombardment film condensation method; other blades were implanted with Ti(+), N(+), H(+), and B(+) ions. All blades were then tested in fatigue and examined metallographically. It is found that the mean fatigue strength of blades with a 1-micron TiN coating is 7 percent lower than that of uncoated blades, but the fatigue strength of blades with a 10-micron coating is 13 percent higher than that of uncoated blades. With a further increase in coating thickness to 20 microns, the mean fatigue strength of the blades is 8 percent higher than that of uncoated blades. The mean fatigue strength of ion-implanted blades is 16 percent higher than that of untreated blades. AIAA

A93-39075

CHARACTERISTICS OF FRICTION AND WEAR IN FLIGHT VEHICLE ENGINE COMPONENTS [OSOBENNOSTI TRENIIA I IZNASHIVANIIA V UZLAKH DVIGATELEI LETATEL'NYKH APPARATOV]

IU. P. ZAMIATIN, L. A. ZAMIATINA, and A. G. TELEGINA (Rybinskii

Aviatsionnyi Tekhnologicheskii Inst., Rybinsk, Russia) *In* Quality of the surface layer and operating properties of aircraft engine components Yaroslavl, Russia Rybinskii Aviatsionnyi Tekhnologicheskii Institut 1990 p. 84-88. In RUSSIAN refs
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Results of a comprehensive study of the wear characteristics of friction pairs commonly used in state-of-the-art aviation gas turbine engines are briefly examined. In particular, attention is given to friction components made of alloys based on iron, titanium, aluminum, nickel, and cobalt, including rolling and sliding bearings, gears, and valve-seat and piston-cylinder combinations. The wear kinetics of friction pairs of these types is analyzed, and possible ways to minimize friction wear are discussed. AIAA

A93-39175

A PRACTICAL COURSE IN AIRCRAFT MAINTENANCE. I - THE POWERPLANT [PRAKTIKUM PO TEKHNICHESKOI EKSPLUATATSII LETATEL'NYKH APPARATOV. I - SILOVAIA USTANOVKA]

VASILII K. ANDREEV, ALEKSANDR F. LOVIAGIN, VALERII N. MUKHIN, and ARTUR N. AVDEEV-FEDOSEEV Riga Rzhskii Aviatsionnyi Universitet 1992 99 p. In RUSSIAN refs
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The principal causes of the damage and failure of gas turbine engines are examined, and methods of failure prevention are discussed. In particular, attention is given to engine damage by foreign objects, contamination of the flow path and cavities of gas turbine engines, and formation of deposits in engine passages and cavities. Among other factors leading to engine failures, consideration is given to the contamination and freezing of fuel filters and contamination of fuel tanks with water. Methods and procedures for restoring the proper engine performance are described. AIAA

A93-39180

SELECTION OF THE SCHEME AND OPTIMAL PARAMETERS OF THE TURBINE OF A HIGH-TEMPERATURE BYPASS ENGINE WITH A LOW BYPASS RATIO [VYBOR SKHEMY I OPTIMAL'NYKH PARAMETROV TURBINY VYSOKOTEMPERATURNOGO TRDD S MALOI STEPEN'IU DVUKHKONTURNOSTI]

S. D. GRITSAI, O. N. EMIN, V. I. KUZNETSOV, and S. L. MKHITARIAN Aviatsionnaia Tekhnika (ISSN 0579-2975) no. 4 1992 p. 22-24. In RUSSIAN refs
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An analysis is made of the operating conditions of the turbine stages of a stoichiometric two-shaft bypass engine with a low bypass ratio with attached low-pressure compressor (fan) stages. The optimization of the principal parameters of the turbine stages is carried out using a specially developed computer program. To further enhance the aerodynamic characteristics of the turbine cascades and cooling systems of such a bypass engine layout, the use of a birotary two-stage turbine without an intermediate nozzle vane cascade is recommended. AIAA

A93-39187

EXPERT EVALUATION OF THE TECHNOLOGICAL LEVEL OF AVIATION GAS TURBINE ENGINE DESIGNS [EKSPERTNAIA OTSENKA NAUCHNO-TEKHNICHESKOGO UROVNIA PROEKTA AVIATIONNOGO GTD]

V. S. KUZ'MICHEV, V. G. MASLOV, M. A. MOROZOV, and O. V. NOVIKOV Aviatsionnaia Tekhnika (ISSN 0579-2975) no. 4 1992 p. 50-55. In RUSSIAN refs
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A method is described for the integral and quantitative evaluation of the technological level of aviation gas turbine engines within a CAD system. The efficiency criteria for a gas turbine engine are selected for a specific flight vehicle application on the basis of a classification table of efficiency criteria. The relative importance of the factors determining the technological level of engine design is evaluated with allowance for their effect on the engine efficiency criteria. AIAA

A93-39193

FUEL FILM FORMATION IN THE FUEL-AIR PREMIXER OF THE COMBUSTION CHAMBER [O FORMIROVANII TOPLIVNOI PLENKI V USTROISTVE PREDVARITEL'NOI PODGOTOVKI TOPLIVOVOZDUSHNOI SMESI KAMERY SGORANIIA]

V. N. AFROSIMOVA, S. I. SHELUKHO, R. Z. GARIPOV, and A. S. DOBROVOL'SKII Aviatsonnaia Tekhnika (ISSN 0579-2975) no. 4 1992 p. 73-75. In RUSSIAN refs

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Devices for the formation of thin liquid films (Re equal to or less than 500) are investigated. Film flow regions where no liquid leakage occurs and no dry spots are formed are determined for the case of an ascending swirling air flow. Tubular and annular ducts are considered as a film-forming apparatus. The results of the study make it possible to determine the limits of the reliable operation of the film apparatus during the design of premixers for combustion chambers. AIAA

A93-39195

AN EXPERIMENTAL STUDY OF THRUST REVERSER MODELS [EKSPERIMENTAL'NOE ISSLEDOVANIE MODELEI REVERSIVNYKH USTROISTV]

V. M. ANDRIENKO, V. A. GOLUBEV, A. V. KOTOVICH, and N. A. RIABOV Aviatsonnaia Tekhnika (ISSN 0579-2975) no. 4 1992 p. 79-82. In RUSSIAN refs

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Results of experimental studies of the flow rate and full pressure loss characteristics are presented for models of axisymmetric exhausts of aerjet engines with a cascade thrust reverser. Calculations are also made of the gasdynamic forces acting on the throttle element of the thrust reverser. AIAA

A93-39200

SOME RECOMMENDATIONS CONCERNING THE PREVENTION OF FUEL BOILING IN THE IGNITERS OF THE COMBUSTION CHAMBERS OF GAS TURBINE ENGINES [NEKOTORYE REKOMENDATSII PO PREDOTVRASHCHENIIU KIPENIIA TOPLIVA V VOSPLAMENITELIAXH KAMERY SGORANIIA GAZOTURBINNYKH DVIGATELEI]

V. A. KUDINOV, A. A. KUDINOV, A. D. ROSLIAKOV, and V. V. GNEDENKO Aviatsonnaia Tekhnika (ISSN 0579-2975) no. 4 1992 p. 96-100. In RUSSIAN refs

Copyright

An analytical solution to the heat transfer problem for the multilayer wall of the igniter of the combustion chamber of a gas turbine engine is obtained for the case of harmonic oscillations of the medium temperature. It is shown that the phases of the temperature oscillations of the medium and of the wall do not coincide, which can give rise, under certain conditions, to resonance phenomena contributing to fuel boiling. The boiling time can be reduced through the use of coatings of heat-insulation materials on the internal and external surfaces of the igniter walls and also by controlling the fuel flow in order to prevent the occurrence of resonance phenomena. AIAA

A93-39201

THE POSSIBILITY OF REDUCING THE EMISSION OF BENZO(A)PYRENE WITH THE EXHAUST GASES OF AVIATION GAS TURBINE ENGINES BY WATER INJECTION INTO THE COMBUSTION CHAMBER [O VOZMOZHNOСТИ SNIZHENIIA VYBROSA BENZ/A/PIRENA S OTRABOTANNYMI GAZAMI AVIATSIONNYKH GTD VPRYSKOM VODY V KAMERU SGORANIIA]

S. V. LUKACHEV, S. G. MATVEEV, and E. IU. MARCHUKOV Aviatsonnaia Tekhnika (ISSN 0579-2975) no. 4 1992 p. 100-102. In RUSSIAN refs

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The possibility of achieving a significant reduction (60-70 percent) of benzo(a)pyrene emission with the exhaust gases of aviation gas turbine engine by injecting water into the primary combustion chamber is demonstrated experimentally. Results of measurements of benzo(a)pyrene, NO(x), CO, and CH(Sigma)

emissions are presented for a combustion chamber model based on a cylindrical burner can of a commercial bypass engine. AIAA

A93-39202

FLIGHT EFFICIENCY THEORY [TEORIIA POLETNOGO KPD]

V. D. ZAKHAROV Aviatsonnaia Tekhnika (ISSN 0579-2975) no. 4 1992 p. 102-107. In RUSSIAN refs

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The principal concepts of a flight efficiency theory for a flight vehicle with a jet engine are presented from the standpoint of the principle of thrust generation (in coordinates tied to the medium in which the flight takes place). The inadequacy of the existing concepts of flight efficiency is demonstrated. AIAA

A93-39271

HIERARCHICAL DEVELOPMENT OF THREE DIRECT-DESIGN METHODS FOR TWO-DIMENSIONAL AXIAL-TURBOMACHINERY CASCADES

T. KORAKIANITIS (Washington Univ., Saint Louis, MO) ASME, Transactions, Journal of Turbomachinery (ISSN 0889-504X) vol. 115, no. 2 April 1993 p. 314-324. ASME, International Power Generation Conference, San Diego, CA, Oct. 6-10, 1991 refs

Copyright

The hierarchical development of three direct blade-design methods of increasing utility for generating 2D blade shapes is presented. The methods can be used to generate inputs to the direct- or inverse-blade design sequences for subsonic or supersonic airfoils for compressors and turbines, or isolated airfoils. In all methods the geometry near the leading edge is specified by a thickness distribution added to a construction line, which eliminates the leading edge overspeed and laminar-separation regions. The blade-design methods under consideration can be used to improve the aerodynamic and heat transfer performance of turbomachinery cascades, and they can result in high-performance airfoils in very few iterations. AIAA

N93-27026*# National Aeronautics and Space Administration, Lewis Research Center, Cleveland, OH.

EXPERIMENTAL INVESTIGATION OF CROSSFLOW JET MIXING IN A RECTANGULAR DUCT

D. S. LISCINSKY (United Technologies Research Center, East Hartford, CT.), B. TRUE (United Technologies Research Center, East Hartford, CT.), and J. D. HOLDEMAN Jun. 1993 10 p Proposed for presentation at the 29th Joint Propulsion Conference and Exhibit, Monterey, CA, 28-30 Jun. 1993; sponsored by AIAA, SAE, ASME, and ASEE Original contains color illustrations (Contract RTOP 537-02-21)

(NASA-TM-106152; E-7834; NAS 1.15:106152; AIAA PAPER 93-2037) Avail: CASI HC A02/MF A01; 2 functional color pages

An experimental investigation of the mixing of nonreacting opposed rows of jets injected normal to a confined rectangular crossflow has been conducted. Planar Mie-scattering was used to measure the time-average concentration distribution of the jet fluid in planes perpendicular to the duct axis. The mixing effectiveness of round orifice injectors was measured as a function of orifice spacing and orifice diameter. Mixing effectiveness was determined using a spatial unmixedness parameter based on the variance of mean jet concentration distributions. Optimum mixing was obtained when the spacing-to-duct height ratio was inversely proportional to the square root of the jet-to-mainstream momentum-flux ratio. For opposed rows of round holes with centerlines inline, mixing was similar for blockages up to 75 percent. Lower levels of unmixedness were obtained as a function of downstream location when axial injection length was minimized. Mixing may be enhanced if orifice centerlines of opposed rows are staggered, but note that blockage must be less than 50 percent for this configuration. Author

N93-27115*# United Technologies Research Center, East Hartford, CT.

EXPERIMENTAL INVESTIGATION OF TURBINE DISK CAVITY AERODYNAMICS AND HEAT TRANSFER Final Report

W. A. DANIELS and B. V. JOHNSON May 1993 103 p
(Contract NAS8-37462)
(NASA-CR-193131; NAS 1.26:193131; UTRC-93-957878-27)
Avail: CASI HC A06/MF A02

An experimental investigation of turbine disk cavity aerodynamics and heat transfer was conducted to provide an experimental data base that can guide the aerodynamic and thermal design of turbine disks and blade attachments for flow conditions and geometries simulating those of the space shuttle main engine (SSME) turbopump drive turbines. Experiments were conducted to define the nature of the aerodynamics and heat transfer of the flow within the disk cavities and blade attachments of a large scale model simulating the SSME turbopump drive turbines. These experiments include flow between the main gas path and the disk cavities, flow within the disk cavities, and leakage flows through the blade attachments and labyrinth seals. Air was used to simulate the combustion products in the gas path. Air and carbon dioxide were used to simulate the coolants injected at three locations in the disk cavities. Trace amounts of carbon dioxide were used to determine the source of the gas at selected locations on the rotors, the cavity walls, and the interstage seal. The measurements on the rotor and stationary walls in the forward and aft cavities showed that the coolant effectiveness was 90 percent or greater when the coolant flow rate was greater than the local free disk entrainment flow rate and when room temperature air was used as both coolant and gas path fluid. When a coolant-to-gas-path density ratio of 1.51 was used in the aft cavity, the coolant effectiveness on the rotor was also 90 percent or greater at the aforementioned condition. However, the coolant concentration on the stationary wall was 60 to 80 percent at the aforementioned condition indicating a more rapid mixing of the coolant and flow through the rotor shank passages. This increased mixing rate was attributed to the destabilizing effects of the adverse density gradients. Author

N93-27128*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

CFD MIXING ANALYSIS OF AXIALLY OPPOSED ROWS OF JETS INJECTED INTO CONFINED CROSSFLOW

D. B. BAIN (CFD Research Corp., Huntsville, AL.), C. E. SMITH (CFD Research Corp., Huntsville, AL.), and J. D. HOLDEMAN May 1993 29 p Prepared for presentation at the 28th Joint Propulsion Conference and Exhibit, Monterey, CA, 28-30 Jun. 1993; sponsored by AIAA, SAE, ASME, and ASEE Original contains color illustrations
(Contract RTOP 537-02-21)
(NASA-TM-106179; E-7884; NAS 1.15:106179; AIAA PAPER 93-2044) Avail: CASI HC A03/MF A01; 12 functional color pages

A computational fluid dynamics (CFD) parametric study was performed to analyze axially opposed rows of jets mixing with crossflow in a rectangular duct. Isothermal analysis was conducted to determine the influence of lateral geometric arrangement on mixing. Two lateral arrangements were analyzed: (1) inline (jets' centerlines aligned with each other on top and bottom walls), and (2) staggered (jets' centerlines offset with each other on top and bottom walls). For a jet-to-mainstream mass flow ratio (MR) of 2.0, design parameters were systematically varied for jet-to-mainstream momentum-flux ratios (J) between 16 and 64 and orifice spacing-to-duct height ratios (S/H) between 0.125 and 1.5. Comparisons were made between geometries optimized for S/H at a specified J. Inline configurations had a unique spacing for best mixing at a specified J. In contrast, staggered configurations had two 'good mixing' spacings for each J, one corresponding to optimum inline spacing and the other corresponding to optimum non-impinging jet spacing. The inline configurations, due to their smaller orifice size at optimum S/H, produced better initial mixing characteristics. At downstream locations (e.g. x/H of 1.5), the optimum non-impinging staggered configuration produced better mixing than the optimum inline configuration for J of 64; the opposite results were observed for J of 16. Increasing J resulted in better mixing characteristics if each configuration was optimized

with respect to orifice spacing. Mixing performance was shown to be similar to results from previous dilution jet mixing investigations (MR less than 0.5). Author (revised)

N93-27130*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

VELOCITY AND DROP SIZE MEASUREMENTS IN A SWIRL-STABILIZED, COMBUSTING SPRAY

DANIEL L. BULZAN Jan. 1993 12 p Presented at the Laser Applications in Combustion and Combustion Diagnostics Meeting, Los Angeles, CA, 16-23 Jan. 1993; sponsored by Society of Photo-Optical Instrumentation Engineers
(Contract RTOP 505-62-52)
(NASA-TM-106130; E-7799; NAS 1.15:106130) Avail: CASI HC A03/MF A01

Velocity and drop size measurements are reported for a swirl-stabilized, combustive spray. For the gas phase, three components of mean and fluctuating velocity are reported. For the droplets, three components of mean and fluctuating velocity, diameter, and number flux are reported. The liquid fuel utilized for all the tests was heptane. The fuel was injected using an air-assist atomizer. The combustor configuration consisted of a center-mounted, air-assist atomizer surrounded by a coflowing air stream. Both the coflow and the atomizing air streams were passed through 45 degree swirlers. The swirl was imparted to both streams in the same direction. The combustion occurred unconfined in stagnant surroundings. The noninvasive measurements were obtained using a two-component phase/Doppler particle analyzer. The laser-based instrument measured two components of velocity as well as droplet size at a particular point. Gas phase measurements were obtained by seeding the air streams with nominal 1 micron size aluminum-oxide particles and using the measured velocity from that size to represent the gas phase velocity. The atomizing air, coflow air, and ambient surroundings were all seeded with the aluminum-oxide particles to prevent biasing. Measurements are reported at an axial distance of 5 mm from the nozzle. Isothermal single-phase gas velocities are also reported for comparison with the combustive case. Author

N93-27131*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

PERFORMANCE CHARACTERISTICS OF A VARIABLE-AREA VANE NOZZLE FOR VECTORING AN ASTOVL EXHAUST JET UP TO 45 DEG

JACK G. MCARDLE and BARBARA S. ESKER Jun. 1993 34 p Presented at the 29th AIAA Joint Propulsion Conference, Monterey, CA, 28-30 Jun. 1993; sponsored by AIAA, SAE, ASME, and ASEE
(Contract RTOP 505-68-32)
(NASA-TM-106114; E-7768; NAS 1.15:106114; AIAA PAPER 93-2437) Avail: CASI HC A03/MF A01

Many conceptual designs for advanced short-takeoff, vertical landing (ASTOVL) aircraft need exhaust nozzles that can vector the jet to provide forces and moments for controlling the aircraft's movement or attitude in flight near the ground. A type of nozzle that can both vector the jet and vary the jet flow area is called a vane nozzle. Basically, the nozzle consists of parallel, spaced-apart flow passages formed by pairs of vanes (vanesets) that can be rotated on axes perpendicular to the flow. Two important features of this type of nozzle are the abilities to vector the jet rearward up to 45 degrees and to produce less harsh pressure and velocity footprints during vertical landing than does an equivalent single jet. A one-third-scale model of a generic vane nozzle was tested with unheated air at the NASA Lewis Research Center's Powered Lift Facility. The model had three parallel flow passages. Each passage was formed by a vaneset consisting of a long and a short vane. The longer vanes controlled the jet vector angle, and the shorter controlled the flow area. Nozzle performance for three nominal flow areas (basic and plus or minus 21 percent of basic area), each at nominal jet vector angles from -20 deg (forward of vertical) to +45 deg (rearward of vertical) are presented. The tests were made with the nozzle mounted on a model tailpipe with a blind flange on the end to simulate a closed cruise nozzle,

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at tailpipe-to-ambient pressure ratios from 1.8 to 4.0. Also included are jet wake data, single-vaneset vector performance for long/short and equal-length vane designs, and pumping capability. The pumping capability arises from the subambient pressure developed in the cavities between the vanesets, which could be used to aspirate flow from a source such as the engine compartment. Some of the performance characteristics are compared with characteristics of a single-jet nozzle previously reported.

Author (revised)

N93-27160* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

AN ANALYTICAL STUDY OF DILUTION JET MIXING IN A CYLINDRICAL DUCT

V. L. OECHSLE (General Motors Corp., Indianapolis, IN.), H. C. MONGIA (General Motors Corp., Indianapolis, IN.), and J. D. HOLDEMAN May 1993 41 p Proposed for presentation at the 29th Joint Propulsion Conference and Exhibit, Monterey, CA, 28-30 Jun. 1993; sponsored by AIAA, SAE, ASME, and ASEE

LIMITED REPRODUCIBILITY: More than 20% of this document may be affected by color photographs Original contains color illustrations
(Contract RTOP 537-02-21)
(NASA-TM-106181; E-7887; NAS 1.15:106181; AIAA PAPER 93-2043) Copyright Avail: CASI HC A03/MF A01; 17 functional color pages

The mixing performance in a mixing section of a rich burn/quick mix/lean burn (RQL) combustor was calculated using a 3-D numerical model in a non-reacting environment. The numerically calculated results were compared with the measured data reported by Hatch, Sowa, Samuelsen, and Holdeman, 1992. The numerical 3-D temperature fields qualitatively agree with the experimental data. Also, the development of the mixing flow and temperature non-uniformity trends throughout the mixing section for the numerically calculated results quantitatively agree with the measured data. The numerical model predicts less mixing and enhances the temperature gradients as compared to the measured data for the cases reported by Hatch et al. (1992) which include circular and slot orifice shapes (with different slant angles and aspect ratios). The predicted and measured results generally agree in the selection of the slanted slot orifice configuration yielding the best overall mixing performance (based on temperature uniformity) of all the configurations analyzed. Author (revised)

N93-27185 Technion - Israel Inst. of Tech., Haifa. Faculty of Aerospace Engineering.

REGRESSION RATE MECHANISM IN A SOLID FUEL RAMJET

ILAN HADAR and ALON GANY In Israel Society of Aeronautics and Astronautics, 32nd Annual Conference on Aviation and Astronautics p 154-162 20 Feb. 1992

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A model relating the combustion characteristics, particularly the regression rate, to the fuel properties in a solid fuel ramjet (SFRJ) is presented. The analysis is based on inspecting the various phenomena (e.g., chemical kinetics and heat transfer) involved in the fuel decomposition process, in order to determine the rate controlling steps, and modeling the important mechanisms. Model results were compared with experimental findings for four polymeric fuels, showing excellent qualitative agreement in classifying different fuels, as well as good quantitative predictions of the fuel regression rates. The model can serve as a useful tool for the selection of appropriate fuels, as well as for a preliminary design of the engine and mission profile prior to static firings of the final SFRJ prototype. ISA

N93-27186 Technion - Israel Inst. of Tech., Haifa. Faculty of Aerospace Engineering.

DEVELOPMENT OF A PULSE RAMJET BASED ON TWIN VALVELESS PULSE COMBUSTORS COUPLED TO OPERATE IN ANTI-PHASE

N. LIBIS and Y. GOLDMAN In Israel Society of Aeronautics and

Astronautics, 32nd Annual Conference on Aviation and Astronautics p 163-170 20 Feb. 1992

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The description of a new pulse ramjet engine of unusual configuration, the first experimental results of its operation, and the analytical approach guiding its development are presented. The developed system is based on a coupling of two valveless pulse engines at their common inlet, by a symmetrical pulse ejector. During preliminary laboratory trials, the engine was shown to produce a stagnation pressure rise of about 0.5 atm and a negative induction pressure of about 0.2 atm. The tests also confirm the expected antiphase mode of operation of the two combustion chambers. Kerosene fuel was supplied at rates up to 40 liter per hour per combustion chamber. The method of characteristics is applied for analysis of the nonsteady flow in the inlet and exhaust pipes. Boundary conditions at the duct ends, including the changes in the combustion chamber pressure and temperature are defined. A simple heat release scheme is used to simulate the combustion process. The analytical model is still in the process of development, and only the governing equations and a description of the numerical procedure on which it is based are presented. ISA

N93-27187 Technion - Israel Inst. of Tech., Haifa. Faculty of Aerospace Engineering.

ANALYSIS OF THRUST MODULATION OF RAM-ROCKETS BY A VORTEX VALVE

CLAUDIO GOLDMAN and ALON GANY In Israel Society of Aeronautics and Astronautics, 32nd Annual Conference on Aviation and Astronautics p 171-177 20 Feb. 1992

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Thrust modulation of a ram-rocket by means of a fluidic vortex valve was analyzed. The controllable parameter was the tangential injection of a secondary flow imposing swirl in the main gas generator flow. An analytical model was developed to predict the swirl effects on the gas generator flow rate and on the engine thrust. The main parameters studied were the propellant burning rate pressure exponent, the nozzle radius ratio, and the vortex type. Model predictions indicated the effectiveness of the vortex valve control method, which allows a 40 to 80 percent thrust increase by the addition of only 10 percent of secondary flow to the main flow. ISA

N93-27189 Israel Society of Aeronautics and Astronautics, Tel Aviv.

BY-PASSING OF HEAT EXCHANGERS IN GAS TURBINES

DAVID LIOR In Israel Society of Aeronautics and Astronautics, 32nd Annual Conference on Aviation and Astronautics p 185-196 20 Feb. 1992

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A methodology is presented to optimize the design of a heat-exchanger in a gas turbine. The effect of by-passing a portion of the hot and cold flows around the heat exchanger is explored, considering variation of pressure drops, heat-exchanger efficiencies, and consequently the influence of the by-pass on gas turbine efficiency and power. As a result, it is shown that the by-pass method results in a substantial gain in heat-exchanger size with only minor sacrifice in performance. A variable by-pass ratio to match the load profile of the gas turbine is shown as the best system optimization. A methodology is presented to derive the optimum relation between load and by-pass ratio. ISA

N93-27610* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

COMPARISON OF REACTING AND NON-REACTING SHEAR LAYERS AT A HIGH SUBSONIC MACH NUMBER

C. T. CHANG, C. J. MAREK, C. WEY (Sverdrup Technology, Inc., Brook Park, OH.), R. A. JONES (Rensselaer Polytechnic Inst.,

Troy, NY.), and M. J. SMITH (Purdue Univ., West Lafayette, IN.) Jun. 1993 13 p Presented at the 29th Joint Propulsion Conference and Exhibit, Monterey, CA, 28-30 Jun. 1993; cosponsored by AIAA, SAE, ASME, and ASEE (Contract RTOP 505-62-52) (NASA-TM-106198; E-7905; NAS 1.15:106198; AIAA PAPER 93-2381) Avail: CASI HC A03/MF A01

The flow field in a hydrogen-fueled planar reacting shear layer was measured with an LDV system and is compared with a similar air to air case without combustion. Measurements were made with a speed ratio of 0.34 with the highspeed stream at Mach 0.71. They show that the shear layer with reaction grows faster than one without, and both cases are within the range of data scatter presented by the established database. The coupling between the streamwise and the cross-stream turbulence components inside the shear layer is slow, and reaction only increased it slightly. However, a more organized pattern of the Reynolds stress is present in the reacting shear layer, possibly as a result of larger scale structure formation in the layer associated with heat release. Author

N93-27640* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

NDE OF PWA 1480 SINGLE CRYSTAL TURBINE BLADE MATERIAL

STANLEY J. KLIMA, THOMAS W. ORANGE, and ROBERT L. DRESHFIELD Apr. 1993 11 p Presented at the SAE Aerospace Atlantic Conference, Dayton, OH, 20-23 Apr. 1993 (Contract RTOP 323-51-60) (NASA-TM-106140; E-7351; NAS 1.15:106140) Avail: CASI HC A03/MF A01

Cantilever bending fatigue specimens were examined by fluorescent liquid penetrant and radioactive gas penetrant (Krypton) non-destructive evaluation (NDE) methods and tested. Specimens with cast, ground, or polished surface were evaluated to study the effect of surface condition on NDE and fatigue crack initiation. Fractographic and metallurgical analyses were performed to determine the nature of crack precursors. Preliminary results show that fatigue strength was lower for specimens with cast surfaces than for specimens with machined surfaces. The liquid penetrant and gas penetrant techniques both provided indications of a large population of defects on the cast surfaces. On ground or polished specimen surfaces, the gas penetrant appeared to estimate the actual number of voids more accurately than the liquid penetrant. Author (revised)

N93-27679* Wright Lab., Wright-Patterson AFB, OH.
AN ASSESSMENT OF INLET TOTAL-PRESSURE DISTORTION REQUIREMENTS FOR THE COMPRESSOR RESEARCH FACILITY (CRF) Final Report, 1 Aug. 1991 - 31 Aug. 1992
GREGORY S. BLOCH Aug. 1992 39 p
(Contract AF PROJ. 3066)

(AD-A262299; WL-TR-92-2066) Avail: CASI HC A03/MF A01

A study was conducted to determine the potential requirements for inlet total-pressure distortion in the Wright Laboratory Compressor Research Facility (CRF). The study included types and levels of distortion of interest, generation methods, instrumentation, and test techniques. Cost comparisons of various options were generated. Based on this study, it was determined that time-variant distortion testing is beyond the scope of the CRF mission and that screens should continue to be used to generate steady-state distortion. DTIC

N93-27680* United Technologies Research Center, East Hartford, CT.

EXPERIMENTAL STUDY OF CROSS FLOW MIXING IN CYLINDRICAL AND RECTANGULAR DUCTS Final Report

D. S. LISINSKY, A. VRANOS (AB Research Associates, South Windsor, CT.), and R. P. LOHMANN (Pratt and Whitney Aircraft, East Hartford, CT.) Apr. 1993 39 p Original contains color illustrations
(Contract NAS3-25952; RTOP 537-02-20)

(NASA-CR-187141; E-7708; NAS 1.26:187141) Avail: CASI HC A03/MF A01; 8 functional color pages

An experimental investigation of non-reacting cross flow jet injection and mixing in cylindrical and rectangular ducts has been conducted with application to a low emissions combustor. Quantitative measurement of injectant concentration distributions perpendicular to the duct axis were obtained by planar digital imaging of the Mie-scattered light from an aerosol seed mixed with the injectant. The flowfield unmixedness was evaluated using (1) a mixing parameter derived from the ratio of the jet concentration fluctuations to the fully mixed concentration, and (2) probability density functions of the concentration distributions. Mixing rate was measured for 45 degree slant slot and round orifice injectors. Author (revised)

N93-28184# Naval Postgraduate School, Monterey, CA.
ESTIMATING CHARACTERISTIC LIFE AND RELIABILITY OF AN AIRCRAFT ENGINE COMPONENT IMPROVEMENT IN THE EARLY STAGES OF THE IMPLEMENTATION PROCESS M.S. Thesis

SCOTT L. MARTENS Dec. 1992 84 p
(AD-A262118) Avail: CASI HC A05/MF A01

This thesis describes the database needed to assess improvement in the performance of a modification to the long electroless nickel (LEN) fuel tube of the TF-34-400 engine during the time the modified component is being introduced into the fleet. It also provides the methods and equations for estimating the reliability of a modified component during its implementation. The component failure times are assumed to have a Weibull distribution. When implemented, this methodology will provide engine program management teams more timely information which should enhance their decision-making process significantly. DTIC

N93-28391# McDonnell-Douglas Electronics Co., Saint Louis, MO.

ANALYTICAL AND EXPERIMENTAL INVESTIGATION OF ANNULAR PROPULSIVE NOZZLES Final Report, 9 Jan. 1984 - 9 Jan. 1986

RALPH R. CONLEY, JOE D. HOFFMAN, and H. D. THOMPSON Mar. 1993 37 p
(Contract F33615-81-C-2078)
(AD-A262685; WL-TR-93-2048) Avail: CASI HC A03/MF A01

The final report consists of AIAA papers. The report presents an analytical performance prediction methodology for annular propulsion nozzles with and without swirl introduced in the combustor upstream of the nozzle. Four types of swirlers were investigated: free vortex, constant angle, forced vortex and Rankine vortex swirlers. For the no-swirl case thrust efficiencies and static pressure profiles from cold flow testing of selected nozzles are summarized and compared to the predictions. DTIC

N93-28609* Ohio Aerospace Inst., Brook Park.
NAVIER-STOKES ANALYSIS OF RADIAL TURBINE ROTOR PERFORMANCE

L. M. LAROSILIERE Jun. 1993 20 p Presented at the 29th Joint Propulsion Conference and Exhibit, Monterey, CA, 28-30 Jun. 1993; sponsored by AIAA, SAE, ASME, and ASEE (Contract NCC3-208; RTOP 505-62-10) (NASA-CR-191153; E-7937; NAS 1.26:191153; AIAA PAPER 93-2555) Avail: CASI HC A03/MF A01

An analysis of flow through a radial turbine rotor using the three-dimensional, thin-layer Navier-Stokes code RVC3D is described. The rotor is a solid version of an air-cooled metallic radial turbine having thick trailing edges, shroud clearance, and scalloped-backface clearance. Results are presented at the nominal operating condition using both a zero-clearance model and a model simulating the effects of the shroud and scalloped-backface clearance flows. A comparison with the available test data is made and details of the internal flow physics are discussed, allowing a better understanding of the complex flow distribution within the rotor. Author

07 AIRCRAFT PROPULSION AND POWER

N93-28617*# Ohio Aerospace Inst., Brook Park. ANALYSIS OF UNSTEADY WAVE PROCESSES IN A ROTATING CHANNEL

L. M. LAROSILIERE and M. MAWID (Illinois Univ., Chicago.) Jun. 1993 22 p Presented at the 29th Joint Propulsion Conference and Exhibit, Monterey, CA, 28-30 Jun. 1993; sponsored by AIAA, SAE, ASME, and ASEE
(Contract NCC3-208; RTOP 505-62-10)
(NASA-CR-191154; E-7939; NAS 1.26:191154; AIAA PAPER 93-2527) Avail: CASI HC A03/MF A01

The impact of passage rotation on the gas dynamic wave processes is analyzed through a numerical simulation of ideal shock-tube flow in a closed rotating-channel. Initial conditions are prescribed by assuming homentropic solid-body rotation. Relevant parameters of the problem such as wheel Mach number, hub-to-tip radius ratio, length-to-tip radius ratio, diaphragm temperature ratio, and diaphragm pressure ratio are varied. The results suggest possible criteria for assessing the consequences of passage rotation on the wave processes, and they may therefore be applicable to pressure-exchange wave rotors. It is shown that for a fixed geometry and initial conditions, the contact interface acquires a distorted three-dimensional time-dependent orientation at non-zero wheel Mach numbers. At a fixed wheel Mach number, the level of distortion depends primarily on the density ratio across the interface as well as the hub-to-tip radius ratio. Rarefaction fronts, shocks, and contact interfaces are observed to propagate faster with increasing wheel Mach number. Author

**N93-28697*# National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, OH.**

EXPERIMENTAL EVALUATION OF A COOLED RADIAL-INFLOW TURBINE

LIZET TIRRES (Sverdrup Technology, Inc., Brook Park, OH.), L. DANIELLE DICICCO, and BRENT C. NOWLIN Jun. 1993 18 p Presented at the 29th AIAA Joint Propulsion Conference and Exhibit, Monterey, CA, 28-30 Jun. 1993; cosponsored by SAE, ASME, and ASEE
(Contract RTOP 535-05-10)
(NASA-TM-106230; E-7948; NAS 1.15:106230; AIAA PAPER 93-1795) Avail: CASI HC A03/MF A01

Two 14.4 inch tip diameter rotors were installed and tested in the Small Engines Component Turbine Facility (SECTF) at NASA Lewis Research Center. The rotors, a solid and a cooled version of a radial-inflow turbine, were tested with a 15 vane stat or over a set of rotational speeds ranging from 80 to 120 percent design speed (17,500 to 21,500 rpm). The total-to-total stage pressure ratios ranged from 2.5 to 5.5. The data obtained at the equivalent conditions using the solid version of the rotor are presented with the cooled rotor data. A Reynolds number of 381,000 was maintained for both rotors, whose stages had a design mass flow of 4.0 lbm/sec, a design work level of 59.61 Btu/lbm, and a design efficiency of 87 percent. The results include mass flow data, turbine torque, turbine exit flow angles, stage efficiency, and rotor inlet and exit surveys. Author

**N93-28984# Naval Postgraduate School, Monterey, CA.
AN ANALYSIS OF THE CORRELATION BETWEEN THE J52
ENGINE COMPONENT IMPROVEMENT PROGRAM AND
IMPROVED MAINTENANCE PARAMETERS M.S. Thesis
LEONARD B. GORDON Dec. 1992 81 p
(AD-A262062) Avail: CASI HC A05/MF A01**

This thesis is a study of the J52 Engine Component Improvement Program (CIP). The objective of the thesis was to determine if the correlation between J52 CIP expenditures and improved maintenance parameters at the component level could be quantified. The major focus of the study revolved around developing a methodology to accomplish the objective using existing databases and open dialogue between the J52 engine manufacturer (Pratt and Whitney), NAVAIRSYSCOM Engine Program Manager, and various NADEP engineers. The methodology evolved using the Fuel Nozzle Support Assembly and was validated using the Fuel Pump. The thesis reached the

conclusion that observed improvements in maintenance parameters can be linked to CIP expenditures at the component level. DTIC

08

AIRCRAFT STABILITY AND CONTROL

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

A93-35955

MI-26 AUTOROTATIONAL LANDINGS

GURGEN R. KARAPETIAN (Moscow Helicopter Plant, Russia) *In* AHS, Annual Forum, 48th, Washington, June 3-5, 1992, Proceedings. Vol. 1 Alexandria, VA American Helicopter Society 1992 p. 671-688.
Copyright

Autorotational power-off landing is one of the most complicated emergencies. Entry into autorotation, steady-state autorotation, and landing execution features depend on a number of helicopter design, weight characteristics, such as solidity ratio, blade Lock number, main rotor inertia, disc loading, etc. Data obtained from the Mi-26 simulation and flight tests with autorotational power-off landings are discussed below. Author

A93-35959

EFFECTS OF HIGHER ORDER DYNAMICS ON HELICOPTER FLIGHT CONTROL LAW DESIGN

STEVEN J. INGLE (Boeing Defense & Space Group, Helicopters Div., Philadelphia, PA) and ROBERTO CELI (Maryland Univ., College Park) *In* AHS, Annual Forum, 48th, Washington, June 3-5, 1992, Proceedings. Vol. 1 Alexandria, VA American Helicopter Society 1992 p. 737-750. refs
(Contract NSF CDR-88-03012)
Copyright

The main objective of the study is to determine whether higher order dynamics such as rotor and inflow dynamics should be taken into account when designing a flight control system to satisfy handling qualities specifications such as ADS-33C. The control methodologies studied are linear quadratic Gaussian (LQG), eigenstructure assignment (EA), and H(infinity). The helicopter is a UH-60 in hover. A representative subset of ADS-33C is used. The results indicate that acceptable controllers can be designed using EA with just a rigid body model of the helicopter, but the control activity is high and the controller is not robust. An H(infinity) design requires the modeling of higher order dynamics, and generates high order controllers, but the resulting controller is robust, and the control activity is lower. It was not possible to determine a suitable LQG based controller that would satisfy the requirements and provide a Rate Command Attitude Hold response type. Author (revised)

A93-35960

FREQUENCY-DOMAIN IDENTIFICATION OF COUPLED ROTOR/BODY MODELS OF AN ADVANCED ATTACK HELICOPTER

JEFFREY W. HARDING (McDonnell Douglas Helicopter Co., Mesa, AZ) *In* AHS, Annual Forum, 48th, Washington, June 3-5, 1992, Proceedings. Vol. 1 Alexandria, VA American Helicopter Society 1992 p. 751-779. refs
Copyright

A frequency-domain approach is used to extract high-order linear models of a U.S. Army/McDonnell Douglas advanced attack helicopter from flight test data at hover. A six degree-of-freedom (DOF) rigid body model with good predictive capabilities is identified which is applicable to around ten rad/sec. Incorporating measured flapping data into the identification, the model frequency range is extended by introducing rotor flapping, dynamic inflow and rotor lag degrees of freedom. First order flapping and inflow effects are based on analytical models which are coupled with the rigid body

dynamics. Identified derivatives show good correlation with analytical model derivatives except for pitch and roll coupling terms which are opposite in sign. Model verification shows good agreement with measured flapping data. Application of the identified model to flight control system design shows that roll rate feedback is limited by the destabilization of the regressing lag mode in the presence of moderate system time delays. Author

A93-35961

HANDLING QUALITIES TESTING USING THE MISSION ORIENTED REQUIREMENTS OF ADS-33C

JOHNNIE A. HAM, MARK METZGER (U.S. Army, Aviation Technical Test Center, Fort Rucker, AL), and ROGER H. HOH (Hoh Aeronautics, Inc., Lomita, CA) *In* AHS, Annual Forum, 48th, Washington, June 3-5, 1992, Proceedings. Vol. 1 Alexandria, VA American Helicopter Society 1992 p. 781-791. refs Copyright

Tests conducted on a variety of aircraft aimed at developing, validating, and refining the flight test techniques to be used in future ADS-33C evaluations are discussed. Research on the handling qualities requirements of the ADS-33C conducted to further develop the mission-oriented maneuvers of the aircraft is reviewed. These stylized maneuvers were designed to evaluate aircraft response characteristics and pilot workload to both single and multiaxis inputs at three levels of aggressiveness. Some of the problems associated with these maneuvers include the lack of 'adequate' performance criteria and the importance of obtaining performance criteria feedback in the maneuvers. Several of the maneuvers are redefined to more easily determine performance compliance using low-cost instrumentation. The maneuvers provide an excellent quick look at a mature aircraft's overall handling qualities, and can serve as a map to further testing to define which of the engineering requirements of the specification need to be reexamined and tested in detail. AIAA

A93-35987* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

HELICOPTER RESPONSE TO ATMOSPHERIC TURBULENCE

J. RIAZ, J. V. R. PRASAD, D. P. SCHRAGE (Georgia Inst. of Technology, Atlanta), and G. H. GAONKAR (Florida Atlantic Univ., Boca Raton) *In* AHS, Annual Forum, 48th, Washington, June 3-5, 1992, Proceedings. Vol. 2 Alexandria, VA American Helicopter Society 1992 p. 1197-1209. refs (Contract NCA2-512) Copyright

A new time-domain method for simulating cyclostationary turbulence as seen by a translating and rotating blade element has recently been developed for the case of one-dimensional spectral distribution. This paper extends the simulation method to the cases of two- and three-dimensional spectral distributions and presents validation results for the two-dimensional case. The statistics of an isolated rigid blade flapping response to turbulence are computed using a two-dimensional spectral representation of the von Karman turbulence model, and the results are compared with those obtained using the conventional space-fixed turbulence analysis. The new turbulence simulation method is used for predicting the Black Hawk helicopter response to atmospheric turbulence. Author

A93-37004 National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

DESIGN AND EVALUATION OF A ROBUST DYNAMIC NEUROCONTROLLER FOR A MULTIVARIABLE AIRCRAFT CONTROL PROBLEM

T. TROUDET, S. GARG, and W. MERRILL (NASA, Lewis Research Center, Cleveland, OH) *In* IJCNN - International Joint Conference on Neural Networks, Baltimore, MD, June 7-11, 1992, Proceedings. Vol. 1 New York Institute of Electrical and Electronics Engineers, Inc. 1992 p. I-308 to I-314. Previously announced in STAR as N92-20586 refs (Contract RTOP 505-62-50) Copyright

The design of a dynamic neurocontroller with good robustness

properties is presented for a multivariable aircraft control problem. The internal dynamics of the neurocontroller are synthesized by a state estimator feedback loop. The neurocontrol is generated by a multilayer feedforward neural network which is trained through backpropagation to minimize an objective function that is a weighted sum of tracking errors, and control input commands and rates. The neurocontroller exhibits good robustness through stability margins in phase and vehicle output gains. By maintaining performance and stability in the presence of sensor failures in the error loops, the structure of the neurocontroller is also consistent with the classical approach of flight control design. Author

A93-37005

NEURAL NETWORK CONTROLLERS FOR THE X29 AIRCRAFT

DENIS J. S. R. BERTRAND (Canadian Armed Forces, Canada) and DANIEL J. COLLINS (U.S. Naval Postgraduate School, Monterey, CA) *In* IJCNN - International Joint Conference on Neural Networks, Baltimore, MD, June 7-11, 1992, Proceedings. Vol. 1 New York Institute of Electrical and Electronics Engineers, Inc. 1992 p. I-321 to I-326. refs

Neural network structures have been developed to evaluate and control the X29 aircraft. The neural network evaluation of the unstable plant is coupled with an evaluation of an H(infinity) controller for the aircraft to reproduce the dynamics of the aircraft. A controller based on the inverse of the plant is also investigated. This technique proved successful for the A4D aircraft but was not possible for the X29 aircraft. Author (revised)

A93-37040

NUMERICAL COMPUTATION AND APPROXIMATIONS OF H(INFINITY) OPTIMAL CONTROLLERS FOR A 2-PARAMETER DISTRIBUTED MODEL OF AN UNSTABLE AIRCRAFT

DALE ENNS (Honeywell, Inc.; Minnesota Univ., Minneapolis), HITAY OZBAY (Ohio State Univ., Columbus), and ALLEN TANNENBAUM (Minnesota Univ., Minneapolis; Technion - Israel Inst. of Technology, Haifa) *In* IEEE International Conference on Systems Engineering, Dayton, OH, Aug. 1-3, 1991, Proceedings New York Institute of Electrical and Electronics Engineers, Inc. 1991 p. 307-310. refs

(Contract NSF ECS-87-04047; NSF DMS-88-11084; AF-AFOSR-90-0024) Copyright

The numerical computation of H(infinity) optimal controllers for an unstable aircraft model with a time delay is discussed. It is shown that the optimal H(infinity) controller for this infinite-dimensional model can be computed from a finite determinantal formula. The properties of the optimal controller are examined. For a particular choice of weights, it is shown with an example that the optimal controller is stable and continuous. Approximations of this controller and suboptimality of the controllers obtained from these approximations are shown. Author (revised)

A93-37044

ROBUST STABILIZATION OF AN AERO-ELASTIC SYSTEM

JANOS TURI (Texas Univ., Richardson) and HITAY OZBAY (Ohio State Univ., Columbus) *In* IEEE International Conference on Systems Engineering, Dayton, OH, Aug. 1-3, 1991, Proceedings New York Institute of Electrical and Electronics Engineers, Inc. 1991 p. 424-427. refs (Contract NSF DMS-89-07019) Copyright

A mathematical model, suitable for robust controller design, is derived for an aero-elastic system. The particular aero-elastic system studied is Theodorsen's problem, i.e., a thin airfoil with trailing-edge flap placed into a perfect two-dimensional unsteady flow, where stabilizing active control is a torque applied at the flap-hinge line. It is shown that the theoretical framework developed by the authors for the robust stabilization of a class of systems governed by singular integro-differential equations provides a proper setting for the control of this aero-elastic system. Author

08 AIRCRAFT STABILITY AND CONTROL

A93-37075

MD-11 AUTOMATIC FLIGHT SYSTEM

B. T. DEVLIN and R. D. GIRTS (Honeywell, Inc., Air Transport Systems Div., Phoenix, AZ) IEEE Aerospace and Electronic Systems Magazine (ISSN 0885-8985) vol. 8, no. 3 March 1993 p. 53-56.

Copyright

The MD-11 Automatic Flight Systems (AFS) jointly developed by Douglas and Honeywell are the most advanced and highly integrated commercial AFS certified to date. In addition to the autoland and windshear functions, the integrated AFS provides Longitudinal Stability Augmentation Systems (LSAS) and roll control wheel steering when autopilot is disengaged; speed envelope protection via autothrottle or LSAS; yaw damper and turn coordination; elevator load feel and flap limiting control; altitude alert; stall warning with stick shaker and autoslat extend; automatic ground spoilers; wheel spin-up and horizontal stabilizer in motion detection; automatic throttle and engine trim via the Full Authority Digital Engine Control, takeoff, cruise, and Cat 11 approach autopilot and flight director. This paper summarizes the overall AFS architecture and redundancy, management concepts, and details the unique application of the Flight Control Computer capabilities to each of the system functions. Author (revised)

A93-37392

INTEGRATED STRUCTURE/CONTROL/AERODYNAMIC SYNTHESIS OF ACTIVELY CONTROLLED COMPOSITE WINGS

E. LIVNE (Washington Univ., Seattle), L. A. SCHMIT, and P. P. FRIEDMANN (California Univ., Los Angeles) Journal of Aircraft (ISSN 0021-8669) vol. 30, no. 3 May-June 1993 p. 387-394. refs

(Contract F49620-87-K-0003)

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A new multidisciplinary optimization capability for integrated synthesis of actively controlled composite wings is reviewed. It is shown that the nonlinear programming/approximation concepts approach to design optimization, combined with appropriate simplified analysis techniques for the different disciplines, make multidisciplinary wing synthesis both feasible and practical for the conceptual and preliminary design stages. The composite wing of a remotely piloted vehicle is used for numerical experimentation. Synthesis studies with design variables and constraints that span the disciplines of structures, control, and aerodynamics are presented. These studies provide new insight into the complex nature of multidisciplinary interactions in wing design. Author

A93-37406

COMMENT ON 'EQUATION DECOUPLING - A NEW APPROACH TO THE AERODYNAMIC IDENTIFICATION OF UNSTABLE AIRCRAFT'

NAIHONG LI, YAOHUA WU, and PINGYUAN CUI (Harbin Inst. of Technology, China) Journal of Aircraft (ISSN 0021-8669) vol. 30, no. 3 May-June 1993 p. 431. refs

Copyright

Two problems are pointed out in the equation decoupling technique proposed by Preissler and Schaeufele (1991). These problems may affect the resulting estimates when the measurement noise is not negligible. A modified procedure is suggested that makes it possible to obtain accurate results. AIAA

A93-37433*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.

ACTUATOR AND AERODYNAMIC MODELING FOR HIGH-ANGLE-OF-ATTACK AEROSERVOELASTICITY

MARTIN J. BRENNER (NASA, Flight Research Center, Edwards, CA) Apr. 1993 28 p. AIAA, ASME, ASCE, AHS, and ASC, Structures, Structural Dynamics and Materials Conference, 34th and AIAA and ASME, Adaptive Structures Forum, La Jolla, CA, Apr. 19-22, 1993 refs

(AIAA PAPER 93-1419) Copyright

Accurate prediction of airframe/actuation coupling is required by the imposing demands of modern flight control systems. In particular, for agility enhancement at high angle of attack and low

dynamic pressure, structural integration characteristics such as hinge moments, effective actuator stiffness, and airframe/control surface damping can have a significant effect on stability predictions. Actuator responses are customarily represented with low-order transfer functions matched to actuator test data, and control surface stiffness is often modeled as a linear spring. The inclusion of the physical properties of actuation and its installation on the airframe is therefore addressed in this paper using detailed actuator models which consider the physical, electrical, and mechanical elements of actuation. The aeroservoelastic analysis procedure is described in which the actuators are modeled as detailed high-order transfer functions and as approximate low-order transfer functions. The impacts of unsteady aerodynamic modeling on aeroservoelastic stability are also investigated in this paper by varying the order of approximation, or number of aerodynamic lag states, in the analysis. Test data from a thrust-vectoring configuration of an F/A-18 aircraft are compared to predictions to determine the effects on accuracy as a function of modeling complexity. Author

A93-38568

NONLINEAR ANALYSIS AND FLIGHT DYNAMICS [ANALYSE NON LINEAIRE ET DYNAMIQUE DU VOL]

PH. GUICHETEAU (ONERA, Chatillon, France) ONERA, TP no. 1992-83 1992 13 p. In FRENCH NATO, AGARD, Workshop on Stability in Aerospace Systems, Toulouse, France, June 23-26, 1992 Research supported by DRET and Service Technique des Programmes Aeronautiques refs

(ONERA, TP NO. 1992-83)

The motion of an aircraft can be rigorously described by an ensemble of nonlinear differential equations which depend on parameters, state variables, and control variables, mediated by the equations of mechanical flight, the aerodynamic model used, and the system of flight control. This paper discusses research aimed at improving understanding and precise prediction of aircraft behavior. Emphasis is given to flight situations in which the usual differential equations are insufficient or invalid. AIAA

A93-38843

F-16 DIGITAL FLIGHT CONTROL SYSTEM IMPROVEMENTS

WILLIAM FLYNN, DOYLE JANZEN, and JOHN FERGIONE (USAF, Test Center, Edwards AFB, CA) In 1992 report to the aerospace profession; SETP Symposium, 36th, Beverly Hills, CA, Sept. 24-26, 1992, Proceedings Lancaster, CA Society of Experimental Test Pilots 1992 p. 165-173.

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This presentation is intended to detail several modifications to the F-16 Digital Flight Control System (DFLCS) which were incorporated in an attempt to enhance F-16 departure resistance and recovery characteristics. Presented here are features of the current production F-16 DFLCS as well as detailed descriptions of the improvements. The purpose of the flight test program was to determine which DFLCS modifications provide sufficient improvement to warrant incorporation into operational F-16 DFLCS (Block 40 and subsequent) aircraft. The flight test program began in February 1992 and is scheduled to continue on into 1993.

Author

A93-39125

AERODYNAMIC QUESTIONS RELATED TO THE SAFETY AND COST-EFFECTIVE UTILIZATION OF AIRSHIPS

[AERODINAMICHESKIE VOPROSY BEZOPASNOSTI I

EKONOMICHNOSTI EKSPLOATATSII VOZDUSHNYKH SUDOV]

VLADIMIR A. SANNIKOV, ALEKSANDR V. GREBENKIN, and MARK A. FRENKEL' Riga Rzhskii Aviatsionnyi Universitet 1992 181 p. In RUSSIAN refs

Copyright

The book is concerned with the practical use of the basic principles of aerodynamics and flight dynamics in increasing the safety and efficiency of aircraft operations. In particular, attention is given to the principal constraints on flight parameters, methods for modeling aircraft behavior under wind shear conditions, in torrential rain, in the presence of microexplosive perturbations,

and in the case of functional system failures. Methods of minimum-fuel flight optimization are discussed. Most of the problems examined are formalized as algorithms suitable for computer implementation. AIAA

A93-39179

EFFECT OF THE AERODYNAMIC INTERFERENCE OF THE ROTOR AND THE FUSELAGE ON THE POWER REQUIREMENTS FOR THE HORIZONTAL FLIGHT OF A HELICOPTER [O VLIANII AERODINAMICHESKOI INTERFERENTSII NESUSHCHEGO VINTA I FIUZELIAZHA NA MOSHCNOST', POTREBNIU DLIA GORIZONTAL'NOGO POLETA VERTOLETA]

L. N. MAKAROV and I. N. RODIONOV *Aviatsionnaia Tekhnika* (ISSN 0579-2975) no. 4 1992 p. 18-21. In RUSSIAN refs Copyright

The effect of certain geometrical parameters of a helicopter (via aerodynamic interference between the rotor and the fuselage) on the power requirements for the horizontal flight is investigated by means of a factorial analysis. Positive effects of the interference are identified which can be used to increase the power efficiency of the helicopter. The results of the study can be used as the basis of a deterministic approach to the design of aerodynamically efficient configurations. AIAA

A93-39190

SPANWISE AILERON OSCILLATIONS [O KOLEBANIIAKH ELERONOV VDOL' RAZMAKHA KRYLA]

N. P. PLAKHTIENKO and B. M. SHIFRIN *Aviatsionnaia Tekhnika* (ISSN 0579-2975) no. 4 1992 p. 63-66. In RUSSIAN refs Copyright

An analysis is made of the dynamic loading of aileron suspension elements during the straight motion of aircraft on the ground. Equations describing the spanwise oscillations of aileron are obtained. It is shown that the aileron oscillation characteristics are largely determined by dynamic and parametric disturbances. AIAA

A93-39191

THE PROBLEM OF AVOIDING AIRCRAFT COLLISIONS DURING GROUP FLIGHTS [K ZADACHE PREDOTVRASHCHENIIA STOLKOVENIIA SAMOLETOV PRI GRUPPOVYKH POLETAKH]

S. E. ZELINSKII *Aviatsionnaia Tekhnika* (ISSN 0579-2975) no. 4 1992 p. 66-68. In RUSSIAN refs Copyright

An algorithm is proposed for generating a collision avoidance maneuver for the wingman aircraft in formation flights. The algorithm ensures collision avoidance while preserving the flight formation. Results of a computational experiment for Il-76 aircraft are presented as an illustration. AIAA

A93-39192

KINEMATICS OF AEROINERTIAL AIRCRAFT ROTATION [KINEMATIKA AEROINERTSIONNOGO VRASHCHENIIA SAMOLETA]

V. F. NATUSHKIN *Aviatsionnaia Tekhnika* (ISSN 0579-2975) no. 4 1992 p. 69-72. In RUSSIAN refs Copyright

The kinematics of the three-dimensional motion of an aircraft relative to the center of mass during stationary and nonstationary aero inertial rotation is investigated analytically. Kinematic equations are obtained which establish an analytical relation between the angular velocities and projections of the velocity vector onto the axes of the reference coordinate system. Oscillograms of stable and unstable spin are presented to illustrate the results of the analysis. AIAA

A93-39418

ALTERNATIVE APPROXIMATIONS FOR INTEGRATED CONTROL/STRUCTURE AEROSERVOELASTIC SYNTHESIS

ELI LIVNE (Washington Univ., Seattle) *AIAA Journal* (ISSN 0001-1452) vol. 31, no. 6 June 1993 p. 1100-1108.

AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics and Materials Conference, 33rd, Dallas, TX, Apr. 13-15, 1992, Technical Papers. Pt. 5, p. 2672-2681. Previously cited in issue 13, p. 2100, Accession no. A92-34547 refs Copyright

N93-26907*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH. ROBUSTNESS ENHANCEMENT OF NEUROCONTROLLER AND STATE ESTIMATOR

TERRY TROUDET (Sverdrup Technology, Inc., Brook Park, OH.) Feb. 1993 7 p Proposed for presentation at the World Congress on Neural Networks (WCNN), Portland, OR, 11-15 Jul. 1993; sponsored by International Neural Network Society (Contract RTOP 505-62-50) (NASA-TM-106028; E-7590; NAS 1.15:106028) Avail: CASI HC A02/MF A01

The feasibility of enhancing neurocontrol robustness, through training of the neurocontroller and state estimator in the presence of system uncertainties, is investigated on the example of a multivariable aircraft control problem. The performance and robustness of the newly trained neurocontroller are compared to those for an existing neurocontrol design scheme. The newly designed dynamic neurocontroller exhibits a better trade-off between phase and gain stability margins, and it is significantly more robust to degradations of the plant dynamics. Author

N93-27156*# California Polytechnic State Univ., San Luis Obispo. Dept. of Aeronautical Engineering.

LOW BANDWIDTH ROBUST CONTROLLERS FOR FLIGHT Final Report, Jun. 1991 - Dec. 1992

DANIEL J. BIEZAD and HWEI-LAN CHOU May 1993 96 p (Contract NCC2-711) (NASA-CR-193085; NAS 1.26:193085) Avail: CASI HC A05/MF A01

Through throttle manipulations, engine thrust can be used for emergency flight control for multi-engine aircraft. Previous study by NASA Dryden has shown the use of throttles for emergency flight control to be very difficult. In general, manual fly-by-throttle is extremely difficult - with landing almost impossible, but control augmentation makes runway landings feasible. Flight path control using throttles-only to achieve safe emergency landing for a large jet transport airplane, Boeing 720, was investigated using Quantitative Feedback Theory (QFT). Results were compared to an augmented control developed in a previous simulation study. The control augmentation corrected the unsatisfactory open-loop characteristics by increasing system bandwidth and damping, but increasing the control bandwidth substantially proved very difficult. The augmented pitch control is robust under no or moderate turbulence. The augmented roll control is sensitive to configuration changes. Author

N93-27171 California Univ., Los Angeles. Dept. of Mechanical, Aerospace and Nuclear Engineering.

GAME THEORETIC SYNTHESIS FOR ROBUST AEROSPACE CONTROLLERS

JASON L. SPEYER *In Israel Society of Aeronautics and Astronautics, 32nd Annual Conference on Aviation and Astronautics* p 31-41 20 Feb. 1992

Copyright Avail: Israel Society of Aeronautics and Astronautics, c/o Faculty of Engineering, Tel-Aviv Univ., Ramat Aviv 69978, Israel

A synthesis method is described and illustrated for the design of feedback controllers in the presence of plant and measurement disturbances and parameter uncertainty. The synthesis method involves a state space description in which the system disturbances and uncertainties are embedded in the system model. Furthermore, the cost criterion is a disturbance attenuation function composed of the ratio of the quadratic norm of certain outputs to the input disturbances. The outputs are chosen so that both desirable performance and stability robustness are obtained. The problem of finding the controller which minimizes the attenuation function in the presence of the worst disturbances is equivalent to a

linear-quadratic game problem. The result is a linear controller whose gains are determined from two algebraic Riccati equations. This compensator is illustrated by three examples. The first, representing the control of a two-mass system, is used to motivate the approach to controller design. However, when viewed as a simple model of a flexible structure, the problem is interesting and challenging, leading to a nonminimal phase compensator. The second example, which illustrates an important control problem with full state feedback, is that of controlling attitude or attitude rate as well as momentum of the space station. Finally, a VSTOL aircraft at a transition velocity illustrates the partial information case. ISA

N93-27264*# Joint Inst. for Advancement of Flight Sciences, Hampton, VA.

PRACTICAL INPUT OPTIMIZATION FOR AIRCRAFT PARAMETER ESTIMATION EXPERIMENTS Ph.D. Thesis, 1990
EUGENE A. MORELLI May 1993 175 p
(Contract NCC1-29; RTOP 505-64-52-01)
(NASA-CR-191462; NAS 1.26:191462) Avail: CASI HC A08/MF A02

The object of this research was to develop an algorithm for the design of practical, optimal flight test inputs for aircraft parameter estimation experiments. A general, single pass technique was developed which allows global optimization of the flight test input design for parameter estimation using the principles of dynamic programming with the input forms limited to square waves only. Provision was made for practical constraints on the input, including amplitude constraints, control system dynamics, and selected input frequency range exclusions. In addition, the input design was accomplished while imposing output amplitude constraints required by model validity and considerations of safety during the flight test. The algorithm has multiple input design capability, with optional inclusion of a constraint that only one control move at a time, so that a human pilot can implement the inputs. It is shown that the technique can be used to design experiments for estimation of open loop model parameters from closed loop flight test data. The report includes a new formulation of the optimal input design problem, a description of a new approach to the solution, and a summary of the characteristics of the algorithm, followed by three example applications of the new technique which demonstrate the quality and expanded capabilities of the input designs produced by the new technique. In all cases, the new input design approach showed significant improvement over previous input design methods in terms of achievable parameter accuracies. Author (revised)

N93-27308*# Kansas Univ., Lawrence.
DESIGN, ANALYSIS, AND CONTROL OF LARGE TRANSPORT AIRCRAFT UTILIZING ENGINE THRUST AS A BACKUP SYSTEM FOR THE PRIMARY FLIGHT CONTROLS
DONNA S. GERREN Feb. 1993 120 p
(Contract NAG2-789)
(NASA-CR-192938; NAS 1.26:192938) Avail: CASI HC A06/MF A02

A review of accidents that involved the loss of hydraulic flight control systems serves as an introduction to this project. In each of the accidents--involving transport aircraft such as the DC-10, the C-5A, the L-1011, and the Boeing 747--the flight crew attempted to control the aircraft by means of thrust control. Although these incidents had tragic endings, in the absence of control power due to primary control system failure, control power generated by selective application of engine thrust has proven to be a viable alternative. NASA Dryden has demonstrated the feasibility of controlling an aircraft during level flight, approach, and landing conditions using an augmented throttles-only control system. This system has been successfully flown in the flight test simulator for the B-720 passenger transport and the F-15 air superiority fighter and in actual flight tests for the F-15 aircraft. The Douglas Aircraft Company is developing a similar system for the MD-11 aircraft. The project's ultimate goal is to provide data for the development of thrust control systems for mega-transport (600+ passengers). Author (revised)

N93-27450*# United Technologies Research Center, East Hartford, CT.

UNSTEADY TRANSITION MEASUREMENTS ON A PITCHING THREE-DIMENSIONAL WING
PETER F. LORBER and FRANKLIN O. CARTA In California State Univ., The Fifth Symposium on Numerical and Physical Aspects of Aerodynamic Flows 14 p 1992
(Contract DAAL03-89-C-0013)
Avail: CASI HC A03/MF A04

Boundary layer transition measurements were made during an experimental study of the aerodynamics of a rectangular wing undergoing unsteady pitching motions. The wing was tested at chordwise Mach numbers between 0.2 and 0.6, at sweep angles of 0, 15, and 30 deg, and for steady state, sinusoidal, and constant pitch rate motions. The model was scaled to represent a full size helicopter rotor blade, with chord Reynolds numbers between 2 and 6 x 10(exp 6). Sixteen surface hot-film gages were located along three spanwise stations: 0.08, 0.27, and 0.70 chords from the wing tip. Qualitative heat transfer information was obtained to identify the unsteady motion of the point of transition to turbulence. In combination with simultaneous measurements of the unsteady surface pressure distributions, the results illustrate the effects of compressibility, sweep, pitch rate, and proximity to the wing tip on the transition and relaminarization locations. Author (revised)

N93-27546# Naval Postgraduate School, Monterey, CA.
THE DESIGN OF A ROBUST AUTOPILOT FOR THE ARCHYTAS PROTOTYPE VIA LINEAR QUADRATIC SYNTHESIS M.S. Thesis

JOSEPH P. DAVIS Dec. 1992 131 p
(AD-A262151) Avail: CASI HC A07/MF A02

The purpose of this research is to design, simulate, and implement a robust autopilot for the vertical mode of operation of the Archytas prototype. Archytas is an Unmanned Air Vehicle that is designed to take off and land vertically, and to transition to horizontal forward flight. A feedback control scheme is designed for both the single-input, single-output and the multi-input, multi-output subsystems using optimal control techniques. In this research, the linear quadratic regulator performance measure is modified to allow for its application to the tracking problem solution. Additionally, the control systems are designed using reduced order models. Computer simulations show that the reduced order controller designs provide results comparable to the full order controller designs. Successful hardware tests with the roll rate control system validated the reduced order model design philosophy used in this research. DTIC

N93-28869*# National Aeronautics and Space Administration, Ames Research Center, Moffett Field, CA.

FLIGHT EVALUATION OF A COMPUTER AIDED LOW-ALTITUDE HELICOPTER FLIGHT GUIDANCE SYSTEM
HARRY N. SWENSON, RAYMOND D. JONES (Army Avionics Research and Development Activity, Fort Monmouth, NJ.), and RAYMOND CLARK (Army Avionics Research and Development Activity, Fort Monmouth, NJ.) In AGARD, Combat Automation for Airborne Weapon Systems: Man/Machine Interface Trends and Technologies 11 p Apr. 1993
Copyright Avail: CASI HC A03/MF A03

The Flight Systems Development branch of the U.S. Army's Avionics Research and Development Activity (AVRADA) and NASA Ames Research Center have developed for flight testing a Computer Aided Low-Altitude Helicopter Flight (CALAHF) guidance system. The system includes a trajectory-generation algorithm which uses dynamic programming and a helmet-mounted display (HMD) presentation of a pathway-in-the-sky, a phantom aircraft, and flight-path vector/predictor guidance symbology. The trajectory-generation algorithm uses knowledge of the global mission requirements, a digital terrain map, aircraft performance capabilities, and precision navigation information to determine a trajectory between mission way points that seeks valleys to minimize threat exposure. This system was developed and evaluated through extensive use of piloted simulation and has demonstrated a 'pilot centered' concept of automated and

integrated navigation and terrain mission planning flight guidance. This system has shown a significant improvement in pilot situational awareness, and mission effectiveness as well as a decrease in training and proficiency time required for a near terrain, nighttime, adverse weather system. AVRADA's NUH-60A STAR (Systems Testbed for Avionics Research) helicopter was specially modified, in house, for the flight evaluation of the CALAHF system. The near terrain trajectory generation algorithm runs on a multiprocessor flight computer. Global Positioning System (GPS) data are integrated with Inertial Navigation Unit (INU) data in the flight computer to provide a precise navigation solution. The near-terrain trajectory and the aircraft state information are passed to a Silicon Graphics computer to provide the graphical 'pilot centered' guidance, presented on a Honeywell Integrated Helmet And Display Sighting System (IHADSS). The system design, piloted simulation, and initial flight test results are presented. Author (revised)

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.

A93-35988

ATTHES - A HELICOPTER IN-FLIGHT SIMULATOR WITH HIGH BANDWIDTH CAPABILITY

GERD BOUWER, HEINZ-JUERGEN PAUSDER, and WOLFGANG VON GRUENHAGEN (DLR, Inst. fuer Flugmechanik, Braunschweig, Germany) *In* AHS, Annual Forum, 48th, Washington, June 3-5, 1992, Proceedings. Vol. 2 Alexandria, VA American Helicopter Society 1992 p. 1211-1224. refs
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The general design, performance characteristics, and applications of a high-performance high-bandwidth in-flight simulator, ATTHES (Advanced Technology Testing Helicopter System), are reviewed. The onboard computer system includes two computers, with one computer responsible for data collection, telemetry, and data storage and the second computer handling the flight control task. Flight tests with ATTHES have been performed to generate handling qualities data with decoupled rate command/attitude hold and attitude command models. The flight test results demonstrate the high fidelity and flexibility of the control system. AIAA

A93-36791

PROBLEMS OF THE ORGANIZATION OF THE MASS TESTING OF LARGE STRUCTURAL ELEMENTS OF AIRCRAFT USING TESTING MACHINES [PROBLEMY ORGANIZATSII MASSOVYKH ISPYTANII KRUPNOGABARITNYKH ELEMENTOV AVIAKONSTRUKTSII NA ISPYTATEL'NYKH MASHINAKH]

L. G. BELOZEROV, I. V. KARTASHEV, and V. A. KIREEV *In* Stress-strain analysis and optimal design of aircraft structures Moscow Izdatel'skii Otdel TsAGI 1992 p. 83-86. *In* Russian. refs
Copyright

The paper is concerned with the development of large computerized testing systems for the mass testing of large aircraft structures. The general organization of the testing system is examined in relation to the classification of the predicted flows of thin-walled structural elements to be tested. The principal requirements for the functional components of the testing system and for parks of testing machines are discussed. AIAA

A93-37069

THE APPLICATION OF AUTOMATIC SURFACE LIGHTS TO IMPROVE AIRPORT SAFETY

ERVIN F. LYON (MIT, Lexington, MA) IEEE Aerospace and

Electronic Systems Magazine (ISSN 0885-8985) vol. 8, no. 3 March 1993 p. 14-20. refs
(Contract DTFA01-89-Z-02033)
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The first phase of the Airport Surface Traffic Automation (ASTA) program, ASTA-1, which focuses on advanced surveillance, communications, and automation techniques in order to improve airport safety, reduce delays, and increase efficiency, calls for the development of a system of automatic runway status lights located at entrances to runways and in front of positions from which takeoffs commonly begin. Both types of ASTA-1 lights are designed for fully automatic operation in all weather conditions. The system is to operate on the basis of live airport traffic and will validate the operational concept using a scale model of Boston's Logan International Airport plus surveillance displays. AIAA

A93-37402

DYNAMIC STABILITY DERIVATIVES EVALUATION IN A LOW-SPEED WIND TUNNEL

G. GUGLIERI (CNR, Centro Studi Dinamica Fluidi, Turin, Italy) and F. B. QUAGLIOTTI (Torino, Politecnico, Turin, Italy) *Journal of Aircraft* (ISSN 0021-8669) vol. 30, no. 3 May-June 1993 p. 421-423. AIAA Applied Aerodynamics Conference, 9th, Baltimore, MD, Sept. 23-25, 1991, Technical Papers. Vol. 1, p. 328-336. Previously cited in issue 23, p. 4023, Accession no. A91-53757 refs
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A93-37763* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

RECENT EXPERIENCES WITH IMPLEMENTING A VIDEO BASED SIX DEGREE OF FREEDOM MEASUREMENT SYSTEM FOR AIRPLANE MODELS IN A 20 FOOT DIAMETER VERTICAL SPIN TUNNEL

WALTER L. SNOW, BROOKS A. CHILDERS, STEPHEN B. JONES (NASA, Langley Research Center, Hampton, VA), and CHARLES M. FREMAUX (Lockheed Engineering & Sciences Co.; NASA, Langley Research Center, Hampton, VA) *In* Videometrics; Proceedings of the Meeting, Boston, MA, Nov. 15, 16, 1992 Bellingham, WA Society of Photo-Optical Instrumentation Engineers 1993 p. 158-180. refs
Copyright

A model space positioning system (MSPS), a state-of-the-art, real-time tracking system to provide the test engineer with on line model pitch and spin rate information, is described. It is noted that the six-degree-of-freedom post processor program will require additional programming effort both in the automated tracking mode for high spin rates and in accuracy to meet the measurement objectives. An independent multicamera system intended to augment the MSPS is studied using laboratory calibration methods based on photogrammetry to characterize the losses in various recording options. Data acquired to Super VHS tape encoded with Vertical Interval Time Code and transcribed to video disk are considered to be a reasonable priced choice for post editing and processing video data. AIAA

A93-37872

AEDC EXPANDED FLOW ARC FACILITY (HEAT-H2) DESCRIPTION AND CALIBRATION

E. J. FELDERMAN, D. D. HORN, D. B. CARVER, and L. M. DAVIS (Calspan Corp., Arnold AFB, TN) *In* International Instrumentation Symposium, 38th, Las Vegas, NV, Apr. 26-30, 1992, Proceedings Research Triangle Park, NC Instrument Society of America 1992 p. 525-532. refs
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A new arc-heated hypersonic facility (HEAT-H2) is now operational at the Arnold Engineering Development Center (AEDC), and the initial flow-field calibration has been completed. A description of the facility is included as is a summary of the facility capabilities and the results from a preliminary flow-field calibration. Simulation conditions at the nozzle exit include altitudes ranging from 80,000 to 160,000 ft, total air temperatures from 6,000 to 8,000 R, velocities from 10,000 to 15,000 ft/sec, and pitot pressures

09 RESEARCH AND SUPPORT FACILITIES (AIR)

from 2 to 50 psia. The facility should prove useful for a wide variety of hypersonic testing requirements including aerothermal testing of structures, heat shields, antenna windows, etc., and aeropropulsion testing of scramjet combustors to evaluate both performance and hardware survivability. Author

A93-37873* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

DEVELOPMENT UPDATE FOR THE NASA AMES 16-INCH SHOCK TUNNEL FACILITY

CHARLES J. CORNELISON (NASA, Ames Research Center, Moffett Field, CA) *In* International Instrumentation Symposium, 38th, Las Vegas, NV, Apr. 26-30, 1992, Proceedings Research Triangle Park, NC Instrument Society of America 1992 p. 533-545. refs

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Results of ongoing developmental testing in the NASA Ames 16-inch combustion-driven Shock Tunnel Facility are presented. Specifically, such factors as mixture composition, mixture uniformity, gas-loading methods, ignition energy, number of ignition wires, etc., are examined to determine their effect on combustion performance. A theoretically based hypothesis is introduced to help explain the cause of driver tube pressure oscillations that occur during combustion. In addition to combustion behavior, results from a recently instituted effort to develop self-breaking primary diaphragms, as well as several additional facility enhancements, are discussed. Author

A93-37875* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

GAS ANALYSIS SYSTEM FOR THE EIGHT FOOT HIGH TEMPERATURE TUNNEL

BRADLEY D. LEIGHTY, PATRICIA P. DAVIS, BILLY T. UPCHURCH, and RICHARD L. PUSTER (NASA, Langley Research Center, Hampton, VA) *In* International Instrumentation Symposium, 38th, Las Vegas, NV, Apr. 26-30, 1992, Proceedings Research Triangle Park, NC Instrument Society of America 1992 p. 581-596. refs

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This paper describes the development of a gas collection and analysis system that is to be installed in the Eight-Foot High Temperature Tunnel (8' HTT) at NASA's Langley Research Center. This system will be used to analyze the test gas medium that results after burning a methane-air mixture to achieve the proper tunnel test parameters. The system consists of a sampling rake, a gas sample storage array, and a gas chromatographic system. Gas samples will be analyzed after each run to assure that proper combustion takes place in the tunnel resulting in a correctly balanced composition of the test gas medium. The proper ratio of gas species is critically necessary in order for the proper operation and testing of scramjet engines in the tunnel. After a variety of methane-air burn conditions have been analyzed, additional oxygen will be introduced into the combusted gas and the enriched test gas medium analyzed. The pre/post enrichment sets of data will be compared to verify that the gas species of the test gas medium is correctly balanced for testing of air-breathing engines. Author

A93-37877

DESIGN PHILOSOPHY FOR WIND TUNNEL MODEL POSITIONING CONTROL SYSTEMS

H. D. HAGAR and ROY G. BUTLER (Calspan Corp., Arnold AFB, TN) *In* International Instrumentation Symposium, 38th, Las Vegas, NV, Apr. 26-30, 1992, Proceedings Research Triangle Park, NC Instrument Society of America 1992 p. 605-618. Previously announced in STAR as N93-12552

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Wind tunnel testing usually requires positioning of the aircraft model in the airstream. This paper presents the design philosophy for a typical generic automatic control system for use in the wind tunnel facilities at Arnold Engineering Development Center in Tullahoma, Tennessee, and is presently used to accurately control the position and/or velocity of an aircraft in one to six degrees of freedom while taking into account the effects of outside influences.

Selection of feedback devices, controller design concepts, safeguard implementation, operator status and display capabilities, and mechanism movement simulation are topics that are addressed. Author

A93-38569

APPLICATION OF A FULL POTENTIAL CODE TO THE DEFINITION OF A TRANSONIC TEST SECTION [APPLICATION DE LA METHODE DE POTENTIEL TRIDIMENSIONNEL A LA DEFINITION D'UNE VEINE D'ESSAI TRANSSONIQUE]

X. VAUCHERET and R. PICHON (ONERA, Chatillon, France) ONERA, TP no. 1992-84 1992 23 p. *In* FRENCH Association Technique Maritime et Aeronautique, Session, 92nd, Paris, France, May 18-21, 1992 refs (ONERA, TP NO. 1992-84)

The N.2 test section of the S1 Modane wind tunnel is being transformed and optimized to permit testing of large sting-mounted civil aircraft models and half models mounted from the floor for Mach numbers reaching 0.95. The flow into the test section is determined using a structured progressive mesh of 80,000 hexahedrons. The full potential code allows low-intensity shocks. AIAA

A93-38592

A NEW ADAPTIVE TEST SECTION AT ONERA CHALAIS-MEUDON

Y. LE SANT and F. BOUVIER (ONERA, Chatillon, France) ONERA, TP no. 1992-117 1992 15 p. European Forum on Wind Tunnels and Wind Tunnel Test Techniques, Southampton Univ., United Kingdom, Sept. 14-17, 1992 refs (ONERA, TP NO. 1992-117)

A study aimed at defining a pre-industrial prototype for the S3Ch transonic wind tunnel in the ONERA Chalais-Meudon Center is presented. A method based on pressure measurements on the upper and lower walls and a model representation that reduces the sensitivity to the test section length limitation is proposed. The method is capable of retrieving the data generated in a nondeformed test section from an arbitrary wind tunnel test. The feasibility of evaluating the wall interferences at any point in the test section according to a symmetrical integral form is demonstrated. The wall shape determination is based on inversion of a matrix system which causes the jack displacements on the target line. AIAA

A93-39414

MILLISECOND AERODYNAMIC FORCE MEASUREMENT WITH SIDE-JET MODEL IN THE ISL SHOCK TUNNEL

K. W. NAUMANN, H. ENDE, G. MATHIEU, and A. GEORGE (Saint-Louis, French-German Research Inst., France) AIAA Journal (ISSN 0001-1452) vol. 31, no. 6 June 1993 p. 1068-1074. AIAA, Aerospace Ground Testing Conference, 17th, Nashville, TN, July 6-8, 1992, AIAA Paper 92-3963. Previously cited in issue 24, p. 4267, Accession no. A92-56790 refs

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N93-26636# Transportation Research Board, Washington, DC.

AIRPORT LANDSIDE PLANNING AND OPERATIONS Transportation Research Record

1992 50 p

(PB93-167880; TRB/TRR-1373) Avail: CASI HC A03/MF A01

This document contains the following: Toronto Island airport access; dynamic capacity of airport enplaning curbside areas; evolution of ground transportation management as a major airport function; public transportation for airport employees: the Q3 extension into John F. Kennedy International Airport; and planning of parallel pier airport terminals with automated people mover systems under constrained conditions. NTIS

N93-27142*# George Washington Univ., Washington, DC. School of Engineering and Applied Science.

ANALYSIS OF FLUCTUATING STATIC PRESSURE MEASUREMENTS IN A LARGE HIGH REYNOLDS NUMBER TRANSONIC CRYOGENIC WIND TUNNEL Ph.D. Thesis

WILLIAM B. IGOE 1991 258 p Sponsored by NASA. Langley Research Center (NASA-TM-108722; NAS 1.15:108722) Avail: CASI HC A12/MF A03

Dynamic measurements of fluctuating static pressure levels were made using flush mounted high frequency response pressure transducers at eleven locations in the circuit of the National Transonic Facility (NTF) over the complete operating range of this wind tunnel. Measurements were made at test section Mach numbers from 0.2 to 1.2, at pressure from 1 to 8.6 atmospheres and at temperatures from ambient to -250 F, resulting in dynamic flow disturbance measurements at the highest Reynolds numbers available in a transonic ground test facility. Tests were also made independently at variable Mach number, variable Reynolds number, and variable drivepower, each time keeping the other two variables constant thus allowing for the first time, a distinct separation of these three important variables. A description of the NTF emphasizing its flow quality features, details on the calibration of the instrumentation, results of measurements with the test section slots covered, downstream choke, effects of liquid nitrogen injection and gaseous nitrogen venting, comparisons between air and nitrogen, isolation of the effects of Mach number, Reynolds number, and fan drive power, and identification of the sources of significant flow disturbances is included. The results indicate that primary sources of flow disturbance in the NTF may be edge-tones generated by test section sidewall re-entry flaps and the venting of nitrogen gas from the return leg of the tunnel circuit between turns 3 and 4 in the cryogenic mode of operation. The tests to isolate the effects of Mach number, Reynolds number, and drive power indicate that Mach number effects predominate. A comparison with other transonic wind tunnels shows that the NTF has low levels of test section fluctuating static pressure especially in the high subsonic Mach number range from 0.7 to 0.9.

Author (revised)

N93-28189# Naval Postgraduate School, Monterey, CA.
MODIFICATION AND CALIBRATION OF THE NAVAL POSTGRADUATE SCHOOL ACADEMIC WIND TUNNEL M.S. Thesis

ROBERT L. BALDOCCHI 17 Dec. 1992 83 p (AD-A262092) Avail: CASI HC A05/MF A01

Since the early 1980's, the Academic Wind Tunnel has operated with only one half its designed power section. Resultant flow qualities have limited the use of this facility. A damping screen was installed in the settling chamber to reduce the level of turbulence intensity in the tunnel. Following this modification, calibration measurements in the vertical centerplane were performed to document flow conditions in the test section. The tunnel calibration investigated lateral pressure variations, flow angularity, and turbulence intensity and included an airspeed calibration. When available results were compared to data from calibrations performed before the tunnel modification. Results indicate the total and static pressure lateral variation is within 1.0% angular variation of approximately +/-1.0 deg exists in the test section, and a 25.0% reduction in turbulence intensity was obtained due to the presence of the damping screen. Flow separation in the diffuser is believed to be influencing total pressure oscillation in the test section.

DTIC

N93-28467# Air Force Inst. of Tech., Wright-Patterson AFB, OH. School of Engineering.

RENDERING THE OUT-THE-WINDOW VIEW FOR THE AFIT VIRTUAL COCKPIT M.S. Thesis

W. D. MCCARTY Mar. 1993 50 p (AD-A262599; AFIT/GCS/ENG/93M-04) Avail: CASI HC A03/MF A01

The Air Force Institute of Technology (AFIT) is developing a distributed interactive flight simulator, the Virtual Cockpit, using

commercial graphics workstations and helmet mounted displays. The Virtual Cockpit communicates with other simulators via local and long-haul networks using the SIMNET protocol. The work reported in this thesis focuses on developing the terrain database for the synthetic environment and on rendering the pilot's view of the database. There are many different file formats for describing 3-dimensional geometric polygonal objects. An analysis of three formats, AFIT GEOM, the Naval Postgraduate School (NPS) DRP, and Software Systems' Flight, is presented. Each file format is described, and their attributes are compared in a decision table. A series of C++ classes were developed to render the file format used by the terrain database. These C++ classes, which include classes for stationary and moving entities, and for textures, are discussed. A technique for increasing the rendering speed is also presented.

DTIC

N93-28490# Wisconsin Univ., Madison.
UNDULATOR SPECTROMICROSCOPY FACILITY AT THE ADVANCED LIGHT SOURCE Annual Report, 1992

1992 6 p (Contract DE-FG02-92ER-45468) (DE93-007964; DOE/ER-45468/1) Avail: CASI HC A02/MF A01

The SpectroMicroscopy Facility is a Participating Research Team (PRT) that was formed to design and build detectors and experimental stations that could take advantage of the specific advantages that the highly coherent undulator source provides. The primary scientific orientation of the team is in materials science and the physics and chemistry of surfaces or interfaces. The SpectroMicroscopy Facility is organized as an ALS 'Type A' project. This report presents progress made on the project for 1992.

DOE

10

ASTRONAUTICS

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

A93-37482
A NUMERICAL INVERSION METHOD FOR DETERMINING AERODYNAMIC EFFECTS ON PARTICULATE EXHAUST PLUMES FROM ONBOARD IRRADIANCE DATA

D. COUSINS (MIT, Lexington, MA) *In* Thermosense XIII; Proceedings of the Meeting, Orlando, FL, Apr. 3-5, 1991 Bellingham, WA Society of Photo-Optical Instrumentation Engineers 1991 p.402-409. refs

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The present ad hoc method for determining the physical properties of particulate exhaust plumes inverts multiband irradiance data collected over fields-of-view that are highly oblique to the plume axis; it is therefore applicable to the onboard measurement of in-flight aerodynamic effects on plume properties. A simple analytical model that predicts irradiance under these assumptions is presented, together with measurements of Mg/PTFE plumes in vacuum. The first step of the inversion process generates the locus of possible temperatures and velocities consistent with a given irradiance measurement; the second step uses two independent irradiance measurements to ascertain a unique temperature and velocity solution.

AIAA

CHEMISTRY AND MATERIALS

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

A93-36003

ENVIRONMENTAL CONDITIONS FOR CERTIFICATION TESTING OF HELICOPTER ADVANCED COMPOSITE MAIN ROTOR COMPONENTS

A. S. LLANOS, L. A. LUCCHETTO, D. STAFFORD, and C. COULLIETTE (McDonnell Douglas Helicopter Co., Mesa, AZ) *In* AHS, Annual Forum, 48th, Washington, June 3-5, 1992, Proceedings. Vol. 2 Alexandria, VA American Helicopter Society 1992 p. 1441-1449. refs

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A survey of the current literature was used to formulate methodology for establishing a set of environmental test conditions suitable for composite structures certification testing. To implement these environmental conditions in an adequate manner, it was required to study the absorption/desorption behavior of the material itself. Environmental conditioning of coupons representative of different main rotor materials, S-2 glass-epoxy and carbon-epoxy, were evaluated at different temperatures and relative humidities. The data from the conditioned coupons were used to characterize equilibrium moisture content levels, and mass diffusivities for the materials. The diffusivity and moisture content values are then used to estimate conditioning times for full scale parts. Sample sections from actual full scale composite rotor components were environmentally conditioned. These data were compared with the analytical predictions based on coupon data. Good correlation between analytical and empirical data was obtained. Author

A93-36005

EVALUATION OF THE FATIGUE BEHAVIOR OF DISCONTINUOUS AND CONTINUOUS FIBER THERMOPLASTIC COMPOSITE LAMINATES

H. A. WHITWORTH (Howard Univ., Washington), STEVEN G. LLORENTE (Boeing Defense & Space Group, Helicopters Div., Philadelphia, PA), and ROBERT CROMAN (Du Pont de Nemours & Co., Wilmington, DE) *In* AHS, Annual Forum, 48th, Washington, June 3-5, 1992, Proceedings. Vol. 2 Alexandria, VA American Helicopter Society 1992 p. 1457-1463. refs

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The objective of the study was to evaluate the effect of fatigue loading on continuous and long discontinuous fiber (LDF) composites based on the AS4/PEKK (polyether ketone ketone) system. Residual stiffness was selected as a means of monitoring fatigue damage. Static tests showed a 13-percent reduction in unnotched LDF strength in comparison with continuous fiber thermoplastics; with a notch, the reduction in strength was only 4 percent. The fatigue behavior of the LDF and continuous fiber AS4/PEKK is similar to that of thermosets. Although the continuous fiber composites sustained approximately 13-percent higher fatigue loads than the LDF composites, the endurance limit for both systems was between 60 and 70 percent of their respective static ultimate strengths. AIAA

A93-36718

RESOURCE CONSERVATION AND IMPROVEMENT OF THE SERVICE CHARACTERISTICS OF CASTINGS OF HIGH-TEMPERATURE NICKEL ALLOYS THROUGH A HIGH-TEMPERATURE MELT TREATMENT [RESURSOSBEREZHENIE I ULUCHSHENIE SLUZHEBNYKH KHARAKTERISTIK OTLIVOK IZ ZHAROPROCHNYKH NIKELEVYKH SPLAVOV POSREDESTVOM VYSOKOTEMPERATURNOI OBRABOTKI RASPLAVOV]

B. A. BAUM, V. N. LARIONOV, L. V. KOVALENKO, G. V. TIAGUNOV, E. A. KULESHOVA, E. E. BARYSHEV, E. E.

TRET'IAKOVA, and E. V. KOLOTUKHIN *Metally* (ISSN 0869-5733) no. 1 Jan.-Feb. 1993 p. 31-37. In Russian. refs

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A study is made of the temperature dependence of the physical properties of liquid high-temperature nickel-based alloys. It is found that there exists a relationship between the alloy preparation conditions and the structure and properties of the solid alloy. Based on the results of the study, resource-conserving high-temperature treatments have been developed for melts of high-temperature nickel alloys. The use of these treatments improves the quality of the metal, significantly enhances their processing and service-related properties, reduces the amount of rejects, and saves scarce materials. AIAA

A93-38200

BIRTH OF THE BETAS

ALAN S. BROWN *Aerospace America* (ISSN 0740-722X) vol. 31, no. 5 May 1993 p. 36, 37.

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Beta-Ti alloys currently under development show promise as replacements for both steel and Al-alloy aerospace structural components, in virtue of their high specific strength, corrosion resistance, and high service temperature capabilities. Representative beta-Ti alloys are Ti-15V-3Cr-3Al-3Sn, Ti-10V-2Fe-3Al, and Timetal 21S. AIAA

A93-38580

POTENTIAL AND PROSPECTS OF INTERMETALLIC MATERIALS FOR APPLICATIONS IN THE AEROSPACE INDUSTRY [POTENTIEL ET PERSPECTIVES DES MATERIAUX INTERMETALLIQUES POUR APPLICATIONS AEROSPATIALES]

TASADDUQ KHAN and SHIGEHISA NAKA (ONERA, Direction de Materiaux, Chatillon, France) ONERA, TP no. 1992-99 1992 20 p. *In* FRENCH Colloque sur les Materiaux pour l'Aeronautique et l'Espace, 14th, Le Bourget, France, June 18, 19, 1991 refs (ONERA, TP NO. 1992-99)

Intermetallics have been found to have diverse potential as an alternative structural material in the aerospace industry. Research on intermetallic alloys includes studies of multiphase materials and intermetallic-matrix composites. Among these materials, Ti3Al and TiAl have been found to be the nearest to actual structural application. Data on these materials are examined, and considerations on the two-phase microstructure of intermetallic compounds are presented. AIAA

A93-38586

STRUCTURAL STABILITY OF 'BETA-CEZ' ALLOY

AGNES HENRI and ALAIN VASSEL (ONERA, Chatillon, France) ONERA, TP no. 1992-106 1992 8 p. World Conference on Titanium, 7th, San Diego, CA, June 28-July 2, 1992 Research supported by SNECMA refs (ONERA, TP NO. 1992-106)

The 'beta-CEZ' alloy (Ti-5Al-2Sn-4Zr-4Mo-2Cr-1Fe) developed by CEZUS in France is designed for use in advanced aeroengines compressors up to 450 C. It is recognized that in this class of titanium alloys, the isothermal omega phase or titanium compounds may precipitate during ageing treatments or service conditions. The presence of these phases has been looked for to detect potential embrittlement of the alloy. Microstructural investigations revealed the good stability of the alloy; no harmful phase precipitates under usual conditions. Author (revised)

A93-38736

MATERIALS PROBLEMS CONNECTED WITH THE PROPULSION OF SUPERSONIC AIR CARRIERS

A. LASALMONIE (SNECMA, Evry, France), C. PLANQUET (SNECMA, Moissy-Cramayel, France), and P. COSTA (ONERA, Chatillon, France) ONERA, TP no. 1992-157 1992 10 p. EUROMAT 92, Genoa, Italy, Sept. 22-29, 1992 refs (ONERA, TP NO. 1992-157)

The paper discusses major improvements to the Concorde

supersonic jet, which must be met with regard to the specific fuel consumption, noise, and pollution in order to fulfill the certification and cost-effectiveness requirements of a Concorde successor called Alliance. Particular attention is given to the improvements to be made in classical materials (superalloys and titanium) which are required for the development of the Alliance engine. The properties of the polyimide, titanium, glass, ceramic-matrix, and intermetallic composites are discussed in the framework of defining a superalloy for disks working at 800 C and materials that can be used for the turbine shaft working at 500 C under very high torques. AIAA

A93-38893

HIGH TEMPERATURE FRACTURE MECHANISM OF GAS-PRESSURE SINTERED SILICON NITRIDE

N. KOHLER (Rheinland-Pfalz, Fachhochschule Koblenz, Germany), Y. IKUHARA, H. AWAJI, and K. FUNATANI (Japan Fine Ceramics Center, Nagoya) *In* Fracture mechanics of ceramics. Vol. 10 - Fracture fundamentals, high-temperature deformation, damage, and design; Proceedings of the 5th International Symposium, Nagoya, Japan, July 15-17, 1991 New York Plenum Press 1992 p. 367-377. refs

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The high temperature strength and the fracture behavior of gas pressure sintered silicon nitride are studied using flexural testing, fracture toughness testing, and microstructure and fractographic SEM and TEM observations. The focus is on the deformation and the fracture behavior at high temperatures which are accompanied by a slow crack growth phenomenon. AIAA

A93-39024

INELASTICITY EFFECT IN A UNIDIRECTIONAL BORON/ALUMINUM COMPOSITE UNDER UNIAXIAL TENSION [OB EFEEKTE NEUPRUGOSTI V ODNONAPRAVLENNOM KOMPOZITE BOROALUMINII PRI ODNOSNOM RASTIAZHENII]

A. N. LOGVINOV and V. I. TREGUB *In* Powder metallurgy and metals science Kuibyshev, Russia Kuibyshevskii Aviatsionnyi Institut 1990 p. 123-126. *In* RUSSIAN

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The deformation behavior of a unidirectional boron/aluminum composite was investigated experimentally under conditions of uniaxial tension. The tests were carried out on specimens of 1.1-mm thick sheet material with a fiber volume fraction of 50 percent. An important effect discovered in the experiments is the absence of the section characteristic of the Hooke law on the tensile diagram. At the early stages of tensile loading, the conditional elastic modulus is higher than the conditional elastic modulus at stresses close to the breaking point. This deformation behavior of the composite is attributed to fiber distortion during the composite production process. AIAA

N93-26702*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

AN OVERVIEW OF ELEVATED TEMPERATURE DAMAGE MECHANISMS AND FATIGUE BEHAVIOR OF A UNIDIRECTIONAL SCS-6/TI-15-3 COMPOSITE

MICHAEL G. CASTELLI (Sverdrup Technology, Inc., Brook Park, OH.) and JOHN GAYDA Apr. 1993 16 p Proposed for presentation at the Tenth Biennial Conference on Reliability, Stress Analysis and Failure Prevention, Albuquerque, NM, 19-22 Sep. 1993; sponsored by ASME (Contract RTOP 510-06-50) (NASA-TM-106131; E-7729; NAS 1.15:106131) Avail: CASI HC A03/MF A01

The fatigue behavior of a unidirectionally reinforced titanium matrix composite (TMC), SiC/Ti-15-3, was thoroughly characterized to support life prediction modeling of advanced TMC disks designed for gas turbine engine applications. The results of this coupon-level experimental investigation are reviewed. On a stress basis, the isothermal fatigue behavior of the (0 deg) TMC revealed significant improvements over the unreinforced matrix. In contrast, the (90 deg) TMC exhibited degraded properties and lives for similar

comparisons. This was attributed to the weak fiber/matrix interfacial bond. Encasing the (0 deg) TMC with a Ti-15-3 case did not affect isothermal fatigue lives at higher strain levels. However, at lower strain levels, rapid initiation and propagation of large fatigue cracks in the case degraded the fatigue lives. Thermomechanical fatigue (TMF) lives were significantly reduced for the (0 deg) TMC when compared to isothermal lives. At high strains, in-phase TMF produced extremely short lives. This degradation was attributed to fiber overload failures brought about by stress relaxation in the matrix. At low strains, out-of-phase TMF conditions became life limiting. Environment-assisted surface cracking was found to accelerate fatigue failure. This produced extensive matrix damage with minimal fiber damage. For the (90 deg) TMC, TMF conditions did not promote an additional degradation in cyclic life beyond that observed under isothermal conditions. Author (revised)

N93-27092*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

PROBABILISTIC ASSESSMENT OF COMPOSITE STRUCTURES C. C. CHAMIS and MICHAEL C. SHIAO (Sverdrup Technology, Inc., Brook Park, OH.) Feb. 1993 20 p (Contract RTOP 510-02-12) (NASA-TM-106024; E-7587; NAS 1.15:106024) Avail: CASI HC A03/MF A01

A methodology and attendant computer code were developed and are used to computationally simulate the uncertain behavior of composite structures. The uncertain behavior includes buckling loads, stress concentration factors, displacements, stress/strain, etc., which are the consequences of the inherent uncertainties (scatter) in the primitive (independent random) variables (constituent, ply, laminate, and structural) that describe the composite structures. The computer code is IPACS (Integrated Probabilistic Assessment of Composite Structures). IPACS can simulate both composite mechanics and composite structural behavior. Application to probabilistic composite mechanics is illustrated by its use to evaluate the uncertainties in the major Poisson's ratio and in laminate stiffness and strength. IPACS' application to probabilistic structural analysis is illustrated by its use to evaluate the uncertainties in the buckling of a composite plate, the stress concentration factor in a composite panel, and the vertical displacement and ply stress in a composite aircraft wing segment. IPACS' application to probabilistic design is illustrated by its use to assess the thin composite shell (pipe). Author (revised)

N93-27667# Space Exploration Association, Cedarville, OH.

JOINING CARBON COMPOSITE FINS TO TITANIUM HEAT PIPES Final Report, 8 Jun. 1992 - 15 Feb. 1993

ELLIOT B. KENNEL, ARNOLD H. DEUTCHMAN, ROBERT L. PARTYKA, ANATOLIY YASTREBKOV, and YURI NIKOLAYEV 15 Feb. 1993 41 p (Contract DASG60-92-C-0137) (AD-A261970) Avail: CASI HC A03/MF A01

An experimental effort was conducted to metallize a high thermal conductivity carbon carbon composite using ion beam enhanced deposition, and then to join it to titanium by diffusion bonding. Basic feasibility of the concept was demonstrated. DTIC

N93-28226# Virginia Polytechnic Inst. and State Univ., Blacksburg. Dept. of Aerospace and Ocean Engineering.

DIRECT MEASUREMENTS OF SKIN FRICTION IN SUPERSONIC COMBUSTION FLOW FIELDS

K. M. CHADWICK, D. J. DETURRIS, J. A. SCHETZ, and R. F. HELLBAUM Mar. 1993 17 p (Contract MIPR-FY1455-90-N0658) (AD-A262878; WL-TR-93-2051) Avail: CASI HC A03/MF A01

The final report consists of an AIAA and an ASME paper. An experimental investigation was conducted to measure skin friction along the chamber walls of supersonic combustors. A direct force measurement device was used to simultaneously measure an axial and transverse component of the small tangential shear force passing over a non-intrusive floating element. Skin friction

11 CHEMISTRY AND MATERIALS

coefficients between 0.001-0.005 were measured dependent on the facility and measurement location. Analysis of the measurement uncertainties indicate an accuracy to within + or - 10-15% of the streamwise component. DTIC

N93-28564# Oak Ridge National Lab., TN.
PROCESS OPTIMIZATION OF HEXOLOY SX-SIC TOWARDS IMPROVED MECHANICAL PROPERTIES

G. V. SRINIVASAN (Carborundum Co., Niagara Falls, NY.), S. K. LAU (Carborundum Co., Niagara Falls, NY.), R. S. STORM (Carborundum Co., Niagara Falls, NY.), M. K. FERBER, and M. G. JENKINS 1993 14 p Presented at the 38th ASME International Gas Turbine and Aeroengine Congress and Exhibition, Cincinnati, OH, 24-27 May 1993

(Contract DE-AC05-84OR-21400)

(DE93-007913; CONF-930502-3) Avail: CASI HC A03/MF A01

Results show that SiC materials sintered with additions of Y and Al compounds can achieve the high level of mechanical properties required for use in heat engines. However, the reaction of the second phase with SiC resulting in strength limiting pools, result in increased variability in materials properties. If this variability can be controlled, the relatively low cost of raw materials and processing for Hexoloy SX manufacture would make these materials attractive for low and high temperature engine applications. DOE

N93-28592# Battelle Pacific Northwest Labs., Richland, WA.
ULTRAHIGH TEMPERATURE ASSESSMENT STUDY: CERAMIC MATRIX COMPOSITES Final Report, Jul. 1988 - May 1990

E. L. COURTRIGHT, H. C. GRAHAM, A. P. KATZ, and R. J. KERANS Sep. 1992 143 p

(Contract MIPR-FY1457-88-N-5052; AF PROJ. 2420)

(AD-A262740; WL-TR-91-4061) Avail: CASI HC A07/MF A02

As part of the U.S. Air Force initiative to develop high temperature materials for use in future gas turbine engines, a literature survey coupled with an assessment of recently completed experimental programs sponsored by the Air Force was made to evaluate prospective materials capable of operating at 1650 deg C or above in oxidizing environments. The assessment reviews fundamental considerations associated with the use of ceramics and ceramic matrix composites in representative environments and includes discussions on potential performance requirements. Key material categories (e.g., borides, carbides, nitrides, silicides, beryllides, and oxides) are evaluated with respect to their strengths and weaknesses. The reinforcements available for high temperature composite applications are reviewed and several prospective composite systems considered. A principal conclusion relative to possible uses for long-term man-rated gas turbine engines is that oxide/oxide composites have the best potential for functional use in oxidizing environments above 1650 deg C provided adequate single-crystal reinforcement fibers can be developed. Several nonoxide materials and composites were identified for possible uses in short-duty cycle non-man-rated applications. In addition to materials development, there will be critical need for high-temperature test facilities that can be operated in representative oxidizing environments. DTIC

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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.

A93-35930
A VIBRATION MONITORING ACQUISITION AND DIAGNOSTIC SYSTEM FOR HELICOPTER DRIVE TRAIN BENCH TESTS

DIMITRI A. DOUSIS (Bell Helicopter Textron, Inc., Fort Worth, TX) /n AHS, Annual Forum, 48th, Washington, June 3-5, 1992, Proceedings. Vol. 1 Alexandria, VA American Helicopter Society 1992 p. 355-369. refs
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An automated drive train test stand vibration monitoring system called VMADS has been developed by Bell Helicopter Textron, Inc., and has been installed at Bell's transmission bench test facility. VMADS provides the operator with warning and alarm indications for preselected degraded conditions, and acquires vibration data to be used by engineers to improve the diagnostics for better fault detection and fault isolation. VMADS is used as a test bed for new monitoring and diagnostic algorithm evaluation and validation, a necessary step to ensure development of accurate, reliable integrated health usage monitoring systems for the Bell rotorcraft fleet. This paper highlights the VMADS features for helicopter and tiltrotor aircraft drive train bench test monitoring and diagnostics and discusses supportive ongoing health and usage monitoring activities at BHTI, both military and commercial for enhanced safety and reduced maintenance costs. Bell is translating VMADS developed capability to airborne applications, while simultaneously enhancing the original VMADS capabilities.

Author

A93-35931
A HIGH DEFLECTION DIAPHRAGM CONCEPT (HDD) FOR POWER TRANSMISSION SHAFTING

JOSEPH A. STOCCO (Lucas Aerospace Power Transmission Corp., Utica, NY) /n AHS, Annual Forum, 48th, Washington, June 3-5, 1992, Proceedings. Vol. 1 Alexandria, VA American Helicopter Society 1992 p. 371-374. refs
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This paper will present a flexible metal diaphragm concept for power transmission shifting or couplings which must not only carry torque, but are also required to accommodate large amounts of axial and angular misalignments. The concept was developed through an analytical research investigation of diaphragm stress and their performance characteristics. This research will be described. The quality, reliability, meantime between failure and expected life characteristics of HDD diaphragms will be presented in this work. As proof of the design concept, diaphragms for a particular hypothetical application were fabricated into a prototype shaft, and tested. The results of this validation study will also be described herein. During the course of the testing program, it was decided to extend the analysis and the test evaluation to examine the effects of inducing damage in a diaphragm, as might occur during hostile encounters or abnormal operation. Author

A93-35953
ON DESIGN AND OPTIMIZATION OF CURVED COMPOSITE BEAMS

A. W. PECK and O. A. BAUCHAU (Rensselaer Polytechnic Inst., Troy, NY) /n AHS, Annual Forum, 48th, Washington, June 3-5, 1992, Proceedings. Vol. 1 Alexandria, VA American Helicopter Society 1992 p. 647-660. refs
(Contract DAAL03-88-C-0004)
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A simple 'strength of materials'-based analytical solution for flange curling and web crushing is used to examine the design and optimization of curved composite I- and box beams under bending. The ply orientations and stacking sequence of the flange are found to drastically affect the nature of these stress redistributions and consequently the overall load-carrying capability of the beam. Overall frame optimization is explored. To maximize the load-carrying capability, for a given amount of material, of a curved beam structure under bending in its own plane, the overall bending stiffness should be maximized and flange curling minimized. For composite beams, this is most effectively accomplished by minimizing web thickness and placing a large percentage of flange fibers perpendicular to the web. For the box beam, a low web bending stiffness appears beneficial in reducing flange curling moments. AIAA

A93-35978* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

AEROELASTIC BEHAVIOR OF COMPOSITE ROTOR BLADES WITH SWEEP TIPS

KUO-AN YUAN, PERETZ P. FRIEDMANN, and COMANDUR VENKATESAN (California Univ., Los Angeles) *In* AHS, Annual Forum, 48th, Washington, June 3-5, 1992, Proceedings. Vol. 2 Alexandria, VA American Helicopter Society 1992 p. 1039-1059. refs

(Contract NAG1-833)

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This paper presents an analytical study of the aeroelastic behavior of composite rotor blades with straight and swept tips. The blade is modeled by beam type finite elements. A single finite element is used to model the swept tip. The nonlinear equations of motion for the finite element model are derived using Hamilton's principle and based on a moderate deflection theory and accounts for: arbitrary cross-sectional shape, pretwist, generally anisotropic material behavior, transverse shears and out-of-plane warping. Numerical results illustrating the effects of tip sweep, anhedral and composite ply orientation on blade aeroelastic behavior are presented. It is shown that composite ply orientation has a substantial effect on blade stability. At low thrust conditions, certain ply orientations can cause instability in the lag mode. The flap-torsion coupling associated with tip sweep can also induce aeroelastic instability in the blade. This instability can be removed by appropriate ply orientation in the composite construction.

Author

A93-36000

EVALUATION OF THERMOPLASTIC STIFFENED PANELS FOR APPLICATION TO ROTORCRAFT AIRFRAMES

DOUGLAS B. WEEMS and STEVEN G. LLORENTE (Boeing Defense & Space Group, Helicopters Div., Philadelphia, PA) *In* AHS, Annual Forum, 48th, Washington, June 3-5, 1992, Proceedings. Vol. 2 Alexandria, VA American Helicopter Society 1992 p. 1411-1419. /* refs

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An experimental evaluation of thermoplastic skin-stiffener structure was conducted by evaluating the shear strength, impact resistance, and damage tolerance of stiffened panels with thin-gage skins. Seventeen 23.5 x 23.5 inch three-stiffener test panels were manufactured with five skin configurations: 0.020 inch, 0.030 inch, and 0.040 inch thick IM7/APC-2 and 0.030 inch and 0.040 inch thick AS4/APC-2. In low-velocity impact trials, the IM7/APC-2 panels showed much higher impact resistance than the AS4/APC-2 panels, and both thermoplastic configurations showed higher impact resistance than AS4/3501-6 graphite/epoxy panels tested previously. In picture-frame shear tests, the undamaged thermoplastic shear panels suffered buckling-induced stiffener debonding but had failure loads above AS4/3501-6 panels with the same skin thickness. Residual panel strength after impact varied considerably due to variation in the damage states, but all failure loads were equal to or higher than those of the AS4/3501-6 panels. In tests of both undamaged and impacted panels, the failure stresses of the IM7/APC-2 and AS4/APC-2 panels were similar.

Author (revised)

A93-36006

NONLINEAR ANALYSIS OF COMPOSITE THIN-WALLED HELICOPTER BLADES

J. P. KALFON and O. RAND (Technion - Israel Inst. of Technology, Haifa) *In* AHS, Annual Forum, 48th, Washington, June 3-5, 1992, Proceedings. Vol. 2 Alexandria, VA American Helicopter Society 1992 p. 1465-1478. refs

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Nonlinear theoretical modeling of laminated thin-walled composite helicopter rotor blades is presented. The derivation is based on nonlinear geometry with a detailed treatment of the body loads in the axial direction which are induced by the rotation. While the in-plane warping is neglected, a three-dimensional generic out-of-plane warping distribution is included. The formulation may also handle varying thicknesses and mass distribution along the

cross-sectional walls. The problem is solved by successive iterations in which a system of equations is constructed and solved for each cross-section. In this method, the differential equations in the spanwise directions are formulated and solved using a finite-differences scheme which allows simple adaptation of the spanwise discretization mesh during iterations.

Author

A93-36588* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

MODAL ANALYSIS OF MULTISTAGE GEAR SYSTEMS COUPLED WITH GEARBOX VIBRATIONS

F. K. CHOY, Y. F. RUAN, Y. K. TU (Akron Univ., OH), J. J. ZAKRAJSEK, and D. P. TOWNSEND (NASA, Lewis Research Center, Cleveland, OH) *ASME, Transactions, Journal of Solar Energy Engineering* (ISSN 0199-6231) vol. 114 Sept. 1992 p. 486-497. Previously announced in STAR as N91-23513 refs

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An analytical procedure to simulate vibrations in gear transmission systems is presented. This procedure couples the dynamics of the rotor-bearing gear system with the vibration in the gear box structure. The model synthesis method is used in solving the overall dynamics of the system, and a variable time-stepping integration scheme is used in evaluating the global transient vibration of the system. Locally each gear stage is modeled as a multimass rotor-bearing system using a discrete model. The modal characteristics are calculated using the matrix-transfer technique. The gearbox structure is represented by a finite element models, and modal parameters are solved by using NASTRAN. The rotor-gear stages are coupled through nonlinear compliance in the gear mesh while the gearbox structure is coupled through the bearing supports of the rotor system. Transient and steady state vibrations of the coupled system are examined in both time and frequency domains. A typical three-gear system is used as an example for demonstration of the developed procedure.

Author

A93-36782

STRESS-STRAIN ANALYSIS AND OPTIMAL DESIGN OF AIRCRAFT STRUCTURES [RASCHETY NAPRIAZHENNO-DEFORMIROVANNOGO SOSTOIANIIA I RATSIONAL'NOE PROEKTIROVANIE AVIATSIONNYKH KONSTRUKTSII]

I. A. LIAKHOVENKO, ED. Moscow Izdatel'skii Otdel TsAGI (TsAGI, Trudy, No. 2495) 1992 166 p. In Russian. For individual items see A93-36783 to A93-36800

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The papers contained in this volume present results of theoretical and experimental research related to the stress-strain analysis and optimal design of aircraft structures. Topics discussed include a study of the origin of residual stresses and strains in the transparencies of supersonic aircraft, methodology for studying the fracture of aircraft structures in static tests, and the stability of a multispan panel under combined loading. The discussion also covers optimization of the stiffness and mass characteristics of lifting surface structures modeled by an elastic beam, a study of the strength of a closed system of wings, and a method for the optimal design of a large-aspect-ratio wing.

AIAA

A93-36789

OPTIMIZATION OF THE STIFFNESS AND MASS CHARACTERISTICS OF LIFTING SURFACE STRUCTURES MODELED BY AN ELASTIC BEAM [OPTIMIZATSIIA ZHESTKOSTNYKH I MASSOVYKH KHARAKTERISTIK KONSTRUKTSII NESUSHCHIKH POVERKHNOSTEI, MODELIRUEMYKH UPRUGOI BALKOI]

E. K. LIPIN and V. V. CHEDRIK *In* Stress-strain analysis and optimal design of aircraft structures Moscow Izdatel'skii Otdel TsAGI 1992 p. 66-77. In Russian. refs

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A method and a program for the design analysis of the lifting surface structures of aircraft using a beam computational scheme are described which involve solving the mass minimization problem for a structural material with constraints on strength and stiffness.

Strength constraints are specified in the form of permissible stresses; stiffness constraints are formulated as bounds on transverse displacements and increments of the flow angles of attack for the end section for several loading schemes. The results are compared with those of a finite element analysis. AIAA

A93-36792

A STUDY OF THE STRENGTH OF A CLOSED SYSTEM OF WINGS [ISSLEDOVANIE PROCHNOSTI ZAMKNUTOI SISTEMY KRYL'EV]

V. N. SEMENOV *In* Stress-strain analysis and optimal design of aircraft structures Moscow Izdatel'skii Otdel TsAGI 1992 p. 87-91. In Russian. refs

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An analysis made of the effect of different structural designs of a closed system of wings on the mass of the required structural material and on the deformations. The locations of the structural load-bearing connecting elements are determined using a minimum-mass criterion. It is shown that, in comparison with a monoplane configuration, closed systems of wings are characterized by a lower mass and a greater stiffness, which makes them promising for future flight vehicles. AIAA

A93-36793

A METHOD FOR THE OPTIMUM DESIGN OF A LARGE-ASPECT-RATIO WING [METODIKA RATSIONAL'NOGO PROEKTIROVANIYA KRYLA BOL'SHOGO UDLINENIYA]

V. P. FOMIN *In* Stress-strain analysis and optimal design of aircraft structures Moscow Izdatel'skii Otdel TsAGI 1992 p. 92-104. In Russian. refs

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A method is presented for the design of a large-aspect-ratio wing box that is nearly optimal with respect to mass and strength characteristics, while satisfying constraints on permissible stresses, local stability, and load-bearing capacity. The principal stages of the computer-aided design process and strength analysis are reviewed. The design allows for the main characteristics of the nonlinear behavior of the structural elements, including plasticity, buckling, and failure. The application of the methodology described here is illustrated by examples. AIAA

A93-36799

A PLATE LOADED BY A TRANSVERSE IMPULSE FORCE AND IN-PLANE FORCES [PLASTINKA POD DEISTVIEM IMPUL'SNOI POPERECHNOI NAGRUZKI I SIL V EE PLOSKOSTI]

A. V. MERKUR'EV *In* Stress-strain analysis and optimal design of aircraft structures Moscow Izdatel'skii Otdel TsAGI 1992 p. 150-156. In Russian. refs

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An analytical solution is presented for the problem of determining the deflections of a hinged rectangular plate loaded by a transverse impulse force over part of its surface and by in-plane forces. Results of calculations for a square plate are found to be in agreement with data in the literature. AIAA

A93-36800

OPTIMAL DESIGN OF HONEYCOMB SANDWICH SHELL AIRCRAFT STRUCTURES OF COMPOSITE MATERIALS [RATSIONAL'NOE PROEKTIROVANIE TREKHSLOINNYKH SOTOVYKH OBOLOCHECHNYKH AVIAKONSTRUKTSII IZ KOMPOZITSIONNYKH MATERIALOV]

IU. F. KRASHAKOV and S. M. KHOKHLENKOV *In* Stress-strain analysis and optimal design of aircraft structures Moscow Izdatel'skii Otdel TsAGI 1992 p. 157-165. In Russian. refs

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Methods for optimizing the design of sandwich composite shells with a honeycomb core are presented using a helicopter tail boom structure as an example. In particular, attention is given to the minimum-mass design using criteria of local and general stability, strength, and stiffness in the presence of structural and technological constraints. The characteristics of two shell structures, one fabricated by the layup method and the other by winding with a varying reinforcement angle, are compared. AIAA

A93-37046* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

MODELING OF LINEAR ISENTROPIC FLOW SYSTEMS

ATHAN D. SARANTOPOULOS and TOM T. HARTLEY (Akron Univ., OH) *In* IEEE International Conference on Systems Engineering, Dayton, OH, Aug. 1-3, 1991, Proceedings New York Institute of Electrical and Electronics Engineers, Inc. 1991 p. 442-445. Previously announced in STAR as N92-22495 refs (Contract NAG3-904)

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A modeling approach for linear isentropic flow systems based on the quasi-one-dimensional Euler equations of non-viscous, compressible flow are presented. Such systems are representative of certain high speed propulsion systems. Accurate models useful in control system studies are developed. A supersonic inlet is considered, and the resulting set of partial differential equations with boundary conditions is solved for a linear transfer matrix using Laplace transforms. Author

A93-37072

SAFEBUS

KENNETH HOYME and KEVIN DRISCOLL (Honeywell Systems and Research Center, Minneapolis, MN) IEEE Aerospace and Electronic Systems Magazine (ISSN 0885-8985) vol. 8, no. 3 March 1993 p. 34-39.

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An innovative backplane bus, called SAFEbus, has been designed to provide communications of all data among the line replaceable modules (LRM) in the Boeing 777 AIMS cabinets. SAFEbus consists of two self-checking buses (SCBs); each SCB is composed of two buses. The interface logic, including the bus interface units (BIUs), is also duplicated. One of the BIUs transmits data on one of the buses in an SCB, and its partner transmits on the other bus. The data on any two buses which come from different BIUs are compared at the receiver. The SCBs provide error-detection coverage that exceeds that provided by CRC codes, and they do so without consuming transmission time. SAFEbus determinism, table versioning, data-message structure, and synchronization messages are also discussed. AIAA

A93-37350

EMBEDDED BRAGG GRATING FIBER OPTIC SENSOR FOR COMPOSITE FLEXBEAMS

DANIEL BULLOCK (Foster-Miller, Inc., Advanced Composite Materials Div., Waltham, MA), JAMES DUNPHY (United Technologies Research Center, East Hartford, CT), and GERARD HUFSTETLER (U.S. Army, Aviation-Applied Technology Directorate, Fort Eustis, VA) *In* Fiber optic smart structures and skins V; Proceedings of the Meeting, Boston, MA, Sept. 8, 9, 1992 Bellingham, WA Society of Photo-Optical Instrumentation Engineers 1993 p. 253-261.

(Contract DAAJ02-91-C-0022)

Copyright

An embedded fiber-optic (F-O) sensor has been developed for transverse monitoring of the structural integrity of composites, with a view to application in composite helicopter flexbeams for bearingless main rotor hubs. This through-thickness strain sensor is much more sensitive than conventional in-plane embedded F-O sensors to ply delamination, on the basis of a novel insertion technique and innovative Bragg grating sensor. Experimental trials have demonstrated the detection by this means of potential failures in advance of the edge-delamination or crack-propagation effect. AIAA

A93-37393

EVALUATION AND EXTENSION OF THE FLUTTER-MARGIN METHOD FOR FLIGHT FLUTTER PREDICTION

S. J. PRICE (McGill Univ., Montreal, Canada) and B. H. K. LEE (Inst. for Aerospace Research, Ottawa, Canada) Journal of Aircraft (ISSN 0021-8669) vol. 30, no. 3 May-June 1993 p. 395-402. AIAA Dynamics Specialists Conference, Dallas, TX, Apr. 16, 17, 1992, Technical Papers, p. 188-200. Previously cited in issue 14,

p. 2376, Accession no. A92-35672 Research supported by Inst. for Aerospace Research, DND, NSERC, and FCAR refs Copyright

A93-37403**SHAPE SENSITIVITIES AND APPROXIMATIONS OF MODAL RESPONSE OF LAMINATED SKEW PLATES**

SARVESH SINGHVI and RAKESH K. KAPANIA (Virginia Polytechnic Inst. and State Univ., Blacksburg) Journal of Aircraft (ISSN 0021-8669) vol. 30, no. 3 May-June 1993 p. 423-426. AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics and Materials Conference, 33rd, Dallas, TX, Apr. 13-15, 1992, Technical Papers. Pt. 4, p. 1858-1869. Previously cited in issue 13, p. 2213, Accession no. A92-34465 refs Copyright

A93-37428*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

HYPersonic FLUTTER OF A CURVED SHALLOW PANEL WITH AERODYNAMIC HEATING

T. BEIN, P. FRIEDMANN, X. ZHONG, and I. NYDICK (California Univ., Los Angeles) Apr. 1993 16 p. AIAA, ASME, ASCE, AHS, and ASC, Structures, Structural Dynamics and Materials Conference, 34th and AIAA and ASME, Adaptive Structures Forum, La Jolla, CA, Apr. 19-22, 1993 Research supported by Univ. of California refs (Contract NCC2-374)

(AIAA PAPER 93-1318) Copyright

The general equations describing the nonlinear fluttering oscillations of shallow, curved, heated orthotropic panels have been derived. The formulation takes into account the location of the panel on the surface of a generic hypersonic vehicle, when calculating the aerodynamic loads. It is also shown that third order piston theory produces unsteady aerodynamic loading which is in close agreement with that based upon direct solution of the Euler equations. Results, for simply supported panels, are obtained using Galerkin's method combined with direct numerical integration in time to compute stable limit cycle amplitudes. These results illustrate the sensitivity of the aeroelastic behavior to the unsteady aerodynamic assumptions, temperature, orthotropicity and flow orientation. Author

A93-37438# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

TRANSONIC PANEL FLUTTER

GARY A. DAVIS and ODDVAR O. BENDIKSEN (California Univ., Los Angeles) Apr. 1993 15 p. AIAA, ASME, ASCE, AHS, and ASC, Structures, Structural Dynamics and Materials Conference, 34th and AIAA and ASME, Adaptive Structures Forum, La Jolla, CA, Apr. 19-22, 1993 Research supported by NASA refs (Contract NCC2-374)

(AIAA PAPER 93-1476) Copyright

FEM is here used to ascertain the stability and aeroelastic response of thin, 2D panels subjected to Mach 0.8-2.5 flows. In the absence of shocks, it is found that the Euler equations used to represent the unsteady flowfield dynamics predict response behaviors resembling those obtained via potential flow methods. Where shocks do play a significant role in the overall motion of the panel, divergence and limit cycle flutter are observed. In the Mach 1.4-1.5 range, flutter involved the higher modes of the panel, tending toward possible chaotic motion. AIAA

A93-37439*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

NONCLASSICAL AILERON BUZZ IN TRANSONIC FLOW

ODDVAR O. BENDIKSEN (California Univ., Los Angeles) Apr. 1993 13 p. AIAA, ASME, ASCE, AHS, and ASC, Structures, Structural Dynamics and Materials Conference, 34th and AIAA and ASME, Adaptive Structures Forum, La Jolla, CA, Apr. 19-22, 1993 refs

(Contract NCC2-374)

(AIAA PAPER 93-1479) Copyright

A computational study of inviscid, transonic aileron and

trailing-edge buzz instabilities is presented. A mixed Eulerian-Lagrangian formulation is used to model the fluid-structure system and to obtain a system of space-discretized equations that is time-marched to simulate the aeroelastic behavior of the wing-aileron system. Results obtained suggest that shock-induced separation may not be an essential driving force behind all buzz phenomena. Several examples are shown where the shock motion interacts with the aileron motion to extract energy from the flow. If the trailing-edge region is sufficiently flexible and the shocks are at the trailing edge, a trailing-edge buzz instability appears possible. Author

A93-37441#**NONLINEAR FLUTTER OF COMPOSITE PLATES WITH DAMAGE EVOLUTION**

YOUNG I. KIM, THOMAS W. STRAGNAC, and ANDREW J. KURDILA (Texas A & M Univ., College Station) Apr. 1993 10 p. AIAA, ASME, ASCE, AHS, and ASC, Structures, Structural Dynamics and Materials Conference, 34th and AIAA and ASME, Adaptive Structures Forum, La Jolla, CA, Apr. 19-22, 1993 refs (Contract F49620-92-J-0450)

(AIAA PAPER 93-1546) Copyright

The investigators present a study of dynamic and aeroelastic response of structures which evolve due to damage. Aeroelastic response is shown to be dependent upon the distribution and accumulation of damage. In turn, the damage is dependent upon the presence of the aerodynamic loads. Dynamic characteristics are unique to the coupled damage/aeroelastic system and are developed as part of the solution methodology. In this study, the damage is due to the natural progression of microcracking of the composite structure; yet, the control model presented is appropriate for distributed actuation systems. The stability boundary for aeroelastic flutter and divergence evolves due to damage. Control design based upon the min-max control theory is presented which addresses model uncertainties. Author

A93-37443#**EXTRACTION OF INHERENT AERODYNAMIC LAG POLES FOR THE TIME DOMAIN REPRESENTATION OF MODAL UNSTEADY AIRLOADS**

S. SURYANARAYAN (Analytical Services and Materials, Inc., Hampton, VA), K. PANDA, and B. G. PRAKASH (Aeronautical Development Agency, Bangalore, India) Apr. 1993 9 p. AIAA, ASME, ASCE, AHS, and ASC, Structures, Structural Dynamics and Materials Conference, 34th and AIAA and ASME, Adaptive Structures Forum, La Jolla, CA, Apr. 19-22, 1993 refs (AIAA PAPER 93-1591) Copyright

Time domain representation of modal unsteady airloads computed in the frequency domain involves finite state modeling of these loads. This is often achieved using a rational function approximation in the Laplace domain with a number of simple or higher order poles to account for the aerodynamic lag effects. The values of the aerodynamic lag poles are either chosen from experience or obtained from elaborate computation involving nonlinear optimization techniques. The actual values of these lag poles computed to minimize the errors have no specific significance and change with the number of lag states chosen in the finite state model. This paper presents the use of a modified rational function approximation which brings out the quasi-steady aerodynamics, acceleration dependent forces, and pure aerodynamic lag effects as explicit components of the total airloads expression. It is shown that the modified rational function approximation enables the extraction of an inherent lag pole from the pure aerodynamic lag term in each of the unsteady airload coefficients. Results are presented for typical unsteady airload coefficients computed for a delta-wing aircraft configuration. Author (revised)

A93-37867* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

RADI EFFECT ON THE TRANSLATION SPRING CONSTANT OF FORCE TRANSDUCER BEAMS

C. E. SCOTT (NASA, Langley Research Center, Hampton, VA)

12 ENGINEERING

In International Instrumentation Symposium, 38th, Las Vegas, NV, Apr. 26-30, 1992, Proceedings Research Triangle Park, NC Instrument Society of America 1992 p. 417-432.
Copyright

Multi-component strain-gage force transducer design requires the designer to determine the spring constant of the numerous beams or flexures incorporated in the transducer. The classical beam deflection formulae that are used in calculating these spring constants typically assume that the beam has a uniform moment of inertia along the entire beam length. In practice all beams have a radius at the end where the beam interfaces with the shoulder of the transducer, and on short beams in particular this increases the beam spring constant considerably. A Basic computer program utilizing numerical integration is presented to determine this effect.
Author

A93-37876

WIND TUNNEL OPERATOR AIMED COMPARISON BETWEEN TWO ELECTRONIC PRESSURE SCANNER SYSTEMS

F. NITTI and F. FUSCO (Centro Italiano Ricerche Aerospaziali, Capua, Italy) *In* International Instrumentation Symposium, 38th, Las Vegas, NV, Apr. 26-30, 1992, Proceedings Research Triangle Park, NC Instrument Society of America 1992 p. 597-603. Previously announced in STAR as N93-11225 refs
Copyright

A comparison made between two different electronic pressure scanner systems is outlined. This comparison was done from the wind tunnel user point of view and covered the following topics: software and hardware setting up for a test configuration; calibration procedure; versatile and user friendly features of the software packages managing the systems; and response stability measurement. Differences and similarities of the systems are outlined.
Author

A93-37878* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

DIGITAL RESOLVER FOR HELICOPTER MODEL BLADE MOTION ANALYSIS

T. S. DANIELS, J. D. BERRY (NASA, Langley Research Center, Hampton, VA), and S. PARK (Old Dominion Univ., Norfolk, VA) *In* International Instrumentation Symposium, 38th, Las Vegas, NV, Apr. 26-30, 1992, Proceedings Research Triangle Park, NC Instrument Society of America 1992 p. 619-628. refs
Copyright

The paper reports the development and initial testing of a digital resolver to replace existing analog signal processing instrumentation. Radiometers, mounted directly on one of the fully articulated blades, are electrically connected through a slip ring to analog signal processing circuitry. The measured signals are periodic with azimuth angle and are resolved into harmonic components, with 0 deg over the tail. The periodic nature of the helicopter blade motion restricts the frequency content of each flapping and yaw signal to the fundamental and harmonics of the rotor rotational frequency. A minicomputer is employed to collect these data and then plot them graphically in real time. With this and other information generated by the instrumentation, a helicopter test pilot can then adjust the helicopter model's controls to achieve the desired aerodynamic test conditions.
AIAA

A93-37890

SILICON DIFFERENTIAL PRESSURE TRANSDUCER LINE PRESSURE EFFECTS AND COMPENSATION

S. E. KIM, MARK J. MILLER, and ROBERT GUZIAK (Mark IV Transducer Corp., Statham Transducer Div., Oxnard, CA) *In* International Instrumentation Symposium, 38th, Las Vegas, NV, Apr. 26-30, 1992, Proceedings Research Triangle Park, NC Instrument Society of America 1992 p. 809-820. refs
Copyright

A digital compensation method to correct the line pressure induced errors in silicon differential pressure sensors is presented. This method uses dual sensors, namely, one differential pressure sensor and one absolute pressure sensor. The digital compensation technique requires data regarding output deviations of both sensors

over varied differential pressure, line pressure, and temperature conditions. The transducer deviations are then corrected with a multivariate polynomial curve which is fit to the data by a microprocessor imbedded in the transducer. Common electronic components are employed in this compensation approach; they include high-accuracy analog-to-digital converters, digital-to-analog converters, microcontrollers, and precision references.
AIAA

A93-38126

NUMERICAL FLUID DYNAMICS SYMPOSIUM, 5TH, TOKYO, JAPAN, DEC. 19-21, 1991, PROCEEDINGS

Tokyo Numerical Fluid Dynamics Symposium Committee 1991 723 p. In Japanese and English. For individual items see A93-38127 to A93-38194

Various papers on numerical fluid dynamics are presented. Individual topics discussed include: numerical analysis (NA) of shock structure problems, CFD development and a future high-speed computer, simulating vortex motion by 3D method, application of CFD to turbomachine design, numerical simulation (NS) of converging shock waves, NS of unsteady 3D shock wave phenomenon, 5th-order accurate compact upwind scheme, development of a multidimensional upwind scheme, fortified solution algorithm, large-eddy simulation of a bound jet, construction of collision model of diatomic molecules, VSL analysis of nonequilibrium flows around a hypersonic body, NA of chemically nonequilibrium flow, topological transition of flow past some axisymmetric bodies, modeling of scalar transport in free turbulence, a contribution to general application of the vortex method. Also addressed are: vortex simulation of artificial control of mixing layers, 3D motion of vortex filaments, Navier-Stokes simulation of 2D mixing layer, active control of vortex shedding frequency by a jet, direct NS of homogeneous turbulent shear flow, NA of fuel spray jet by Eulerian method, NS of ignition using a premixed pulsed jet, NS of a scram jet combustor flow, numerical simulation of supersonic flow CO chemical laser, adaptive grid generation using optimal control theory, NS of characteristics of the Stalker tube, incompressible flow solver using velocity vector and a new variable, unsteady analysis of helicopter rotor.
AIAA

A93-38140

DOMAIN SPLITTING EXPLICIT TIME MARCHING SCHEME FOR SIMULATION OF UNSTEADY HIGH REYNOLDS NUMBER FLOW

KEISUKE SAWADA and OSAMU INOUE (Tohoku Univ., Sendai, Japan) *In* Numerical Fluid Dynamics Symposium, 5th, Tokyo, Japan, Dec. 19-21, 1991, Proceedings Tokyo Numerical Fluid Dynamics Symposium Committee 1991 p. 87-90. In JAPANESE refs

A domain splitting explicit time marching scheme is developed with the aim of conducting unsteady simulation of high Reynolds number flows. We employ a second-order MUSCL-type finite volume upwind scheme with an explicit one-step time integration adopting the Lax-Wendroff type recursive substitution in the preprocessing stage. A multidomain splitting is used to attain the required efficiency of the scheme. A conservative procedure retaining the accuracy of the scheme at the zone interface is described. A typical example which solves the flow field over a delta wing is shown.
Author (revised)

A93-38155

TURBULENT FLOW SIMULATION AROUND THE AEROFOIL WITH PSEUDO-COMPRESSIBILITY

YI QIAN and CHUICHI ARAKAWA (Tokyo Univ., Japan) *In* Numerical Fluid Dynamics Symposium, 5th, Tokyo, Japan, Dec. 19-21, 1991, Proceedings Tokyo Numerical Fluid Dynamics Symposium Committee 1991 p. 235-238. In JAPANESE refs

The method of pseudocompressibility was tested for its accuracy in solving the incompressible Navier-Stokes equation. Some turbulence models are introduced to calculate the flow in the high Reynolds number around the aerofoil (NACA-0012). These turbulence models are Baldwin-Lomax zero-equation model, low-Reynolds number version in k-epsilon two-equation model by

Chien, and q-omega two equation model by Coakley. The computational results qualitatively agree with the experimental data in the flows of small attack angle. Author (revised)

A93-38431
POST-CRITICAL BEHAVIOUR OF A TAPERED CANTILEVER COLUMN SUBJECTED TO A UNIFORMLY DISTRIBUTED TANGENTIAL FOLLOWER FORCE

B. NAGESWARA RAO and G. VENKATESWARA RAO (ISRO, Vikram Sarabhai Space Centre, Trivandrum, India) *Journal of Sound and Vibration* (ISSN 0022-460X) vol. 162, no. 2 April 8, 1993 p. 380-385. refs

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The post-critical behavior of a tapered cantilever column subjected to a uniformly distributed subtangential follower force, which at any point of the column axis forms the angle with the vertical direction at that point was studied. The formulation is based on the moment-curvature relationship, and the resultant eigenvalue problem is solved using a simple and reliable iterative numerical scheme. AIAA

A93-38571
THIN GRADIENT HEAT FLUXMETERS DEVELOPED AT ONERA

P. KAYSER, M. RODRIGUES, and J. C. GODEFROY (ONERA, Chatillon, France) ONERA, TP no. 1992-87 1992 13 p. ONERA, Workshop on New Trends in Instrumentation for Hypersonic Research, Toulouse, France, Apr. 27-May 1, 1992 Research supported by DRET refs (ONERA, TP NO. 1992-87)

Design of two types of transducers for measuring steady or quasi-steady fluxes developed at ONERA are described. A simple gradient fluxmeter operates on aerodynamical profiles or blades at temperatures up to 230 C. A multijunction gradient fluxmeter which is directly deposited on turbine blades or profiles operates at temperatures up to 1000 C. Both transducers are based on the thermoelectric effect which occurs at the junction point between two partially superimposed metals deposited as thin layers on electric insulating substrate. AIAA

A93-38583
INFRARED THERMOGRAPHY FOR HOT-SHOT WIND TUNNEL
 S. BARBE, D. BOSCHER, J. DESCHAMPS, G. GAUFFRE, and A. GIRARD (ONERA, Chatillon, France) ONERA, TP no. 1992-103 1992 5 p. ONERA, Workshop on New Trends in Instrumentation for Hypersonic Research, Toulouse, France, Apr. 27-May 1, 1992 (ONERA, TP NO. 1992-103)

Two high frame rate devices including a 1D scanning camera with a rate of 2500 lines per second and a staring infrared camera of 64x64 pixels with a rate of 400 images per second to be tested in a high enthalpy F4 facility are considered. The line scanner uses a commercial IR camera, Agema 880 LWB, with a HgCdTe detector operating in 8-12 microns wavelength range. The staring IR camera is based on a HgCdTe focal plane array from CENG-LIR, cooled at 77 K, and sensitive to the 3-5 microns spectral range. AIAA

A93-38593
DIGITAL IMAGE PROCESSING APPLIED TO HEAT TRANSFER MEASUREMENT IN HYPERSONIC WIND TUNNEL

M. C. MERIENNE, J. L. EDY, M. GIRARD, X. BRIOTTET, and M. DINGUIRARD (ONERA, Chatillon, France) ONERA, TP no. 1992-118 1992 7 p. European Forum on Wind Tunnels and Wind Tunnel Test Techniques, Southampton Univ., United Kingdom, Sept. 14-17, 1992 refs (ONERA, TP NO. 1992-118)

A digital image processing method to detect color transition lines developed under the test conditions of the ONERA Chalais-Meudon wind tunnels is presented. Data reduction of digital images includes preprocessing of the image sequence to eliminate nonuniform background, incorrect registration, and lighting defects; segmentation and detection of the three transition regions; and plotting of the results for thermal mapping and computing. AIAA

A93-38601
THE MEASUREMENT OF BLADE DEFLECTIONS - A NEW IMPLEMENTATION OF THE STRAIN PATTERN ANALYSIS
 NICOLAS TOURJANSKY and EDMOND SZECHENYI (ONERA, Chatillon, France) ONERA, TP no. 1992-127 1992 13 p. European Rotorcraft Forum, 18th, Avignon, France, Sept. 15-18, 1992 refs (ONERA, TP NO. 1992-127)

A new method is proposed for measuring blade deflections of a helicopter in flight, using strain patterns analysis, which overcomes the difficulty of instrumenting the blades with strain gauges in such a manner as to give modal strain patterns which clearly characterize each mode. Results are presented of laboratory tests on a beam, showing the robustness and reliability which the new strain gauge implementation gives the strain pattern analysis. Blade deflection measurements performed on rotors in wind tunnels yielded a vast data base for the use in code validation, and the computations showed closely agreeing predictions with both torsional and flap deflections. AIAA

A93-38613
LASER VELOCIMETRY AROUND HELICOPTER BLADES IN THE DNW WIND TUNNEL OF THE NLR [VELOCIMETRIE LASER AUTOUR DE PALES D'HELICOPTERE A LA SOUFFLERIE DNW DU NLR]

JEAN LEFEVRE, ALAIN BOUTIER, DIDIER SOULEVANT, and FRANCOIS DUNAND (ONERA, Chatillon, France) ONERA, TP no. 1992-143 1992 10 p. In FRENCH Congres Francophone de Velocimetrie Laser, 3rd, Toulouse, France, Sept. 21-24, 1992 (ONERA, TP NO. 1992-143)

A test was conducted at the DNW wind tunnel of the NLR in order to measure the position of a helicopter blade in rotation in advancing flight and to determine the components of the velocity vector projected on a two-dimensional reference. Two series of measurements were performed: in a guided test section (8 x 10 m) with a sight distance of 2.70 m and in an open section with a sight distance of 5 m. The optomechanical setup and the synchronization of the measurements are described, and some typical results are presented. AIAA

A93-38614
TWO-DIMENSIONAL LASER VELOCIMETRY FOR THE STUDY OF DUAL-FLOW JETS WITH FLIGHT EFFECT IN THE CEPRA 19 ANECHOIC WIND TUNNEL [VELOCIMETRE LASER BIDIMENSIONNELLE POUR L'ETUDE DES JETS DOUBLE-FLUX AVEC EFFET DE VOL DANS LA SOUFFLERIE ANECHOIQUE CEPRA 19]

JACQUES GATARD, DIDIER SOULEVANT (ONERA, Chatillon, France), and SERGE AVELINE (Centre d'Essais des Propulseurs, Orsay, France) ONERA, TP no. 1992-144 1992 10 p. In FRENCH Congres Francophone de Velocimetrie Laser, 3rd, Toulouse, France, Sept. 21-24, 1992 (ONERA, TP NO. 1992-144)

A feasibility study concerning the use of a two-dimensional laser velocimeter to study dual-flow jets with flight effect was performed in the CEPRA 19 anechoic wind tunnel. The measurement setup is described, and results are presented. Owing to the accuracy of the measurements obtained and the automation of the various processes involved, the two-dimensional laser velocimeter has been added to the operational tools for use in CEPRA 19 anechoic wind tunnel for the study of dual-flow jets with flight effect. AIAA

A93-38629
OPTIMAL DESIGN OF CENTERED SQUEEZE FILM DAMPERS
 C. NATARAJ and H. ASHRAFIUON (Villanova Univ., PA) ASME, Transactions, Journal of Vibration and Acoustics (ISSN 0739-3717) vol. 115, no. 2 April 1993 p. 210-215. refs Copyright

A two degree-of-freedom model, consisting of a rigid rotor supported on rigid bearings which are in turn supported on squeeze film dampers, is considered. Isotropic centering springs are assumed resulting in a steady synchronous centered circular

response for the rotor. The resulting nonlinear system is modeled in nondimensional form. The transmissibility ratio of the system as well as the power dissipated are minimized for various values of unbalance and at several speeds, with the squeeze film bearing parameter as the primary design variable. Expressions are derived for linear variational stability of the circular orbit, and are imposed as constraints in the optimization process. The dependence of the optimal configuration on speed and unbalance is discussed.

Author

A93-38739

SCHLIENEN DEVICE AND HOLOGRAPHIC INTERFEROMETER FOR HYPERSONIC FLOW VISUALIZATION

J. SURGET, M. PHILBERT, and D. BIZE (ONERA, Chatillon, France) ONERA, TP no. 1992-160 1992 6 p. International Symposium on Flow Visualization, 6th, Yokohama, Japan, Oct. 5-9, 1992 refs

(ONERA, TP NO. 1992-160)

A schlieren apparatus which is presently in exploitation at the F4 high enthalpy hypersonic wind tunnel of Le Fauga-Mauzac ONERA center and a multipass holographic interferometer under construction are described. The schlieren device is aimed at visualizing the whole aerodynamic phenomena surrounding any model set in the test section. The multipass holographic interferometer makes it possible to establish density maps around 2D or axisymmetric small models and also to characterize the flow upstream of these models.

AIAA

A93-38764

THE LIMIT MODEL OF A THIN STRIP EXHIBITING TWO DELAMINATIONS [MODELE LIMITE DE BANDE MINCE PRESENTANT DEUX DELAMINAGES]

Y. OUSSET and F. ROUDOLFF (ONERA, Chatillon, France) ONERA, TP no. 1992-212 1992 12 p. In FRENCH Journees Nationales sur les Composites, 8th, Palaiseau, France, Nov. 16-18, 1992, Comptes Rendus, p. 775-785 refs

(ONERA, TP NO. 1992-212) Copyright

A 2D thin strip of thickness epsilon consisting of two outer layers of material 1 enclosing a layer of material 2 is examined. The strip is loaded in mode I and exhibits two superposed delaminations. An asymptotic method is used to derive a limit model as epsilon tends to 0, and energy release rates associated with the two delaminations are given. The solution, obtained analytically, shows that these energy release rates are discontinuous when one delamination overtakes the other. This discontinuity is investigated via the finite-element solution of the initial 2D elasticity problem.

AIAA

A93-38975

COMPUTED TOMOGRAPHY OF ADVANCED MATERIALS AND PROCESSES

G. E. GEORGESON and R. H. BOSSI (Boeing Defense & Space Group, Seattle, WA) In Nondestructive evaluation and material properties of advanced materials; Proceedings of the Symposium, TMS Annual Meeting, New Orleans, LA, Feb. 17-21, 1991 Warrendale, PA Minerals, Metals & Materials Society 1991 p. 99-108. refs

(Contract F33615-88-C-5404)

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The development of many new materials and processes is generating a need for improved nondestructive inspection technology. Conventional methodologies (ultrasonics, radiography, and visual) are proving inadequate for many advanced materials. New inspection methods like computed tomography (CT) are needed to characterize properties and defects of advanced materials and processes. CT provides quantitative volumetric measures of density, constituents, and dimensions. CT offers considerable potential to reveal three-dimensional information useful for design and manufacturing inspection and analysis. Under a task assignment of an Air Force sponsored research and development program, the application of CT to advanced materials and processes in the aircraft/aerospace industry is being explored.

Preliminary work suggests that CT will have a significant impact upon the development of advanced materials and processes in the years ahead.

Author (revised)

A93-39027

DYNAMIC PROCESSES IN THE POWERPLANTS AND POWER-GENERATING EQUIPMENT OF FLIGHT VEHICLES [DINAMICHESKIE PROTSESSY V SILOVYKH I ENERGETICHESKIKH USTANOVKAKH LETATEL'NYKH APPARATOV]

V. P. SHORIN, ED., V. V. BERDNIKOV, ED., A. G. GIMADIEV, ED., B. F. GLIKMAN, ED., A. E. ZHUKOVSKII, ED., A. F. MALEEV, ED., and V. N. ORLOV, ED. Kuibyshev, Russia Kuibyshevskii Aviatsionnyi Institut 1990 145 p. In RUSSIAN For individual items see A93-39028 to A93-39043

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The papers presented in this volume deal with the experimental study and modeling of dynamic processes taking place in the pneumatic and hydraulic systems of powerplants, power generators, and control systems. In particular, attention is given to the control of the quality of dynamic processes in the valves of power-generating equipment, absolute stability of an automatic control system for gas turbine engines, and the required damping and control process quality in a fuel pressure regulator. Papers are also included on the modeling of the characteristics of small gas generators in continuous and pulsed operating modes, an approach to the modeling of dynamic processes in the powerplant of a spacecraft, and dynamic characteristics of a hydraulic servo drive.

AIAA

A93-39030

CONTROL OF THE QUALITY OF DYNAMIC PROCESSES IN THE VALVES OF POWER-GENERATING EQUIPMENT [UPRAVLENIE KACHESTVOM DINAMICHESKIKH PROTSESSOV V KlapannoI ARMATURE ENERGETICHESKIKH USTANOVOK]

D. E. CHEGODAEV, O. P. MULIUKIN, and V. G. KINELEV In Dynamic processes in the powerplants and power-generating equipment of flight vehicles Kuibyshev, Russia Kuibyshevskii Aviatsionnyi Institut 1990 p. 29-37. In RUSSIAN refs

Copyright

The operation phases of automatic valve mechanisms are characterized, and methods of increasing the speed of valve operation are discussed with particular reference to two-way high-lift safety valves. Practical recommendations are presented concerning the design of automatic valves in which transition processes are controlled by varying the cross-sectional area of the passage at the inlet or outlet and by varying the valve lift force during the power stroke.

AIAA

A93-39032

COMPUTATIONAL MODELS OF DAMPERS FOR COMPUTER-AIDED DESIGN [RASCHETNYE MODELI GASITELEI DLIA AVTOMATIZIROVANNOGO PROEKTIROVANIIA]

G. V. SHESTAKOV and A. N. GOLOVIN In Dynamic processes in the powerplants and power-generating equipment of flight vehicles Kuibyshev, Russia Kuibyshevskii Aviatsionnyi Institut 1990 p. 44-51. In RUSSIAN refs

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A classification of the structures of pressure oscillation dampers is proposed. Based on the proposed classification, generalized computational models are developed for oscillation dampers. The models provide a way to standardize the calculation of dampers and to develop CAD systems for damper design.

AIAA

A93-39036

CORRECTION OF THE FREQUENCY CHARACTERISTIC OF THE WAVEGUIDE CIRCUIT OF AN ACOUSTIC-JET TEMPERATURE TRANSDUCER [KORREKTSIIA CHASTOTNOI KHARAKTERISTIKI VOLNOVODNOI TSEPI STRUINO-AKUSTICHESKOGO DATCHIKA TEMPERATURY]

A. G. GIMADIEV, A. I. KOZLOV, and V. A. ISHAL In Dynamic

processes in the powerplants and power-generating equipment of flight vehicles Kuibyshev, Russia Kuibyshevskii Aviatsionnyi Institut 1990 p. 78-86. In RUSSIAN refs
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For the waveguide circuit of an acoustic-jet temperature transducer, a correction device is proposed which consists of in-series acoustic amplifier and vibration damper, with a pressure fluctuation transducer between them. A procedure for selecting the parameters of the correction device is described. Experimental results are presented which demonstrate an increase in the characteristic stability of the temperature transducer of an aviation gas turbine engine. AIAA

A93-39044

**HEAT EXCHANGERS OF GAS TURBINE ENGINES
[TEPLOBMENNYE APPARATY GAZOTURBINNYKH
DVIGATELEI]**

IU. F. BARANOV, ED. and B. M. MITIN, ED. Moscow, Russia Tsentral'nyi Institut Aviatsionnogo Motorostroeniia (TsIAM, Trudy, No. 1282) 1991 127 p. In RUSSIAN For individual items see A93-39045 to A93-39060

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The papers presented in this volume focus on methods for studying the thermal and hydraulic characteristics of heat exchangers used in gas turbine engines and methods for the analysis and experimental investigation of the dynamic characteristics of heat exchangers with different coolant flow schemes, including cryogenic heat exchangers. In particular, attention is given to the effect of tube bundle parameters on the dimensional and mass characteristics of high-temperature heat exchangers, a numerical method for calculating the dynamic characteristics of a fuel-air heat exchanger with a buffer cavity, and an experimental study of the air drying process in air coolers. AIAA

A93-39045

**CALCULATION OF A COLLECTOR-TYPE ANNULAR PLATE
HEAT EXCHANGER [RASCHET KOLLEKTORNOGO
KOL'TSEVOGO PLASTINCHATOGO TEPLOBMENNIKA]**

A. I. KHUDIYAKOV and S. I. TSVETKOV *In* Heat exchangers of gas turbine engines Moscow, Russia Tsentral'nyi Institut Aviatsionnogo Motorostroeniia 1991 p. 4-11. In RUSSIAN refs

Copyright

The use of an annular plate recuperative heat exchanger, assembled by welding, is recommended for the heat regeneration system of gas turbine engines. Here, a procedure is presented for calculating the dimensions of the intake and receiving collectors and the dimensions and mass of the heat exchanger matrix. Calculations for a heat exchanger with a Frenkel surface are presented as an example. AIAA

A93-39046

**A MODEL FOR CALCULATING THE ELEMENT OF A
HIGH-TEMPERATURE HEAT EXCHANGER WITH
SPIRAL-WIRE FINS [RASCHETNAIA MODEL' ELEMENTA
VYSOKOTEMPERATURNOGO TEPLOBMENNIKA SO
SPIRAL'NO-PROVOLOCHNYM OREBRENIEM]**

N. P. GERASHCHENKO and V. M. MATVEEV *In* Heat exchangers of gas turbine engines Moscow, Russia Tsentral'nyi Institut Aviatsionnogo Motorostroeniia 1991 p. 12-18. In RUSSIAN
Copyright

A computational model is proposed which makes it possible to convert heat transfer data obtained for heat exchangers with copper elements to other types of elements and elements with different parameters (e.g., different wire, spiral, and tube diameters) and also to spirals of bimetal wires. Results obtained with the model proposed here are in good agreement with experimental data for a heat exchanger with bimetal wire spiral fins. AIAA

A93-39047

**A HEAT TRANSFER ELEMENT OF A HIGH-TEMPERATURE
HEAT EXCHANGER [TEPLOPEREDAUSHCHII ELEMENT
VYSOKOTEMPERATURNOGO TEPLOBMENNIKA]**

V. I. DIUZHEV, V. M. MATVEEV, E. V. OKHAPKIN, and IU. N. FILIPPOV *In* Heat exchangers of gas turbine engines Moscow, Russia Tsentral'nyi Institut Aviatsionnogo Motorostroeniia 1991 p. 19-23. In RUSSIAN

Copyright

Results of an experimental study of the thermal and hydraulic characteristics of an element of a high-temperature heat exchanger with spiral wire fins are reported. The fins are made of a bimetal wire consisting of a copper core and a shell of stainless steel. It is found that the heat efficiency of the bimetal wire is practically the same as that of all-copper fins of the same geometrical characteristics. AIAA

A93-39050

**THE USE OF AVIATION GAS-LIQUID HEAT EXCHANGERS
EMPLOYING HEAT PIPES [PRIMENENIE AVIATSIONNYKH
GAZOZHIDKOSTNYKH TEPLOBMENNIKOV NA TEPLOVYKH
TRUBAKH]**

IU. F. BARANOV, N. V. LOKAI, and R. I. KHANANOV *In* Heat exchangers of gas turbine engines Moscow, Russia Tsentral'nyi Institut Aviatsionnogo Motorostroeniia 1991 p. 49-53. In RUSSIAN refs

Copyright

The possibility of using gas-liquid heat-pipe exchangers in different systems of aviation engines is examined, and methods for calculating the characteristics of such heat exchangers are discussed. A program developed for calculating the static and dynamic characteristics of heat-pipe exchangers is described. The program, which consists of 13 modules, uses the finite difference method. The program includes modules for calculating the gravitational characteristics of heat pipes with and without a capillary structure; the vapor parameters are calculated in the one-dimensional formulation for the viscous and inertial components with allowance for compressibility. AIAA

A93-39051

**OPERATION OF A CROSS-FLOW HEAT EXCHANGER WITH
PARTIAL RECIRCULATION OF ONE OF THE COOLANTS
[RABOTA TEPLOBMENNIKA PEREKRESTNOTOCHNOI
SKHEMY PRI CHASTICHNOI RETSIRKULIATSII ODNOGO IZ
TEPLONOSITELEI]**

N. I. ZHIDOV *In* Heat exchangers of gas turbine engines Moscow, Russia Tsentral'nyi Institut Aviatsionnogo Motorostroeniia 1991 p. 54-58. In RUSSIAN refs

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Some potential advantages of cross-flow heat exchangers with partial recirculation of one of the coolants are examined. In particular, it is shown that the use of partial coolant recirculation makes it possible to increase the thermal efficiency of the heat exchanger, reduce the wall temperature, reduce thermal stresses in the heat exchanger core by providing a more uniform temperature distribution, and reduce deposits on the walls. Possible applications of heat exchangers of this type are briefly discussed. AIAA

A93-39052

**A FUEL-OIL MATRIX HEAT EXCHANGER
[TOPLIVOMASLIANYI MATRICHNYI TEPLOBMENNIK]**

E. I. MIKULIN, IU. A. SHEVICH, V. N. POTAPOV, V. A. VESELOV, E. A. SALTAIS, and G. I. GLUKHOVSKII *In* Heat exchangers of gas turbine engines Moscow, Russia Tsentral'nyi Institut Aviatsionnogo Motorostroeniia 1991 p. 59-64. In RUSSIAN
Copyright

A novel design of a welded matrix heat exchanger capable of handling high-pressure liquid and gas coolants is described. Results of tests conducted on matrix heat exchangers and their models are presented, and formulas are recommended for calculating the heat transfer and hydraulic resistance characteristics. A comparison of the characteristics of matrix and tube heat exchangers demonstrates the advantages of the former. AIAA

A93-39053

DEVELOPMENT OF A PROCESS FOR FABRICATING A PLATE HEAT EXCHANGER FOR THE HEAT RECOVERY SYSTEM OF GAS TURBINE ENGINES [OTRABOTKA TEKHNologii IZGOTOVLENIIA PLASTINCHATOGO TEPLOOBMENNIIKA SISTEMY REGENERATSII TEPLA GTD]

M. P. EROCHKIN, M. T. MISHCHENKOV, A. S. NOVIKOV, V. V. ORESHNIKOV, G. V. SABAEV, V. B. SERGEEV, and A. I. KHUDIYAKOV *In* Heat exchangers of gas turbine engines Moscow, Russia Tsentral'nyi Institut Aviatsionnogo Motorostroeniia 1991 p. 65-74. In RUSSIAN Copyright

A process for the die forming of corrugated plates with deep drawing has been tested on 0.2-mm-thick chromium-nickel steel 12Kh18N10T and alloys EP-648-VI, VZh145, VZh135, and VZh98. It is found that the drawing depth is largely determined by the type of material and the number of steps, whereas the type of lubricant and die material have only a slight effect. The optimal parameters of the die forming process are determined, and a laser welding process for assembling the corrugated plates is developed. AIAA

A93-39054

DETERMINATION OF THE DYNAMIC CHARACTERISTICS OF HEAT EXCHANGERS FOR THE HEAT RECOVERY SYSTEM OF GAS TURBINE ENGINES [OPREDELENIE DINAMICHESKIKH KHARAKTERISTIK TEPLOOBMENNYKH APPARATOV SISTEMY REGENERATSII TEPLA GTD]

A. N. ANTONOV and S. V. CHIVANOV *In* Heat exchangers of gas turbine engines Moscow, Russia Tsentral'nyi Institut Aviatsionnogo Motorostroeniia 1991 p. 75-78. In RUSSIAN refs Copyright

Systems of equations are presented for determining the dynamic characteristics of counter-flow and cross-flow heat exchangers for the heat recovery system of gas turbine engines. Results of calculations obtained by a numerical method are compared with those of an analytical solution. The difference between the numerical and analytical results is 13 percent. The factors responsible for the difference between the two sets of results are examined. AIAA

A93-39055

SOLUTION OF THE PROBLEM OF DETERMINING THE DYNAMIC CHARACTERISTICS OF THE CROSS-FLOW HEAT EXCHANGER OF THE HEAT RECOVERY SYSTEM OF GAS TURBINE ENGINES [RESHENIE ZADACHI OPREDELENIIA DINAMICHESKIKH KHARAKTERISTIK TEPLOOBMENNOGO APPARATA PEREKRESTNOTOCHNOI SKHEMY SISTEMY REGENERATSII TEPLA GTD]

A. N. ANTONOV and S. V. CHIVANOV *In* Heat exchangers of gas turbine engines Moscow, Russia Tsentral'nyi Institut Aviatsionnogo Motorostroeniia 1991 p. 79-85. In RUSSIAN refs Copyright

A solution is presented for a system of equations describing the dynamic characteristics of a cross-flow heat exchanger of the heat recovery system of gas turbine engines under conditions of simultaneous changes in the flow rate, temperature and pressure of the coolants. The solution is obtained by the Riemann method using an approach based on the integration of a system of hyperbolic equations; proposed by Makarov (1979). AIAA

A93-39059

AN EXPERIMENTAL STUDY OF THE AIR DRYING PROCESS IN AIR COOLERS [EKSPERIMENTAL'NOE ISSLEDOVANIE PROTSESSA OSUSHENIIA VOZDUKHA V VOZDUKHOOKHLADITELIAKH]

L. P. ANNUSHKINA *In* Heat exchangers of gas turbine engines Moscow, Russia Tsentral'nyi Institut Aviatsionnogo Motorostroeniia 1991 p. 109-115. In RUSSIAN refs Copyright

Results of an experimental study of the air moisture content

during the simultaneous cooling and drying of air in tubular air coolers are reported. Experimental data are presented on the frosting of smooth and finned tubes under different operating conditions of air coolers. It is shown that the amount of the moisture separated through frosting constitutes 10-15 percent of the total moisture at the inlet of the low-temperature stage of the air cooler. AIAA

A93-39061

QUALITY OF THE SURFACE LAYER AND OPERATING PROPERTIES OF AIRCRAFT ENGINE COMPONENTS [KACHESTVO POVERKHNOSTNOGO SLOIA I EKSPLOATSIONNYE SVOISTVA DETALEI AVIATSIONNYKH DVIGATELEI]

V. F. BEZ'IAZYCHNYI, ED. (Rybinskii Aviatsionnyi Tekhnologicheskii Inst., Rybinsk, Russia) Yaroslavl, Russia Rybinskii Aviatsionnyi Tekhnologicheskii Institut 1990 136 p. In RUSSIAN For individual items see A93-39062 to A93-39083 Copyright

The papers presented in this volume are concerned with analytical determination of the distribution of surface layer parameters in aircraft engine parts during machining, effect of surface layer parameters on the service-related characteristics of gas turbine engines, and automation of the design of technological processes which would ensure the required properties of the surface layer. Specific topics discussed include determination of the hardening modulus of machined materials, calculation of the process-induced residual stresses from friction test results, effect of ion treatment methods on the residual strength of blades, and automation of process design with incorporation of the hardening-finishing treatment of parts. AIAA

A93-39062

PREDICTION AND CONTROL OF THE SERVICE-RELATED PROPERTIES OF PARTS AT THE TECHNOLOGICAL PREPARATION STAGE AND DURING THE MANUFACTURE PROCESS [PROGNOZIROVANIE I UPRAVLENIE EKSPLOATSIONNYMI SVOISTVAMI DETALEI NA STADII TEKHNOLOGICHESKOI PODGOTOVKI PROIZVODSTVA I V PROTSESSIE IZGOTOVLENIIA]

V. F. BEZ'IAZYCHNYI (Rybinskii Aviatsionnyi Tekhnologicheskii Inst., Rybinsk, Russia) *In* Quality of the surface layer and operating properties of aircraft engine components Yaroslavl, Russia Rybinskii Aviatsionnyi Tekhnologicheskii Institut 1990 p. 5-12. In RUSSIAN Copyright

The paper is concerned with the problem of optimizing the machining of aircraft engine parts in order to satisfy certain requirements for tool wear, machining precision and surface layer characteristics, and hardening depth. A generalized multiple-objective function and its computer implementation are developed which make it possible to optimize the machining process without the use of experimental data. Alternative methods of controlling the machining process are discussed. AIAA

A93-39081

AUTOMATED MEASUREMENT OF RESIDUAL STRESSES IN THE SURFACE LAYER OF PARTS [AVTOMATIZIROVANNOE IZMERENIE OSTATOCHNYKH NAPRIAZHENII POVERKHNOSTNOGO SLOIA DETALI]

T. D. KOZHINA, E. V. KISELEV, and A. N. POSTNOV (Rybinskii Aviatsionnyi Tekhnologicheskii Inst., Rybinsk, Russia) *In* Quality of the surface layer and operating properties of aircraft engine components Yaroslavl, Russia Rybinskii Aviatsionnyi Tekhnologicheskii Institut 1990 p. 122-126. In RUSSIAN refs Copyright

The general design and operation of a computerized system for measuring residual stresses in the surface layers of parts following machining and various mechanical and thermal treatments are examined. The major modules of the system, which employs the PION-2 measuring instrument, are described, as are the major

components of the software. A schematic diagram of the system is included. AIAA

A93-39084
HIGH-EFFICIENCY MACHINING METHODS FOR AVIATION MATERIALS [VYSOKOEFFEKTIVNYE METODY MEKHANICHESKOI OBRABOTKI AVIATSIONNYKH MATERIALOV]

V. K. KONONOV, ED. Samara, Russia Kuibyshevskii Aviatsonnyi Institut 1991 192 p. In RUSSIAN For individual items see A93-39085 to A93-39112 (ISBN 5-230-16902-8) Copyright

The papers contained in this volume present results of theoretical and experimental studies aimed at increasing the efficiency of cutting tools during the machining of high-temperature materials and titanium alloys. Specific topics discussed include a study of the performance of disk cutters during the machining of flexible parts of a high-temperature alloy, VZhL14N; a study of the wear resistance of cutters of hard alloys of various types; effect of a deformed electric field on the precision of the electrochemical machining of gas turbine engine components; and efficient machining of parts of composite materials. The discussion also covers the effect of the technological process structure on the residual stress distribution in the blades of gas turbine engines; modeling of the multiparameter assembly of engineering products for a specified priority of geometrical output parameters; and a study of the quality of the surface and surface layer of specimens machined by a high-temperature pulsed plasma. AIAA

A93-39091
THEORY OF THE MACHINING OF POLYHEDRAL HOLES BY PLUNGE CUTTING [TEORIYA OBRABOTKI MNOGOGRANNYKH OTVERSTII METODOM VREZANIYA]

V. I. PETROV, M. A. NIKITIN, and A. L. MEN'SHOV /n High-efficiency machining methods for aviation materials Samara, Russia Kuibyshevskii Aviatsonnyi Institut 1991 p. 53-61. In RUSSIAN refs Copyright

The principal concepts of the theory of the machining of polyhedral holes in flexible structures are presented. Various methods of polyhedral hole machining are examined, and ways of optimizing the cutting regimes and geometrical and dynamic parameters of the technological system are discussed. AIAA

A93-39093
SOME CHARACTERISTICS OF THE DESIGN OF HEADS FOR THE CUTTING OF BEVEL GEARS WITH NEGATIVE CURVATURE OF THE CIRCULAR-ARC TOOTH LINE [NEKOTORYE OSOBENNOСТИ PROEKTIROVANIYA REZTSOVYKH GOLOVOK DLIYA NAREZANIYA KONICHESKIKH KOLES S OTRITSATEL'NOI KRIVIZNOI LINII KRUGOVOGO ZUBA]

A. P. SAVINOV and V. M. IASTREBOV /n High-efficiency machining methods for aviation materials Samara, Russia Kuibyshevskii Aviatsonnyi Institut 1991 p. 67-72. In RUSSIAN refs Copyright

The principles of the design of the external and internal finishing cutters of heads for the machining of bevel gears with negative curvature of the circular-arc tooth line are examined. The differences between heads for the machining of circular-arc teeth with positive and negative curvatures are discussed. A newly developed design of a head for the machining of bevel gears with negative curvature of the circular-arc tooth is described as an example. AIAA

A93-39094
EFFECT OF A DEFORMED ELECTRIC FIELD ON THE PRECISION OF THE ELECTROCHEMICAL MACHINING OF GAS TURBINE ENGINE COMPONENTS [VLIYANIE DEFORMIROVANNOGO ELEKTRICHESKOGO POLIA NA TOCHNOST' ELEKTROKHMICHESKOI OBRABOTKI DETALEI GTD]

IU. A. SIRAZH /n High-efficiency machining methods for aviation materials Samara, Russia Kuibyshevskii Aviatsonnyi Institut 1991 p. 72-78. In RUSSIAN Copyright

New data are presented on the structure and mathematical description of the electric field used in electrochemical machining. Results of an analysis of machining errors resulting from the deformation and instability of the electric field are examined. Recommendations are given concerning ways of increasing the precision of electrochemical machining. AIAA

A93-39095
INCREASING THE EFFICIENCY OF THE ELECTROCHEMICAL DIMENSIONAL MACHINING OF GAS TURBINE ENGINE BLADES OF EP718VD ALLOY [POVYSHENIE EFFEKTIVNOSTI ELEKTROKHMICHESKOI RAZMERNOI OBRABOTKI LOPATOK GTD IZ SPALVA EP718VD]

M. V. DEMIN, O. A. SENINA, and V. F. GERASIMOV /n High-efficiency machining methods for aviation materials Samara, Russia Kuibyshevskii Aviatsonnyi Institut 1991 p. 78-82. In RUSSIAN Copyright

Results of a study aimed at improving a process for the vibrational/electrochemical machining of gas turbine blades of EP718VD alloy with a foil length up to 100 mm by optimizing the electrolyte composition are reported. The process described here uses a sodium perchlorate-based electrolyte which makes it possible to improve the precision and quality of the surface layer. The sodium perchlorate electrolyte does not release toxic compounds into the ambient air but may present a fire hazard. Provided that fire prevention rules are observed, the new electrolyte is recommended for the electrochemical machining of blade alloys. AIAA

A93-39099
INCREASING THE DURABILITY OF GAS TURBINE ENGINE COMPRESSOR BLADES BY USING A COMBINED HARDENING/FINISHING TREATMENT TO CONTROL THE STRESSED STATE OF THE SURFACE LAYER [POVYSHENIE VYNOSLIVOSTI LOPATOK KOMPRESSORA GTD REGULIROVANIEM NAPRIAZHENNOGO SOSTOYANIYA POVERKHNOSTNOGO SLOIA KOMBINIROVANNOI UPROCHNIAIUSHCHE-OTDELOCHNOI OBRABOTKOI]

K. F. MITRIAEV and M. B. SAZONOV /n High-efficiency machining methods for aviation materials Samara, Russia Kuibyshevskii Aviatsonnyi Institut 1991 p. 102-112. In RUSSIAN refs Copyright

Results of an analysis of the stressed state of gas turbine compressor blades of VT9 alloy are reported. The analysis allows for residual stresses and stresses induced by operating loads during service. It is demonstrated that the service life of the blades can be extended by optimizing the residual stress curves through the use of a hardening/finishing treatment by microspheres. AIAA

A93-39102
HARDENING/FINISHING TREATMENT OF COMPRESSOR BLADES USING A MACHINE WITH PLANETARY CONTAINER MOTION [UPROCHNIAIUSHCHE-OTDELOCHNAIA OBRABOTKA LOPATOK KOMPRESSORA NA USTANOVKE S PLANETARNYM DVIZHENIEM KONTEINEROV]

A. F. SHPATAKOVSKII /n High-efficiency machining methods for aviation materials Samara, Russia Kuibyshevskii Aviatsonnyi Institut 1991 p. 120-127. In RUSSIAN refs Copyright

A process for the hardening and finishing of high-pressure compressor blades for aircraft powerplants is described whereby the blades are placed in containers that move along a planetary path in a hardening medium consisting of steel balls. The extent of surface hardening, surface roughness, and residual stresses are determined for specimens of U8A steel and blades of EP718VD alloy treated under different conditions. The efficiency of the treatment in terms of increased blade durability and productivity is estimated. AIAA

A93-39106

EFFECT OF THE TECHNOLOGICAL PROCESS STRUCTURE ON RESIDUAL STRESS DISTRIBUTION IN THE BLADE FOIL OF GAS TURBINE ENGINES [VLIANIE STRUKTURY TEKHNOLOGICHESKOGO PROTSESSA NA PASTREDELENIE OSTATOCHNYKH NAPRIAZHENII V PERE LOPATOK GTD]G. V. SMIRNOV and N. D. PRONICHEV *In* High-efficiency machining methods for aviation materials Samara, Russia Kuibyshevskii Aviatsionnyi Institut 1991 p. 144-150. In RUSSIAN refs

Copyright

A process for the manufacture of small compressor blades of VT9 alloy is analyzed using concepts of the technological heredity theory. The formation and distribution of residual stresses in different areas of the blade foil after electrochemical dimensional machining are discussed. Ways of producing an optimal stress distribution are examined. AIAA

A93-39109

MODELING OF THE MULTIPARAMETER ASSEMBLY OF ENGINEERING PRODUCTS FOR A SPECIFIED PRIORITY OF OUTPUT GEOMETRICAL PARAMETERS [O MODELIROVANII MNOGOPARAMETRNOI SBORKI IZDELII MASHINOSTROENIIA PRI ZADANNOM PRIORITETE VYKHODNYKH GEOMETRICHESKIKH PARAMETROV]V. A. KOLDORKINA *In* High-efficiency machining methods for aviation materials Samara, Russia Kuibyshevskii Aviatsionnyi Institut 1991 p. 161-170. In RUSSIAN refs

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Steps that can be taken in order to improve the quality and reduce the time of assembly are discussed. These include periodic analysis of the distributions of the output geometrical parameters of the products; analysis of the interdependences of the output geometrical parameters through the use of conditional histograms; determination of the number of parts required for product assembly with a probability close to unity by using the conditional histograms; and assembly based on a priority parameter without any additional machining of the parts. AIAA

A93-39122

OPTIMAL CONDITIONS FOR FLOW TURBULENCE REDUCTION BY A SET OF GRIDS [OPTIMAL'NYE USLOVIA DETURBULIZATSII POTOKA S POMOSHCH'IU NABORA SETOK]

G. I. DERBUNOVICH, A. S. ZEMSKAIA, E. U. REPIK, and I. U. P. SOSEDKO Rossiiskaia Akademiia Nauk, Izvestiia, Mekhanika Zhidkosti i Gaza (ISSN 0568-5281) no. 1 Jan.-Feb. 1993 p. 181-191. In RUSSIAN refs

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Experiments were carried out to determine the conditions for reducing flow turbulence by means of a set of attenuating grids, each of which would operate in the optimal regime. Recommendations are presented with regard to the optimal number of the grids, their geometric parameters, and their locations within the flow, for reducing turbulence in the incoming flow. AIAA

A93-39137

NUMERICAL MODELING OF IONIZATION IN NONEQUILIBRIUM NITROGEN FLOWS IN HYPERSONIC NOZZLES [CHISLENNOE MODELIROVANIE IONIZATSII V NERAVNOVESNYKH TECHENIIAKH AZOTA V SOPLAKH GIPERZVUKOVYKH USTANOVOK]A. I. KIREEV and G. N. SAIAPIN *In* Problems in physical gas dynamics Moscow Izdatel'skii Otdel TsAGI 1990 p. 176-182. In RUSSIAN refs

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Calculations are made of nonequilibrium ionization in nitrogen flows in hypersonic nozzles. Data are obtained on the thermodynamic characteristics of nitrogen flow in the duct of a hypersonic wind tunnel. The possibility of a substantial increase of electron concentrations in the working section of a nozzle due to the use of low concentrations of alkali metal impurity vapor is

demonstrated. This effect makes it possible to significantly widen the range of ionization modeling conditions typical of flight in dense layers of the atmosphere. AIAA

A93-39144

FLOW DENSITY DISTRIBUTION IN A TWO-PHASE SUBMERGED JET [RASPREDELENIE PLOTNOSTEI POTOKOV V DVUKHFAZNOI ZATOPLENNOI STRUE]V. I. BLAGOSKLONOV, A. L. STASENKO, and V. F. CHEKHOVSKII *In* Problems in physical gas dynamics Moscow Izdatel'skii Otdel TsAGI 1990 p. 244-253. In RUSSIAN refs

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Results of a numerical study of mass, momentum, and energy distributions in a two-phase axisymmetric flow in a nozzle and in a submerged jet are reported. In the hypersonic flow region, the results can be used for estimating the force and thermal effects of a jet on bodies in its path. A study is also made of the effect of the internal-to-external pressure ratio on the maximum diameter of the first jet expansion. For internal-to-external pressure ratios of the order of 1, an analysis is made of the periodic structure of the jet over several expansions. AIAA

A93-39147

MODELING OF THE PHYSICO-CHEMICAL PROCESSES OF NONEQUILIBRIUM HEAT TRANSFER IN THE SUBSONIC JETS OF AN INDUCTION PLASMATRON [MODELIROVANIE FIZIKO-KHIMICHESKIKH PROTSESSOV NERAVNOVESNOGO TEPLOBMENA V DOZVUKOVYKH STRUIAKH INDUKSIONNOGO PLAZMATRONA]P. N. BARONETS, A. F. KOLESNIKOV, V. M. MYSOVA, I. S. PERSHIN, I. U. K. RULEV, and M. I. IAKUSHIN *In* Problems in physical gas dynamics Moscow Izdatel'skii Otdel TsAGI 1990 p. 283-293. In RUSSIAN refs

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The general design and operation of a new induction plasmatron, VGU-3, designed for the experimental study of phenomena associated with the aerodynamic heating of bodies moving in the atmosphere at high velocities are described. In comparison with older plasmatron models, the VGU-3 provides better capabilities for the modeling of nonequilibrium heat transfer over a wider range of flow and heat transfer parameters. The modeling of the enthalpy, concentrations of the chemical components of air, nonviscous flow velocity gradients, and body surface temperature is described. AIAA

A93-39176

THE MINIMAL MULTIPLIER METHOD IN CALCULATIONS OF THE STABILITY, LIMITING VIBRATION CYCLES, AND LIMITING STATES OF NONLINEARLY DEFORMED STRUCTURES [METOD 'MINIMAL'NOGO MNOZHITELIA' V RASCHETAKH USTOICHIVOSTI, PREDEL'NYKH TSIKLOV KOLEBANII I PREDEL'NYKH SOSTOIANII NELINEINO DEFORMIRUEMYKH KONSTRUKTSII]V. G. GAINUTDINOV *Aviatsionnaia Tekhnika* (ISSN 0579-2975) no. 4 1992 p. 3-7. In RUSSIAN refs

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A method is proposed for solving nonlinear equations of the statics and natural vibrations of flexible elements of aircraft structures in the case of finite displacements. A numerical algorithm for solving these problems is described. An illustrative example demonstrating the method is included. AIAA

A93-39177

ESTIMATION OF WING STABILITY IN FLOW FROM THE CHARACTERISTICS OF THE TRANSIENT PROCESS [OTSENKA USTOICHIVOSTI KRYLA V POTOKE PO KHARAKTERU PEREKHODNOGO PROTSESSA]M. F. GARIFULLIN *Aviatsionnaia Tekhnika* (ISSN 0579-2975) no. 4 1992 p. 7-12. In RUSSIAN refs

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The effect of a wind gust on a moving wing is examined. The calculations are carried out in time by the integral-difference method

using an implicit scheme. Based on the characteristics of the transient process, a conclusion is made concerning the stability or instability of the wing. AIAA

A93-39185

A MATHEMATICAL MODEL OF THE VIBRATIONAL IMPACT HARDENING OF PARTS [MATEMATICHESKAIA MODEL' VIBROUDARNOGO UPROCHNENIIA DETALEI]

R. M. KHALIMULIN *Aviatsionnaia Tekhnika* (ISSN 0579-2975) no. 4 1992 p. 44-46. In RUSSIAN refs
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A mathematical model is proposed which describes the vibrational impact hardening of parts by a free working medium. The working medium is modeled by a set of infinitely thin rigid plates with elastic-plastic and viscous coupling between them. A method for optimizing the hardening process is described. Results obtained for a compressor blade of KhN70MVTyB alloy are presented as an example. AIAA

A93-39198

SELECTION OF THE PRINCIPAL INITIAL PARAMETERS FOR AN AXIAL-FLOW BIROTARY TURBINE [VYBOR OSNOVNYKH ISKHODNYKH PARAMETROV OSEVOI BIROTATIVNOI TURBINY]

L. IA. LAZAREV and V. V. CHIZHOV *Aviatsionnaia Tekhnika* (ISSN 0579-2975) no. 4 1992 p. 89-92. In RUSSIAN refs
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Equations are presented for calculating the efficiency of axial-flow birotary turbines as a function of the principal initial parameters. A numerical analysis of the calculation results is carried out. Recommendations are given concerning the design of birotary turbines. AIAA

A93-39407* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

INVESTIGATION OF A CONTOURED WALL INJECTOR FOR HYPERVELOCITY MIXING AUGMENTATION

IAN A. WAITZ (MIT, Cambridge, MA), FRANK E. MARBLE, and EDWARD E. ZUKOSKI (California Inst. of Technology, Pasadena) *AIAA Journal* (ISSN 0001-1452) vol. 31, no. 6 June 1993 p. 1014-1021. AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991, AIAA Paper 91-2265. Previously cited in issue 18, p. 3140, Accession no. A91-44179 refs
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A93-39416* National Aeronautics and Space Administration, Washington, DC.

REVIEW OF CRACK PROPAGATION UNDER UNSTEADY LOADING

H. H. BRYAN and K. K. AHUJA (Georgia Inst. of Technology, Atlanta) *AIAA Journal* (ISSN 0001-1452) vol. 31, no. 6 June 1993 p. 1077-1089. DGLR/AIAA Aeroacoustics Conference, 14th, Aachen, Germany, May 11-14, 1992, Proceedings. Vol. 2, p. 767-778. Previously cited in issue 05, p. 788, Accession no. A93-19207 Research supported by NASA and Georgia Inst. of Technology refs
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A93-39417* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

LARGE-AMPLITUDE FINITE ELEMENT FLUTTER ANALYSIS OF COMPOSITE PANELS IN HYPERSONIC FLOW

CARL E. GRAY, JR. (NASA, Langley Research Center, Hampton, VA) and CHUH MEI (Old Dominion Univ., Norfolk, VA) *AIAA Journal* (ISSN 0001-1452) vol. 31, no. 6 June 1993 p. 1090-1099. AIAA Dynamics Specialists Conference, Dallas, TX, Apr. 16, 17, 1992, Technical Papers, p. 492-512. Previously cited in issue 14, p. 2377, Accession no. A92-35697 refs
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A93-39419

SUPERSONIC FLUTTER ANALYSIS OF COMPOSITE PLATES AND SHELLS

R. M. V. PIDAPARTI (Purdue Univ., Indianapolis, IN) and HENRY T. Y. YANG (Purdue Univ., West Lafayette, IN) *AIAA Journal* (ISSN 0001-1452) vol. 31, no. 6 June 1993 p. 1109-1117. refs

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A high-precision doubly curved quadrilateral thin shell finite element is used for studying the supersonic flutter behavior of laminated composite plates and shells. The composite material property is included using classical lamination theory, and the supersonic aerodynamic effect is included using linearized piston theory. To reduce the number of degrees of freedom of the finite element aeroelastic system, the normal modes approach is adopted. Results are presented to illustrate the behavior of flutter characteristics for composite plates and curved panels, and composite cylindrical and conical shells. Parametric studies concerning the effects of boundary conditions, fiber orientation, degree of orthotropy, and flow angle on the flutter characteristics are presented for a series of selected examples. The accuracy, efficiency, and applicability of the present finite element method are demonstrated by illustrative examples, and, whenever possible, the results are compared to alternative solutions available in the literature. Author

A93-39422

EXPERIMENTAL AND THEORETICAL STUDY FOR NONLINEAR AEROELASTIC BEHAVIOR OF A FLEXIBLE ROTOR BLADE

D. M. TANG and E. H. DOWELL (Duke Univ., Durham, NC) *AIAA Journal* (ISSN 0001-1452) vol. 31, no. 6 June 1993 p. 1133-1142. AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics and Materials Conference, 33rd, Dallas, TX, Apr. 13-15, 1992, Technical Papers. Pt. 3, p. 1324-1339. Previously cited in issue 13, p. 2210, Accession no. A92-34410 refs
(Contract DAAL03-87-K-0023)
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A93-39427

VORTEX-INDUCED ENERGY SEPARATION IN SHEAR FLOWS

J. J. O'CALLAGHAN and M. KUROSAKA (Washington Univ., Seattle) *AIAA Journal* (ISSN 0001-1452) vol. 31, no. 6 June 1993 p. 1157-1159. AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992, AIAA Paper 92-0192. Previously cited in issue 08, p. 1170, Accession no. A92-23801 refs
(Contract F49620-88-C-0041)
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A93-39722

CANADIAN EXPERIENCE WITH AIR CUSHION VEHICLE SKIRTS

P. A. SULLIVAN (Toronto Univ., Canada) and D. JONES (Jones, Kirwan and Associates, Ltd., Hamilton, Canada) *Canadian Aeronautics and Space Journal* (ISSN 0008-2821) vol. 39, no. 1 March 1993 p. 23-34. Research supported by Transportation Development Centre of Canada and NSERC refs

Canadian developments in air cushion skirts are discussed, with emphasis on the authors' experience. Early field trial and laboratory tests of two European designs, a multicell and a loop-segment system, are reviewed; both are shown to have deficiencies. A simplified version of the loop-segment skirt, developed for use on large platform cushions, is described. Although this skirt is attractively simple both to build and to maintain, and although it has been used successfully on a small high-speed craft, it is shown to have significant dynamical limitations. A hybrid cellular-segmented skirt is proposed to circumvent these limitations, and results obtained from model tests of components of such a skirt are presented, together with some field test data obtained from a recreational vehicle. It is suggested that hybrid configurations may be the appropriate development path for most skirt systems;

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this includes those using a bag to obtain the responsiveness necessary for adequate comfort at high speed. Author

N93-26648# International Maritime Satellite Organization, London (England). Aeronautical Services Div.

SATELLITE COMMUNICATIONS FOR AERONAUTICAL AND NAVIGATION SERVICE

RICHARD SMITH *In* Ministry of Communications, The 1992 United Nations Workshop on Space Communication for Development: Proceedings p 131-139 1992

Avail: CASI HC A02/MF A03

This paper describes the satellite-based systems to be used by the civil aviation community to meet the future communications, navigation and surveillance requirements for air traffic management over oceans and remote land areas, as well as for other aeronautical mobile communications purposes. Author

N93-26999*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

STRUCTURAL TAILORING OF AIRCRAFT ENGINE BLADE SUBJECT TO ICE IMPACT CONSTRAINTS

E. S. REDDY (Sverdrup Technology, Inc., Brook Park, OH.), G. H. ABUMERI (Sverdrup Technology, Inc., Brook Park, OH.), P. L. N. MURTHY, and C. C. CHAMIS Apr. 1993 22 p Presented at the Fourth AIAA/Air Force/OAI Symposium on Multidisciplinary Analysis, Cleveland, OH, 21-23 Sep. 1992; sponsored by AIAA, USAF, and OAI

(Contract RTOP 505-62-OK)

(NASA-TM-106033; E-7599; NAS 1.15:106033) Avail: CASI HC A03/MF A01

Results are presented for the minimum weight design of SR2 unswept blade made of (titanium/graphite-epoxy/titanium) sub s fiber composite. The blade which is rotating at high RPM is subject to ice impact. The root chord length, blade thicknesses at five stations, and graphite-epoxy ply orientation are chosen as design variables. Design constraints are placed on the behavior variables: local leading edge strain and root damage parameter (combined stress failure criteria) as a function due to ice impact, maximum spanwise centrifugal stress at the root of the deformed blade due to local damage, first three natural frequencies, and resonance margin after impact. The method of feasible directions is employed to solve the inequality constrained minimization problem. The effect of ice speed and the ice impact location on the final design are discussed. Author

N93-27020*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

INCREASED HEAT TRANSFER TO ELLIPTICAL LEADING EDGES DUE TO SPANWISE VARIATIONS IN THE FREESTREAM MOMENTUM: NUMERICAL AND EXPERIMENTAL RESULTS

D. L. RIGBY (Sverdrup Technology, Inc., Brook Park, OH.) and G. J. VANFOSSEN Jul. 1992 13 p Presented at the 28th Joint Propulsion Conference and Exhibit, Nashville, TN, 6-8 Jul. 1992; sponsored by AIAA, SAE, ASME, and ASEE

(Contract RTOP 505-62-52)

(NASA-TM-106150; E-7835; NAS 1.15:106150; AIAA PAPER 92-3070) Avail: CASI HC A03/MF A01

A study of the effect of spanwise variation in momentum on leading edge heat transfer is discussed. Numerical and experimental results are presented for both a circular leading edge and a 3:1 elliptical leading edge. Reynolds numbers in the range of 10,000 to 240,000 based on leading edge diameter are investigated. The surface of the body is held at a constant uniform temperature. Numerical and experimental results with and without spanwise variations are presented. Direct comparison of the two-dimensional results, that is, with no spanwise variations, to the analytical results of Frossling is very good. The numerical calculation, which uses the PARC3D code, solves the three-dimensional Navier-Stokes equations, assuming steady laminar flow on the leading edge region. Experimentally, increases in the spanwise-averaged heat transfer coefficient as high as 50 percent above the two-dimensional value were observed.

Numerically, the heat transfer coefficient was seen to increase by as much as 25 percent. In general, under the same flow conditions, the circular leading edge produced a higher heat transfer rate than the elliptical leading edge. As a percentage of the respective two-dimensional values, the circular and elliptical leading edges showed similar sensitivity to span wise variations in momentum. By equating the root mean square of the amplitude of the spanwise variation in momentum to the turbulence intensity, a qualitative comparison between the present work and turbulent results was possible. It is shown that increases in leading edge heat transfer due to spanwise variations in freestream momentum are comparable to those due to freestream turbulence. Author

N93-27069*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

FAULT DETECTION OF HELICOPTER GEARBOXES USING THE MULTI-VALUED INFLUENCE MATRIX METHOD

HSINYUNG CHIN (Massachusetts Univ., Amherst.), KOUROSH DANAI (Massachusetts Univ., Amherst.), and DAVID G. LEWICKI Apr. 1993 32 p

(Contract DA PROJ. 1L1-62211-A-47-A; RTOP 505-63-36)

(NASA-TM-106100; E-7742; NAS 1.15:106100;

AVSCOM-TR-92-C-015) Avail: CASI HC A03/MF A01

In this paper we investigate the effectiveness of a pattern classifying fault detection system that is designed to cope with the variability of fault signatures inherent in helicopter gearboxes. For detection, the measurements are monitored on-line and flagged upon the detection of abnormalities, so that they can be attributed to a faulty or normal case. As such, the detection system is composed of two components, a quantization matrix to flag the measurements, and a multi-valued influence matrix (MVIM) that represents the behavior of measurements during normal operation and at fault instances. Both the quantization matrix and influence matrix are tuned during a training session so as to minimize the error in detection. To demonstrate the effectiveness of this detection system, it was applied to vibration measurements collected from a helicopter gearbox during normal operation and at various fault instances. The results indicate that the MVIM method provides excellent results when the full range of faults effects on the measurements are included in the training set. Author

N93-27088*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

A TRANSFER MATRIX APPROACH TO VIBRATION LOCALIZATION IN MISTUNED BLADE ASSEMBLIES

GISLI OTTARSON (Michigan Univ., Ann Arbor.) and CHRITOPHE PIERRE (Michigan Univ., Ann Arbor.) May 1993 39 p

(Contract NCC3-233; RTOP 505-62-21)

(NASA-TM-106112; E-7764; NAS 1.15:106112; ICOMP-93-10)

Avail: CASI HC A03/MF A01

A study of mode localization in mistuned bladed disks is performed using transfer matrices. The transfer matrix approach yields the free response of a general, mono-coupled, perfectly cyclic assembly in closed form. A mistuned structure is represented by random transfer matrices, and the expansion of these matrices in terms of the small mistuning parameter leads to the definition of a measure of sensitivity to mistuning. An approximation of the localization factor, the spatially averaged rate of exponential attenuation per blade-disk sector, is obtained through perturbation techniques in the limits of high and low sensitivity. The methodology is applied to a common model of a bladed disk and the results verified by Monte Carlo simulations. The easily calculated sensitivity measure may prove to be a valuable design tool due to its system-independent quantification of mistuning effects such as mode localization. Author (revised)

N93-27132*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

BRUSH SEAL LOW SURFACE SPEED HARD-RUB CHARACTERISTICS

ROBERT C. HENDRICKS, JULIE A. CARLILE, and ANITA D. LIANG Jun. 1993 14 p Presented at the 29th AIAA Joint

Propulsion Conference and Exhibit, Monterey, CA, 28-30 Jun. 1993; sponsored by AIAA, SAE, ASME, and ASEE (Contract RTOP 584-03-11)

(NASA-TM-106169; E-7868; NAS 1.15:106169; AIAA PAPER 93-2534) Avail: CASI HC A03/MF A01

The bristles of a 38.1-mm (1.5-in.) diameter brush seal were flexed by a tapered, 40-tooth rotor operating at 2600 rpm that provided sharp leading-edge impact of the bristles with hard rubbing of the rotor lands. Three separate tests were run with the same brush accumulating over 1.3×10^9 flexure cycles while deteriorating 0.2 mm (0.008 in.) radially. In each, the test bristle incursion depth varied from 0.130 to 0.025 mm (0.005 to 0.001 in.) or less (start to stop), and in the third test the rotor was set 0.25 mm (0.010 in.) eccentric. Runout varied from 0.025 to 0.076 mm (0.001 to 0.003 in.) radially. The bristles wore but did not pull out, fracture, or fragment. Bristle and rotor wear debris were deposited as very fine, nearly amorphous, highly porous materials at the rotor groove leading edges and within the rotor grooves. The land leading edges showed irregular wear and the beginning of a convergent groove that exhibited sharp, detailed wear at the land trailing edges. Surface grooving, burnishing, 'whipping,' and hot spots and streaks were found. With a smooth-plug rotor, post-test leakage increased 30 percent over pretest leakage.

Author (revised)

N93-27133* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

FACE-GEAR DRIVES: DESIGN, ANALYSIS, AND TESTING FOR HELICOPTER TRANSMISSION APPLICATIONS

F. L. LITVIN (Illinois Univ., Chicago.), J.-C. WANG (Illinois Univ., Chicago.), R. B. BOSSLER, JR. (Lucas Western, Inc., City of Industry, CA.), Y.-J. D. CHEN (McDonnell-Douglas Helicopter Co., Mesa, AZ.), G. HEATH (McDonnell-Douglas Helicopter Co., Mesa, AZ.), and D. G. LEWICKI Oct. 1992 16 p Presented at the AGMA 1992 Fall Technical Meeting, Baltimore, MD, 26-28 Oct. 1992; sponsored by American Gear Manufacturers Association (Contract DA PROJ. 1L1-62211-A-47-A; RTOP 505-63-36) (NASA-TM-106101; E-7743; NAS 1.15:106101; AVSCOM-TR-92-C-009) Avail: CASI HC A03/MF A01

The use of face-gears in helicopter transmissions was explored. A light-weight, split-torque transmission design utilizing face-gears is described. Face-gear design and geometry were investigated. Topics included tooth generation, limiting inner and outer radii, tooth contact analysis, contact ratio, gear eccentricity, grinding, and structural stiffness. Design charts were developed to determine minimum and maximum face-gear inner and outer radii. An analytical study showed that the face-gear drive is relatively insensitive to gear misalignment with respect to transmission errors, but the tooth contact is affected by misalignment. A method of localizing the bearing contact to permit operation with misalignment was explored. Two new methods for grinding of the face-gear tooth surfaces were also investigated. The proper choice of shaft stiffness enabled good load sharing in the split-torque transmission design. Face-gear experimental studies were also conducted. These tests demonstrated the feasibility of face-gears in high-speed, high-load applications such as helicopter transmissions.

Author

N93-27151* Stanford Univ., CA. Dept. of Aeronautics and Astronautics.

THE GENERATION OF SIDE FORCE BY DISTRIBUTED SUCTION

LEONARD ROBERTS and JOHN HONG May 1993 15 p Sponsored by NASA. Ames Research Center (NASA-CR-193129; NAS 1.26:193129; JIAA-TR-108) Avail: CASI HC A03/MF A01

This report provides an approximate analysis of the generation of side force on a cylinder placed horizontal to the flow direction by the application of distributed suction on the rearward side of the cylinder. Relationships are derived between the side force coefficients and the required suction coefficients necessary to maintain attached flow on one side of the cylinder, thereby inducing

circulation around the cylinder and a corresponding side force.

Author

N93-27170 Tel-Aviv Univ. (Israel). Faculty of Exact Sciences. **SPURIOUS FREQUENCIES AS A RESULT OF NUMERICAL BOUNDARY TREATMENTS**

S. ABARBANEL In Israel Society of Aeronautics and Astronautics, 32nd Annual Conference on Aviation and Astronautics p 26-29 20 Feb. 1992

Copyright Avail: Israel Society of Aeronautics and Astronautics, c/o Faculty of Engineering, Tel-Aviv Univ., Ramat Aviv 69978, Israel

Historically, CFD (computational fluid dynamics) methodologies have been used mostly to tackle aerodynamic problems that possess steady state solutions. More recently, however, the increases in computer speed and memory have allowed researchers to investigate fluid dynamical problems with greater attention to the more delicate details of the flow. Thus, one can now not only compute the pressure distribution on an airfoil (or cylinder) but also, for example, study the temporal problem of vortex shedding by such a body. It has previously been shown that a legitimate (i.e., stable) statement of physical and numerical far-field boundary conditions may lead to spurious oscillations not connected to the vortex shedding and that they may even overshadow the physical processes in the flow. We discuss the reasons for this state of affairs and ways to correct the situation, and speculate about what might await us in the case of truly time-periodic excitations of the flow, such as caused by aileron buzz, incipient flutter, etc.

ISA

N93-27182 Tel-Aviv Univ. (Israel). Fracture Mechanics Lab. **APPLICATION OF THE CYCLIC J-INTEGRAL TO FATIGUE CRACK PROPAGATION**

YEHUDA VOLPERT and LESLIE BANKS-SILLS In Israel Society of Aeronautics and Astronautics, 32nd Annual Conference on Aviation and Astronautics p 136-143 20 Feb. 1992

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A cyclic J-integral method is investigated considering correlation of fatigue crack growth rate under elastic and small scale yielding conditions. An experimental/numerical study is carried out in order to explain more clearly the meaning of the cyclic J-integral delta J, for fatigue crack growth studies. Compact tension specimens fabricated from Al 2024-T351 were subjected to constant amplitude loading with two R-ratios (R approximately equal to 0.05 and 0.5). A simulation of conducted tests is carried out numerically, employing the finite element method with the material modeled to be elasto-plastic. From the numerical results, values of delta J are calculated from both a path independent integral and load versus load-line displacement data. Comparison between these values, as well as with those determined from experiments are seen to be reasonable. The delta J parameter is seen to correlate properly with the crack growth rate under elastic and small-scale yielding conditions.

ISA

N93-27210 Israeli Air Force, Zahal. **DAMAGE TOLERANCE ASSESSMENT AND USAGE VARIATION ANALYSIS FOR C-130 AIRCRAFT IN THE ISRAELI AIR FORCE**

D. SCHUR, E. MAKEVET, and A. DUMANIS In Israel Society of Aeronautics and Astronautics, 32nd Annual Conference on Aviation and Astronautics p 368-372 20 Feb. 1992

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The development of damage tolerance assessment (DTA) and individual aircraft tracking (IAT) programs for the IAF C-130 fleet is presented in this paper. An 'Aircraft Manager' computer program (USE) for usage variation analysis is described, and its application to support C-130 structural maintenance is discussed in depth. The USE computer program is applied in the assessment of usage variation effects on analytic safety limits, damage growth rates,

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and, consequently, on structural inspection requirements. The discussion of USE applications also highlights certain aspects of aircraft fatigue methodology and fleet management. As the IAF C-130 fleet ages, the IAF combines DTA results, IAT capability and USE applications to maintain the structural integrity of the aircraft. ISA

N93-27250*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

THE ADDITION OF ALGEBRAIC TURBULENCE MODELING TO PROGRAM LAURA

F. MCNEIL CHEATWOOD (Vigyan Research Associates, Inc., Hampton, VA.) and R. A. THOMPSON Apr. 1993 34 p
(Contract RTOP 506-40-91-01)
(NASA-TM-107758; NAS 1.15:107758) Avail: CASI HC A03/MF A01

The Langley Aerothermodynamic Upwind Relaxation Algorithm (LAURA) is modified to allow the calculation of turbulent flows. This is accomplished using the Cebeci-Smith and Baldwin-Lomax eddy-viscosity models in conjunction with the thin-layer Navier-Stokes options of the program. Turbulent calculations can be performed for both perfect-gas and equilibrium flows. However, a requirement of the models is that the flow be attached. It is seen that for slender bodies, adequate resolution of the boundary-layer gradients may require more cells in the normal direction than a laminar solution, even when grid stretching is employed. Results for axisymmetric and three-dimensional flows are presented. Comparison with experimental data and other numerical results reveal generally good agreement, except in the regions of detached flow. Author

N93-27268*# United Technologies Corp., Stratford, CT. Aircraft Div.

SIKORSKY AIRCRAFT ADVANCED ROTORCRAFT TRANSMISSION (ART) PROGRAM Final Report

JULES G. KISH Mar. 1993 209 p
(Contract NAS3-25423; DA PROJ. 1L1-62211-A-47-A; RTOP 505-62-10)
(NASA-CR-191079; NAS 1.26:191079; ARL-CR-49) Avail: CASI HC A10/MF A03

The objectives of the Advanced Rotorcraft Transmission program were to achieve a 25 percent weight reduction, a 10 dB noise reduction, and a 5,000 hour mean time between removals (MTBR). A three engine Army Cargo Aircraft (ACA) of 85,000 pounds gross weight was used as the baseline. Preliminary designs were conducted of split path and split torque transmissions to evaluate weight, reliability, and noise. A split path gearbox was determined to be 23-percent-lighter, greater than 10 dB quieter, and almost four times more reliable than the baseline two stage planetary design. Detail design studies were conducted of the chosen split path configuration, and drawings were produced of a 1/2 size gearbox consisting of a single engine path of the split path section. Fabrication and testing was then conducted on the 1/2 size gearbox. The 1/2 size gearbox testing proved that the concept of the split path gearbox with high reduction ratio double helical output gear was sound. The improvements were attributed to extensive use of composites, spring clutches, advanced high hot hardness gear steels, the split path configuration itself, high reduction ratio, double helical gearing on the output stage, elastomeric load sharing devices, and elimination of accessory drives. Author (revised)

N93-27438*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

NUMERICAL MODELING OF RUNBACK WATER ON ICE PROTECTED AIRCRAFT SURFACES

KAMEL M. AL-KHALIL (National Academy of Sciences - National Research Council, Washington, DC.), THEO G. KEITH, JR. (Toledo Univ., OH.), and KENNETH J. DEWITT (Toledo Univ., OH.) *In* California State Univ., The Fifth Symposium on Numerical and Physical Aspects of Aerodynamic Flows 12 p 1992
Avail: CASI HC A03/MF A04

A numerical simulation for 'running wet' aircraft anti-icing

systems is developed. The model includes breakup of the water film, which exists in regions of direct impingement, into individual rivulets. The wetness factor distribution resulting from the film breakup and the rivulet configuration on the surface are predicted in the numerical solution procedure. The solid wall is modeled as a multilayer structure and the anti-icing system used is of the thermal type utilizing hot air and/or electrical heating elements embedded with the layers. Details of the calculation procedure and the methods used are presented. Author

N93-27451*# Cincinnati Univ., OH. Dept. of Aerospace Engineering and Engineering Mechanics.

INVESTIGATION OF FORCED UNSTEADY SEPARATED FLOWS USING VELOCITY-VORTICITY FORM OF NAVIER-STOKES EQUATIONS

K. N. GHIA, U. GHIA, and G. A. OSSWALD *In* California State Univ., The Fifth Symposium on Numerical and Physical Aspects of Aerodynamic Flows 10 p 1992
Avail: CASI HC A02/MF A04

The phenomenon of forced unsteady separation and eruption of boundary-layer vorticity is a highly-complex, high-Reynolds number flow phenomenon, which abruptly leads to the formation of a dynamic stall vortex as demonstrated earlier by the authors for a NACA 0015 airfoil undergoing constant rate pitch-up motion. This, as well as the results of other researchers, have convincingly demonstrated a complex vortical structure within the state of unsteady separation prior to the evolution of dynamic stall. This phenomenon of vortex eruption, although observed in studying dynamic stall phenomena, is also associated with transition from laminar to turbulence flow and its generic nature has been stressed by many researchers including the present investigators. An unsteady Navier-Stokes (NS) analysis is developed for arbitrarily maneuvering bodies using velocity-vorticity variables; this formulation is nearly form-invariant under a generalized non-inertial coordinate transformation. A fully-implicit uniformly second-order accurate method is used, with the nonlinear convective terms approximated using a biased third-order upwind differencing scheme to be able to simulate higher-Re flows. No explicit artificial dissipation is added. The numerical method is fully vectorized and currently achieves a computational index of 7 micro-seconds per time step per mesh point, using a single processor on a CRAY Y-MP. The simulation results show that the energetic free shear from the leading edge is responsible for the wall viscous layer to abruptly erupt near the center of the counterclockwise rotating eddy in the unsteady boundary layer. Primary, secondary, tertiary and quaternary vortices have been observed before the dynamic stall vortex evolves and gathers its maximum strength. This study will discuss the simulation results of Reynolds number up to $Re = 45,000$ and will also discuss the efforts of initial acceleration in a specific maneuver, on the evolution of the stall vortex. Author

N93-27466*# Iowa Univ., Iowa City. Inst. of Hydraulic Research.

SHIP VISCOUS FLOW: A REPORT ON THE 1990 SSPA-IIHR WORKSHOP

VIRENDRA C. PATEL and LARS LARSSON (Chalmers Univ. of Technology, Goeteborg, Sweden.) *In* California State Univ., The Fifth Symposium on Numerical and Physical Aspects of Aerodynamic Flows 15 p 1992 Sponsored in part by Swedish National Board for Technical Development
(Contract N00014-89-J-1670)
Avail: CASI HC A03/MF A04

To assess the state of the art in ship viscous flow computation a Workshop was organized in 1990 by three organizations: SSPA Maritime Consulting AB, Chalmers University of Technology, and the Iowa Institute of Hydraulic Research. Two test cases were specified by the organizers and sent out to all interested research groups, which were asked to submit results in a prescribed format. In September 1990 a meeting was held at Chalmers University of Technology. All results had then been collected and presented in a common format, and the theories based on responses to a questionnaire sent out earlier. During the meeting, each research group was first given the opportunity to briefly introduce their

method and results. Thereafter, a considerable time was spent on general discussions on the performance of the different methods considering the differences in the underlying theories. Specific items that were addressed were grid generation, governing equations, boundary conditions, turbulence modelling, and numerical methods. Practical aspects of the results, for instance from the point of view of propeller design, were also discussed. The Workshop Proceedings contain a description of the participating methods, and the results of both test cases. In the present paper, a summary of the Workshop and its results is presented. Author (revised)

N93-27570*# Virginia Polytechnic Inst. and State Univ., Blacksburg.

ACTIVE MAGNETIC BEARINGS APPLIED TO INDUSTRIAL COMPRESSORS

R. G. KIRK, J. F. HUSTAK (Dresser Industries, Inc., Olean, NY.), and K. A. SCHOENECK (Dresser Industries, Inc., Olean, NY.) *In* NASA. Langley Research Center, Magnetic Suspension Technology Workshop p 253-269 1993
Avail: CASI HC A03/MF A03

The design and shop test results are given for a high-speed eight-stage centrifugal compressor supported by active magnetic bearings. A brief summary of the basic operation of active magnetic bearings and the required rotor dynamics analysis are presented with specific attention given to design considerations for optimum rotor stability. The concerns for retrofits of magnetic bearings in existing machinery are discussed with supporting analysis of a four-stage centrifugal compressor. The current status of industrial machinery in North America using this new support system is presented and recommendations are given on design and analysis requirements for successful machinery operation of either retrofit or new design turbomachinery. Author

N93-27727*# Millitech Corp., South Deerfield, MA.
COHERENT SYSTEMS IN THE TERAHERTZ FREQUENCY RANGE: ELEMENTS, OPERATION, AND EXAMPLES

PAUL F. GOLDSMITH *In* Michigan Univ., The Third International Symposium on Space Terahertz Technology: Symposium Proceedings p 1-23 1992 Prepared in cooperation with Five-College Astronomy Dept., Amherst, MA
Avail: CASI HC A03/MF A06

The topics are presented in viewgraph form and include the following: terahertz coherent systems applications; a brief overview of selected components; radiometry and spectroscopy—astronomy; radiometry—aircraft all weather landing system; radiometry—atmospheric remote sensing; plasma diagnostics; communications; radar systems; and materials measurement and manufacturing process control. Derived from text

N93-27832# Technical Research Centre of Finland, Espoo. Ship Lab.

INTERACTION BETWEEN ICE AND PROPELLER

MATTI JUSSILA and HARRI SOININEN Sep. 1991 84 p (ISSN 0358-5085)
(VTT-TIED-1281; ISBN-951-38-4014-X; ETN-93-93776) Copyright
Avail: CASI HC A05/MF A01

A state of art review of work aiming to achieve a practical dimensioning tool for ice operating ship machineries is presented. The main emphasis is on various models of propeller-ice interaction. This was chosen as the starting point since the loads impacted to the shaft system originate from the propeller. Further work is needed to cover the requirements of the shaft modeling. The most important existing models of propeller-ice interaction are presented. The equations are worked out and the theoretical idea of each method is discussed. A few published field measurements are outlined. The areas of lack of knowledge are discussed. The basics of the present ice regulations for machineries are presented, without details of the equations. The physical background for the ice load is revealed to be vague. ESA

N93-28053*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

STATUS OF THE FIBER OPTIC CONTROL SYSTEM INTEGRATION (FOCSI) PROGRAM

ROBERT J. BAUMBICK May 1993 17 p
(Contract RTOP 505-62-50)
(NASA-TM-106151; E-7832; NAS 1.15:106151) Avail: CASI HC A03/MF A01

This report presents a discussion of the progress made in the NASA/NAVY Fiber Optic Control System Integration (FOCSI) program. This program will culminate in open-loop flight tests of passive optical sensors and associated electro-optics on an F-18 aircraft. Currently, the program is in the final stages of hardware fabrication and environmental testing of the passive optical sensors and electro-optics. This program is a foundation for future Fly-by-Light (FBL) programs. The term Fly-by-Light is used to describe the utilization of passive optical sensors and fiber optic data links for monitoring and control of aircraft in which sensor and actuation signals are transmitted optically. The benefits of this technology for advanced aircraft include the following: improved reliability and reduced certification cost due to greater immunity to EME (electromagnetic effects); reduced harness volume and weight; elimination of short circuits and sparking in wiring due to insulation deterioration; lower maintenance costs (fewer components); greater flexibility in data bus protocol and architecture; absence of ground loops; and higher operating temperatures for electrically passive optical sensors.

Author (revised)

N93-28054# Federal Aviation Administration, Atlantic City, NJ. Technical Center.

NEXT GENERATION WEATHER RADAR (NEXRAD) PRINCIPAL USER PROCESSOR (PUP) OPERATIONAL TEST AND EVALUATION (OT&E) OPERATIONAL TEST PLAN

BAXTER R. STRETCHER Jun. 1993 14 p
(DOT/FAA/CT-TN93/22) Avail: CASI HC A03/MF A01

The purpose of this plan is to describe and detail the procedural approach, method, and responsibilities to be employed in conducting the Operational Test and Evaluation (OT&E) on the Next Generation Weather Radar (NEXRAD) Principal User Processor (PUP) system. The testing of the NEXRAD PUP will determine the operational suitability and effectiveness of the NEXRAD PUP aviation weather products used by the Center Weather Service Unit (CWSU) meteorologists for air traffic control (ATC). Author

N93-28242# California Univ., San Diego, La Jolla. Office of Contract and Grant Administration.

STUDIES OF ORIGIN OF THREE-DIMENSIONALITY IN LAMINAR WAKES Final Technical Report, 1 Dec. 1989 - 31 Jan. 1993

MORTEZA GHARIB 17 Feb. 1993 32 p
(Contract N00014-90-J-1314)
(AD-A262281) Avail: CASI HC A03/MF A01

Wind tunnel experiments, using hot-wire anemometry and smoke-wire flow visualization, were conducted to study the process of transition from laminar to turbulent flow of parallel and oblique vortex streets from circular cylinders. It was found that the origin and scale of three-dimensionality which appears at Reynolds numbers just below the transition from laminar to turbulent flow are dependent on the vortex shedding geometry in the near-wake. Oblique vortex streets develop large scale three-dimensional structures and undergo an early transition, i.e. at lower Reynolds numbers, when compared to parallel vortex streets. This is due to the presence of three-dimensionality in oblique wakes at pretransition Reynolds numbers, whereas parallel wakes remain laminar until the vortices themselves develop three-dimensional features. The downstream evolution of these two wake geometries from the primary Karman vortices to the far-wake vortical structures was also investigated. The far-wake structures are parallel to the cylinder axis for parallel shedding. For oblique shedding, these structures are initially parallel to the cylinder axis, but further

downstream they develop a strong spanwise modulation whose wavelength is the spanwise distance between two consecutive Karman vortices of the same sign of vorticity. DTIC

N93-28289# Air Force Inst. of Tech., Wright-Patterson AFB, OH. Foreign Aerospace Science and Technology Center.
DETECTION PERFORMANCE OF DIGITAL POLARITY SAMPLED PHASE REVERSAL CODE PULSE COMPRESSORS
 ZHU SHAODA and TU SHUDE 2 Apr. 1993 11 p Transl. into ENGLISH from Dianzixue Xuekan (China), v. 9, no. 3, May 1987 p 269-272
 (AD-A262930; FASTC-ID(RS)T-0309-92) Avail: CASI HC A03/MF A01

The nonparametric constant false alarm rate (CFAR) property of digital polarity sampled phase reversal coded pulse compressors is described. The detection performance in Gaussian and non-Gaussian noise is determined. It is shown that the loss in signal-to-noise ratio of the processor, relative to the incoherent matched filter, decreases as the code length increases. The asymptotic loss in Gaussian noise is 1.96dB, and the loss in Weibull noise decreases with the shape parameter of the Weibull distribution and can even become a gain. DTIC

N93-28555# Federal Aviation Administration, Atlantic City, NJ.
TIME DELAY MEASUREMENTS OF CURRENT PRIMARY FAA AIR/GROUND TRANSMITTERS AND RECEIVERS
 JOHN PETRO and PHILIP RANDAZZO Jun. 1993 25 p
 (DOT/FAA/CT-TN93/14) Avail: CASI HC A03/MF A01

The results of tests performed by ACW-300B, Spectrum Engineering Group, in determining the amount of time delay present in various air/ground communications equipment are detailed. This test was comprised of a Federal Aviation Administration (FAA) Air Navigation Ground Radio Transmitter (AN-GRT-21) and an FAA Air Navigation Ground Radio Receiver (AN-GRR-23): two aircraft transceivers, a King KTR-905 very high frequency (VHF) transceiver, and a Collins VHF-251 Technical Standard Order (TSO) transceiver Author (revised)

N93-28635# Joint Publications Research Service, Arlington, VA.
JPRS REPORT: SCIENCE AND TECHNOLOGY. CENTRAL EURASIA: ENGINEERING AND EQUIPMENT
 8 Jun. 1992 52 p Transl. into ENGLISH from various Russian articles
 (JPRS-UEQ-92-007) Avail: CASI HC A04/MF A01

Translated articles cover the following topics: aviation and space technology; optics, high energy devices; nuclear energy; non-nuclear energy; and mechanics of gases, liquids, and solids. CASI

N93-28636# Joint Publications Research Service, Arlington, VA.
JPRS REPORT: SCIENCE AND TECHNOLOGY. CENTRAL EURASIA: ENGINEERING AND EQUIPMENT
 30 Apr. 1992 46 p Transl. into ENGLISH from various Russian articles
 (JPRS-UEQ-92-006) Avail: CASI HC A03/MF A01

Translated articles cover the following topics: aviation and space technology; optics, high energy devices; nuclear energy; non-nuclear energy; mechanics of gases, liquids, and solids; and industrial technology, planning, and productivity. CASI

N93-28674# Joint Publications Research Service, Arlington, VA.
JPRS REPORT: SCIENCE AND TECHNOLOGY. CENTRAL EURASIA: ENGINEERING AND EQUIPMENT
 21 Sep. 1992 55 p Transl. into ENGLISH from various Russian articles
 (JPRS-UEQ-92-010) Avail: CASI HC A04/MF A01

Translated articles cover the following topics: aviation and space technology; optics, high energy devices; nuclear energy; non-nuclear energy; mechanics of gases, liquids, and solids; and industrial technology, planning, and productivity. CASI

N93-28675# Joint Publications Research Service, Arlington, VA.
JPRS REPORT: SCIENCE AND TECHNOLOGY. CENTRAL EURASIA: ENGINEERING AND EQUIPMENT

8 Jul. 1992 44 p Transl. into ENGLISH from various Russian articles
 (JPRS-UEQ-92-008) Avail: CASI HC A03/MF A01

Translated articles cover the following topics: aviation and space technology; optics, high energy devices; nuclear energy; mechanics of gases, liquids, and solids; and industrial technology, planning, and productivity. CASI

N93-28685# Sandia National Labs., Albuquerque, NM.
RELIABILITY ASSESSMENT AT AIRLINE INSPECTION FACILITIES. VOLUME 2: PROTOCOL FOR AN EDDY CURRENT INSPECTION RELIABILITY EXPERIMENT Final Report

FLOYD SPENCER, GIANCARLO BORGONOV (Science Applications, Inc., Albuquerque, NM.), DENNIS ROACH, DON SCHURMAN (Science Applications, Inc., Albuquerque, NM.), and RON SMITH (AEA Technology, London, England.) May 1993 62 p
 (DOT/FAA/CT-92/12-VOL-2) Avail: CASI HC A04/MF A01

The Aging Aircraft NDI Development and Demonstration Center (AANC) at Sandia National Laboratories is charged by the FAA to support technology transfer, technology assessment, and technology validation. A key task facing the center is the establishment of a consistent and systematic methodology to assess the reliability of inspections through field experiments. This task is divided into three major areas: reliability of eddy current lap splice inspections at transport aircraft maintenance facilities; reliability of inspection at commuter aircraft maintenance facilities; and reliability of inspection associated with visual inspection of aircraft structural parts. Volume 2 is the second document in a series of three describing the planning, execution, and results of an eddy current inspection field experiment. This document provides a detailed description of the experimental hardware and protocols. It also describes the methodology to be used in the analysis of the data. Author (revised)

N93-28691# Joint Publications Research Service, Arlington, VA.
JPRS REPORT: SCIENCE AND TECHNOLOGY. CENTRAL EURASIA: ENGINEERING AND EQUIPMENT
 22 Feb. 1993 38 p Transl. into ENGLISH from various Russian articles
 (JPRS-UEQ-93-003) Avail: CASI HC A03/MF A01

Translated articles cover the following topics: aviation and space technology; nuclear energy; non-nuclear energy; mechanics of gases, liquids, and solids; and industrial technology, planning, and productivity. Author

N93-28766*# Hughes Danbury Optical Systems, Inc., CT.
THE HYDICE INSTRUMENT DESIGN AND ITS APPLICATION TO PLANETARY INSTRUMENTS Abstract Only
 R. BASEDOW, P. SILVERGLATE, W. RAPPOPORT, R. ROCKWELL, D. ROSENBERG, K. SHU, R. WHITTLESEY, and E. ZALEWSKI In Lunar and Planetary Inst., Workshop on Advanced Technologies for Planetary Instruments, Part 1 p 1 1993
 Avail: CASI HC A01/MF A01

The Hyperspectral Digital Imagery Collection Experiment (HYDICE) instrument represents a significant advance in the state of the art in hyperspectral sensors. It combines a higher signal-to-noise ratio (SNR) and significantly better spatial and spectral resolution and radiometric accuracy than systems flying on aircraft today. The need for 'clean' data, i.e., data free of sampling artifacts and excessive spatial or spectral noise, is a key driver behind the difficult combination of performance requirements laid out for HYDICE. Most of these involve the sensor optics and detector. This paper presents an optimized approach to those requirements, one that comprises push broom scanning, a single, mechanically cooled focal plane, a double-pass prism spectrometer, and an easily fabricated yet wide-field telescope. Central to the approach is a detector array that covers the entire spectrum from 0.4 to 2.5 microns. Among the major benefits conferred by such a design are optical and mechanical simplicity, low polarization sensitivity, and coverage of the entire spectrum without suffering the spectral gaps caused by beam splitters. The

overall system minimizes interfaces to the C-141 aircraft on which it will be flown, can be calibrated on the ground and in flight to accuracies better than those required, and is designed for simple, push-button operation. Only unprocessed data are recorded during flight. A ground data processing station provides quick-look, calibration correction, and archiving capabilities, with a throughput better than the requirements. Overall performance of the system is expected to provide the solid database required to evaluate the potential of hyperspectral imagery in a wide variety of applications. HYDICE can be regarded as a test bed for future planetary instruments. The ability to spectrally image a wide field of view over multiple spectral octaves offers obvious advantages and is expected to maximize science return for the required cost and weight. Author (revised)

N93-28943# Argonne National Lab., IL. Materials and Components Technology Div.

USE OF LOCAL X RAY COMPUTERIZED TOMOGRAPHY FOR HIGH-RESOLUTION, REGION-OF-INTEREST INSPECTION OF LARGE CERAMIC COMPONENTS FOR ENGINES

E. A. SIVERS, D. A. HOLLOWAY, and W. A. ELLINGSON 1993 21 p Presented at the 38th ASME International Gas Turbine and Aeroengine Congress and Exhibition, Cincinnati, OH, 24-27 May 1993

(Contract W-31-109-ENG-38)
(DE93-005564; ANL/MCT/CP-77501; CONF-930502-2) Avail: CASI HC A03/MF A01

Reliability continues to be an issue in ceramic components for high-temperature, high-wear applications in advanced engine designs. Recently, high-resolution, three-dimensional, X-ray computerized tomography (XRCT) has been shown to be invaluable for inspecting relatively small components. However, the time and system capacity required to collect complete high-resolution data for large ceramic objects is often prohibitive. When only the critical regions of a large component need be inspected with high resolution, region-of-interest XRCT is a viable alternative. With local XRCT methods used on data taken through only the critical area, it is possible to reconstruct flat, 'edge-enhanced' images in which density differences are clearly delineated. We present XRCT results from local scans of critical regions in a large, pressure-slip-cast, Si3N4 turbine rotor and two Si3N4 test phantoms. We also illustrate how the method can be extended to larger assemblies of ceramic components. DOE

N93-28975*# Institute for Computer Applications in Science and Engineering, Hampton, VA.

SOME ASPECTS OF THE AEROACOUSTICS OF HIGH-SPEED JETS Final Report

JAMES LIGHTHILL (University Coll., London, England.) Washington May 1993 47 p Submitted for publication
(Contract NAS1-19480; RTOP 50-90-52-01)
(NASA-CR-191458; NAS 1.26:191458; ICASE-93-20) Avail: CASI HC A03/MF A01

Some of the background to contemporary jet aeroacoustics is addressed. Then scaling laws for noise generation by low-Mach-number airflows and by turbulence convected at 'not so low' Mach number is reviewed. These laws take into account the influence of Doppler effects associated with the convection of aeroacoustic sources. Next, a uniformly valid Doppler-effect approximation exhibits the transition, with increasing Mach number of convection, from compact-source radiation at low Mach numbers to a statistical assemblage of conical shock waves radiated by eddies convected at supersonic speed. In jets, for example, supersonic eddy convection is typically found for jet exit speeds exceeding twice the atmospheric speed of sound. The Lecture continues by describing a new dynamical theory of the nonlinear propagation of such statistically random assemblages of conical shock waves. It is shown, both by a general theoretical analysis and by an illustrative computational study, how their propagation is dominated by a characteristic 'bunching' process. That process associated with a tendency for shock waves that have already formed unions with other shock waves to acquire an increased

proneness to form further unions - acts so as to enhance the high-frequency part of the spectrum of noise emission from jets at these high exit speeds. Author (revised)

N93-28994# Aeronautical Research Inst. of Sweden, Bromma. Dept. of Aerodynamics.

IMPLEMENTATION OF A MULTIDOMAIN NAVIER-STOKES CODE ON THE INTEL IPSC2 HYPERCUBE

PETER ELIASSON, INGEMAR LINDBLAD, and PER WAHLUND 18 Nov. 1992 19 p
(Contract NUTEK-90-02278P; PROJ. AU-4093)
(FFA-TN-1992-37) Avail: CASI HC A03/MF A01

This report describes the implementation of a multidomain/multigrid 3D Navier-Stokes code on a parallel computer, namely the Intel iPSC2 hypercube. The sequential flow code was the EURANUS code, developed at VUB, Brussels and FFA, Stockholm. In addition to the Navier-Stokes and multigrid algorithms, this code is characterized by a software-engineering-based coding approach to produce a structured and flexible program. It has a dynamic memory handling to facilitate the storage and maintenance of multiple domains of different sizes. The data structure supports more than one (super)computer architecture and facilitates parallel processing. Multidomain calculations are handled in the code in a flexible manner which can be used on MIMD type computers as well as supercomputers. The host-node program structure and explicit send-receive routines for data exchange between domains on the hypercube meant that the start-up of the code and the handling of external files had to undergo the largest changes. The code was tested on a realistic hypersonic problem, a delta wing at Mach 10. This is a one domain problem, to run it parallel the domain was split up into several smaller equally sized domains. The domains were then distributed to the nodes, one domain per node. Due to the small memory of the machine (4 Mbytes/nodes) rather small problems fit into the memory. Two different cases were run using 1 to 16 nodes (domains). The results revealed that the overhead from the data structure and boundary conditions is rather high. This indicates that the subdivided domains are too small for good efficiency. High speedups require larger cases and machines with much larger memory. Author (revised)

N93-29040 Minnesota Univ., Minneapolis.
STABILIZED SPACE-TIME FINITE ELEMENT FORMULATIONS FOR UNSTEADY INCOMPRESSIBLE FLOWS INVOLVING FLUID-BODY INTERACTIONS Ph.D. Thesis

SANJAY MITTAL 1992 177 p
Avail: Univ. Microfilms Order No. DA9308739

Stabilized space-time finite element formulations are presented for unsteady incompressible flows involving fluid-body interactions. A detailed numerical investigation is carried out for flows past an elastically mounted cylinder. The non-linear coupling between the flow field and the motion of the cylinder leads to interesting phenomena like 'hysteresis' and 'lock-in'. Flows past a horizontally oscillating cylinder and a pitching airfoil are also studied. The method is also applied to compute the dynamics of a freely falling airfoil and a projectile that has certain initial velocity. In all these computations, smart mesh moving schemes are used that minimize the projection errors and increase the parallelization potential. The formulations are used to study laminar flow past a fixed airfoil at high Reynolds numbers. Preliminary results are presented for a three-dimensional simulation that involves time-dependent Taylor instabilities in Couette flow. Efficient iteration techniques are employed to solve the equation systems resulting from the finite element discretizations of these large-scale problems. A large fraction of these computations are carried out on massively parallel supercomputers. Dissert. Abstr.

GEOSCIENCES

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

A93-36034**AN OBSERVATIONAL STUDY OF THE DRYLINE**

CONRAD L. ZIEGLER (NOAA, National Severe Storms Lab., Boulder, CO) and CARL E. HANE (NOAA, National Severe Storms Lab., Norman, OK) *Monthly Weather Review* (ISSN 0027-0644) vol. 121, no. 4 April 1993 p. 1134-1151. Research supported by NOAA refs

An analysis is presented of aircraft, sounding, and surface measurements across a dryline that occurred in western Oklahoma on May 24, 1989. The analysis reveals that the dryline environment on this day was typical of other dryline cases; of greatest significance is a pronounced gradient of virtual potential temperature. AIAA

A93-37691**COMPARISON OF THREE METHODS TO DEDUCE THREE-DIMENSIONAL WIND FIELDS IN A HURRICANE WITH AIRBORNE DOPPLER RADAR**

JOHN F. GAMACHE (NOAA, Hurricane Research Div., Miami, FL), FRANK ROUX (Centre de Recherches en Physique de l'Environnement Terrestre et Planetaire, Issy-les-Moulineaux, France), and FRANK D. MARKS, JR. (NOAA, Hurricane Research Div., Miami, FL) *In International Conference on Radar Meteorology, 25th, Paris, France, June 24-28, 1991, Preprints Boston, MA American Meteorological Society 1991 p. 462-465. refs*

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Winds obtained by the dual-Doppler, pseudo-dual Doppler and forward/aft scanning techniques (FAST) are compared with in situ measurements obtained by research aircraft along the flight track. The relative sizes of the differences between the analyses and the in situ data, and the reasons for these differences are explored. When two Doppler aircraft are flown in a coordinated dual-Doppler pattern, the best analysis of the hurricane's inner core is possible. The evolution of the inner core may be explored successfully over a 6-8 h period. If the aircraft drift angle is small, an accurate wind field may be obtained by one aircraft employing the FAST technique. It is argued that the mounting of a dual-antenna radar will provide effective dual-Doppler coverage with one aircraft. AIAA

A93-37694**COMPARISON OF AIRBORNE DUAL-DOPPLER AND AIRBORNE/GROUND-BASED DUAL-DOPPLER ANALYSES OF NORTH DAKOTA THUNDERSTORMS**

REBECCA J. MEITIN (Cooperative Inst. for Research in Environmental Sciences, Boulder, CO), RODGER A. BROWN (NOAA, National Severe Storms Lab., Norman, OK), and JOSE G. MEITIN (NOAA, National Severe Storms Lab., Boulder, CO) *In International Conference on Radar Meteorology, 25th, Paris, France, June 24-28, 1991, Preprints Boston, MA American Meteorological Society 1991 p. 474-477. Research sponsored by NOAA, NSF, and North Dakota Atmospheric Resource Board refs*

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Dual-Doppler analyses using aircraft radar data are compared with analysis from a previous study of North Dakota thunderstorms. Combinations of ground and airborne Doppler radar and aircraft radar data are found to produce a consistent picture of storm evolution. On the basis of the limited sample in this study, Doppler radar data collected over a 10-15 min period along two orthogonal legs of a flight track do not appear to seriously violate the steady-state assumption within convective storms. AIAA

A93-37719**HYDROMETEOR IDENTIFICATION USING CROSS POLAR RADAR MEASUREMENTS AND AIRCRAFT VERIFICATION**

I. R. FROST (Univ. of Manchester Inst. of Science and Technology, United Kingdom), J. W. F. GODDARD (Rutherford Appleton Lab., Didcot, United Kingdom), and A. J. ILLINGWORTH (Univ. of Manchester Inst. of Science and Technology, United Kingdom) *In International Conference on Radar Meteorology, 25th, Paris, France, June 24-28, 1991, Preprints Boston, MA American Meteorological Society 1991 p. 658-661. Research supported by Meteorological Office refs* (Contract NERC-GR/3/5896; AF-AFOSR-88-0121) Copyright

Observations of the linear depolarization ratio (LDR) of different types of precipitation made at S-band with the Chilbolton radar in southern England are reported. The suggestion of Illingworth and Caylor (1989) that melting graupel is associated with LDR values of -25 dB and that values of -15 dB occur for melting snow having an axial ratio of 0.5 is confirmed. The LDR values suggest that the maximum mean canting angle for rain is 10 deg and that real values may be even lower than this. AIAA

A93-38567**ELECTROSTATIC DISCHARGES [LES DECHARGES ELECTROSTATIQUES]**

J. L. BOULAY (ONERA, Chatillon, France) ONERA, TP no. 1992-82 1992 10 p. *In FRENCH Colloque Europeen ASTELAB, Paris, France, June 16-18, 1992 refs* (ONERA, TP NO. 1992-82)

Surface discharges generated in the laboratory have made it possible to analyze different phases of lightning strikes on aircraft. Various experimental techniques have been used to investigate leader discharges and return arcs, i.e., bidirectional discharges which constitute the major phases of an aircraft lightning strike. Measurements of currents and electric fields, as well as discharge-channel spectroscopy, have made it possible to develop reliable theoretical models for the phenomenon. AIAA

A93-39762**SEA FOG AND STRATUS - A MAJOR AVIATION AND MARINE HAZARD IN THE NORTHERN GULF OF MEXICO**

G. A. JOHNSON and JEFFREY GRASCHEL (NOAA, National Weather Service Forecast Office, New Orleans, LA) *In Symposium on Weather Forecasting, Atlanta, GA, Jan. 5-10, 1992, Preprints Boston, MA American Meteorological Society 1992 p. 55-60. refs*

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An effort is made to develop techniques for the identification of those synoptic patterns that are conducive to sea fog and low stratus formation in the northern Gulf of Mexico, making extensive use of graphical techniques. An account is given of the forecasting technique recommended to the New Orleans National Weather Service Forecast Office. AIAA

N93-27012*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

NITRIC OXIDE FORMATION IN A LEAN, PREMIXED-PREVAPORIZED JET A/AIR FLAME TUBE: AN EXPERIMENTAL AND ANALYTICAL STUDY

CHI-MING LEE, JEAN BIANCO (Ohio Aerospace Inst., Brook Park.), JOHN M. DEUR (Sverdrup Technology, Inc., Brook Park, OH.), and BAHMAN GHORASHI (Cleveland State Univ., OH.) Nov. 1992 15 p

(Contract RTOP 537-01-11)

(NASA-TM-105722; E-7121; NAS 1.15:105722) Avail: CASI HC A03/MF A01

An experimental and analytical study was performed on a lean, premixed-prevaporized Jet A/air flame tube. The NO(x) emissions were measured in a flame tube apparatus at inlet temperatures ranging from 755 to 866 K (900 to 1100 F), pressures from 10 to 15 atm, and equivalence ratios from 0.37 to 0.62. The data were then used in regressing an equation to predict the NO(x) production levels in combustors of similar design. Through an evaluation of

parameters it was found that $NO(x)$ is dependent on adiabatic flame temperature and combustion residence time, yet independent of pressure and inlet air temperature for the range of conditions studied. This equation was then applied to experimental data that were obtained from the literature, and a good correlation was achieved. Author

N93-27179 Technion - Israel Inst. of Tech., Haifa. Faculty of Aerospace Engineering.

MERGING SPARSE OPTICAL FLOW AND EDGE CONNECTIVITY BETWEEN IMAGE FEATURES: A REPRESENTATION SCHEME FOR 2-D DISPLAY OF SCENE DEPTH

J. WALDMANN and S. J. MERHAV *In* Israel Society of Aeronautics and Astronautics, 32nd Annual Conference on Aviation and Astronautics p 107-115 20 Feb. 1992

Copyright Avail: Israel Society of Aeronautics and Astronautics, c/o Faculty of Engineering, Tel-Aviv Univ., Ramat Aviv 69978, Israel

A representation scheme for sparse depth maps which supports 3-D interpretation is developed. The sparse depth map is obtained by combining the optical flow with noisy measurements of the motion parameters. An edge-connectivity digraph is built with its nodes mapping image features. The edge connectivity in the image is mapped into the digraph connectivity. A depth-parameterized grammar has been created to generate strings from the digraph. This model copes with images of unstructured surroundings which cannot be easily dealt with by object modelling and matching techniques. Connected nodes with similar depth attributes are clustered into strings that correspond to distinct edges in the image, using data at pixel level. The scheme was tested on blurred synthetic images of house-shaped obstacles. The spatial distribution of the resulting edges closely approximates the actual 3-D contour of the obstacles, with occlusions successfully resolved. The resulting 3-D connectivity can be used to augment a coarse-resolution terrain database with the purpose of automated obstacle avoidance during nap-of-the-earth flight. ISA

N93-27675# National Center for Atmospheric Research, Boulder, CO.

A STATISTICAL CHARACTERIZATION OF DENVER-AREA MICROBURSTS Final Report

KIMBERLY L. ELMORE and JOHN MCCARTHY Dec. 1992 55 p Revised

(Contract DTFA01-82-Y-10513)

(AD-A262127; DOT/FAA/NR-92/13-REV; XH-DOT/FAA/NR)

Avail: CASI HC A04/MF A01

This document describes statistical characteristics of microbursts that occurred in the Denver area during the summers of 1982 and 1984. The Joint Airport Weather Studies (JAWS) Project, conducted between 15 May and 13 August 1982, is the primary data source for this report, and radar data from the Classify, Locate and Avoid Wind Shear (CLAWS) Project are also included for microburst lines and low-reflectivity microbursts. All surface mesonet data come from the JAWS Project. This report describes the statistical characteristics of the JAWS and CLAWS data that have been analyzed to date and is intended to be used as a working document. It is primarily a compendium of several different sources brought together in a single document. DTIC

N93-28603# Sandia National Labs., Albuquerque, NM. Experimental Mechanics Dept.

THE NATURAL EXCITATION TECHNIQUE (NEXT) FOR MODAL PARAMETER EXTRACTION FROM OPERATING WIND TURBINES

GEORGE H. JAMES, III, THOMAS G. CARNE, and JAMES P. LAUFFER Feb. 1993 46 p

(Contract DE-AC04-76DP-00789)

(DE93-010611; SAND-92-1666) Avail: CASI HC A03/MF A01

The Natural Excitation Technique (NEXt) is a method of modal testing that allows structures to be tested in their ambient environments. This report is a compilation of developments and results since 1990, and contains a new theoretical derivation of

NEXt, as well as a verification using analytically generated data. In addition, we compare results from NEXt with conventional modal testing for a parked, vertical-axis wind turbine, and, for a rotating turbine, NEXt is used to calculate the model parameters as functions of the rotation speed, since substantial damping is derived from the aeroelastic interactions during operation. Finally, we compare experimental results calculated using NEXt with analytical predictions of damping using aeroelastic theory. DOE

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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.

A93-35915

DEVELOPMENT OF AN EXPERT SYSTEM FOR COCKPIT EMERGENCY PROCEDURES

MIKE CARTER, C. D. HOLLEY, and J. H. EMERY (Bell Helicopter Textron, Inc., Fort Worth, TX) *In* AHS, Annual Forum, 48th, Washington, June 3-5, 1992, Proceedings. Vol. 1 Alexandria, VA American Helicopter Society 1992 p. 215-222. refs Copyright

Several studies were conducted by Bell Helicopter Textron, Inc. (BHTI), circa 1985, to examine the role of human error in helicopter accidents. These efforts included formulating constructs related to pilot error accidents and, where appropriate, training rationale as a potential intervening strategy. The foregoing background and the software-based training tool that was subsequently developed to attenuate some aspects of the pilot error problem are discussed in this paper. Preliminary results suggest that the software tool provides a practical approach for remediating some aspects of the pilot error problem. Author

A93-35920

MIDAS TECHNOLOGY TRANSFER

ROBERT M. BEGGS (Boeing Defense & Space Group, Helicopters Div., Philadelphia, PA) *In* AHS, Annual Forum, 48th, Washington, June 3-5, 1992, Proceedings. Vol. 1 Alexandria, VA American Helicopter Society 1992 p. 267-274. refs Copyright

This paper discusses recent research activities associated with the transfer of the Army-NASA Man/Machine Integration Design and Analysis System (MIDAS) technologies to Boeing Helicopters. It describes the nature of the Army-NASA/Boeing Technical Exchange Agreement (TEA) and the benefits of this collaboration. The paper also introduces supplemental software developed at Boeing, entitled the MIDAS/Systems Analysis Tool (M/SAT). M/SAT provides a method for Boeing Human Factors analysts and NASA system developers to exercise and test the Task Loading Model, a critical module of the MIDAS architecture. Author

A93-36007

VALISYS - A NEW QUALITY ASSURANCE TOOL

JOHN J. MAZUR, JR. (Boeing Defense & Space Group, Helicopters Div., Philadelphia, PA) *In* AHS, Annual Forum, 48th, Washington, June 3-5, 1992, Proceedings. Vol. 2 Alexandria, VA American Helicopter Society 1992 p. 1481-1493.

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This paper details the use of Valisys software for inspection of parts at Boeing Helicopters. Valisys, developed by the Valisys Corporation and marketed by IBM, runs on the CATIA (Computer-Aided Three-Dimensional Interactive Application) CAD/CAM System. Valisys is presently used at Boeing Helicopters to program coordinate measuring machines (CMMs) for inspection of aircraft parts and analysis of CMM data. Valisys works interactively with CATIA to assure that engineering designs conform

15 MATHEMATICAL AND COMPUTER SCIENCES

to the ANSI Y14.5 Standard and produces CMM programs directly from the CATIA designs. One of the keys to Valisys is a revolutionary tool called a Softgauge (Registered Trademark of Valisys Corporation). It is a precise three-dimensional CAD model of a part's tolerance zone and its associated datums. Design Engineers can use Softgauges to graphically visualize a part's worstcase condition and Quality Engineers use them as inspection criteria for CMM inspection. Valisys produces CMM programs directly from the Softgauges, creates an electronic CAD model of the as-built part and then compares it to the Softgauge definition. This paper examines the Valisys inspection process at Boeing Helicopters with specific applications and examples of the benefits that are currently being realized. Also discussed are plans to implement Valisys in a Flexible Machining Cell for in-process inspection on milling machines. Author

A93-36010

AN APPLICATION OF KNOWLEDGE-BASED ENGINEERING TO COMPOSITE TOOLING DESIGN

SHARON LEWIS and PIERRE JOUIN (McDonnell Douglas Helicopter Co., Mesa, AZ) *In* AHS, Annual Forum, 48th, Washington, June 3-5, 1992, Proceedings. Vol. 2 Alexandria, VA American Helicopter Society 1992 p. 1507-1515. refs Copyright

McDonnell Douglas Helicopter Company is using a knowledge-based engineering system to reduce the development cycle time and unit costs of its advanced technology commercial helicopter, the MDX. The largely composite aircraft requires extensive tooling strings that greatly increase both development time and unit costs. With knowledge-based engineering, the tooling expertise is stored in the system's rule base which is then used to automatically generate new designs. Currently, efforts are focused on automating the time consuming but relatively routine task of designing the 'trim and drill fixture' component of the MDX tool string. Estimates show that this automation reduces the design time and cost by 50 percent. Savings, such as these will help MDHC, and other aerospace companies, to be cost effective competitors in the future. Author

A93-36327

A THEORETICAL STUDY ON THE ETHYLENE SYSTEM - A FUZZY DIAGNOSTIC EXPERT SYSTEM FOR LARGE ROTATING MACHINERY

MEIDE ZHAO, WENHU HUANG, SONGBO XIA, and GENFA XU (Harbin Inst. of Technology, China) *Journal of Vibration Engineering* (ISSN 1004-4523) vol. 5, no. 2 June 1992 p. 105-113. In Chinese. refs

A weighting fuzzy connection-operator is introduced in fuzzy production systems, and four kinds of symptoms are presented. Based on two new concepts, a new fuzzy knowledge representation method, called the generalized fuzzy production rule, is proposed for the formal representation of the diagnostic expert knowledge in rotating machinery. An endorsement factor is introduced for describing the semantics of fuzzy implication, and a fuzzy reasoning algorithm is proposed. The ETHYLENE system, a fuzzy diagnostic expert system for turbocompressors, is built based on the new fuzzy knowledge representation method and the new fuzzy reasoning algorithm. Two diagnostic results obtained by running the ETHYLENE system show that the system can act as a useful decision aid in the fault diagnosis of large rotating machinery. Author (revised)

A93-37034

MODEL REFERENCE CONTROL OF A LINEAR PLANT WITH FEEDTHROUGH ELEMENT

RONALD A. PEREZ (Wisconsin Univ., Milwaukee) and OSITA D. I. NWOKAH (Purdue Univ., West Lafayette, IN) *In* IEEE International Conference on Systems Engineering, Dayton, OH, Aug. 1-3, 1991, Proceedings New York Institute of Electrical and Electronics Engineers, Inc. 1991 p. 81-84. Research supported by General Motors Corp. and Purdue Research Foundation refs Copyright

A simple control law that guarantees that the outputs of a linear time invariant plant with feedthrough element will converge asymptotically to a prespecified set of desired trajectories is developed. This control law is illustrated on a gas turbine engine to demonstrate its applicability to higher dimension problems and the fast asymptotic convergence to the desired trajectories. With this method, the plant transfer function or plant state equation can be identified continuously and parameter variations in the transfer function of the plant simply can be compensated for by adjusting parameters of the controller and thereby obtaining satisfactory system performance continuously. The algorithm presented allows for the use of model reference control when the plant model has a feedthrough element and bypasses the selection of a candidate Lyapunov function. It is easy to implement and can be made to converge arbitrarily fast. Author

A93-37041

ROBOTIC AIRCRAFT REFUELING - A CONCEPT DEMONSTRATION

M. B. LEAHY, JR., R. A. BENNETT (USAF, Inst., of Technology, Wright-Patterson AFB, OH), Y. C. SHIU (Wright State Univ., Dayton, OH), and C. A. ANDERSEN (USAF, Inst., of Technology, Wright-Patterson AFB, OH) *In* IEEE International Conference on Systems Engineering, Dayton, OH, Aug. 1-3, 1991, Proceedings New York Institute of Electrical and Electronics Engineers, Inc. 1991 p. 320-323. Research sponsored by USAF refs Copyright

A shared system in which a human positions the refueling arm in the vicinity of an aircraft and then allows the refueling port detection and nozzle insertion to be done automatically by a combination of visual servoing and compliant control is discussed. Experimental concept evaluations have successfully demonstrated algorithms for port detection, visual servoing, and compliant control of nozzle motion and insertion. A project overview is provided. Author (revised)

A93-37623* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

FORMAL VERIFICATION OF ALGORITHMS FOR CRITICAL SYSTEMS

JOHN M. RUSHBY (SRI International, Computer Science Lab., Menlo Park, CA) and FRIEDRICH VON HENKE (Ulm Univ., Germany) *IEEE Transactions on Software Engineering* (ISSN 0098-5589) vol. 19, no. 1 Jan. 1993 p. 13-23. SIGSOFT'91: Software for Critical Systems, Conference, New Orleans, LA, Dec. 4-6, 1991 refs (Contract NAS1-17067) Copyright

We describe our experience with formal, machine-checked verification of algorithms for critical applications, concentrating on a Byzantine fault-tolerant algorithm for synchronizing the clocks in the replicated computers of a digital flight control system. First, we explain the problems encountered in unsynchronized systems and the necessity, and criticality, of fault-tolerant synchronization. We give an overview of one such algorithm, and of the arguments for its correctness. Next, we describe a verification of the algorithm that we performed using our EHD system for formal specification and verification. We indicate the errors we found in the published analysis of the algorithm, and other benefits that we derived from the verification. Based on our experience, we derive some key requirements for a formal specification and verification system adequate to the task of verifying algorithms of the type considered. Finally, we summarize our conclusions regarding the benefits of formal verification in this domain, and the capabilities required of verification systems in order to realize those benefits. Author (revised)

A93-37856

USE OF PCS IN CONTROLLING SIMULATED ALTITUDE ENVIRONMENTAL TEST CONDITIONS IN SUPPORT OF TURBINE ENGINE TESTING

K. S. BURGESS and T. W. HAYES (Sverdrup Technology, Inc.,

Arnold AFB, TN) *In* International Instrumentation Symposium, 38th, Las Vegas, NV, Apr. 26-30, 1992, Proceedings Research Triangle Park, NC Instrument Society of America 1992 p. 89-106.

Copyright

The application of conventional PC's in controlling complex simulated altitude test environment parameters is discussed. The parameters (pressure, temperature, and mass flow) are controlled in an integrated fashion and coordinated with the turbine engine power settings. The integrated controls include a multi-PC configuration with data recording and operating displays linked with an IEEE-488 communication bus. Checkout and experience to date is reviewed. Author

A93-37866

A DATA REDUCTION SYSTEM FOR PROCESSING INSTRUMENTED FLIGHT TEST DATA

JOHN E. BLYLER (Idaho State Univ., Pocatello) *In* International Instrumentation Symposium, 38th, Las Vegas, NV, Apr. 26-30, 1992, Proceedings Research Triangle Park, NC Instrument Society of America 1992 p. 401-408. refs

Copyright

A modern data reduction, processing and analysis facility has been developed for the U.S. Navy's west coast F-14D aircraft support center. The subject of this paper and a major component of this facility is the main data reduction, preprocessing and computer interface station, called the Data Reduction Interface Assembly (DRIA). This assembly is part of a system used to compile the voluminous data generated by test flights of specially instrumented F-14D jet aircraft. Most major data formats, e.g., frequency modulation (FM), pulse code modulation (PCM), pulse amplitude modulation (PAM), Mil-Std-1553 serial and non-standard serial bus streams, are handled by the DRIA. Author

A93-38128

CFD DEVELOPMENT AND A FUTURE HIGH SPEED COMPUTER

HAJIME MIYOSHI (National Aerospace Lab., Chofu, Japan) *In* Numerical Fluid Dynamics Symposium, 5th, Tokyo, Japan, Dec. 19-21, 1991, Proceedings Tokyo Numerical Fluid Dynamics Symposium Committee 1991 p. 9-16. *In* JAPANESE refs

In order to promote CFB research activities and to make use of the fruits for the R&D of future aircraft and space planes, it is necessary to develop a CFD-oriented computer (NWT) whose processing speed for CFD programs is more than 100 times higher than that of the VP400. This paper is concerned with requirements to the NWT from the viewpoint of the development cost and operation cost, reliability, affinity with CFD programs, operation environment and so on. The discussion concludes that the NWT with performance of more than 100 times higher than the VP400 is feasible with a parallel computer with distributed memory. Author (revised)

A93-38214

OUTPUT FEEDBACK EIGENSTRUCTURE ASSIGNMENT USING TWO SYLVESTER EQUATIONS

V. L. SYRMOS (Manoa Univ. of Hawaii, Honolulu) and F. L. LEWIS (Texas Univ., Arlington) IEEE Transactions on Automatic Control (ISSN 0018-9286) vol. 38, no. 3 March 1993 p. 495-499. refs

Copyright

The problem of output feedback is investigated for systems that satisfy the condition $(p + m)$ greater than n , the condition which makes possible arbitrary pole placement using output feedback. The technique is based on the concept of (C, A, B) invariance and two coupled Sylvester equations. The solution leads to the computation of an output stabilizing feedback. A computationally efficient algorithm for the solution of the two coupled equations is developed, which leads to the computation of a desired output feedback. AIAA

A93-39043

ALGORITHMS FOR CONSTRUCTING MODELS OF THE INTERACTION OF DIAGNOSTIC SYSTEMS WITH RESERVED AVIATION EQUIPMENT [ALGORITMZATSIIA POSTROENIIA MODELEI VZAIMODEISTVIA SREDSTV DIAGNOSTIROVANIIA S REZERVIROVANNYM AVIATSIONNYM OBOURODOVANIEM]

A. M. MALYSHEV *In* Dynamic processes in the powerplants and power-generating equipment of flight vehicles Kuibyshev, Russia Kuibyshevskii Aviatsionnyi Institut 1990 p. 134-143. *In* RUSSIAN

Copyright

An algorithm is presented for the construction of formal graph models describing the interaction of ideal diagnostic systems with the reserved aviation equipment consisting of a series of similar structural units and capable of normal operation only when a certain specified number of units is fully functional. In the process of its interaction with the equipment, the diagnostic system solves problems related to performance monitoring and fault detection. The recovery of the failed structural units is fully limited. The algorithm is based on the scanning of the vector-line elements input for each failed structural unit and subsequent correction that is determined by the recovery strategy with respect to the failed structural units. AIAA

A93-39537

SOFTWARE - DESIGN FOR MAINTENANCE

RON ASHPOLE (British Aerospace Airbus, Ltd., Bristol, United Kingdom) *In* Avionic systems/design and maintenance; Proceedings of the Conference, Hounslow, United Kingdom, Apr. 22, 1993 London Royal Aeronautical Society 1993 p. 2.1-2.10. refs

Copyright

Software used in contemporary avionics is periodically 'maintained' through its incorporation of incremental improvements of its design. These changes may be corrective, adaptive, preventive, or meliorative. The design of software for such maintainability underscores its intrinsic modifiability for such purposes at the lowest associated cost. AIAA

N93-27063*# Institute for Computer Applications in Science and Engineering, Hampton, VA.

CUMULATIVE REPORTS AND PUBLICATIONS

Washington Apr. 1993 92 p
(Contract NAS1-19480; NAS1-18605; NAS1-18107; NAS1-17070; NAS1-17130; NAS1-15830; NAS1-16394; NAS1-14101; NAS1-14472; RTOP 505-90-52-01)
(NASA-CR-191440; NAS 1.26:191440) Avail: CASI HC A05/MF A01

A complete list of Institute for Computer Applications in Science and Engineering (ICASE) reports are listed. Since ICASE reports are intended to be preprints of articles that will appear in journals or conference proceedings, the published reference is included when it is available. The major categories of the current ICASE research program are: applied and numerical mathematics, including numerical analysis and algorithm development; theoretical and computational research in fluid mechanics in selected areas of interest to LaRC, including acoustics and combustion; experimental research in transition and turbulence and aerodynamics involving LaRC facilities and scientists; and computer science. Author (revised)

N93-27180 Regional Engineering Coll., Kerala (India). Dept. of Electrical Engineering.

NEW ADAPTIVE CONTROLLERS FOR AIRCRAFT

F. GAJENDRAN *In* Israel Society of Aeronautics and Astronautics, 32nd Annual Conference on Aviation and Astronautics p 116-127 20 Feb. 1992

Copyright Avail: Israel Society of Aeronautics and Astronautics, c/o Faculty of Engineering, Tel-Aviv Univ., Ramat Aviv 69978, Israel

This investigation is concerned with the model reference adaptive control (MRAC) of the pitch rate of the aircraft. A new adaptive control scheme is proposed and its stability analysis is

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presented, employing certain novel Liapunov functions. This scheme gives better performance when appropriate measures are taken. ISA

N93-27289*# Stanford Univ., CA. Dept. of Electrical Engineering.

CENTER FOR AERONAUTICS AND SPACE INFORMATION SCIENCES Annual Report, 1992

MICHAEL J. FLYNN 1992 62 p

(Contract NAGW-419)

(NASA-CR-193140; NAS 1.26:193140) Avail: CASI HC A04/MF A01

This report summarizes the research done during 1991/92 under the Center for Aeronautics and Space Information Science (CASIS) program. The topics covered are computer architecture, networking, and neural nets. Derived from text

N93-27531# Kaman Aerospace Corp., Bloomfield, CT.

DYNAMIC SYSTEM COUPLER PROGRAM (DYSCO 4.1).

VOLUME 1: THEORETICAL MANUAL Final Report, 13 Sep.

1985 - 13 May 1988

ALEX BERMAN, SHYI-YUANG CHEN, BRUCE GUSTAVSON, and PATRICIA HURST Jan. 1989 146 p

(Contract DAAJ02-85-C-0033; DA PROJ. 1L1-62209-AH-76)

(AD-B131156L; R-1790-14A-VOL-1;

USAAVSCOM-TR-88-D-14A-VOL-1) Avail: CASI HC A07/MF A02

The work performed to enhance the Dynamic System Coupler (DYSCO) computer program through the addition of advanced modeling capabilities is reported. These capabilities include rotor blade damage modeling, Eigen analysis development, general time histories solution development, frequency domain solution development, general modal representation of three-dimensional structures, lifting surface modal representation, landing gear, general force, linear constraints, lifting surface aerodynamics, calculation of component interface and internal loads, and a nonlinear spring and damper system. While the improvements incorporated into DYSCO increase the analytical capabilities of the program, it still has limitations in several areas. More correlation with flight test data or with similar proven analytical tools is needed to validate program results. A new or improved trim algorithm is needed to eliminate deficiencies in the current DYSCO trim algorithm. Also, DYSCO should be converted to double precision to increase the accuracy of program results. Author (revised)

N93-27589# Kaman Aerospace Corp., Bloomfield, CT.

DYNAMIC SYSTEM COUPLER PROGRAM (DYSCO 4.1).

VOLUME 2: USER'S MANUAL Final Report, 13 Sep. 1985 - 13 May 1988

ALEX BERMAN, SHYI-YUANG CHEN, BRUCE GUSTAVSON, and PATRICIA HURST Jan. 1989 356 p

(Contract DAAJ02-85-C-0033; DA PROJ. 1L1-62209-AH-76)

(AD-B131157L; R-1790-14B-VOL-2;

USAAVSCOM-TR-88-D-14B-VOL-2) Avail: CASI HC A16/MF A03

Work performed to enhance the Dynamic System Coupler (DYSCO) computer program through the addition of advanced modeling capabilities is reported. These capabilities include rotor blade damage modeling, Eigen analysis development, general time history solution development, frequency domain solution development, general modal representation of three-dimensional structures, lifting surface modal representation, landing gear, general force, linear constraints, lifting surface aerodynamics, calculation of component interface and internal loads, and a nonlinear spring and damper system. While the improvements incorporated into DYSCO increase the analytical capabilities of the program, it still has limitations in several areas. More correlation with flight test data or with similar proven analytical tools is needed to validate program results. A new or improved trim algorithm is needed to eliminate deficiencies in the current DYSCO trim algorithm. Also, DYSCO should be converted to double precision to increase the accuracy of program results. Author (revised)

N93-27590# Kaman Aerospace Corp., Bloomfield, CT.

DYNAMIC SYSTEM COUPLER PROGRAM (DYSCO 4.1).

VOLUME 3: USER'S MANUAL SUPPLEMENT Final Report, 13 Sep. 1985 - 13 May 1988

ALEX BERMAN, SHYI-YUANG CHEN, BRUCE GUSTAVSON, and PATRICIA HURST Jan. 1989 467 p

(Contract DAAJ02-85-C-0033; DA PROJ. 1L1-62209-AH-76)

(AD-B131158L; R-1790-14C-VOL-3;

USAAVSCOM-TR-88-D-14C-VOL-3) Avail: CASI HC A20/MF A04

The work performed to enhance the Dynamic System Coupler (DYSCO) computer program through the addition of advanced modeling capabilities is reported. These capabilities include rotor blade damage modeling, Eigen analysis development, general time history solution development, frequency domain solution development, general modal representation of three-dimensional structures, lifting surface modal representation, landing gear, general force, linear constraints, lifting surface aerodynamics, calculation of component interface and internal loads, and a nonlinear spring and damper system. While the improvements incorporated into DYSCO increase the analytical capabilities of the program, it still has limitations in several areas. More correlation with flight test data or with similar proven analytical tools is needed to validate program results. A new or improved trim algorithm is needed to eliminate deficiencies in the current DYSCO trim algorithm. Also, DYSCO should be converted to double precision to increase the accuracy of program results. Author (revised)

N93-28051*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

A MODIFIED APPROACH TO CONTROLLER PARTITIONING

SANJAY GARG and ROBERT J. VEILLETTE (Akron Univ., OH.) May 1993 25 p

(Contract RTOP 505-62-50)

(NASA-TM-106167; E-7861; NAS 1.15:106167) Avail: CASI HC A03/MF A01

The idea of computing a decentralized control law for the integrated flight/propulsion control of an aircraft by partitioning a given centralized controller is investigated. An existing controller partitioning methodology is described, and a modified approach is proposed with the objective of simplifying the associated controller approximation problem. Under the existing approach, the decentralized control structure is a variable in the partitioning process; by contrast, the modified approach assumes that the structure is fixed a priori. Hence, the centralized controller design may take the decentralized control structure into account. Specifically, the centralized controller may be designed to include all the same inputs and outputs as the decentralized controller; then, the two controllers may be compared directly, simplifying the partitioning process considerably. Following the modified approach, a centralized controller is designed for an example aircraft mode. The design includes all the inputs and outputs to be used in a specified decentralized control structure. However, it is shown that the resulting centralized controller is not well suited for approximation by a decentralized controller of the given structure. The results indicate that it is not practical in general to cast the controller partitioning problem as a direct controller approximation problem. Author (revised)

N93-28498# Washington Univ., Saint Louis, MO. Dept. of Systems Science and Mathematics.

ARTIFICIAL INTELLIGENCE METHODOLOGIES IN FLIGHT RELATED DIFFERENTIAL GAME, CONTROL AND OPTIMIZATION PROBLEMS Final Report, 30 Sep. 1989 - 29 Dec. 1992

ERVIN Y. RODIN 31 Jan. 1993 175 p

(Contract AF-AFOSR-0518-89)

(AD-A262405; AFOSR-93-0187TR) Avail: CASI HC A08/MF A02

Artificial intelligence methodologies have been applied to the modeling and implementation of control systems and differential games problems. To be more specific, artificial neural networks, a multiple instruction multiple data parallel processor tuned by connection weights, are used to model a control system or used

as an identifier/controller which functions as a mapping between two information domains. Significant advances have been achieved in applying differential games theory to practical problems. DTIC

N93-28577# Air Force Inst. of Tech., Wright-Patterson AFB, OH. School of Engineering.

TOWARD REUSABLE GRAPHICS COMPONENTS IN ADA M.S. Thesis

SAM-KYU LIM Mar. 1993 119 p
(AD-A262568; AFIT/GCS/ENG/93M-03) Avail: CASI HC
A06/MF A02

This thesis demonstrates and illustrates a way of developing reusable graphics software components in Ada associated with a C++/C library. The work was carried out using object-oriented software development techniques that were used to analyze, design and implement a partial flight simulator. The objective of this thesis was to present a way of building reusable software components with Ada in a graphics application environment. An object-oriented approach was taken in the development of a set of reusable graphics software components for a flight simulator domain. A selection of a set of reusable software components came from domain analysis. These components were analyzed in detail, then redesigned to demonstrate and illustrate the thesis objective. Examples from design and implementation demonstrate how Ada 83 was applied in building reusable graphics software components associated with C++ routines, the limitations of Ada 83, and how Ada9X addresses these limitations. DTIC

N93-28841*# Institute for Computer Applications in Science and Engineering, Hampton, VA.

GODUNOV-TYPE SCHEMES APPLIED TO DETONATION FLOWS

JAMES J. QUIRK Washington Apr. 1993 92 p
(Contract NAS1-19480; NAS1-18605; NAS1-18107; NAS1-17070;
NAS1-17130; NAS1-15830; NAS1-16394; NAS1-14101;
NAS1-14472; RTOP 505-90-52-01)
(NASA-CR-191447; NAS 1.26:191447; ICASE-93-15) Avail: CASI
HC A05/MF A01

The Institute for Computer Applications in Science and Engineering (ICASE) is operated at the Langley Research Center of NASA by the Universities Space Research Association (USRA) under a contract with the Center. The Institute conducts research in applied mathematics, numerical analysis, fluid mechanics, and computer science in order to extend and improve problem solving capabilities in science and engineering, particularly in aeronautics and space. Current ICASE research programs are applied and numerical mathematics, including numerical analysis and algorithm development; theoretical and computational research in fluid mechanics in selected areas of interest to LaRC, including acoustics and combustion; experimental research in transition and turbulence and aerodynamics involving LaRC facilities and scientists; and computer science. A complete listing of ICASE reports for 1975 - 1991 are given. Derived from text

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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.

A93-35963

A CLOSED LOOP CONTROLLER FOR BVI IMPULSIVE NOISE REDUCTION BY HIGHER HARMONIC CONTROL

R. KUBE (DLR, Inst. fuer Flugmechanik, Braunschweig, Germany), M. ACHACHE (Eurocopter France, Marignane), G. NIESL (Eurocopter Deutschland, Ottobrunn, Germany), and W. R. SPLETTSTOESSER (DLR, Inst. fuer Entwurfsaerodynamik, Braunschweig, Germany) *In* AHS, Annual Forum, 48th,

Washington, June 3-5, 1992, Proceedings. Vol. 2 Alexandria, VA American Helicopter Society 1992 p. 819-842. refs
Copyright

Within a joint research program of DLR, ECF and ECD a wind tunnel experiment was performed with the DLR rotor test rig in the German Dutch Wind Tunnel. The tests aimed on an automatic reduction of the Blade-Vortex Interaction (BVI) impulsive noise radiated by the main rotor and were based on former investigations which had shown, that the most annoying part of the helicopter noise can be reduced considerably by means of Higher Harmonic Control (HHC). However, one prerequisite for this reduction is a proper adjustment of the higher harmonic control parameters which have to be optimized according to the actual flight condition. Therefore a suited closed loop controller is required being able to keep the noise small within the whole flight envelope. Due to the nonlinear dependence of the noise level on the higher harmonic control parameters, the design of this controller becomes a nontrivial task. Therefore three different control approaches were investigated, both within the scope of simulation and during wind tunnel tests. The corresponding results are presented for various flight conditions and parameter configurations and the long term as well as the transient behavior of the different controllers are compared. Author

A93-35964* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

EFFECTS OF INGESTED ATMOSPHERIC TURBULENCE ON MEASURED TAIL ROTOR ACOUSTICS

DAVID B. SIGNOR, GLORIA K. YAMAUCHI, MARIANNE MOSHER (NASA, Ames Research Center, Moffett Field, CA), MARTIN J. HAGEN (California Polytechnic State Univ., San Luis Obispo), and ALBERT R. GEORGE (Cornell Univ., Ithaca, NY) *In* AHS, Annual Forum, 48th, Washington, June 3-5, 1992, Proceedings. Vol. 2 Alexandria, VA American Helicopter Society 1992 p. 843-868. refs
Copyright

Results from an outdoor hover test of a full-scale Lynx tail rotor are presented. The investigation was designed to further the understanding of the acoustics of an isolated tail rotor hovering out-of-ground effect in atmospheric turbulence, without the effects of the main rotor wake or other helicopter components. Measurements include simultaneous rotor performance, noise, inflow, and far-field atmospheric turbulence. Results with grid-generated inflow turbulence are also presented. The effects of turbulence ingestion on rotor noise are quantified. Turbulence ingestion noise is found to be the dominant noise mechanism at locations near the rotor axis. At these locations, the sound radiated by the hovering rotor increases with both increasing atmospheric wind speed and ingested rms turbulent velocity. Author

A93-35965

AN ANALYSIS ON HIGH SPEED IMPULSIVE NOISE OF TRANSONIC HELICOPTER ROTOR

OHYUN RHO and YONG S. KIM (Seoul National Univ., Republic of Korea) *In* AHS, Annual Forum, 48th, Washington, June 3-5, 1992, Proceedings. Vol. 2 Alexandria, VA American Helicopter Society 1992 p. 869-879. Research supported by Korea Science and Engineering Foundation refs
Copyright

A modified version of Farassat's formulation which explicitly describes shock surface noise has been presented for predicting impulsive noise generated by a transonic rotor blade. The formulation is written in frequency domain and an Euler Solver is used to obtain the near field input data for acoustic predictions. The technique is applied to the nonlifting hovering model rotor. Acoustic predictions are compared with experimental data for cases of transonic tip Mach numbers and some quantitative characters of shock surface noise are discussed. Author

A93-35966* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

PREDICTION OF BVI NOISE PATTERNS AND CORRELATION WITH WAKE INTERACTION LOCATIONS

MICHAEL A. MARCOLINI, RUTH M. MARTIN (NASA, Langley Research Center, Hampton, VA), PETER F. LORBER, and T. A. EGOLF (United Technologies Research Center, East Hartford, CT) *In* AHS, Annual Forum, 48th, Washington, June 3-5, 1992, Proceedings. Vol. 2 Alexandria, VA American Helicopter Society 1992 p. 881-897. refs
Copyright

High resolution fluctuating airloads data were acquired during a test of a contemporary design United Technologies model rotor in the Duits-Nederlandse Windtunnel (DNW). The airloads are used as input to the noise prediction program WOPWOP, in order to predict the blade-vortex interaction (BVI) noise field on a large plane below the rotor. Trends of predicted advancing and retreating side BVI noise levels and directionality as functions of flight condition are presented. The measured airloads have been analyzed to determine the BVI locations on the blade surface, and are used to interpret the predicted BVI noise radiation patterns. Predicted BVI locations are obtained using the free wake model in CAMRAD/JA, the UTRC Generalized Forward Flight Distorted Wake Model, and the UTRC FREEWAKE analysis. These predicted BVI locations are compared with those obtained from the measured pressure data. Author

A93-35967
CIVIL TILTROTOR NOISE IMPACT PREDICTION METHODOLOGY

RICHARD G. RILEY, JR. (Bell Helicopter Textron, Inc., Fort Worth, TX) *In* AHS, Annual Forum, 48th, Washington, June 3-5, 1992, Proceedings. Vol. 2 Alexandria, VA American Helicopter Society 1992 p. 899-917. refs
Copyright

This paper describes the early development of a methodology to predict the noise impact of tiltrotor aircraft. Existing XV-15 and V-22 tiltrotor noise data are used, in conjunction with the FAA's Heliport Noise Model (HNM), to predict noise contours and the effects of operating modes on approach noise. Results of these predictions illustrate the tiltrotor's effectiveness in minimizing noise impact through proper selection of airspeed and nacelle angle. In addition to noise contour predictions of the two tiltrotor aircraft, the paper demonstrates the capability to make predictions for new designs, showing the effects of gross weight and tip speed on noise. Author

A93-35968
PREDICTING ROTORCRAFT TRANSMISSION NOISE

JIM O'CONNELL (McDonnell Douglas Helicopter Co., Mesa, AZ) *In* AHS, Annual Forum, 48th, Washington, June 3-5, 1992, Proceedings. Vol. 2 Alexandria, VA American Helicopter Society 1992 p. 919-929. refs
Copyright

A methodology for predicting the acoustic emissions of high-speed transmissions is proposed which employs finite element methods to determine the dynamic response of the gear box casing. Acoustic calculations are accomplished using two different approaches. A deterministic approach based on the boundary element method is used for the lowest gear mesh frequency; the higher frequencies are evaluated by using a stochastic approach, based on statistical energy analysis. An implementation of the overall noise prediction methodology to evaluate the noise emissions of a transmission currently used in the AH-54 Apache helicopter is described. The computed sound power levels at the gear mesh frequencies and associated harmonics are within 2-5 dB of the measured values. AIAA

A93-37032
DETECTION AND CLASSIFICATION OF ACOUSTIC SIGNALS FROM FIXED-WING AIRCRAFT

CLAYTON STEWART and VICTOR LARSON (George Mason Univ., Fairfax, VA) *In* IEEE International Conference on Systems Engineering, Dayton, OH, Aug. 1-3, 1991, Proceedings New York Institute of Electrical and Electronics Engineers, Inc. 1991 p. 25-28. refs
Copyright

The acoustic emission from a twin propeller aircraft is analyzed in the frequency domain. The time-varying power spectrum estimate of the signal is generated. The approach is to generate frequency spectra for fixed time segments of the signal using the Welch method. A confidence interval is calculated, and if the confidence interval is too wide, the power spectrum estimate is not incorporated into the detection decision. The spectral peaks in the power spectrum estimate are identified by thresholding with a local mean. An algorithm to detect and classify the aircraft based on these spectral peaks is proposed. Author

A93-37380* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

LIMITATIONS OF LINEAR THEORY FOR SONIC BOOM CALCULATIONS

CHRISTINE M. DARDEN (NASA, Langley Research Center, Hampton, VA) *Journal of Aircraft* (ISSN 0021-8669) vol. 30, no. 3 May-June 1993 p. 309-314. AIAA, Aerospace Sciences Meeting, 28th, Reno, NV, Jan. 8-11, 1990, AIAA Paper 90-0368. Previously cited in issue 06, p. 870, Accession no. A90-19817 refs
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A93-37396* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

TRANSONIC BLADE-VORTEX INTERACTIONS - NOISE REDUCTION

Y. XUE and A. S. LYRINTZIS (Minnesota Univ., Minneapolis) *Journal of Aircraft* (ISSN 0021-8669) vol. 30, no. 3 May-June 1993 p. 408-411. Research supported by Univ. of Minnesota refs
(Contract NAG2-646)
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Several ideas for the reduction of transonic blade-vortex interaction (BVI) noise are proposed and tested. Noise due to transonic BVI is analyzed using a finite difference code; the numerically calculated 2D near-field aerodynamic results are extended to 3D linear acoustic far field using the Kirchhoff method. It is shown that the noise can be significantly reduced by splitting the vortex in two. BVI noise is also substantially reduced by reducing the vortex strength and by increasing the angle of attack. AIAA

A93-38150
NUMERICAL PREDICTION OF AERODYNAMIC SOUND USING LARGE EDDY SIMULATION

TOSHIO KOBAYASHI and MASATO SATAKE (Tokyo Univ., Japan) *In* Numerical Fluid Dynamics Symposium, 5th, Tokyo, Japan, Dec. 19-21, 1991, Proceedings Tokyo Numerical Fluid Dynamics Symposium Committee 1991 p. 191-194. In JAPANESE refs

The present paper discusses a numerical prediction method of aerodynamic sound generated by a solid in low Mach number turbulent flow. A target flow phenomenon is calculated by the large eddy simulation (LES) assumed incompressibility. Using results of LES, the Lighthill's equation is solved approximately and the generated sound is predicted. To examine the accuracy of the method, the sound generated by a flat plate in turbulence is calculated and compared with the experimental data. Author (revised)

A93-38151
NUMERICAL COMPUTATION OF AERODYNAMIC NOISE RADIATION BY THE LARGE EDDY SIMULATION

CHISACHI KATO, YASUSHI TAKANO, AKIYISHI IIDA, and MASAHIRO Ikegawa (Hitachi, Ltd., Mechanical Engineering Research Lab., Tsuchiura, Japan) *In* Numerical Fluid Dynamics Symposium, 5th, Tokyo, Japan, Dec. 19-21, 1991, Proceedings Tokyo Numerical Fluid Dynamics Symposium Committee 1991 p. 195-198. In JAPANESE refs

Aerodynamic sound radiated from the low Mach number turbulent wake of a circular cylinder was computed using the large eddy simulation technique and compared with the measured data obtained in a low noise wind tunnel. In this study, a new upwinding

FEM has been proposed and used for the simulation to obtain the unsteady flow field around the circular cylinder. The sound pressure was computed based on the Lighthill-Curle equation using the fluctuating surface pressure obtained from the large eddy simulation. The computed sound pressure spectrum shows reasonable agreement with the measured data. The present approach, thus, seems quite promising for predictions of aerodynamic noise radiated in complicated turbulent flow fields.

Author (revised)

A93-38600

BLADE-VORTEX INTERACTION NOISE - PREDICTION AND COMPARISON WITH FLIGHT AND WIND TUNNEL TESTS

P. SPIEGEL, G. RAHIER, and B. MICHEA (ONERA, Chatillon, France) ONERA, TP no. 1992-126 1992 13 p. European Rotorcraft Forum, 18th, Avignon, France, Sept. 15-18, 1992 Research supported by DRET refs (ONERA, TP NO. 1992-126)

The BVI noise prediction method developed at ONERA is a combination of three computer programs. The first program (MESIR) calculates the geometry and the intensity of the main rotor wake using a free wake analysis. The second program (ARRHS) provides the blade pressure fluctuations induced by the rotor wake even for close interactions. The third code (PARIS), based on the Ffowcs Williams and Hawkings equation, computes the resulting radiated noise. The last two programs have been specially developed to save computing time. The main lines of the computer programs are presented. Emphasis is laid on aerodynamic and acoustic predictions using these three codes. Comparisons are made with two tests: a wind tunnel test of the US Army AH1G-OLS rotor model, and an Aerospatiale Gazelle flight test. Lift coefficients, blade pressures coefficients and radiated noise are compared.

Author (revised)

A93-38774

TOWARD THE SILENT HELICOPTER [VERS L'HELICOPTERE SILENCIEUX]

SERGE LEWY (ONERA, Chatillon, France) and HENRI-JAMES MARZE (Eurocopter France, Marignane) ONERA, TP no. 1992-229 1992 6 p. In FRENCH Telecom, no. 93, Fall 1992, p. 35-39 Research supported by Direction Generale de l'Aviation Civile, DRET, and Service Technique des Programmes Aeronautiques (ONERA, TP NO. 1992-229) Copyright

The development of a 'silent helicopter' program in Europe, whose aim would be noise reduction for both commercial and military helicopters over the next five years, is discussed. Attention is given to acoustic constraints for helicopters and to noise reduction techniques (with particular reference to the main rotor, the rear rotor, and the engines). For commercial helicopters, the noise reduction over the next five years is projected to be at least down to 6 dB below the OACI norms; for military helicopters, the aim is a variable-frequency signature in near-tactical-flight conditions, with a factor-of-two reduction in the maximum impulsivity in the far field.

AIAA

A93-39040

IDENTIFICATION OF NOISE SOURCES BASED ON EXPERIMENTAL AMPLITUDE-FREQUENCY NOISE CHARACTERISTICS OF AIRCRAFT [IDENTIFIKATSIIA ISTOCHNIKOV SHUMOOBRAZOVANIIA NA OSNOVE KHSRPERIMENTAL'NYKH AMPLITUDNO-CHASTOTNYKH KHARAKTERISTIK SHUMA SAMOLETA]

I. S. ZAGUZOV In Dynamic processes in the powerplants and power-generating equipment of flight vehicles Kuibyshev, Russia Kuibyshevskii Aviatsonnyi Institut 1990 p. 108-122. In RUSSIAN refs

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Problems involved in the identification of the principal sources of noise generation from experimentally obtained amplitude-frequency noise characteristics of aircraft on the ground and under flight conditions are examined. Particular attention is given to the analysis of sound interference and edge diffraction

phenomena, which introduce noticeable distortions in the amplitude-frequency aircraft noise characteristics and make the task of identifying the true noise sources more difficult. AIAA

A93-39057

A METHOD FOR CALCULATING THE DYNAMIC CHARACTERISTICS OF HEAT EXCHANGERS WITH SINGLE-PHASE CRYOGENIC COOLANTS [METOD RASCHETA DINAMICHESKIKH KHARAKTERISTIK TEPLOOBMENNYYKH APPARATOV S ODNOFAZNYMI KRIOGENNYMI TEPLONOSITELIAMI]

A. N. ANTONOV, S. I. MARTYNYENKO, and S. V. CHIVANOV In Heat exchangers of gas turbine engines Moscow, Russia Tsentral'nyi Institut Aviatsonnogo Motorostroeniia 1991 p. 92-95. In RUSSIAN

Copyright

A mathematical model is developed which describes thermophysical processes occurring in heat exchangers at cryogenic temperatures. The model is based on the following simplifying assumptions: coolant flow is one dimensional, and the hydraulic and heat transfer characteristics are taken into account by means of empirical coefficients; the heat resistance of the heat exchanger walls in the transverse direction is zero; pressure changes due to hydraulic resistance are negligible; and the thermal expansion of the structure, energy dissipation, and heat flow in the coolant in the longitudinal direction are not taken into account. The calculation results are in satisfactory agreement with experimental data.

AIAA

A93-39127

KINETIC THEORY OF NONEQUILIBRIUM FLOWS OF GAS AND DISPERSE MEDIA WITH INTERNAL DEGREES OF FREEDOM AND CHEMICAL REACTIONS [KINETICHESKAIA TEORIIA NERAVNOVESNYKH TECHENII GAZOVYKH I DISPERSNYKH SRED S VNUTRENNIMI STEPENIAMI SVOBODY I KHIMICHESKIMI REAKTSIAMI]

V. M. KUZNETSOV In Problems in physical gas dynamics Moscow Izdatel'skii Otdel TsAGI 1990 p. 3-31. In RUSSIAN refs

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Some fundamental problems in physical gas dynamics are stated and solved using the kinetic theory of gases. In particular, attention is given to an asymptotic method for solving kinetic equations, models of physical gas dynamics for mixtures of polyatomic gases, a multiple-temperature model of a disperse medium with homogeneous and heterogeneous vibrational relaxation processes, and a kinetic model of a nonequilibrium medium with high-threshold chemical reactions. The discussion also covers multiple-temperature models in physical aerodynamics problems and applicability regions of solutions for kinetic equations with a small parameter.

AIAA

A93-39544

IR WINDOW DAMAGE MEASURED BY REFLECTIVE SCATTER

MARVIN BERNT and JOHN C. STOVER (TMA Technologies, Inc., Bozeman, MT) In Optical scatter: Applications, measurement, and theory; Proceedings of the Meeting, San Diego, CA, July 24-26, 1991 Bellingham, WA Society of Photo-Optical Instrumentation Engineers 1991 p. 42-49. refs

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It has been demonstrated that erosion of sensor window surfaces can be measured on the flight line with reflective scatter instrumentation. At issue is the relationship between these damage sensitive measurements and the corresponding loss of system performance. Rain and sand erosion of IR sensor windows can limit system performance in three ways. In the case of IRST's, background scatter from window defects increases the system noise floor which limits range. Image resolution degrades in FLIR instrumentation as window erosion increases. Finally for both systems, severe damage can cause window breakage resulting in loss of the sensor system and possibly the aircraft. This paper reports the results of initial studies that correlate reflective scatter measurements to the loss of mid-IR performance. High angle and

near angle transmissive scatter from window damage are responsible for different types of system degradation. Both are studied and related to reflective scatter measurements. Author

N93-27058*# National Aeronautics and Space Administration, Lewis Research Center, Cleveland, OH.

IN-FLIGHT NEAR- AND FAR-FIELD ACOUSTIC DATA MEASURED ON THE PROPFAN TEST ASSESSMENT (PTA) TESTBED AND WITH AN ADJACENT AIRCRAFT

RICHARD P. WOODWARD and IRVIN J. LOEFFLER Apr. 1993 161 p

(Contract RTOP 535-03-10)

(NASA-TM-103719; E-6402; NAS 1.15:103719) Avail: CASI HC A08/MF A02

Flight tests to define the far-field tone source at cruise conditions were completed on the full-scale SR-7L advanced turboprop that was installed on the left wing of a Gulfstream 2 aircraft. This program, designated Propfan Test Assessment (PTA), involved aeroacoustic testing of the propeller over a range of test conditions. These measurements defined source levels for input into long-distance propagation models to predict en route noise. In-flight data were taken for seven test cases. Near-field acoustic data were taken on the Gulfstream fuselage and on a microphone boom that was mounted on the Gulfstream wing outboard of the propeller. Far-field acoustic data were taken by an acoustically instrumented Learjet that flew in formation with the Gulfstream. These flight tests were flown from El Paso, Texas, and from the NASA Lewis Research Center. A comprehensive listing of the aeroacoustic results from these flight tests which may be used for future analysis are presented. Author

N93-27148*# United Technologies Corp., Windsor Locks, CT. Standard Div.

USER'S MANUAL FOR UCAP: UNIFIED COUNTER-ROTATION AERO-ACOUSTICS PROGRAM Final Report

E. M. CULVER and C. J. MCCOLGAN Apr. 1993 176 p

(Contract NAS3-24222; RTOP 535-03-10)

(NASA-CR-191064; NAS 1.26:191064) Avail: CASI HC A09/MF A02

This is the user's manual for the Unified Counter-rotation Aeroacoustics Program (UCAP), the counter-rotation derivative of the UAAP (Unified Aero-Acoustic Program). The purpose of this program is to predict steady and unsteady air loading on the blades and the noise produced by a counter-rotation Prop-Fan. The aerodynamic method is based on linear potential theory with corrections for nonlinearity associated with axial flux induction, vortex lift on the blades, and rotor-to-rotor interference. The theory for acoustics and the theory for individual blade loading and wakes are derived in Unified Aeroacoustics Analysis for High Speed Turboprop Aerodynamics and Noise, Volume 1 (NASA CR-4329). This user's manual also includes a brief explanation of the theory used for the modelling of counter-rotation. Author (revised)

N93-27271*# National Aeronautics and Space Administration, Langley Research Center, Hampton, VA.

LOUDNESS AND ANNOYANCE RESPONSE TO SIMULATED OUTDOOR AND INDOOR SONIC BOOMS

JACK D. LEATHERWOOD and BRENDA M. SULLIVAN (Lockheed Engineering and Sciences Co., Hampton, VA.) May 1993 38 p (Contract RTOP 537-03-21-03)

(NASA-TM-107756; NAS 1.15:107756) Avail: CASI HC A03/MF A01

The sonic boom simulator of the Langley Research Center was used to quantify subjective loudness and annoyance response to simulated indoor and outdoor sonic boom signatures. The indoor signatures were derived from the outdoor signatures by application of house filters that approximated the noise reduction characteristics of a residential structure. Two indoor listening situations were simulated: one with the windows open and the other with the windows closed. Results were used to assess loudness and annoyance as sonic boom criterion measures and to evaluate several metrics as estimators of loudness and annoyance. The findings indicated that loudness and annoyance

were equivalent criterion measures for outdoor booms but not for indoor booms. Annoyance scores for indoor booms were significantly higher than indoor loudness scores. Thus, annoyance was recommended as the criterion measure of choice for general use in assessing sonic boom subjective effects. Perceived level was determined to be the best estimator of annoyance for both indoor and outdoor booms, and of loudness for outdoor booms. It was recommended as the metric of choice for predicting sonic boom subjective effects. Author (revised)

N93-27272*# National Aeronautics and Space Administration, Langley Research Center, Hampton, VA.

A LABORATORY STUDY OF SUBJECTIVE RESPONSE TO SONIC BOOMS MEASURED AT WHITE SANDS MISSILE RANGE

BRENDA M. SULLIVAN (Lockheed Engineering and Sciences Co., Hampton, VA.) and JACK D. LEATHERWOOD May 1993 31 p

(Contract RTOP 537-03-21-03)

(NASA-TM-107746; NAS 1.15:107746) Avail: CASI HC A03/MF A01

The Sonic Boom Simulator of the Langley Research Center was used to quantify subjective loudness response to boom signatures consisting of: (1) simulator reproductions of booms recently recorded at White Sands Missile Range; (2) idealized N-waves; and (3) idealized booms having intermediate shocks. The booms with intermediate shocks represented signatures derived from CFD predictions. The recorded booms represented those generated by F15 and T38 aircraft flyovers and represented a variety of waveforms reflecting the effects of propagation through a turbulent atmosphere. These waveforms included the following shape categories: N-waves, peaked, rounded, and U-shaped. Results showed that Perceived Level and Zwicker Loudness Level were good estimators of the loudness of turbulence modified sonic booms. No significant differences were observed between loudness responses for the several shape categories when expressed in terms of Perceived Level. Thus, Perceived Level effectively accounted for waveform differences due to turbulence. Idealized booms with intermediate shocks, however, were rated as being approximately 2.7 dB(PL) less loud than the recorded signatures. This difference was not accounted for by PL. Author (revised)

N93-27662# National Physical Lab., Teddington (England).

A PREDICTION MODEL FOR NOISE FROM LOW-ALTITUDE MILITARY AIRCRAFT

B. F. BERRY and J. D. SPEAKMAN 13 Mar. 1993 6 p LIMITED REPRODUCIBILITY: More than 20% of this document may be affected by microfiche quality

(AD-A262494; AL-TR-1992-0151) Avail: CASI HC A02/MF A01

For a number of years, the National Physical Laboratory, supported by the Ministry of Defense, has been developing AIRNOISE, a mathematical model for computing aircraft noise contours. As part of the continuous program of development of the model we were asked to extend it to include low-altitude military operations. The objective is to predict the complete time-history of the noise of these vary rapid events, thus providing information on onset rates as well as maximum levels. In order to provide high quality data with which to validate and refine the model, a special noise trial - Exercise Luce Belle - was conducted in which a number of aircraft types flew low, straight and level at various speeds and engine power settings. This paper firstly describes the noise trial and then the prediction models. The comparison of prediction with measurements is discussed. In particular the effects of changes in the assumptions in the model about lateral attenuation are explored. DTIC

N93-28692*# National Aeronautics and Space Administration, Langley Research Center, Hampton, VA.

SUBJECTIVE RESPONSE TO SIMULATED SONIC BOOMS WITH GROUND REFLECTIONS

B. M. SULLIVAN (Lockheed Engineering and Sciences Co., Hampton, VA.) and J. D. LEATHERWOOD Jun. 1993 35 p

(Contract RTOP 537-03-21-03)

(NASA-TM-107764; NAS 1.15:107764) Avail: CASI HC A03/MF A01

The Sonic Boom Simulator at NASA LaRC was used for the following: (1) quantify subjective loudness of simulated composite sonic booms, each of which was comprised of a simulated direct (non-reflected) boom combined with a simulated reflection of the direct boom; and (2) evaluate several metrics as estimators of loudness for these composite booms. The direct booms consisted of selected N-wave and minimized signatures having front-shock rise times of 3, 6, and 9 milliseconds and durations of 300 milliseconds. Delay times of the reflected booms ranged from 0 to 12 milliseconds. Subjective loudness results indicated that composite booms formed using reflections with non-zero delay times were generally rated as being less loud than composite booms containing non-delayed reflections. The largest reductions in loudness occurred when delay times were equal to the front shock rise times of the direct booms and were, in some cases, equivalent to reductions in Perceived Level of 6 to 7 dB. Results also showed Perceived Level to be an effective metric for assessing subjective loudness effects for the composite signatures. This was confirmed by statistical analysis, which showed that, for equal Perceived Level, no significant differences existed between the subjective loudness responses to composite booms containing reflections with zero delay and those containing reflections with non-zero delays. Author (revised)

N93-28788*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, MD.

OPTICAL TECHNOLOGIES FOR UV REMOTE SENSING INSTRUMENTS Abstract Only

R. A. M. KESKI-KUHA, J. F. OSANTOWSKI, D. B. LEVITON, T. T. SAHA, D. A. CONTENT, R. A. BOUCARUT, J. S. GUM, G. A. WRIGHT, C. M. FLEETWOOD, and T. J. MADISON *In* Lunar and Planetary Inst., Workshop on Advanced Technologies for Planetary Instruments, Part 1 p 12 1993

Avail: CASI HC A01/MF A01

Over the last decade significant advances in technology have made possible development of instruments with substantially improved efficiency in the UV spectral region. In the area of optical coatings and materials, the importance of recent developments in chemical vapor deposited (CVD) silicon carbide (SiC) mirrors, SiC films, and multilayer coatings in the context of ultraviolet instrumentation design are discussed. For example, the development of chemically vapor deposited (CVD) silicon carbide (SiC) mirrors, with high ultraviolet (UV) reflectance and low scatter surfaces, provides the opportunity to extend higher spectral/spatial resolution capability into the 50-nm region. Optical coatings for normal incidence diffraction gratings are particularly important for the evolution of efficient extreme ultraviolet (EUV) spectrographs. SiC films are important for optimizing the spectrograph performance in the 90 nm spectral region. The performance evaluation of the flight optical components for the Solar Ultraviolet Measurements of Emitted Radiation (SUMER) instrument, a spectroscopic instrument to fly aboard the Solar and Heliospheric Observatory (SOHO) mission, designed to study dynamic processes, temperatures, and densities in the plasma of the upper atmosphere of the Sun in the wavelength range from 50 nm to 160 nm, is discussed. The optical components were evaluated for imaging and scatter in the UV. The performance evaluation of SOHO/CDS (Coronal Diagnostic Spectrometer) flight gratings tested for spectral resolution and scatter in the DGEF is reviewed and preliminary results on resolution and scatter testing of Space Telescope Imaging Spectrograph (STIS) technology development diffraction gratings are presented. Author (revised)

N93-28953*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

JET MIXER NOISE SUPPRESSOR USING ACOUSTIC FEEDBACK Patent Application

EDWARD J. RICE, inventor (to NASA) 14 Apr. 1993 20 p (NASA-CASE-LEW-15170-1; NAS 1.71:LEW-15170-1; US-PATENT-APPL-SN-046256) Avail: CASI HC A03/MF A01

The present invention generally relates to providing an improved

jet mixer noise suppressor for high speed jets that rapidly mixes high speed air flow with a lower speed air flow, and more particularly, relates to an improved jet mixer noise suppressor that uses feedback of acoustic waves produced by the interaction of shear flow instability waves with an obstacle downstream of the jet nozzle. NASA

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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.

A93-35922

CONFIGURATION MANAGEMENT IMPACTS ON CUSTOMER SUPPORT AND SATISFACTION

ROLLIE JONES, JR. and WENDELL W. SHIVERS (McDonnell Douglas Helicopter Co., Mesa, AZ) *In* AHS, Annual Forum, 48th, Washington, June 3-5, 1992, Proceedings. Vol. 1 Alexandria, VA American Helicopter Society 1992 p. 283-304. refs

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An integrated configuration management process and its impact on cost effective sustainment of customer support and customer satisfaction are addressed. It is shown that the impact of support considerations on change alternatives and implementation options is significant both quantitatively in financial performance and qualitatively in the confidence levels and attitudes of customers. This function must be accepted as a coequal in configuration management. It is concluded that understanding, acceptance, and integration of customer support interests and expertise throughout the configuration management process is a critical factor to both customer satisfaction and enterprise survival. AIAA

A93-35926

THE IMPORTANCE OF CONFIGURATION MANAGEMENT - AN OVERVIEW WITH TEST PROGRAM SETS

CHRIS MERLENBACH (McDonnell Douglas Helicopter Co., Mesa, AZ) *In* AHS, Annual Forum, 48th, Washington, June 3-5, 1992, Proceedings. Vol. 1 Alexandria, VA American Helicopter Society 1992 p. 315-323. refs

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The use of configuration management (CM) in the development and sustainment of test program sets (TPSs) is examined. Attention is given to the role of CM in commerce as well as the military arena, the mainstreaming and streamlining of CM, CM functioning for the postdelivery customer, and CM cost. The TPS example is used to illustrate the applicability of CM to three major development and production areas: hardware, software, and documentation. AIAA

A93-38535

RUSSIANS COMPLETING NEW GROUND-EFFECT VEHICLE

JEFFREY M. LENOROVITZ *Aviation Week & Space Technology* (ISSN 0005-2175) vol. 138, no. 17 April 26, 1993 p. 62, 63. Copyright

An eight-engined, 400 metric-ton maximum takeoff weight wing-in-ground effect vehicle, designated 'Lun', which had been designed for the Russian Navy, is being offered for commercial sale by the Central Hydrofoil Design Bureau. Lun has a cruise speed of 450-550 km/hr, and would in civilian service carry more than 400 passengers; range is about 3000 km. AIAA

A93-39701

THE ROLE OF THE RADIOLOGIST IN THE MEDICOLEGAL PROCEDURE AFTER AN AVIATION ACCIDENT [ROLE DU RADIOLOGISTE DANS L'ENQUETE MEDICO-LEGALE APRES UNE CATASTROPHE AERIENNE]

19 GENERAL

V. HAZERBROUCQ, A. BONNIN, F. KANNAPELL, C. PIEDELIEVRE, J. P. CAMPANA, J. F. MERCIER, and D. LECOMTE (Hopital Cochin, Service de Radiologie, Paris, France) Journal de Radiologie (ISSN 0221-0363) vol. 73, no. 11 Nov. 1992 p. 633-638. In FRENCH

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The role of radiologic imaging studies in the forensic medical procedure following an airborne disaster is now well established. This report summarizes the experience and the results acquired with a recent air crash, and offers three suggestions: the necessity of a prepared identification team consisting of specialist in forensic medicine, in forensic odontology, and in forensic radiology; the usefulness of a suitable structure for the study and the storage of the dead bodies; and the need for a compilation of radiological informations, notably dental X-ray examinations for the flying personnel. Author (revised)

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GENERAL

N93-27041# Office of the White House Press Secretary, Washington, DC.

AERONAUTICS AND SPACE REPORT OF THE PRESIDENT: FISCAL YEAR 1992 ACTIVITIES

NASA 1993 112 p

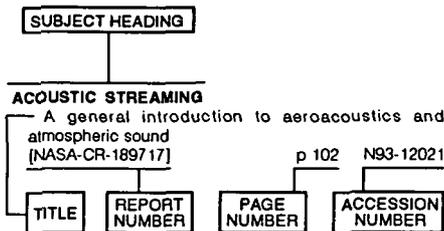
Avail: CASI HC A06/MF A02

The annual Aeronautics and Space Report includes a comprehensive description of the programmed activities and the accomplishments of all agencies of the United States in the field of aeronautics and space activities during the preceding calendar year. This year's report was prepared on a fiscal year basis, which is consistent with the budgetary period now used in programs of the Federal Government. The following areas are covered: space launch activities; space science; space flight and space technology; space communications; aeronautical activities; studies of the planet earth; and other aeronautical and space activities.

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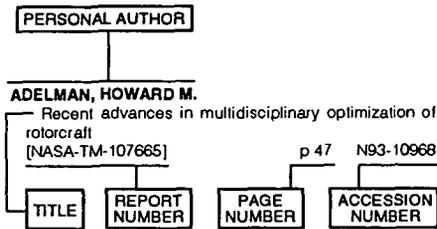
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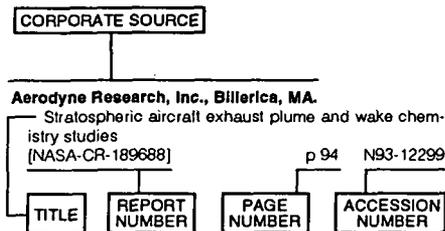
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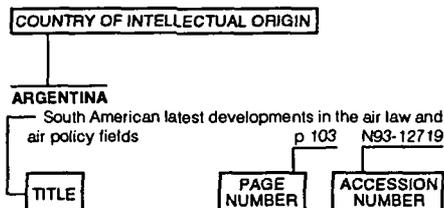
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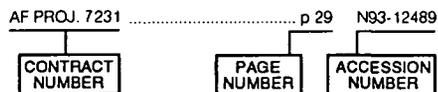
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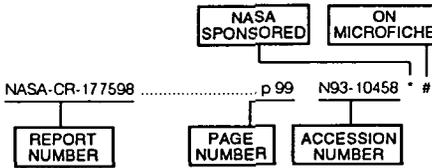
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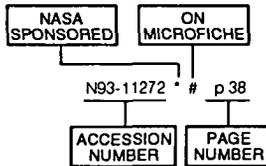
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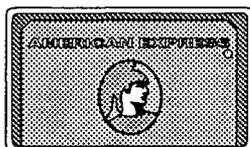
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