NASA SP-7037 (278)
May 1992

AERONAUTICAL ENGINEERING

A CONTINUING BIBLIOGRAPHY WITH INDEXES

NASA STI PROGRAM
SCIENTIFIC & TECHNICAL INFORMATION

NASA SP-7037 (278)
May 1992

AERONAUTICAL ENGINEERING

A CONTINUING BIBLIOGRAPHY WITH INDEXES

National Aeronautics and Space Administration
Scientific and Technical Information Program
Washington, DC 1992

INTRODUCTION

This issue of *Aeronautical Engineering—A Continuing Bibliography* (NASA SP-7037) lists 414 reports, journal articles, and other documents originally announced in April 1992 in *Scientific and Technical Aerospace Reports (STAR)* or in *International Aerospace Abstracts (IAA).*

Accession numbers cited in this issue are:

STAR (N-10000 Series)	N92-15962 — N92-18005
IAA (A-10000 Series)	A92-20827 — A92-24398

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.

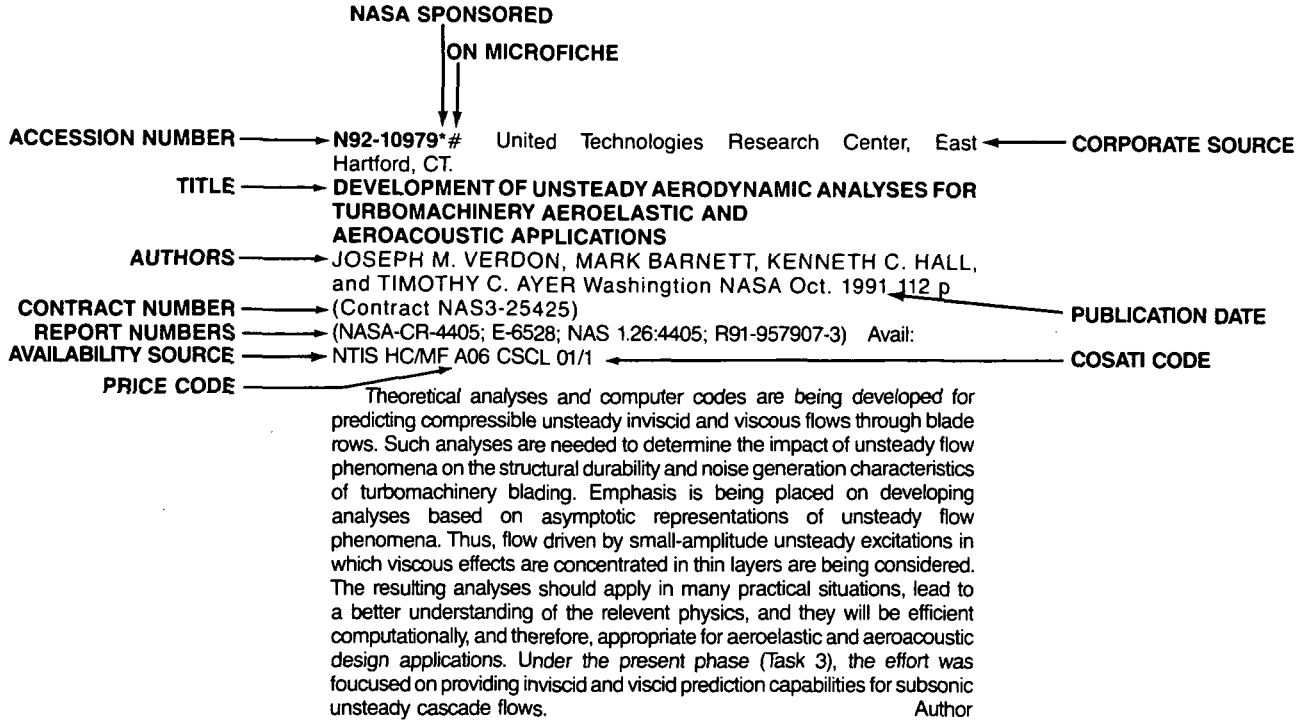
A cumulative index for 1992 will be published in early 1993.

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

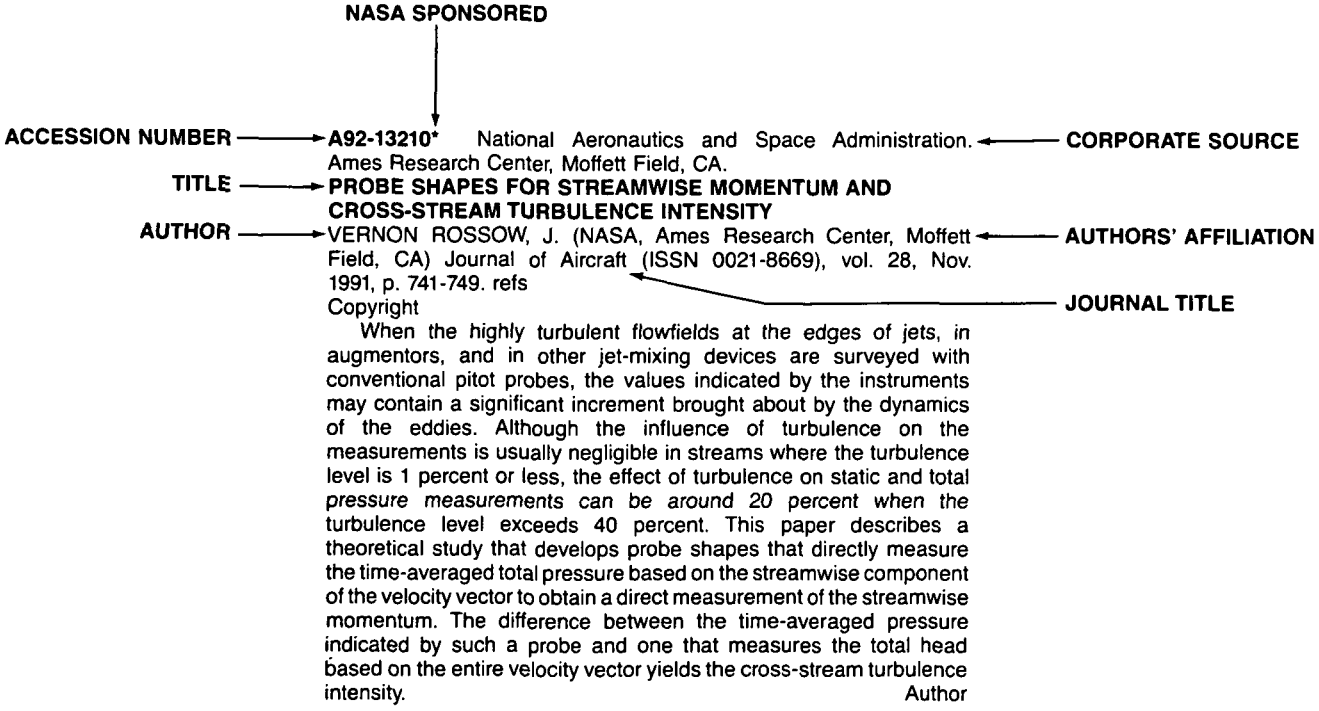
Page Intentionally Left Blank

CONTENTS

TYPICAL REPORT CITATION AND ABSTRACT



TYPICAL JOURNAL ARTICLE CITATION AND ABSTRACT



AERONAUTICAL ENGINEERING

A Continuing Bibliography (Suppl. 278)

May 1992

01

AERONAUTICS (GENERAL)

A92-21014
AIR TRANSPORT RESEARCH IN GERMANY [LUFTFAHRTFORSCHUNG IN DEUTSCHLAND]
HEINZ MAX (DLR, Cologne, Federal Republic of Germany) Luft- und Raumfahrt (ISSN 0173-6264), vol. 12, Nov.-Dec. 1991, p. 42-44. In German. refs
Copyright

The major lines of aircraft engine research in Germany are briefly reviewed. The distribution of resources among these lines of research is pointed out. C.D.

A92-21700
CLEVER COCKPITS
GRAHAM WARWICK Flight International (ISSN 0015-3710), vol. 141, Jan. 8, 1992, p. 19, 20, 22, 24.
Copyright

Ultra-fast computers connected by high-capacity fiber-optic data networks will transform future USAF and Army aircraft into new powerful information processing machines rather than loose collections of uncommunicative microchips. New packaging, as much as any single avionics advance, will improve maintainability and enhance reliability. The YF-22 has demonstrated the vehicle management system that integrates control of the aircraft's many subsystems, including its FBW flight controls. Several other examples are given, including the Longbow radar that will supplement the primary electrooptical targeting systems on both the Comanche and Apache helicopters, detecting and classifying armored targets in conditions where IR visibility is degraded. R.E.P.

A92-22707
THE CIVIL ROTORCRAFT INITIATIVE - AN ACTION AGENDA
DAVID LAWRENCE (Sikorsky Aircraft, Stratford, CT), RON REBER (Bell Helicopter Textron, Inc., Fort Worth, TX), EUAN HOOPER (Boeing Defense and Space Group, Helicopters Div., Philadelphia, PA), DEBORAH PEISEN (Systems Control Technology, Inc., Arlington, VA), and JOHN W. LEVERTON (EH Industries, Inc., Arlington, VA) Vertiflite (ISSN 0042-4455), vol. 38, Jan.-Feb. 1992, p. 8-12.
Copyright

The Civil Rotorcraft Initiative (CRI) was instituted in 1989 to ascertain whether scheduled rotorcraft route services could mitigate existing and projected short-haul aviation problems, and whether any obstacles lie in the way of such services. CRI has prompted investigations of operator economics, external and internal noise, vibration, terminal flight-path control, safety and infrastructure factors such as vertiport and heliport availability, the regulatory environment, route structures, and noise. O.C.

A92-22708
HELICOPTER/HELIPORT OPERATIONS - ENVIRONMENTAL IMPLICATIONS
JOHN W. LEVERTON (Westland, Inc., Arlington, VA) Vertiflite (ISSN 0042-4455), vol. 38, Jan.-Feb. 1992, p. 19-23. refs
Copyright

The two most subjectively annoying sources of helicopter noise are blade slap and tail rotor whine; the present development status evaluation of helicopter design features indicates that incremental changes are gradually mitigating these problems. Noise abatement procedures, control of routes and especially of overflight altitudes, are available for the control of noise from existing helicopters. Generalized prediction methods are also available for assessing the environmental impact of helicopter operations near a given community. O.C.

A92-22711
ROTOR REVOLUTIONS IN THE FAR EAST - HELICOPTERS IN CHINA, MONGOLIA, AND SIBERIA
W. E. HOOPER (Boeing Defense and Space Group, Helicopters Div., Philadelphia, PA) Vertiflite (ISSN 0042-4455), vol. 38, Jan.-Feb. 1992, p. 60-66.
Copyright

An account is given of the economic and technological development status of major rotorcraft design and manufacturing facilities in East Asia. Attention is given to the Nanjing Aeronautical Institute and the Harbin Aircraft Manufacturing Corporation of China, as well as the Mil Mi-8 Manufacturing plant at Ulan Ude, in formerly Soviet Siberia. The status of rotorcraft aviation in the Mongolian Republic is also noted. O.C.

A92-23776#
WHAT WE NEED IN EXPERIMENTAL AERODYNAMICS - ONE ENGINEERING EDUCATOR'S VIEW
W. H. MASON (Virginia Polytechnic Institute and State University, Blacksburg) AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992. 16 p. refs
(AIAA PAPER 92-0161) Copyright

Recent experience and difficulties with both experimental and computational aerodynamics are discussed, with emphasis on the possibilities for coordination of the two fields. Attention is given to (1) improved connections between subscale testing to full-scale aerodynamics, (2) advanced flow visualization, (3) improvements in unsteady aerodynamics testing capability, and (4) greater emphasis on experimental foundations for advanced concept development. Three representative problem areas are illustrated by the nose-down pitching moment of the F-16, discrepancies between flight and wind tunnel pressure distributions of the C-141, and the flap-deflection effectiveness of the DC-10. O.C.

N92-15962# Sandia National Labs., Albuquerque, NM.
AGING AIRCRAFT NDI DEVELOPMENT AND DEMONSTRATION CENTER (AANC): AN OVERVIEW
P. L. WALTER 1991 7 p Presented at the 1991 International Conference on Aging Aircraft and Structural Airworthiness, Washington, DC, 19-21 Nov. 1991
(Contract DE-AC04-76DP-00789)
(DE92-002358; SAND-91-2309C; CONF-9111112-1) Avail: NTIS HC/MF A02

A major center with emphasis on validation of nondestructive inspection techniques for aging aircraft, the Aging Aircraft NDI Development and Demonstration Center (AANC), has been funded by the FAA at Sandia National Laboratories. The Center has been

assigned specific tasks in developing techniques for the nondestructive inspection of static engine parts, assessing inspection reliability (POD experiments), developing test beds for nondestructive inspection validation, maintaining a FAA library of characterized aircraft structural test specimens, and leasing a hangar to house a high flight cycle transport aircraft for use as a full scale test bed. DOE

N92-15963# General Accounting Office, Washington, DC. National Security and International Affairs Div.
B-2 PROGRAM: TRENDS IN MANUFACTURING
Jul. 1991 32 p
(AD-A242141; GAO/NSIAD-91-211) Avail: NTIS HC/MF A03 CSCL 01/3

During the past several years, GAO has issued a series of reports on the B-2 stealth bomber program identifying causes of instability in the program, including manufacturing problems being encountered by the contractors. The objectives of this review were to determine the B-2 bomber's recent manufacturing progress and evaluate whether estimates to produce aircraft at planned production rates can be met. To meet the GAO objectives, GAO evaluated selected manufacturing indicators, including labor efficiency rates, manufacturing defects, changes to engineering drawings, work transferred to final assembly, and programs for production management. The B-2 aircraft combines conventional and state-of-the-art aircraft technology, such as special shaping and radar absorbing materials, and is designed to precise specifications needed to meet stealth requirements. GRA

N92-17346*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
VISCOUS THREE-DIMENSIONAL CALCULATIONS OF TRANSONIC FAN PERFORMANCE
RODRICK V. CHIMA 1991 19 p Presented at the 77th Symposium of the Propulsion and Energetics Panel entitled CFD Techniques for Propulsion Applications, San Antonio, TX, 27-31 May 1991; sponsored by AGARD Original contains color illustrations
(NASA-TM-103800; E-6088; NAS 1.15:103800) Avail: NTIS HC/MF A03; 5 functional color pages CSCL 01/2

A 3-D flow analysis code was used to compute the design speed operating line of a transonic fan rotor, and the results were compared with experimental data. The code is an explicit finite difference code with an algebraic turbulence model. The transonic fan, called rotor 67, was tested experimentally at NASA-Lewis with conventional aerodynamic probes and with user anemometry and was included as one of the AGARD test cases for the computation of internal flows. The experimental data are described. Maps of total pressure ratio and adiabatic efficiency versus mass flow were computed and are compared with the experimental maps, with good agreement. Detailed comparisons between calculations and experiment are made at two operating points, one near peak efficiency and the other near stall. Blade-to-blade contour plots are used to show the shock structure. Comparisons of circumferentially integrated flow quantities downstream of the rotor show spanwise distributions of several aerodynamic parameters. Calculated Mach number distributions are compared with laser anemometer data within the blade row and the wake to quantify the accuracy of the calculations. Particle traces are used to show the nature of secondary flow. Author

N92-17477# Naval Postgraduate School, Monterey, CA.
THE V-22: CAN THE NATION AFFORD TO FORGO ITS PRODUCTION? M.S. Thesis
MICHAEL CROUCH Dec. 1991 103 p
(AD-A243158) Avail: NTIS HC/MF A06 CSCL 05/1

The V-22 was designed for the ground up to satisfy missions required by all military services. It is an airplane that represents the leading edge of tiltrotor technology. Since Secretary Cheney's decision to cancel the V-22 in 1989, lines of political competition have been drawn. Continued support for the V-22 comes from an influential group within Congress determined to advance the program based on its civil application. The V-22 no longer represents a battle between the Executive and Legislative branches over their specific defense responsibilities. This thesis addresses two questions: (1) using the V-22 as a case study, the programmatic and financial implications are examined for the Department of Defense and industry on dual-use technology and (2) the lessons of the V-22 about the process of defense budgeting. Throughout the thesis emphasis is places on the actions of the committees of Congress responsible for the defense budget, and specifically the V-22. This thesis examines the roles and relationships between the 'players' throughout the history of the V-22 program to determine if any useful analogies may be identified with respect to present and future defense budgeting and acquisition practices. GRA

N92-17984*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
JOINT UNIVERSITY PROGRAM FOR AIR TRANSPORTATION RESEARCH, 1990-1991
FREDERICK R. MORRELL, comp. Washington Dec. 1991 183 p Conference held in Athens, OH, 20-21 Jun. 1991; sponsored by NASA and FAA
(NASA-CP-3131; L-17017; NAS 1.55:3131) Avail: NTIS HC/MF A09 CSCL 01/2

The goals of this program are consistent with the interests of both NASA and the FAA in furthering the safety and efficiency of the National Airspace System. Research carried out at the Massachusetts Institute of Technology (MIT), Ohio University, and Princeton University are covered. Topics studied include passive infrared ice detection for helicopters, the cockpit display of hazardous windshear information, fault detection and isolation for multisensor navigation systems, neural networks for aircraft system identification, and intelligent failure tolerant control.

02

AERODYNAMICS

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

A92-21051
ESTIMATION OF THE MAXIMUM INSTANTANEOUS DISTORTION
D. W. LIANG and S. Y. ZHANG (Nanjing Aeronautical Institute, People's Republic of China) Journal of Propulsion and Power (ISSN 0748-4658), vol. 8, Jan.-Feb. 1992, p. 5, 6.
Copyright

A new statistical method of estimating the maximum instantaneous inlet pressure distortion is described. By this method, the time average and rms values of the instantaneous pressure distortion index K(theta), K(rad), and K(42) can be obtained analytically from the measured inlet total steady-state pressure and rms values. The most probable maximum instantaneous distortion index that occurs in a given duration can also be obtained. Comparison between the estimated values and the experimental results shows that the described method can estimate accurately the maximum instantaneous distortion index with 3 s on an Intel 86/330 microcomputer. Author

A92-21070* Sverdrup Technology, Inc., Brook Park, OH.
UNSTEADY EULER ANALYSIS OF THE FLOWFIELD OF A PROPFAN AT AN ANGLE OF ATTACK
M. NALLASAMY (Sverdrup Technology, Inc., Brook Park, OH) and J. F. GROENEWEG (NASA, Lewis Research Center, Cleveland, OH) Journal of Propulsion and Power (ISSN 0748-4658), vol. 8, Jan.-Feb. 1992, p. 136-143. Previously cited in issue 09, p. 1256, Accession no. A90-25028. refs
Copyright

A92-21072
NUMERICAL AND EXPERIMENTAL INVESTIGATION OF AIRFRAME-INTEGRATED INLET FOR HIGH VELOCITIES
V. A. VINOGRADOV, V. A. STEPANOV (Tsentral'nyi NII Aviatsionnogo Motorostroeniia, Moscow, USSR), and E. V. ALEKSANDROVICH (Tsentral'nyi Aerogidrodinamicheskii Institut, Zhukovski, USSR) Journal of Propulsion and Power (ISSN 0748-4658), vol. 8, Jan.-Feb. 1992, p. 151-157. Previously cited in issue 20, p. 3083, Accession no. A89-47009. refs

A92-21073
NUMERICAL INVESTIGATION OF SUPERSONIC MIXED-COMPRESSION INLET USING AN IMPLICIT UPWIND SCHEME
JYH-JANG CHAN and SHEN-MIN LIANG (National Cheng Kung University, Tainan, Republic of China) Journal of Propulsion and Power (ISSN 0748-4658), vol. 8, Jan.-Feb. 1992, p. 158-167. refs

Numerical simulation of a two-dimensional mixed-compression supersonic inlet by solving time-dependent, compressible Navier-Stokes equations associated with the Baldwin-Lomax turbulent model is presented. An implicit second-order upwind scheme was employed to obtain numerical solutions. The inlet experimentally studied by Anderson and Wong (1970) at design Mach number 3.0 and the pressure ratio as high as 31.5 is successfully simulated. The deterioration of the inlet performance caused by viscous effect is controlled by incorporating a bleed system. For a 2D inlet contour designed by method of characteristics, the current numerical experimentation shows that the flow is unstarted (choked). However, an overspeed to Mach number 3.05 can start the inlet flow. To numerically start the inlet at design Mach number 3.0, a minimum 2-percent increase in the throat area is found necessary. The relations between the engine face pressure and the total pressure recovery and the flow distortion level are analyzed. Under boundary-layer control, numerical results indicate that a minimum 12-percent bleed is necessary to sustain a stable operation for the supersonic inlet. Author

A92-21075
COMPUTATIONAL FLUID DYNAMICS BASED THREE-DIMENSIONAL TURBOFAN INLET/FAN COWL ANALYSIS SYSTEM
K. UENISHI, M. S. PEARSON, T. R. LEHNIG, and R. M. LEON (GE Aircraft Engines, Cincinnati, OH) Journal of Propulsion and Power (ISSN 0748-4658), vol. 8, Jan.-Feb. 1992, p. 175-183. Previously cited in issue 04, p. 470, Accession no. A91-16278. refs

A92-21315
AN IMPROVEMENT OF THE DOUBLE-POINT METHOD FOR UNSTEADY SUBSONIC FLOW
S. DANAILA (Polytechnic Institute, Bucharest, Romania) Revue Roumaine des Sciences Techniques, Serie de Mecanique Appliquee (ISSN 0035-4074), vol. 36, Sept.-Dec. 1991, p. 369-374. refs

A simple and efficient method is proposed for calculating the pressure distribution of thin wings in compressible unsteady (harmonically oscillating) flow. The method is an improved version of the doublet point method developed by Ueda and Dowell (1982) and uses a correct series for calculating the kernel function of the pressure distribution equation. Numerical calculations for various wing geometries are presented and compared with other analyses. V.L.

A92-21318
CONCERNING THE FUNCTIONAL SOLUTION OF TRANSONIC FLOWS [CONTRIBUTION A LA RESOLUTION FONCTIONNELLE D'ECOULEMENTS TRANSSONIQUES]
M. POGU (Ecole Nationale Superieure de Mecanique, Nantes, France) and G. TOURNEMINE (Rennes I, Universite, France) Revue Roumaine des Sciences Techniques, Serie de Mecanique Appliquee (ISSN 0035-4074), vol. 36, Sept.-Dec. 1991, p. 405-425. In French. refs

A problem of transonic flow around a profile is considered. The velocity field is the solution of a nonlinear elliptic-hyperbolic problem. In function space an iterative algorithm provides an approximate solution to the problem. This approach also leads to a constructive adjustment procedure of the Kutta-Joukowski condition. L.M.

A92-21319
A METHOD OF CALCULATION FOR THE RADIUS OF CURVATURE OF THE ATTACHED SHOCK WAVES IN FRONT OF A SHARP-NOSED AXI-SYMMETRICAL BODY PLACED IN A UNIFORM STREAM
N.-S. TOMESCU (Polytechnic Institute, Bucharest, Romania) Revue Roumaine des Sciences Techniques, Serie de Mecanique Appliquee (ISSN 0035-4074), vol. 36, Sept.-Dec. 1991, p. 427-440. refs

An analytical method is proposed for calculating the ratio of *the initial radii of curvatures of the attached shock wave and the* body for a tapered axisymmetric body in uniform supersonic flow. The flow behind the attached curved shock near the nose of the body is analyzed by considering perturbations from the initial Carafoli-Berbente solution for the Taylor equation. The first-order perturbation yields the initial radii of curvature of the shock wave and the body. The method provides an analytical solution that is valid for a wide range of parameters. V.L.

A92-21469
THE EXPERIMENTAL APPROACH TO THE LEBU ON TURBULENT DRAG REDUCTION
JIAZHENG PAN (Research Institute of Pilotless Aircraft, People's Republic of China) Nanjing Aeronautical Institute, Journal (ISSN 1000-1956), vol. 23, Dec. 1991, p. 29-36. In Chinese. refs

Setting a thin 2D airfoil with a symmetric streamline section at a certain location within the turbulent boundary layer is employed to develop a preliminary experimental approach to the large-eddy break-up (LEBU) in wind tunnels, which is a concept of turbulent skin-friction drag reduction, and gets some efficiency of the drag reduction to a different extent. In this experiment different effects on drag reduction are investigated for parameters such as the location L, height H, angle of attack, and thickness/chord ratio of the airfoil. The 'fining' action for turbulent flow of the airfoil is proposed as a basic reason of the drag reduction from the point of view of the vortex construction of the turbulent boundary layer, and the improvement of the velocity pattern of the turbulent boundary layer is considered as a means of approaching turbulent drag reduction. The results measured with a high-sensitivity balance are in good agreement with those calculated using Ludwieg-Tillman formula. Author

A92-21504
A BOUNDARY INTEGRAL FORMULATION FOR THE KINETIC FIELD IN AERODYNAMICS. I - MATHEMATICAL ANALYSIS
P. BASSANINI, R. PIVA (Roma I, Universita, Rome, Italy), C. M. CASCIOLA (Istituto Nazionale per Studi ed Esperienze di Architettura Navale, Rome, Italy), and M. R. LANCIA (CNR, Istituto per le Applicazioni del Calcolo, Rome, Italy) European Journal of Mechanics, B/Fluids (ISSN 0997-7546), vol. 10, no. 6, 1991, p. 605-627. Research supported by MURST. refs
(Contract CNR-89,01214,01; CNR-90,01532,01)

This paper presents a new boundary integral formulation for the velocity field in aerodynamics, which includes rotational flows with wakes, sources, sinks and vorticity blobs. The velocity field is represented via the Poincare identity in terms of its divergence, curl, and normal and tangential trace on the boundary. If the first three quantities are supposed to be given, the determination of the velocity field reduces to solving a vector boundary integral equation for the latter. Existence, uniqueness and stability estimates for the solution of this integral equation are proved by a suitable variational method. This kinematical problem is thus well-posed.

The formulation here deals explicitly with 3D external flows, but a discussion is also included concerning the different qualitative behavior of 3D and 2D flows. Author

A92-21602
OPTIMIZATION OF THE THREE-DIMENSIONAL SHAPE OF LIFTING BODIES OF SMALL ASPECT RATIO AT HYPERSONIC VELOCITIES [OPTIMIZATSIIA PROSTRANSTVENNOI FORMY NESUSHCHIKH TEL MALOGO UDLINENIIA PRI GIPERZVUKOVYKH SKOROSTIAKH]
V. N. GOLUBKIN and V. V. NEGODA Zhurnal Vychislitel'noi Matematiki i Matematicheskoi Fiziki (ISSN 0044-4669), vol. 31, Dec. 1991, p. 1858-1870. In Russian. refs
Copyright
Problems of the partial (for a specified shape of the shock wave) and full optimization of hypersonic lifting bodies of small aspect ratio are formulated in the context of the theory of a thin shock layer with a view to achieving maximum lift-drag ratio for a given lift force. The partial optimization problem is solved analytically. In the case of the full problem, an approximate solution is obtained numerically using the direct optimization method. V.L.

A92-21617
AXISYMMETRIC ANALOGY FOR THREE-DIMENSIONAL VISCOUS FLOW PROBLEMS [OSESIMMETRICHNAIA ANALOGIIA DLIA TREKHMERNYKH ZADACH VIAZKOGO OBTEKANIIA]
I. G. BRYKINA, V. V. RUSAKOV, and V. G. SHCHERBAK Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza (ISSN 0568-5281), Nov.-Dec. 1991, p. 111-118. In Russian. refs
Copyright
A method for solving three-dimensional flow problems is proposed which employs two-dimensional solutions and is valid for any Reynolds numbers. The method is based on the use of similarity relations obtained as a result of a theoretical analysis of an approximate analytical solution for equations of a three-dimensional viscous shock layer. The relations describe the heat flow and the friction stress at the lateral surface of a three-dimensional body in terms of their values on the surface of an axisymmetric body. The accuracy of the method is evaluated by comparing the results with the results of finite-difference calculations of flow past bodies of different shapes. V.L.

A92-21618
SOLUTION OF THE PROBLEM OF THREE-DIMENSIONAL FLOW PAST THE BLADE ROWS OF TURBOMACHINES WITH ALLOWANCE FOR VISCOSITY EFFECTS [RESHENIE ZADACHI OBTEKANIIA VENTSOV TURBOMASHIN PROSTRANSTVENNYM POTOKOM S UCHETOM EFFEKTOV VIAZKOSTI]
V. A. MEN'SHIKOV, IU. A. SKOB, and M. L. UGRIUMOV Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza (ISSN 0568-5281), Nov.-Dec. 1991, p. 119-127. In Russian. refs
Copyright
Three-dimensional flow of a viscous compressible fluid in the blade passage of a turbomachine is examined. A mathematical model is proposed which describes steady state separated turbulent flow with allowance for wall flow effects. The boundary layer thickness and the scales of wall flow mixing zones are assumed to be small in comparison with the characteristic size of the system. Subsonic flows are calculated for flow regimes close to the design conditions. V.L.

A92-21623
A HOT-WIRE ANEMOMETER IN COMPRESSIBLE SUBSONIC FLOW [TERMOANEMOMETR V SZHIMAEMOM DOZVUKOVOM POTOKE]
V. A. LEBIGA Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza (ISSN 0568-5281), Nov.-Dec. 1991, p. 160-167. In Russian. refs
Copyright
Problems associated with the use of hot-wire anemometry for measuring fluctuations in subsonic gas flows are examined. At high subsonic velocities, the use of the fluctuation diagram method is recommended for measuring vortex, entropy, and acoustic perturbations. These diagrams are similar to those for the vortex and entropy perturbations in supersonic flow but have qualitative distinctions in the case of acoustic perturbations. Some particular cases, where additional data are available on the acoustic perturbations and acoustic source distributions, are discussed. V.L.

A92-21624
CALCULATION OF THE PARAMETERS OF SEPARATED FLOW BEHIND A PLANE ROUNDED BODY IN THE PATH OF TWO SUPERSONIC FLOWS [RASCHET PARAMETROV OTRYVNOGO TECHENIIA ZA PLOSKIM ZAKRUGLENNYM TELOM, OBTEKAEMYM DVUMIA SVERKHZVUKOVYMI POTOKAMI]
V. K. MASALOV and R. K. TAGIROV Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza (ISSN 0568-5281), Nov.-Dec. 1991, p. 170-173. In Russian. refs
Copyright
A method is proposed for calculating the base pressure and the coordinates of separation points on the curvilinear surface of the trailing edge of a plane body in the path of two supersonic flows, with allowance made for local flow overexpansion. To validate the method, calculations are performed for flow past a semicircular step for three different sets of conditions determining the separation point. In all the cases, the calculated base pressures are essentially the same and agree well with the experimentally determined values. V.L.

A92-21629
WAVE MOTIONS IN A THREE-DIMENSIONAL BOUNDARY LAYER [O VOLNOVYKH DVIZHENIIAKH V PROSTRANSTVENNOM POGRANICHNOM SLOE]
O. S. RYZHKOV and E. D. TERENT'EV Prikladnaia Matematika i Mekhanika (ISSN 0032-8235), vol. 55, Nov.-Dec. 1991, p. 912-927. In Russian. refs
Copyright
Propagation of perturbations in a boundary layer is examined for both subsonic and supersonic free-stream velocities. With a stationary three-dimensional flow assumed in the boundary layer, linearized equations describing waves of vanishing amplitudes are studied in detail. An analysis of the dispersion equation relating the natural frequencies to the wave vector components reveals a number of singularities that are characteristic of motions with a three-dimensional velocity field only. In particular, it is shown that the Cauchy problem is ill-posed for a system of linear equations. V.L.

A92-21718
EFFECTS OF GAS-SURFACE INTERACTION MODELS ON AERODYNAMIC CHARACTERISTICS
KAZUTO KUZUU and HIROTOSHI KUBOTA (Tokyo, University, Japan) (ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990) Japan Society for Aeronautical and Space Sciences, Transactions (ISSN 0549-3811), vol. 34, Nov. 1991, p. 109-120. refs
This paper describes an attempt at choosing and adopting a few gas-surface interaction models in calculating aerodynamic characteristics and heating within a transition regime of rarefied gas flows. A hypersonic rarefied gas flow around a two-dimensional cylinder is solved by the method of Direct Simulation Monte Carlo (DSMC). Two kinds of gas-surface interaction models are adopted with nonequilibrium chemical reactions and relaxation of rotational energy taken into account. The first gas-surface interaction model shows a scattering of gas molecules on the body surface, while a full diffuse reflection model and a lobular reflection model are set up as the reflection models. The second model explains accommodation of rotational energy, which is contained in a diatomic molecule. The degree of the effects of each interaction model is shown from the results of the calculation. Author

A92-21722
ANALYSIS OF CIRCULAR ELASTIC MEMBRANE WINGS
TAKESHI SUGIMOTO (Tokyo, University, Japan) (Japan Society for Aeronautical and Space Sciences, Journal, vol. 39, no. 447, 1991, p. 180-187) Japan Society for Aeronautical and Space Sciences, Transactions (ISSN 0549-3811), vol. 34, Nov. 1991, p. 153-166. Translation. Research supported by MOESC. Previously cited in issue 16, p. 2667, Accession no. A91-40472. refs

A92-21742
PRELIMINARY INVESTIGATION OF INLET DYNAMIC DISTORTION AND IT'S PASSIVE CONTROL
XIJIN HUANG and XU PENG (Beijing University of Aeronautics and Astronautics, People's Republic of China) Journal of Propulsion Technology (ISSN 1001-4055), Dec. 1991, p. 10-16. In Chinese. refs

In this paper, the inlet diffuser flow under critical and supercritical operation condition was studied. From the investigation of supercritical operation condition, the formation and characteristics of dynamic distortion have been determined. The dynamic distortion of inlet diffuser is mainly caused by interaction of shock wave with boundary layer. A passive control method was used to reduce the interaction of shock wave with boundary layer. The results of experiments show that, under supercritical operation condition, the passive control method reduces the unsteadiness and oscillation of terminal shock wave in diffuser; the peak value of pressure fluctuation decreases by about 60 percent. Author

A92-21743
FLOW CHARACTERISTIC AND FLOW CONTROL OF HIGH ASPECT RATIO AND HIGHLY CURVED S-BEND DIFFUSER
XIAO CHEN and WENYUE HE (Nanjing Aeronautical Institute, People's Republic of China) Journal of Propulsion Technology (ISSN 1001-4055), Dec. 1991, p. 17-22. In Chinese. refs

This paper presents the experimental results of the flow characteristics in a high-aspect-ratio and highly curved S-bend subsonic diffuser. The flow feature is analyzed by using the flow visualization, the static pressure distribution, the total pressure contour map, and the swirl flow field at exit. The paper also presents the result of separation control in the S-bend diffuser. The experimental result shows that the separation region can be reduced and the diffuser performance can be improved by using the boundary-layer submerged vortex generators if the installation location and the geometrical parameters of the vortex generator are selected property. Author

A92-21837
NUMERICAL ANALYSIS OF AIRFLOW IN AIRCRAFT CABINS
FRED ABOOSAIDI, MATTHEW J. WARFIELD (Boeing Co., Seattle, WA), and DIPANKAR CHOUDHURY (Creare.x, Hanover, NH) SAE, International Conference on Environmental Systems, 21st, San Francisco, CA, July 15-18, 1991. 13 p. refs
(SAE PAPER 911441) Copyright

Two three-dimensional cabin airflow configurations have been the subject of experimental and analytical testing to establish the validity and role of computational fluid dynamics (CFD) tools in the design of cabin airflow distribution systems. The CFD tools considered here are two separate Navier-Stokes computer codes which have been used for a number of applications, including those in the present study. A correlative study of a detailed air supply nozzle configuration has been examined to further understand its flow characteristics and to establish a procedure for examining cases with large size scale differences. The comparison of experimental results with the numerical simulations in the two cases is generally quite good, leading to an increased confidence in the application of CFD methods within the cabin airflow distribution system design arena. Author

A92-21976
COMPUTATIONAL METHODS IN VISCOUS AERODYNAMICS
T. K. S. MURTHY, ED. and C. A. BREBBIA, ED. (Wessex Institute of Technology, Ashurst, England) Amsterdam, Netherlands and New York/Southampton, England, Elsevier/Computational Mechanics Publications, 1990, 380 p. For individual items see A92-21977 to A92-21987.
Copyright

This volume presents papers on the finite volume approach for the Navier-Stokes equations, calculation methods of 3D boundary layers, Navier-Stokes computations for aerodynamic configurations at high angles of attack, and adaptation methods for viscous flows. Also presented are finite element vorticity based methods for the solution of the compressible Navier-Stokes equations, Navier-Stokes code development for transonic flow simulations, a fast viscous correction method for transonic aerodynamics, and 2D incompressible airfoil design and analysis. R.E.P.

A92-21977
INTRODUCTION TO THREE DIMENSIONAL BOUNDARY LAYERS
R. GRUNDMANN (Von Karman Institute for Fluid Dynamics, Rhode-Saint-Genese, Belgium) IN: Computational methods in viscous aerodynamics. Amsterdam, Netherlands and New York/Southampton, England, Elsevier/Computational Mechanics Publications, 1990, p. 1-41. refs
Copyright

Two dimensional boundary layers usually are exceptional flows. Effort has to be made to establish the proper conditions such that no flows in the crossflow direction are visible. The most frequent flows are three dimensional and as a consequence the boundary layer computations have to be treated as three dimensional as well. Therefore certain flow properties change and the coordinate system has to be extended to a third dimension which strongly influences the choice of the discretization model. These basic requirements are discussed in this chapter including the detailed description of a solution method followed by a sample calculation. Author

A92-21978
CALCULATION METHODS OF THREE-DIMENSIONAL BOUNDARY LAYERS
J. COUSTEIX (ONERA, Centre d'Etudes et de Recherches de Toulouse, France) IN: Computational methods in viscous aerodynamics. Amsterdam, Netherlands and New York/Southampton, England, Elsevier/Computational Mechanics Publications, 1990, p. 43-76. refs
Copyright

This paper describes various calculation methods of three-dimensional boundary layers. This includes integral methods and turbulence modeling. Numerical techniques for solving the boundary layer equations are also presented. The occurrence of singularities in boundary layer solutions is discussed in the framework of an integral method. Author

A92-21979
COMPUTATION OF UNSTEADY, LAMINAR, INCOMPRESSIBLE, VISCOUS FLOWS USING THE VORTICITY STREAMFUNCTION FORMULATION
Y. LECOINTE and J. PIQUET (CNRS; Ecole Nationale Superieure de Mecanique, Nantes, France) IN: Computational methods in viscous aerodynamics. Amsterdam, Netherlands and New York/Southampton, England, Elsevier/Computational Mechanics Publications, 1990, p. 77-116. refs
Copyright

The finite difference computation of unsteady laminar viscous flows using the vorticity-streamfunction formulation is reviewed for two-dimensional outer flow problems. The differential equations and problems associated with wall boundary conditions, far field approximations and computation of forces are discussed in the first part. The second part focuses on the numerics and discusses resolution requirements. The last part discusses results. The benchmark test used for the comparisons is the impulsively started circular cylinder problem for several values of the Reynolds number. In-line and transverse superimposed oscillations of a uniform cylinder immersed in a uniform stream are considered last. Lock-on phenomena are demonstrated with evidence of possible

configurations (symmetric and asymmetric) for several values of the reduced amplitude and of the reduced frequency of the motion. Mode competition and frequency response phenomena are presented and compared with available experimental results.
Author

A92-21980
THE FINITE VOLUME APPROACH FOR THE NAVIER-STOKES EQUATIONS
J. G. KALLINDERIS and J. R. BARON (MIT, Cambridge, MA) IN: Computational methods in viscous aerodynamics. Amsterdam, Netherlands and New York/Southampton, England, Elsevier/Computational Mechanics Publications, 1990, p. 117-146. refs
(Contract AF-AFOSR-82-0136)
Copyright
This paper focuses on the basic principles and problems that are common to most of the numerical schemes for solving the Navier-Stokes equations using the finite volume approach. These include such issues as viscous grid requirements, accuracy, and smoothing. The Navier-Stokes equations are presented and the finite volume discretization is discussed; finite volume approaches to evaluating viscous terms are examined; and issues of spatial accuracy and requirements of a viscous grid are addressed.
R.E.P.

A92-21981* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
NAVIER-STOKES COMPUTATIONS FOR AERODYNAMIC CONFIGURATIONS AT HIGH ANGLES OF ATTACK
J. L. THOMAS (NASA, Langley Research Center, Hampton, VA) and R. W. WALTERS (Virginia Polytechnic Institute and State University, Blacksburg) IN: Computational methods in viscous aerodynamics. Amsterdam, Netherlands and New York/Southampton, England, Elsevier/Computational Mechanics Publications, 1990, p. 147-162. refs
Copyright
Navier-Stokes computations at high angles of attack over aerodynamic configurations are presented using an implicit finite-volume algorithm. The spatial differencing is upwind-biased for the convective and pressure terms and central for the shear stress and heat transfer terms. The equations are relaxed to steady state with a spatially factored implicit algorithm. In order to treat general geometries, a multiblock patched-grid framework is implemented. Applications and detailed comparisons with experimental data are made for two simple but representative geometric shapes: (1) a highly swept delta wing and (2) a prolate spheroid of 6:1 length-to-diameter. Recent extensions of the algorithm to compute the flow over an F-18 forebody-strake configuration are shown, including comparisons with wind tunnel and flight test results. Comparisons across the range of Reynolds number for all cases indicate that either low Reynolds number or high Reynolds number flows are simulated well, but that flows at intermediate Reynolds number cannot be simulated accurately without a detailed knowledge of the transitional zone between laminar and turbulent flow.
Author

A92-21982
ADAPTATION METHODS FOR VISCOUS FLOWS
J. G. KALLINDERIS and J. R. BARON (MIT, Cambridge, MA) IN: Computational methods in viscous aerodynamics. Amsterdam, Netherlands and New York/Southampton, England, Elsevier/Computational Mechanics Publications, 1990, p. 163-196. refs
(Contract AF-AFOSR-82-0136)
Copyright
Several adaptation methods, emphasizing those which are viscous, as well as other concepts that can be applied to the efficient simulation of fluid flows, are presented. The basis for developing adaptive algorithms is examined, and the techniques of grid, equation, and temporal adaptation are described. The question of detecting the flow features of interest, the communication between different grids, and the utilization of a turbulence model are discussed. Special coding requirements for an adaptive algorithm, sample problems, and an evaluation of the methods in terms of accuracy and efficiency are presented.
R.E.P.

A92-21983
FINITE ELEMENT VORTICITY BASED METHODS FOR THE SOLUTION OF THE COMPRESSIBLE NAVIER-STOKES EQUATIONS
W. G. HABASHI, G. GUEVREMONT, M. F. PEETERS (Concordia University, Montreal, Canada), S. M. PRZYBYTKOWSKI (Pratt and Whitney Canada, Longueil), and M. M. HAFEZ (California, University, Davis) IN: Computational methods in viscous aerodynamics. Amsterdam, Netherlands and New York/Southampton, England, Elsevier/Computational Mechanics Publications, 1990, p. 197-230. refs
Copyright
Finite element vorticity based methods are applied to the analysis of viscous and viscous-inviscid interaction type flows. This is carried out in terms of stream function-vorticity and velocity-vorticity formulations. These alternative methods to primitive variables present inherent advantages, most notably dispensing with artificial viscosity for the stability of the iteration algorithm. The discretization is based on the weak-Galerkin weighted residual method and isoparametric elements. The nonlinearity is iterated upon using a Newton method and, at each iteration, the linear algebraic system is solved by a direct solver. The schemes demonstrate the advantages of the finite element method in providing natural boundary conditions for such problems.
Author

A92-21984
EXPERIENCES WITH FINITE ELEMENT METHODS FOR THE VELOCITY-VORTICITY FORMULATION OF THREE-DIMENSIONAL, VISCOUS, INCOMPRESSIBLE FLOWS
M. GUNZBURGER (Carnegie Mellon University, Pittsburgh, PA), M. MUNDT, and J. PETERSON (Los Alamos National Laboratory, NM) IN: Computational methods in viscous aerodynamics. Amsterdam, Netherlands and New York/Southampton, England, Elsevier/Computational Mechanics Publications, 1990, p. 231-271. Research supported by DOE. refs
(Contract AF-AFOSR-88-0197)
Copyright
Various aspects of the finite element methodology for the approximate solution of the velocity-vorticity equations for incompressible viscous flow are discussed. First, different choices of mathematical models are given and evaluated, with particular emphasis on the number and nature of the boundary conditions that both the velocity and vorticity must satisfy at solid boundaries. Arguments are given for specifying all components of the velocity and setting the vorticity equal to the curl of the velocity at such boundaries. Next, finite element discretizations are discussed, again focusing on the difficulties associated with the specification of the vorticity on solid boundaries. It is shown that naive approximations of the normal derivative of the velocity components at the boundary can lead to a serious loss of accuracy. Various methods for ameliorating this situation are then given. Finally, a number of iterative methods for the solution of the nonlinear system of discrete equations are listed and evaluated. Of particular interest in the context of three-dimenional calculations is a method which requires the solution of six uncoupled Poisson equations at every step of the iteration. This allows for both the use of iterative linear system solvers and of parallel processing algorithms. In all probability, these are features that any successful algorithm for three-dimensional computations should include. Many of the evaluations and conclusions are supported by numerical experiments.
Author

A92-21985
NAVIER-STOKES CODE DEVELOPMENT FOR TRANSONIC FLOW SIMULATIONS
H. NAGASU (National Aerospace Laboratory, Tokyo, Japan) and K. FUJII (Institute of Space and Astronautical Science, Sagamihara,

Japan) IN: Computational methods in viscous aerodynamics. Amsterdam, Netherlands and New York/Southampton, England, Elsevier/Computational Mechanics Publications, 1990, p. 273-300. refs
Copyright

Research Activities on the Computational Fluid Dynamics at the National Aerospace Laboratory are described. Emphasis is laid on the code development for the viscous transonic flow simulations. Computational algorithms used in these simulations are briefly described. Then, the developed computer codes that solve the 'Reynolds averaged' Navier-Stokes equations and their applications are reviewed. Computational examples vary from the flow simulation over a transport aircraft configuration to the flow simulation in cascades and nozzles. Recent effort for the simulation of unsteady transonic flow is also presented. Several computational methods that can handle complex configurations that have been developed lately are described with the future possibilities. The supporting computer system is also described. Author

A92-21986
A FAST VISCOUS CORRECTION METHOD FOR TRANSONIC AERODYNAMICS
S. C. LEE (Missouri-Rolla, University, Rolla) IN: Computational methods in viscous aerodynamics. Amsterdam, Netherlands and New York/Southampton, England, Elsevier/Computational Mechanics Publications, 1990, p. 301-330. refs
Copyright

The effect on aerodynamic performance in transonic flows by shock wave/boundary layer interaction was considered by superpositioning a viscous wedge on a turbulent boundary layer. An empirical relation was established for the wedge thickness so that it can be superimposed on a boundary layer displacement thickness obtained from a conventional method. The same model was used for viscous corrections of steady, full-potential solutions about airfoils and wings as well as of unsteady, small-disturbance solutions for airfoils during pitching and oscillatory maneuverings. Comparing with experimental data, the corrected solutions improved the accuracy of inviscid solutions in pressure-coefficient predictions for all investigated cases and reduced computational time for most of the cases. Instead of using the more accurate and extremely time-consuming Navier-Stokes solvers, this method can be a reasonable alternative for preliminary design of transonic flight with moderately strong shock situations. Author

A92-21987
TWO-DIMENSIONAL, INCOMPRESSIBLE AEROFOIL DESIGN AND ANALYSIS
R. A. GALBRAITH and F. N. COTON (Glasgow, University, Scotland) IN: Computational methods in viscous aerodynamics. Amsterdam, Netherlands and New York/Southampton, England, Elsevier/Computational Mechanics Publications, 1990, p. 331-367. refs
Copyright

A description is presented of the various numerical tools available to assist in the design of two-dimensional incompressible single element aerofoils. The topic is introduced by a description of the various flow states to be encountered and is followed by a discussion of contemporary aerofoil performance and design codes. The manner of modeling the various flow phenomena is then discussed followed by a few concluding remarks in which the importance of the designer's personal flair is reiterated. Author

A92-22135*# Complere, Inc., Palo Alto, CA.
AN ASSESSMENT OF PARTICLE VELOCIMETRY POTENTIAL IN HYPERSONIC FLOW
F. K. OWEN (Complere, Inc., Palo Alto, CA) AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992. 9 p. refs
(Contract F33615-88-C-3014; NAS2-12853)
(AIAA PAPER 92-0010) Copyright

Future progress in the computation of hypersonic flow fields is restricted by the need for a reliable turbulence modeling data base which could be used for the development of empirical models for use in numerical codes. Currently, there are few compressible flow measurements which could be used for this purpose. Procedures for hot wire measurements in hypersonic flows are presently outlined, and assessments are made of the potential for hot wire and laser velocimeter measurements of turbulent fluctuations in hypersonic flow fields. The results of recent experiments conducted in two hypersonic wind tunnels will be presented and comparisons made with previous hot wire turbulence measurements. Author

A92-22139#
X-29 FOREBODY JET BLOWING
ROBERT W. GUYTON (USAF, Flight Dynamics Laboratory, Wright-Patterson AFB, OH) and GLENN MAERKI (Grumman Corp., Aircraft Systems Div., Bethpage NY) AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992. 16 p. refs
(AIAA PAPER 92-0017)

A wind tunnel developmental testing campaign was undertaken for the application of jet-blowing forebody vortex control to the X-29 forward-swept wing aircraft configuration. Arrangements were defined in which a high level of yaw control was obtainable within a conventional fighter's maneuvering envelope; these are also found to substantially improve directional stability at high angles-of-attack. Careful optimizations of the blown jet's orientation and exit geometry were found to yield an order-of-magnitude reduction in jet mass-flow requirements. O.C.

A92-22140#
AN EXPERIMENTAL STUDY OF PNEUMATIC VORTEX FLOW CONTROL ON HIGH ANGLE OF ATTACK FOREBODY MODEL
KENNETH C. CORNELIUS (Wright State University, Dayton, OH), RUSS F. OSBORN, BOB W. GUYTON (USAF, Wright Laboratory, Wright-Patterson AFB, OH), and NOORULHAQ PANDIT AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992. 12 p. refs
(Contract F49620-88-C-0053)
(AIAA PAPER 92-0018) Copyright

Fighter aircraft forebody vortex flowfield control by means of pneumatic jets can exert a significant influence on maneuverability at high angles of attack, as indicated by the present wind tunnel test data for an X-29 forebody model. The greatest maneuverability enhancements were obtained by means of the underexpanded jet of an extended, slotted nozzle throat which underwent supersonic expansion at a high pressure ratio; this yielded favorable aerodynamic interactions which increased the yawing moment at low blowing coefficients. The slotted nozzle yielded a factor of 3 increase in entrainment relative to an axisymmetric nozzle at a pressure ratio of 8. O.C.

A92-22141*# Air Force Wright Aeronautical Labs., Wright-Patterson AFB, OH.
FOREBODY VORTEX FLOW CONTROL ON THE F-16C USING TANGENTIAL SLOT AND JET NOZZLE BLOWING
SCOTT P. LEMAY (USAF, Wright Laboratory, Wright-Patterson AFB, OH), WILLIAM G. SEWALL (NASA, Langley Research Center, Hampton, VA), and JOHN F. HENDERSON (General Dynamics Corp., Fort Worth, TX) AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992. 12 p. refs
(AIAA PAPER 92-0019)

The present experimental investigation of the effects of tangential slot and nozzle forebody blowing on the aerodynamic and stability characteristics of the F-16C configuration, for up-to-55 deg alpha and up-to-20 deg sideslip, was conducted on a 1/15th-scale model at freestream Mach = 0.4 and Re of 2.5 million/ft, for one tangential slot-nozzle location and two chordwise jet nozzle locations. Both the slot and the jet nozzles generated large yawing moments at very low blowing rates, over a wide range of alpha and sideslip angles. The centers of pressure of the side forces which generated the yawing moments due to slot and nozzle blowing were located in the region of the leading-edge extensions (LEXs); the moments may accordingly be due to the manipulation of the combined forebody and LEX flowfields. O.C.

A92-22142*# MCAT Inst., Moffett Field, CA.
COMPUTATIONAL INVESTIGATION OF SLOT BLOWING FOR FUSELAGE FOREBODY FLOW CONTROL
SCOTT M. MURMAN (MCAT Institute; NASA, Ames Research Center, Moffett Field, CA), YEHIA M. RIZK, LEWIS B. SCHIFF (NASA, Ames Research Center, Moffett Field, CA), and RUSSELL M. CUMMINGS (California Polytechnic State University, San Luis Obispo) AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992. 11 p. refs
(Contract NCC2-564)
(AIAA PAPER 92-0020) Copyright

This paper presents a computational investigation of a tangential slot blowing concept for generating lateral control forces on an aircraft fuselage forebody. The effects of varying both the jet width and jet exit velocity for a fixed location slot are analyzed. This work is aimed at aiding researchers in designing future experimental and computational models of tangential slot blowing. The primary influence on the resulting side force of the forebody is seen to be the jet mass flow rate. This influence is sensitive to different combinations of slot widths and jet velocities over the range of variables considered. Both an actuator plane and an overset grid technique are used to model the tangential slot. The overset method successfully resolves the details of the actual slot geometry, extending the generality of the numerical method. The actuator plane concept predicts side forces similar to those produced by resolving the actual slot geometry. Author

A92-22145#
AN EFFICIENT UPWIND RELAXATION-SWEEPING ALGORITHM FOR THREE-DIMENSIONAL NAVIER-STOKES EQUATIONS
GE-CHENG ZHA and E. BILGEN (Montreal, Universite, Montreal, Canada) AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992. 8 p. refs
(AIAA PAPER 92-0023) Copyright

An upwind relaxation-sweeping algorithm for the complete 3D compressible Navier-Stokes equations has been developed. The algorithm implements the relaxation iteration on the vertical streamwise plane, and then sweeps alternately in spanwise direction. The algorithm can reach very high CFL number due to the unfactored relaxation scheme without the approximation error introduced. The memory requirement is greatly reduced because the matrices are only stored in one iterating plane. The computational experiments show that the high convergence rate of the algorithm is independent of grid size. The computational results agree with the experiments. Author

A92-22146*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
NAVIER-STOKES ANALYSIS OF BLUNT TRAILING EDGE AIRFOILS
SHARON STANAWAY, W. J. MCCROSKEY (NASA, Ames Research Center; U.S. Army, Aeroflightdynamics Directorate, Moffett Field, CA), and ILAN KROO (Stanford University, CA) AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992. 13 p. refs
(AIAA PAPER 92-0024)

The flow around blunt trailing edge airfoils was studied by solving the Reynolds-averaged Navier-Stokes equations. The solution procedure combines a grid around the airfoil with a second grid for the wake so that the time advancement over the domain is fully implicit. This is not only very efficient for the algorithm but also allows implicit solutions of a one equation turbulence model appropriate for both boundary layers and wakes. An algebraic and two one-equation turbulence models are tested for a blunt RAE 2822 airfoil section and detailed comparisons with experimental data are presented in the trailing edge region. Author

A92-22147*# Weizmann Inst. of Science, Rehovoth (Israel).
AERODYNAMIC DESIGN AND OPTIMIZATION IN ONE SHOT
SHLOMO TA'ASAN (Weizmann Institute of Science, Rehovot, Israel; ICASE, Hampton, VA), G. KURUVILA (Vigyan, Inc., Hampton, VA), and M. D. SALAS (NASA, Langley Research Center, Hampton, VA) AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992. 16 p. refs
(AIAA PAPER 92-0025) Copyright

This paper describes an efficient numerical approach for the design and optimization of aerodynamic bodies. As in classical optimal control methods, the present approach introduces a cost function and a costate variable (Lagrange multiplier) in order to achieve a minimum. High efficiency is achieved by using a multigrid technique to solve for all the unknowns simultaneously, but restricting work on a design variable only to grids on which their changes produce nonsmooth perturbations. Thus, the effort required to evaluate design variables that have nonlocal effects on the solution is confined to the coarse grids. However, if a variable has a nonsmooth local effect on the solution in some neighborhood, it is relaxed in that neighborhood on finer grids. The cost of solving the optimal control problem is shown to be approximately two to three times the cost of the equivalent analysis problem. Examples are presented to illustrate the application of the method to aerodynamic design and constraint optimization. Author

A92-22148*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
NONEQUILIBRIUM ALGEBRAIC TURBULENCE MODELING CONSIDERATIONS FOR TRANSONIC AIRFOILS AND WINGS
D. A. JOHNSON (NASA, Ames Research Center, Moffett Field, CA) AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992. 10 p. refs
(AIAA PAPER 92-0026) Copyright

The nonequilibrium algebraic turbulence model of Johnson and King has been applied successfully to both airfoils and wings. However, in wing applications a different expression for the outer 'equilibrium' eddy viscosity has been used because of apparent difficulties in determining the boundary-layer thickness. It is shown in this paper, that this expression does not give eddy viscosity levels for two-dimensional flows that are consistent with Clauser's correlation for equilibrium turbulent boundary layers. And as a consequence, results in inferior predictions when used in airfoil calculations. The objective of this paper is to develop a formulation applicable to wing flows which reduces to the proper form in the two-dimensional case. This necessitates, in part, finding a better way of estimating the boundary-layer thickness from the computed flowfield. Author

A92-22149#
EFFECT OF TURBULENCE MODELING ON DYNAMIC STALL OF A NACA0012 AIRFOIL
MUSTAFA DINDAR and UNVER KAYNAK (Tusas Aerospace Industries, Ankara, Turkey) AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992. 15 p. refs
(AIAA PAPER 92-0027) Copyright

The present numerical investigation of the dynamic stall phenomenon gave attention to turbulence-modeling effects, using a Navier-Stokes code for solving the flow field around an airfoil undergoing unsteady harmonic motion. It is established that nonequilibrium effects play an important role in determining the separation and vortex-shedding mechanisms of the dynamic stall regimes; in particular, only the Johnson-King nonequilibrium turbulence model is capable of producing a light-stall hysteresis loop similar to experiment. In the deep stall regime, the same model is found to represent the most realistic features of dynamic stall. O.C.

A92-22150#
INVERSE SOLUTION UNIQUENESS AND DOMAIN OF EXISTENCE FOR SUPERSONIC SPACE MARCHING APPLICATIONS
JAEWOO LEE and W. H. MASON (Virginia Polytechnic Institute and State University, Blacksburg) AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992. 10 p. refs
(AIAA PAPER 92-0028) Copyright

Existence and uniqueness issues are discussed for supersonic

and hypersonic three-dimensional inverse solution procedures which use space marching techniques. A simple method to estimate the limiting domain of inverse solution existence is proposed and applied to several example test cases. This method provides useful information about possible target pressure distributions and inverse solution existence without performing any inverse calculations. By investigating the relations between the surface pressure and the body geometry, a general explanation for inverse solution uniqueness has been described. Sample calculations to support this explanation are presented. Author

A92-22151#
WEAK COUPLING BETWEEN AN UNSTEADY 3D FULL POTENTIAL CODE AND AN UNSTEADY TURBULENT BOUNDARY LAYER CODE - APPLICATION TO A HELICOPTER ROTOR IN FORWARD FLIGHT
M. COSTES, M. RAHAINGOMANANA, and A. DESOPPER (ONERA, Chatillon, France) AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992. 10 p. Research supported by Ministere de la Defense and EEC. refs
(AIAA PAPER 92-0029) Copyright

A viscous correction is implemented in an unsteady three-dimensional full potential code for helicopter rotors. The viscous calculations are performed with an unsteady three-dimensional turbulent integral boundary layer code. The method is applied to a nonlifting rotor at high-speed forward flight and compared to experimental results. The effect of viscosity is small on the computed pressure distribution for the part of the rotor considered, i.e., the last 50 percent of the blade span. A good correlation with experiment is obtained. A first attempt to estimate the torque necessary to drive the rotor is performed and the result is promising, even if the experimental torque is underestimated. Author

A92-22152*# Virginia Polytechnic Inst. and State Univ., Blacksburg.
A COMPUTATIONAL STUDY ON DIRECTIONAL STABILITY OF CHINE-SHAPED FOREBODIES AT HIGH-ALPHA
R. RAVI and WILLIAM H. MASON (Virginia Polytechnic Institute and State University, Blacksburg) AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992. 16 p. refs
(Contract NAG1-1037)
(AIAA PAPER 92-0030) Copyright

CFD is employed to study the flowfields over chine-shaped forebodies at low-speed high-angle-of-attack conditions with sideslip. This study is conducted to define forebody geometries that provide good directional stability characteristics under these conditions. An analytically defined generic forebody model is developed and a systematic examination of forebody shapes is performed to determine which shapes promote a positive contribution to directional stability at high-alpha. Results of the initial parametric study and some guidelines for aerodynamic design to promote positive directional stability are presented. R.E.P.

A92-22153*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
WALL INTERFERENCE CALCULATION IN A TRANSONIC TEST SECTION INCLUDING SIMULATION OF DISCRETE SLOTS
JASSIM A. AL-SAADI (NASA, Langley Research Center, Hampton, VA) and FRED R. DEJARNETTE (North Carolina State University, Raleigh) AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992. 12 p. refs
(AIAA PAPER 92-0032) Copyright

A computational simulation of a transonic wind tunnel test section with longitudinally slotted walls is described. This nonlinear slot model includes dynamic-pressure effects and a plenum pressure constraint. The simulation method developed is found to be a useful tool for analyzing the nature of the flowfield that exists in a longitudinally slotted transonic test section. Results obtained from the discrete-slot model are similar to those of a homogeneous model when a plenum pressure coefficient of zero is utilized, indicating little effect of slot discreteness with the transport aircraft models examined. R.E.P.

A92-22155#
SIMULATION OF WIND TUNNEL FLOWFIELDS
JERRY E. DEESE, JERRY G. JOHNSON, RAMESH K. AGARWAL (McDonnell Douglas Research Laboratories, Saint Louis, MO), BHARAT K. SONI (Mississippi State University, Mississippi State), ROGER C. CRITES, and MATHEW L. RUEGER (McDonnell Aircraft Co., Saint Louis, MO) AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992. 11 p. refs
(AIAA PAPER 92-0034) Copyright

A boundary interference correction procedure based on solution of the Euler equations has been developed. The method computes free flight and wind tunnel flowfields, calculates the predicted force and moment differences between the two, and uses these force and moment increments to correct the experimental tunnel data. The resulting corrected data is a better appproximation to the values one would measure on the vehicle in free flight than the original wind tunnel data. Data from tests in a tunnel where the blockage ratio is 2.664 percent are corrected using the procedure and compared with data from tests where the blockage ratio is 0.17 percent. The boundary interference corrections significantly improve the correlation between the two sets of data. Author

A92-22156#
MODELING THE VENTILATED WIND TUNNEL WALL
ROGER C. CRITES and MATHEW L. RUEGER (McDonnell Aircraft Co., Saint Louis, MO) AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992. 9 p. refs
(AIAA PAPER 92-0035) Copyright

The objective of this effort was the development of improved methods for obtaining accurate boundary conditions for CFD simulation of transonic wind tunnel flows. An experimental study of the cross-flow characteristics of five perforated transonic wall geometries is reported. A correlation, collapsing the cross-flow characteristics of all five geometries is obtained. Cross-flow is found to be dependent on local wall pressure and boundary layer displacement thickness. A relation between cross-flow velocity and equivalent inviscid normal velocity (flow angle) is derived. A set of equations is given allowing the simultaneous numerical solution for cross-flow velocity, boundary layer displacement thickness, and equivalent inviscid normal velocity - given the pressure distribution and test section inlet displacement thickness. Author

A92-22157#
WIND TUNNEL BOUNDARY INTERFERENCE PREDICTION AND CORRECTION
MATHEW L. RUEGER and ROGER C. CRITES (McDonnell Aircraft Co., Saint Louis, MO) AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992. 13 p. refs
(AIAA PAPER 92-0036) Copyright

The paper discusses the current effort to develop methods for the correction of transonic wind tunnel boundary interference. A correction procedure is outlined on the basis of computational modeling of the wind tunnel flow field. In order to validate the correction method, four geometrically similar wind tunnel models, of different sizes, were tested in three separate transonic facilities. The results from two of these tests are presented. It is also shown that higher order panel methods give useful corrections for subsonic Mach numbers. Author

A92-22170#
STEADY SUPERSONIC AND HYPERSONIC FLOW COMPUTATIONS USING EULERIAN AND NEW LAGRANGIAN FORMULATIONS
J. Y. YANG, W. H. HUI (National Taiwan University, Taipei, Republic of China), and S. H. CHANG AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992. 11 p. refs
(Contract NSCRC-81-0401-E002-03)
(AIAA PAPER 92-0055) Copyright

A comparative study of numerical computations of two-dimensional steady supersonic and hypersonic flows using

Eulerian and new Lagrangian formulations of the steady Euler equations in conservation form is presented. The same Godunov method and second order nonoscillatory schemes are used for both formulations. Numerical experiments indicate that oblique shocks can be resolved well using both formulations, and the new Lagrangian method always resolves slip lines excellently. For strong shocks, the results using Eulerian formulation deteriorate with increasing Mach number while the Lagrangian method can retain the same quality of resolution. Author

A92-22171#
COMPUTATIONAL VORTICITY CAPTURING - APPLICATION TO HELICOPTER ROTOR FLOWS
JOHN STEINHOFF, WENREN YONGHU (Tennessee, University; Flow Analysis, Inc., Tullahoma), THOMAS MERSCH, and HEINRICH SENGE (Tennessee, University, Tullahoma) AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992. 14 p. refs
(Contract DAAL03-89-C-0027)
(AIAA PAPER 92-0056) Copyright

A method for computing flows with strong, concentrated vorticity, such as helicopter rotor flows is presented. The basic premise involves the utilization of an auxiliary scalar field that is defined on the (fixed) grid and numerically convected. Numerical flow solutions of the equations result in vortex sheets which have an internal structure that reaches a steady limit asymptotically and does not continue to spread, even though the basic numerical method has numerical diffusion and would result in vortex sheets that continue to spread as they convect. R.E.P.

A92-22172#
A SIMPLE NUMERICAL CRITERION FOR VORTEX BREAKDOWN
B. A. ROBINSON, R. M. BARNETT, and S. AGRAWAL (McDonnell Aircraft Co., Saint Louis, MO) AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992. 9 p. Research supported by McDonnell Douglas Corp. refs
(AIAA PAPER 92-0057) Copyright

Vortex breakdown is currently identified in numerical flow solutions through post-processing techniques. Although these methods can identify breakdown accurately, they need to be simplified and their cost reduced for practical aircraft design use. Therefore, a simple Rossby number criterion is proposed. The criterion is established using solutions to Euler and Navier-Stokes equations for low speed flow over a flat plate delta wing at high angles of attack. Comparison with experimental data shows consistent values of Rossby number at breakdown. The proposed Rossby number criterion provides an efficient means of locating breakdown in numerical solutions. It is also straightforward to incorporate in any flow solver. Author

A92-22176#
AN EXPERIMENTAL SYSTEM TO INVESTIGATE SUBSONIC AEROELASTIC BEHAVIOR OF LIFTING SURFACES
F. FINAISH and E. FELTROP (Missouri-Rolla, University, Rolla) AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992. 6 p. Research supported by University of Missouri-Rolla. refs
(AIAA PAPER 92-0061) Copyright

This study reports development of an experimental system that can be employed to investigate aeroelastic behavior of lifting surfaces that execute pitching and plunging motions in steady flow. The setup is designed to perform future investigation on vortex development and interactions over a rigid airfoil mounted on translational and rotational elastic supports. The development of simplified numerical experiments, details of the experimental system setup, and preliminary flow visualization experiments of vortex developments over an aeroelastic flat plate airfoil are presented. Author

A92-22178#
SHOCK-BOUNDARY LAYER INTERACTION CONTROL WITH LOW-PROFILE VORTEX GENERATORS AND PASSIVE CAVITY
D. C. MCCORMICK (United Technologies Research Center, East Hartford, CT) AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992. 10 p. Research supported by U.S. Navy. refs
(AIAA PAPER 92-0064) Copyright

An experimental comparison is conducted between two passive methods for control of the interaction of a supersonic shock with a turbulent boundary layer: (1) low-profile vortex generators (LPVGs), and (2) a passive cavity consisting of a porous wall covering a shallow cavity. The tests were conducted with a normal shock wave of $M = 1.56$ to 1.65, whose magnitude was sufficient to induce a large separation bubble and thereby incur substantial boundary-layer losses. While the LPVGs substantially suppressed the shock-induced separation and improved boundary-layer characteristics downstream of the shock, the extent of the low total pressure region was reduced. The passive cavity reduced total pressure loss and wave drag by creating a more isentropic compression over a greater lateral extent, but increased boundary-layer losses downstream of the shock. O.C.

A92-22179#
CONTROL OF TURBULENT FLOW ON A BACKWARD-FACING STEP
J. V. HEALEY (U.S. Naval Postgraduate School, Monterey, CA) AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992. 11 p. refs
(AIAA PAPER 92-0066) Copyright

The superstructures of even the most modern ships have many elements that are, from the aerodynamic standpoint, bluff bodies. These sharp edged elements give rise to highly turbulent recirculating zones that wreak havoc on the slowly-revolving blades of helicopters interfacing with such ships and severely limit helicopter/ship operations in high winds. Since there are very many problem ships it is of interest to know the degree to which the flows can be rendered more benign through the use of deflectors. The present study of an attempt to control the flow on a ramp and backward facing step represents a first step in that direction. The primary interest is in the qualitative control and an extensive experimental study was carried out using still-photography and video recording. Some computational grids were established and a boundary element model of the time averaged Navier-Stokes equations solved for some simple deflector geometries. In the studies conducted so far, the agreement is quite good for vertical deflectors but worsens as the angle of the deflector to the vertical increases. Author

A92-22446
COMPUTATION OF NORMAL IMPINGING JETS IN CROSS-FLOW AND COMPARISON WITH EXPERIMENT
K. KNOWLES and D. BRAY (Royal Military College of Science, Shrivenham, England) International Journal for Numerical Methods in Fluids (ISSN 0271-2091), vol. 13, Dec. 1991, p. 1225-1233. refs
Copyright

The PHOENICS code is used to model the flow field surrounding subsonic and underexpanded jets impinging on a ground plane in the presence of a cross-flow, for cases with both a fixed ground plane and a 'rolling road'. The standard K-epsilon turbulence model is used, without correction factors. It is confirmed that this overpredicts the free-jet entrainment rate; the wall-jet spreading rate is slightly underpredicted but the initial thickness is too high. Agreement with experiment is, nevertheless, much better than for previous calculations, showing the importance of the extent of the grid used. The ground vortex formed in cross-flow is shown to move with varying effective velocity ratio and with rolling-road operation in the same manner as experimentally observed. Ground-vortex self-similarity is also accurately predicted with the numerical modeling. Author

A92-22517
FOREBODY VORTEX CONTROL
GERALD N. MALCOLM (Eidetics International, Inc., Torrance, CA) Progress in Aerospace Sciences (ISSN 0376-0421), vol. 28, no. 3, 1991, p. 171-234. refs
Copyright

A comparative evaluation is made of experimental results for several techniques aimed at manipulating fighter aircraft forebody vortices to generate controlled forces and moments at high angles of attack. These techniques encompass movable strakes, blowing surface jets, blowing and suction through surface slots, suction through surface holes, and miniaturized, rotatable tip strakes; most operate on the basis of boundary layer separation control and all are effective over various ranges of attack angle and sideslip. In all cases, maximum effectiveness is obtained when the given method is applied near the forebody's tip. Relative advantages among the techniques are a function of fighter configuration and performance goals. O.C.

A92-22519
THE PROBLEM OF TRANSITION FROM CONTINUUM TO RAREFIED GAS FLOWS
MICHIRU YASUHARA Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 40, no. 456, 1992, p. 1-8. In Japanese. refs

The transition from continuum to rarefied gas flows and supersonic flows around a flat plate is examined. The direct simulation Monte Carlo and total variation diminishing methods are discussed. Pressure distributions on a circular cylinder at hypersonic Mach numbers in the range between continuum flow and free molecular flow are described. Y.P.Q.

A92-22521
MINIMUM INDUCED DRAG OF A WING IN A CIRCULAR OPEN WIND TUNNEL
YUZO YAMAMOTO Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 40, no. 456, 1992, p. 23-27. In Japanese. refs

The aerodynamic characteristics of a straight wing lying on a diameter in a circular open wind tunnel are studied, where minimum induced drag is assumed. In a previous work, exact expressions of spanwise optimum lift distribution and minimum induced drag were obtained from Trefftz plane flowfield analysis, where an independent variable transformation and Soehngen's inversion integral formula were used. In the present study, an alternative analysis is done, where a conformal mapping and Soehngen's formula are used. The results obtained agree with those of the previous work. Author

A92-22524
AERODYNAMIC CHARACTERISTICS OF A WING NEAR ITS TIP USING PANEL METHOD
JANG-SOO CHOI and YOSHIYUKI SUGIYAMA Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 40, no. 456, 1992, p. 45-53. In Japanese. refs

The aerodynamic characteristics around a wing tip are investigated with a first-order panel method. The geometry chosen for the study is a rectangular wing of aspect ratio 8.43, with RAF6 airfoil of 10-percent thickness ratio. The panel method gives similar aerodynamic characteristics to experimental ones even near the tip, such as very low pressure distribution near the trailing edge around the tip, and increase in local lift and drag at the very narrow region of the tip. These properties are caused by the strong spanwise velocity component around the wing tip, the inviscid effects of which are described in detail with respect to pressure coefficient, local lift and drag coefficients, downwash, and vorticity on the wing. Author

A92-22635
COMPUTATIONAL AERODYNAMIC SIMULATION ON HOPE
SIGEAKI NOMURA, YUKIMITU YAMAMOTO, SUSUMU TAKANASHI, SATORU OGAWA, MITUNORI YANAGIZAWA, and TOSHIO AKIMOTO Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 39, no. 454, 1991, p. 596-603. In Japanese. refs

Research and development on the aerodynamic design of HOPE (H-II Orbiting Plane) is presented. Numerical simulation of hypersonic flow around a spaceplane is discussed. Y.P.Q.

A92-22720
A CALCULATING METHOD OF SHOCK WAVE OSCILLATING FREQUENCY DUE TO TURBULENT SHEAR LAYER FLUCTUATIONS IN SUPERSONIC FLOW
LI-GONG XU (University of Science and Technology of China, Hefei, People's Republic of China) and ZHENG RAN (China Aerodynamics Research and Development Center, Mianyang, People's Republic of China) Applied Mathematics and Mechanics (English Edition) (ISSN 0253-4827), vol. 12, Aug. 1991, p. 777-784. Research supported by NNSFC. refs

A detailed theoretical discussion of the shock wave oscillation driven by turbulent shear layer fluctuation is presented. The characteristic frequency of the oscillating shock wave is solved. The method can calculate the law of change of the shock oscillation frequency with Mach number and compression a turning angle. C.D.

A92-22790
SIMULATION OF SUPERSONIC AND HYPERSONIC FLOWS
J. F. MILTHORPE (Australian Defence Force Academy, Campbell, Australia) International Journal for Numerical Methods in Fluids (ISSN 0271-2091), vol. 14, Feb. 15, 1992, p. 267-288. refs
Copyright

A simple convection algorithm for simulation of time-dependent supersonic and hypersonic flows of a perfect but viscous gas is described. The algorithm is based on conservation and convection of mass, momentum and energy in a grid of rectangular cells. Examples are given for starting flow in a shock tube and oblique shocks generated by a wedge at Mach numbers up to 30.4. Good comparisons are achieved with well-known perfect gas flows. Author

A92-23380
AN AF3 ALGORITHM FOR THE CALCULATION OF TRANSONIC NONCONSERVATIVE FULL POTENTIAL FLOW AROUND AXISYMMETRIC INLET COWLS
HONGQUAN CHEN and MINGKE HUANG (Nanjing Aeronautical Institute, People's Republic of China) Nanjing Aeronautical Institute, Journal (English Edition), vol. 8, Oct. 1991, p. 1-8. refs

Three types of fully implicit Baker's AF3 schemes, approximate factorization (AF) iteration algorithms, have been constructed for the transonic flow around axisymmetric inlet cowls in body-fitted coordinate mesh. A suitable AF3 scheme has been found for the calculation of both subcritical and supercritical flowfields about axisymmetric inlets by numerical experiments and analytical comparisons. With this AF3 scheme, a computer code has been developed for analyzing the transonic flow over arbitrary axisymmetric inlet cowls. An axisymmetric nonconservative full potential equation in arbitrary curved coordinate system, which is suitable for different grid topologies, has been used in the present work, so it is quite possible to make a further extension for the solution of more complicated flowfields about transonic axisymmetric inlets. The numerical calculations show that the method presented converges rapidly to give good agreements with experimental or existing results. Author

A92-23381
AN INVESTIGATION ON DETACHED SHOCK WAVES AHEAD OF BODIES OF REVOLUTION AT TRANSONIC SPEEDS
KEMING CHENG and YIYI HUANG (Nanjing Aeronautical Institute, People's Republic of China) Nanjing Aeronautical Institute, Journal (English Edition), vol. 8, Oct. 1991, p. 9-15. refs

An engineering method for calculating detached shock waves ahead of three kinds of bodies (cone-cylinder-boattail, ogive-cylinder-boattail, and sphere) is presented. Experimental results show that the sonic line, particularly at free-stream Mach

approaching 1, is almost perpendicular to the free-stream direction in a rather long lateral distance from the body surface. Accordingly, a corresponding correction is made in this paper. The corrected method satisfies both the theoretical detachment condition and the practical cases simultaneously and is applicable in a relatively wide range. Author

A92-23383
AN EFFICIENT CALCULATION METHOD OF SUBSONIC AERODYNAMIC CHARACTERISTICS FOR A SPACE SHUTTLE ORBITER IN THE REENTRY ATTITUDE
LIANQYI WANG (Nanjing Aeronautical Institute, People's Republic of China) Nanjing Aeronautical Institute, Journal (English Edition), vol. 8, Oct. 1991, p. 25-32. refs

The suction analogy principle combined with vortex-lattice method is used to calculate the subsonic longitudinal aerodynamic characteristics of the wing of a Space Shuttle orbiter from small to high angle-of-attack with satisfactory results. For the calculation of zero-lift drag and aerodynamic characteristics of the body, an engineering prediction method is adopted. Taking vortex effects into account, formulas have been derived to predict subsonic aerodynamic characteristics for arbitrary strake-wing planforms and spanwise lift distribution of strake-wing with pointed tip. Results of the prediction for several kinds of wing and a Space Shuttle orbiter are compared with the experimental data, showing that it is simple, fast and accurate in calculation. This method is valid for predicting the aerodynamic characteristics of a Space Shuttle orbiter. Author

A92-23409
ON THE CALCULATION OF THE COMPRESSIBLE BOUNDARY LAYER ON A NONPLANAR DELTA WING WITH SUPERSONIC LEADING EDGES
V. N. VETLUTSKII and T. V. POPLAVSKAIA (AN SSSR, Institut Teoreticheskoi i Prikladnoi Mekhaniki, Novosibirsk, USSR) Russian Journal of Theoretical and Applied Mechanics (ISSN 1051-8045), vol. 1, Dec. 1991, p. 301-314. refs
Copyright

An algorithm is developed for calculating a three-dimensional compressible boundary layer on a nonplanar delta wing in the case where a bow wave touches the leading edges. The conditions at the outer edge of the boundary layer are derived from calculations of the inviscid flow around the body. The problem is solved numerically using a two-layer implicit difference weighted scheme. The velocity and temperature profiles are calculated, and the results are used to determine the local skin-friction coefficients and Stanton numbers. V.L.

A92-23414
COMPUTATION OF TRANSONIC FLOW OVER AN AIRFOIL AT LARGE REYNOLDS NUMBERS
V. B. KARAMYSHEV and V. I. PINCHUKOV (AN SSSR, Institut Teoreticheskoi i Prikladnoi Mekhaniki, Novosibirsk, USSR) Russian Journal of Theoretical and Applied Mechanics (ISSN 1051-8045), vol. 1, Dec. 1991, p. 369-381. refs
Copyright

An algorithm is developed for computing Reynolds averaged Navier-Stokes equations supplemented by two transfer equations of the turbulent viscosity model. Subsonic and supersonic flows over wing airfoils are computed on a difference grid containing 73 x 31 nodes. The test computation results support the conclusion that models with two additional transport equations produce satisfactory agreement with experimental data for continuous flows and flows with local circulation zones at moderate Mach numbers. V.L.

A92-23416
MATHEMATICAL MODELING OF SUPERSONIC FLOW OVER A CONVEX-CONCAVE FORMED BODY BASED ON THE EULER AND NAVIER-STOKES EQUATIONS
V. A. ANTONOV, A. M. GRISHIN, and O. I. POGORELOV (Tomskii Gosudarstvennyi Universitet, Tomsk, USSR) Russian Journal of Theoretical and Applied Mechanics (ISSN 1051-8045), vol. 1, Dec. 1991, p. 395-406. refs
Copyright

Solutions obtained on the basis of the Euler and Navier-Stokes equations for free-stream Mach 3, 4, and 6 and Re = 10 exp 4 - 10 exp 6 for three convex-concave bodies are compared. Both the local flow characteristics and the integral characteristics of the bodies are considered. Local differences in pressure distribution in the hollow region are shown to affect the resistance pressure coefficient. Heat flow and pressure distribution over the body profile are analyzed as a function of the Re number. V.L.

A92-23502
A STUDY OF FLOW PAST BODIES OF REVOLUTION WITH A RIABUSHINSKII GENERATRIX [ISSLEDOVANIE OBTEKANIIA TEL VRASHCHENIIA S OBRAZUIUSHCHEI RIABUSHINSKOGO]
V. V. VYSHINSKII and E. N. KUZNETSOV (Tsentral'nyi Aerogidrodinamicheskii Institut, Zhukovski, USSR) Akademiia Nauk SSSR, Doklady (ISSN 0002-3264), vol. 321, no. 1, 1991, p. 33-35. In Russian. refs
Copyright

Wind tunnel experiments were carried out in order to determine the aerodynamic characteristics of optimal nose sections. In the experiments, a nose section with an aspect ratio of 0.87 was attached to a cylinder, with a total aspect ratio of 3.5; the maximum cross section of the nose was 0.1 m; the test cross section of the wind tunnel was 0.6 x 0.6 m. It is found that a blunt Riabushinskii nose section exhibits optimal aerodynamic characteristics in the free-stream Mach range between the critical Mach number and 0.97 at angles of attack 0-10 deg. V.L.

A92-23730#
UNSTEADY AERODYNAMIC METHODS FOR TURBOMACHINERY AEROELASTIC AND AEROACOUSTIC APPLICATIONS
JOSEPH M. VERDON (United Technologies Research Center, East Hartford, CT) AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992. 25 p. Research supported by United Technologies Corp. refs
(AIAA PAPER 92-0011) Copyright

Recent advances in theoretical and computational modeling of turbomachinery unsteady flows are reviewed. It is pointed out that two distinct approaches are being actively pursued for providing accurate unsteady aerodynamic information. In the first approach, the time-dependent, nonlinear equations describing viscous or inviscid fluid motions are solved by advancing numerical calculation in time until a converged periodic unsteady state is determined. In the second, more traditional approach, inviscid (Re yields infinity) and small unsteady disturbance assumptions are implemented to obtain time-dependent, nonlinear steady and linearized steady equations that are solved sequentially to determine the steady and first-harmonic, unsteady inviscid flow properties. O.G.

A92-23751#
UNSTEADY EULER SOLUTION FOR OSCILLATORY AIRFOIL AND OSCILLATING FLAP
MARIUS PARASCHIVOIU (Ecole Polytechnique, Montreal, Canada) AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992. 17 p. refs
(AIAA PAPER 92-0131) Copyright

A numerical simulation is conducted of the unsteady 2D inviscid compressible flow around an airfoil in oscillatory pitching and around an oscillating flap, employing a triangular grid in conjunction with a dynamic mesh algorithm in order to handle moving solid bodies and to adapt the triangulation according to density gradient distribution. Instantaneous pressure distribution, lift, and moment coefficients during an oscillatory cycle of the NACA 0012 airfoil's motion are compared with experimental data. Attention is given to the normal-forces hysteresis and shock displacement generated by the oscillating flap in the case of an NLR 7301 airfoil. O.C.

A92-23762*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
AERODYNAMICS OF LOADED CASCADES IN SUBSONIC FLOWS SUBJECT TO UNSTEADY THREE-DIMENSIONAL VORTICAL DISTURBANCES
J. FANG and H. M. ATASSI (Notre Dame, University, IN) AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992. 14 p. refs
(Contract NAG3-732)
(AIAA PAPER 92-0146) Copyright

A highly efficient numerical method is developed for three-dimensional, periodic, vortical flows around a cascade of loaded airfoils. The method linearizes Euler's equations about the mean flow of the cascade and thus fully accounts for the effects of distortion of the vortical disturbances as they propogate and interact with the cascade mean flow. The numerical scheme is based on splitting the unsteady velocity into vortical and potential parts. The latter is governed by a non-constant coefficient inhomogeneous convective wave equation. A new and computationally suitable out-flow conditions are derived and avoid the difficulties associated with the singular velocity downstream. Solutions were obtained in the frequency domain by using a body-fitted coordinate system. Results are presented to demonstrate the effects of the out-flow boundary conditions, cascade spacing, mean blade loading and gust upstream conditions on the aerodynamics response and unsteady pressure field of a cascade. Author

A92-23763#
COMPRESSOR BLADE ROW UNSTEADY AERODYNAMIC RESPONSE TO ATTACHED AND SEPARATED FLOW FORCING FUNCTIONS
KUK H. KIM and SANFORD FLEETER (Purdue University, West Lafayette, IN) AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992. 13 p. refs
(Contract F49620-88-C-0022)
(AIAA PAPER 92-0147) Copyright

The present experimental investigation of the fundamental flow-forcing function phenomena generating different blade-row gust responses gives attention to the attached and separated gust-forcing functions. Two NACA 0024 airfoils were installed in an instrumented axial-flow compressor inlet to generate the periodic, 2/rev insteady aerodynamic forcing functions ahead of the first-stage rotor. The rotor blade gust response unsteady aerodynamic data are correlated with suitable predictions. The forcing-function generator's fluid dynamics generates significant rotor airfoil flow gust response. O.C.

A92-23764*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
THE BALDWIN-LOMAX MODEL FOR SEPARATED AND WAKE FLOWS USING THE ENTROPY ENVELOPE CONCEPT
J. S. BROCK and W. F. NG (Virginia Polytechnic Institute and State University, Blacksburg) AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992. 10 p. Research supported by NASA. refs
(AIAA PAPER 92-0148) Copyright

Implementation of the Baldwin-Lomax algebraic turbulence model is difficult and ambiguous within flows characterized by strong viscous-inviscid interactions and flow separations. A new method of implementation is proposed which uses an entropy envelope concept and is demonstrated to ensure the proper evaluation of modeling parameters. The method is simple, computationally fast, and applicable to both wake and boundary layer flows. The method is general, making it applicable to any turbulence model which requires the automated determination of the proper maxima of a vorticity-based function. The new method is evalulated within two test cases involving strong viscous-inviscid interaction. Author

A92-23765#
APPLICATION OF A UNIVERSE-SERIES CODE FOR INVISCID FLOW OVER COMPLEX 3-DIMENSIONAL CONFIGURATIONS
K.-Y. SZEMA, S. R. CHAKRAVARTHY, K. M. PEPPI, C. M. ROWELL (Rockwell International Science Center, Thousand Oaks, CA), R. G. BURMAN, and R. E. SCHULTZ (U.S. Navy, Naval Weapons Center, China Lake, CA) AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992. 11 p. Research supported by U.S. Navy. refs
(AIAA PAPER 92-0150) Copyright

A new computer code (UNIVC) developed at Rockwell Science Center has been employed to investigate the flow field over a variety of complex three-dimensional configurations. The finite-element-like formulation includes treatment of hexahedral, triangular prism and tetrahedral cell shapes. Truly multidimensional interpolation is employed along with least-squares and ENO treatments. Simple and complex Riemann Solvers can be employed as needed. This paper describes the application of the methodology to Space Shuttle Orbiter, Orbiter with External Tank and Solid Rocket Boosters, and F18 fighter with pylon, rack and bombs using unstructured grids. Author

A92-23766#
AN ALGORITHM FOR PREDICTING THE FLOW PAST FUSELAGE-MOUNTED ENGINE ARRANGEMENTS
ARVIN SHMILOVICH and K. C. CHANG (Douglas Aircraft Co., Long Beach, CA) AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992. 19 p. refs
(AIAA PAPER 92-0151) Copyright

A method for calculating transonic flows past aft fuselage mounted nacelle/pylon combinations has been developed. A viscous/inviscid interactive procedure is used to compute flowfields with viscous effects. The inviscid flowfield is described by the Euler equations which are approximated and solved numerically using a finite-volume method. The multigrid method is incorporated to accelerate convergence rate for steady-state calculations. The inviscid flow technique is coupled with a boundary-layer method that uses an inverse formulation in order to ensure stability of calculations for shock-induced separated flows. Experimental results are used to evaluate the accuracy of the method in predicting transonic flowfields. Author

A92-23767*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
A STUDY ON VORTEX FLOW CONTROL OF INLET DISTORTION IN THE RE-ENGINED 727-100 CENTER INLET DUCT USING COMPUTATIONAL FLUID DYNAMICS
BERNHARD H. ANDERSON (NASA, Lewis Research Center, Cleveland, OH), PAO S. HUANG, WILLIAM A. PASCHAL, and ENRICO CAVATORTA (Dee Howard Co., San Antonio, TX) AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992. 12 p. Previously announced in STAR as N92-13998. refs
(AIAA PAPER 92-0152) Copyright

Computational fluid dynamics was used to investigate the management of inlet distortion by the introduction of discrete vorticity sources at selected locations in the inlet for the purpose of controlling secondary flow. These sources of vorticity were introduced by means of vortex generators. A series of design observations were made concerning the importance of various vortex generator design parameters in minimizing engine face circumferential distortion. The study showed that vortex strength, generator scale, and secondary flow field structure have a complicated and interrelated influence on the engine face distortion, over and above the initial geometry and arrangement of the generators. The installed vortex generator performance was found to be a function of three categories of variables: the inflow conditions, the aerodynamic characteristics associated with the inlet duct, and the design parameters related to the geometry, arrangement, and placement of the vortex generators within the outlet duct itself. Author

A92-23770#
FLOW VISUALIZATION AND WAKE ANALYSIS FOR COMPLEX THREE-DIMENSIONAL BLUFF BODIES AT SUBCRITICAL THROUGH CRITICAL REYNOLDS NUMBERS

J. F. SMALL (U.S. Navy, Naval Air Systems Command, Washington, DC), S. K. HEBBAR, and M. F. PLATZER (U.S. Naval Postgraduate School, Monterey, CA) AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992. 12 p. Research sponsored by U.S. Navy. refs
(AIAA PAPER 92-0155)

A low-speed wind tunnel investigation was conducted to compare the aerodynamic flow field characteristics of two complex 3D bluff bodies. The primary focus of this effort was the verification of existing bluff body aerodynamic concepts applied to the 3D problem. Wake flow visualization was conducted to determine the general characteristics of the flow field. Base pressure measurements were made to assess three-dimensional effects. The presence of coherent vortex shedding in the wake was investigated using a constant temperature hot-film anemometer and a spectrum analyzer. Asymmetric vortex shedding was visualized in the wakes of both shapes at subcritical Reynolds numbers. Spectral analysis of the hot-film output confirmed the presence of coherent vortex shedding in the wakes of both models at subcritical Reynolds numbers. The results achieved compare quite favorably with 2D bluff body theory and with the results obtained by numerous researchers for 2D and simple 3D shapes. Author

A92-23771*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
FUTURE EXPERIMENTAL NEEDS TO SUPPORT APPLIED AERODYNAMICS - A TRANSONIC PERSPECTIVE
BLAIR B. GLOSS (NASA, Langley Research Center, Hampton, VA) AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992. 8 p. refs
(AIAA PAPER 92-0156) Copyright

Advancements in facilities, test techniques, and instrumentation are needed to provide data required for the development of advanced aircraft and to verify computational methods. An industry survey of major users of wind tunnel facilities at Langley Research Center (LaRC) was recently carried out to determine future facility requirements, test techniques, and instrumentation requirements; results from this survey are reflected in this paper. In addition, areas related to transonic testing at LaRC which are either currently being developed or are recognized as needing improvements are discussed. Author

A92-23772*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
FUTURE EXPERIMENTAL NEEDS IN LOW-SPEED AERODYNAMICS
LAWRENCE E. OLSON (NASA, Ames Research Center, Moffett Field, CA) AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992. 10 p. refs
(AIAA PAPER 92-0157) Copyright

This paper presents a review of future experimental needs in low-speed aerodynamic research. Emphasis is on fixed wind aircraft and the review uses the anticipated technical needs of subsonic transport aircraft and supersonic transport aircraft to establish and prioritize future low-speed experimental needs and directions. These technical needs, combined with a continuing improvement in computational capability, suggest changes in the experimental capabilities and adjustments in the use of existing capabilities. Three factors emerge that will have a major influence on the future directions for low-speed aerodynamic research: a recognition of the significance of three-dimensional high-lift aerodynamics, the increasing importance of aeroacoustics, and additional emphasis on the importance of propulsion/airframe integration. These analyses are combined with a review of the status of experimental capabilities in low-speed aerodynamic research to suggest future directions in the development and utilization of advanced instrumentation, test techniques, and test capabilities. Author

A92-23773#
EXPERIMENTAL NECESSITIES FOR SUBSONIC TRANSPORT CONFIGURATION DEVELOPMENT
F. T. LYNCH (Douglas Aircraft Co., Long Beach, CA) AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992. 17 p. refs
(AIAA PAPER 92-0158) Copyright

New transonic wind tunnel facilities and powerful flow diagnostics are needed for the effective development of the new generation of subsonic transport aircraft, in light of strong Reynolds-number effects found in multielement airfoils and the inadequacy of viscous scaling techniques for the modeling of separated-flow situations. Transition-detection and surface-flow visualization methods applicable at high Reynolds number, as well as the experimental counterpart of CFD colored-isobar displays and techniques for the estimation of aircraft-buffeting intensity, are noted to be required. O.C.

A92-23774#
FUTURE EXPERIMENTAL NEEDS IN HIGH-ALPHA VEHICLE DYNAMICS
L. E. ERICSSON (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA) AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992. 14 p. refs
(AIAA PAPER 92-0159) Copyright

The evolution of tactical missiles and aircraft toward ever-increasing maneuverability and agility, including flight at high angles of attack and vehicle motions of large amplitudes and high angular rates, has led to the need for prediction of vehicle dynamics that are dominated by unsteady separated flow effects. Such prediction by purely theoretical means is presently not possible, and will not be for some time. In the meantime, the development of the needed prediction methods requires the interactive use of experimental and analytical means. The existing data base is reviewed to determine what further development is needed to be able to predict the effects of symmetric and asymmetric forebody flow separation with associated vortices on the high-alpha vehicle dynamics of high performance missiles and aircraft. The problem of extrapolation from subscale test results to full-scale flight is analyzed in depth to find out what novel experimental and analytical tools will be needed. Author

A92-23775#
ONE VIEW OF EXPERIMENTAL AERODYNAMICS
NEAL J. PFEIFFER (Beech Aircraft Corp., Wichita, KS) AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992. 6 p. refs
(AIAA PAPER 92-0160) Copyright

A development-status evaluation is conducted for experimental aerodynamics in project-oriented perspective. Test method improvements are desired which will both increase the speed of data acquisition and increase the amount of surface and flowfield data. The emergence of personal computer spreadsheet software is noted to present a very flexible means for the evaluation of aerodynamic test data; advanced workstations and CFD software have also expanded capabilities for experimental data display. The cooperative use of CFD in conjunction with wind tunnel testing is expected to progressively yield usable design/analysis tools. O.C.

A92-23779#
CENTER OF PRESSURE CALCULATIONS FOR A BENT-AXIS VEHICLE
W. H. RUTLEDGE and G. F. POLANSKY (Sandia National Laboratories, Albuquerque, NM) AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992. 26 p. refs
(Contract DE-AC04-76DP-00789)
(AIAA PAPER 92-0168)

Bent-axis maneuvering vehicles provide a unique type of control for a variety of supersonic and hypersonic missions. Unfortunately, large hinge moments, incomplete pitching moment predictions, and a misunderstanding of corresponding center of pressure calculations have prevented their application. A procedure will be presented for the efficient design of bent-axis vehicles given an adequate understanding of origins of pitching moment effects. In particular, sources of pitching moment contributions will be described including not only normal force, but inviscid axial force

and viscous effects as well. Off-centerline center of pressure effects are first reviewed for symmetric hypersonic sphere-cone configurations. Next, the effects of the bent-axis geometry are considered where axial force, acting on the deflected tail section, can generate significant pitching moment components. The unique relationship between hinge moments and pitching moments for the bent-axis class of vehicles is discussed. Author

A92-23780# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
PREDICTION OF DRAG AT SUBSONIC AND TRANSONIC SPEEDS USING EULER METHODS
K. NIKFETRAT, C. P. VAN DAM (California, University, Davis), P. M. H. W. VIJGEN (High Technology Corp., Hampton, VA), and I. C. CHANG (NASA, Ames Research Center, Moffett Field, CA) AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992. 10 p. refs
(Contract NCA2-397; NCA2-581; NAS1-18240)
(AIAA PAPER 92-0169) Copyright

A technique for the evaluation of aerodynamic drag from flowfield solutions based on the Euler equations is discussed. The technique is limited to steady attached flows around three-dimensional configurations in the absence of active systems such as surface blowing/suction and propulsion. It allows the decomposition of the total drag into induced drag and wave drag and, consequently, it provides more information on the drag sources than the conventional surface-pressure integration technique. The induced drag is obtained from the integration of the kinetic energy (per unit distance) of the trailing vortex system on a wake plane and the wave drag is obtained from the integration of the entropy production on a plane just downstream of the shocks. The drag-evaluation technique is applied to three-dimensional flowfield solutions for the ONERA M6 wing as well as an aspect-ratio-7 wing with an elliptic spanwise chord distribution and an NACA-0012 section shape. Comparisons between the drag obtained with the present technique and the drag based on the integration of surface pressures are presented for two Euler codes. Author

A92-23783# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
IDENTIFICATION OF AERODYNAMIC COEFFICIENTS USING COMPUTATIONAL NEURAL NETWORKS
DENNIS J. LINSE and ROBERT F. STENGEL (Princeton University, NJ) AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992. 12 p. Research supported by FAA and NASA. refs
(Contract NGL-31-001-252; DAAL03-89-K-0092)
(AIAA PAPER 92-0172) Copyright

Precise, smooth aerodynamic models are required for implementing adaptive, nonlinear control strategies. Accurate representations of aerodynamic coefficients can be generated for the complete flight envelope by combining computational neural network models with an Estimation-Before-Modeling paradigm for on-line training information. A novel method of incorporating first-partial-derivative information is employed to estimate the weights in individual feedforward neural networks for each aerodynamic coefficient. The method is demonstrated by generating a model of the normal force coefficient of a twin-jet transport aircraft from simulated flight data, and promising results are obtained. Author

A92-23784#
EFFECT OF LEADING-EDGE CROSS-SECTIONAL GEOMETRY ON SLENDER WING UNSTEADY AERODYNAMICS
L. E. ERICSSON and H. H. C. KING (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA) AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992. 9 p. refs
(AIAA PAPER 92-0173) Copyright

The complexity of the flow field on aircraft and aircraft-like configurations at high angles of attack prohibits the use of numerical computational methods for preliminary design. Because of the continual changes in the early design, a purely experimental method cannot be used either. One needs rapid computational methods to guide the early stages of preliminary design until a firmer design has evolved on which experimental and numerical methods can be applied. A fast prediction method, developed earlier for the nonlinear unsteady longitudinal aerodynamics of sharp-edged delta wings, has been extended to include the effect of leading-edge cross-sectional geometry. The predicted high-alpha aerodynamics are compared with existing experimental low-speed results for slender wings and wing-body configurations at zero sideslip. Author

A92-23785#
MEASUREMENTS OF LATERAL AERODYNAMICS CHARACTERISTICS OF FOREBODIES AT HIGH ANGLE OF ATTACK IN SUBSONIC AND TRANSONIC FLOWS
S. KOREN (Technion - Israel Institute of Technology, Haifa), R. ARIELI (Rafael Armament Development Authority, Haifa, Israel), and J. ROM (Technion - Israel Institute of Technology, Haifa) AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992. 12 p. refs
(AIAA PAPER 92-0174) Copyright

This paper presents a part of a comprehensive experimental investigation where the aerodynamic characteristics of elongated forebodies with circular cross section and various bluntness ratio are measured. The nose shape varies from pointed forebodies like cone and ogives up to a blunt nosed hemisphere. The experimental data is measured at low subsonic speed ($M = 0.1$) with high angles of attack, up to 80 deg, through transonic Mach numbers with angles of attack up to 30 deg, and supersonic speeds up to $M = 3.2$ with angles of attack up to 15 deg. Measurements of the longitudinal and lateral forces and moments as well as flow visualization data are presented for 8 model geometries. Effects of the variation of Mach number and Reynolds number are discussed. Author

A92-23787#
AN EXPERIMENTAL INVESTIGATION OF LARGE SCALE INSTABILITIES IN A LOW REYNOLDS NUMBER TWO-STREAM SUPERSONIC SHEAR LAYER
DENNIS K. MCLAUGHLIN, STEVEN MARTENS, and KEVIN W. KINZIE (Pennsylvania State University, University Park) AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992. 14 p. refs
(Contract N00014-88-K-0242)
(AIAA PAPER 92-0177) Copyright

A preliminary characterization of large-scale instabilities in a supersonic free shear layer has been conducted at high-speed Mach number ranges from 2 to 4 and low-speed ranges from subsonic to Mach 2. A method of artificially exciting the shear layer using an oscillating glow discharge technique has been developed, and it is shown that this excitation will significantly concentrate the fluctuations to the spectral band around the frequency of interest. The excitation raises the level of fluctuation energy and causes the shear layer to spread more rapidly. Detailed phase measurements with hot wires in the flow field excited by 2D and oblique glow discharge electrodes produce relatively accurate estimates of instability phase fronts. C.D.

A92-23788*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
THE DYNAMICS AND CONTROL OF FLUCTUATING PRESSURE LOADS IN THE REATTACHMENT REGION OF A SUPERSONIC FREE SHEAR LAYER
J. POGGIE, A. J. SMITS (Princeton University, NJ), and A. GLEZER (Arizona, University, Tucson) AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992. 12 p. refs
(Contract NAG1-1072; AF-AFOSR-90-0217)
(AIAA PAPER 92-0178) Copyright

An experimental program to investigate the control of a turbulent, reattaching shear layer at Mach 2.9 is described. In preliminary experiments, schlieren photography and Rayleigh scattering were used to visualize the effects of air injection normal to the plane of the shear layer. Localized blowing was qualitatively found to increase the growth rate of the shear layer, the intensity

of the turbulence, and the unsteadiness of the reattachment shock. However, uniformly distributed air injection did not appear to affect the flow strongly. These results suggest that three-dimensional disturbances are more effective for flow control than two-dimensional disturbances, and that there is a strong connection between the incoming turbulence and the shock motion in this flow. Author

A92-23790#
ORGANIZED STRUCTURE IN A MACH 5/MACH 3 TURBULENT SHEAR LAYER
Y. R. SHAU, D. S. DOLLING, and K. Y. CHOI (Texas, University, Austin) AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992. 13 p. refs
(Contract N00014-89-J-1221)
(AIAA PAPER 92-0180) Copyright

The large-scale structures in the 2D shear layer with a high Reynolds number are investigated experimentally in a Mach-5 wind tunnel and confirmed with time-series analyses. The mean flowfield and the shear-layer growth rate are studied downstream of the shear-layer origin with two-point pitot pressure measurements. A progressive increase in large-scale structural organization is noted as the distance downstream increases, and the power spectra are concentrated at a Strouhal number of close to 0.35. The schlieren photographs confirm the analysis of the large-scale structural inclination, and the pitot measurements confirm that the structures are three-dimensional and span about 1-1.5 times the shear-layer thickness. A hot-wire study of the turbulent structures confirms the data from the pitot measurements, and the organized structure is defined for the Mach 5/Mach 3 turbulent-shear layer. C.C.S.

A92-23793#
A NAVIER-STOKES SOLVER FOR STRETCHED TRIANGULAR GRIDS
H. ZHANG, J. Y. TREPANIER, M. REGGIO, and R. CAMARERO (Ecole Polytechnique, Montreal, Canada) AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992. 12 p. Research supported by NSERC. refs
(AIAA PAPER 92-0183) Copyright

A finite-volume method for solving the compressible, time-dependent, two-dimensional Navier-Stokes equations using unstructured stretched triangular grids is described. The methodology is based on the extension of flux-difference splitting methods to include viscous terms. The approach differs from the traditional way of adding viscous terms explicitly to an Euler solver in the sense that a unified formulation is introduced where viscid and inviscid parts are handled simultaneously. A new method for the generation of stretched triangular grids is introduced and coupled with the flow solver through error estimates based on a projection method. The procedure has proven to be effective for both subsonic and supersonic flow regimes computed with triangles having large aspect ratios. Numerical calculations for the flows in the boundary-layer over a flat plate and around the NACA0012 airfoil have been carried out and validated with available analytical and numerical data. Author

A92-23794#
GRID STUDIES FOR THIN-LAYER NAVIER-STOKES COMPUTATIONS OF AIRFOIL FLOWFIELDS
D. W. ZINGG (Toronto, University, Canada) AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992. 12 p. Research supported by NSERC. refs
(AIAA PAPER 92-0184) Copyright

A detailed investigation of the effects of grid clustering and refinement on the prediction of lift and drag in thin-layer Navier-Stokes computations of viscous airfoil flowfields is presented. The effect of the location of the outer boundary of the grid is examined as well. Computational results are presented for subsonic and transonic flow about the NACA 0012 and RAE 2822 airfoils. The cases studied exhibit a variety of flow features, including shock-induced separation and trailing-edge separation. The studies show the levels of grid refinement and the outer boundary position required to reduce the numerical errors in both lift and drag to below 1 percent for most cases. These grid-independent solutions are compared with experimental data to provide an assessment of the errors associated with the physical models used. Author

A92-23798*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
IMPLEMENTATION OF VIGNERON'S STREAMWISE PRESSURE GRADIENT APPROXIMATION IN THE PNS EQUATIONS
JOSEPH H. MORRISON (Analytical Services and Materials, Inc., Hampton, VA) and JOHN J. KORTE (NASA, Langley Research Center, Hampton, VA) AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992. 9 p. refs
(Contract NAS1-18599)
(AIAA PAPER 92-0189)

For single sweep parabolized Navier-Stokes solvers, the streamwise pressure gradient must be modified in the subsonic region to eliminate numerical instabilities. The accuracy of this modification on the solution of the parabolized Navier-Stokes equations with Vigneron's technique is shown to depend on how the numerical approximation of the pressure gradient is formed. A simple test case of supersonic laminar flow over a flat plate is computed with two different numerical methods for solving the PNS equations. Significant errors in the temperature profile and skin friction coefficient are demonstrated using a fully conservative differencing treatment of Vigneron's splitting for the pressure gradient typically used in parabolized Navier-Stokes solvers. The physical reason for this error is discussed. An alternate formulation is demonstrated which minimizes these errors. Author

A92-23799#
MULTIGRID NAVIER-STOKES CALCULATIONS FOR THREE DIMENSIONAL CASCADES
FENG LIU and ANTONY JAMESON (Princeton University, NJ) AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992. 16 p. refs
(AIAA PAPER 92-0190) Copyright

A vertex-based finite volume method for solving the three-dimensional compressible Reynolds-averaged Navier-Stokes equations is presented for calculating turbomachinery cascade flows. A discretization scheme for the viscous terms is proposed. This discretization scheme avoids a potential problem on kinked meshes. The Baldwin-Lomax algebraic turbulence model is used. The scheme is verified against laminar and turbulent flows over a flat plate. Perfect agreement is obtained with the Blasius solution for the laminar flow. Agreement with empirical solutions is also obtained for turbulent flows. Both two- and three-dimensional computations were carried out for a low pressure turbine cascade. Results are compared with inviscid solutions and experimental data. Predicted pressure distributions agree with experiments at both design and off-design conditions. Surface skin-friction distribution and velocity vectors in the flow field are also presented. Author

A92-23800#
COMPRESSIBILITY EFFECTS ON THE DYNAMIC STALL OF A THREE-DIMENSIONAL WING
PETER F. LORBER (United Technologies Research Center, East Hartford, CT) AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992. Research supported by USAF. refs
(Contract DAAL03-89-C-0013)
(AIAA PAPER 92-0191) Copyright

Experimental measurements are made of the unsteady separation process on a pitching 3D wing. Surface-pressure transducers and hot-film sensors were used to provide a detailed description of the events prior to and during separation. The geometric and flow conditions were selected to approximate the Reynolds number, Mach number, pitch rate, and angle-of-attack range of a full-scale helicopter main-rotor blade. Separation characteristics are described at five Mach numbers between 0.2 and 0.6. At 0.2, the local velocities always remain subsonic, and

an abrupt separation of the turbulent boundary layer occurs starting near 10 percent of chord. A well-defined stall vortex is formed and propagates aft along the chord. At 0.3, the small region of supersonic flow at the leading edge initiates a high-frequency instability, resulting in an earlier, but less abrupt, stall. At 0.4-0.6, a significant shock develops. Flow separation at the shock causes stall to occur at considerably lower angles of attack. The stall is more gradual, and results in a more diffuse stall vortex. Author

A92-23801#
VORTEX-INDUCED ENERGY SEPARATION IN SHEAR FLOWS
J. J. O'CALLAGHAN and M. KUROSAKA (Washington, University, Seattle) AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992. 14 p. refs
(Contract F49620-88-C-0041)
(AIAA PAPER 92-0192) Copyright

The purpose of this research is to confirm the mechanism of vortex-induced energy separation, in the simplest context, by studying the total temperature distribution in a flow that can be modeled by a row of vortices convecting downstream in an otherwise uniform flow. Such a flow can be approximated by a shear layer, in which vortical structures are convected downstream between two uniform streams. Shear layers are created by inserting a wire-mesh screen normal to a uniform flow in a wind tunnel; the velocity gradient behind this obstruction causes a shear layer to be shed from the screen tip. The mechanism of vortex-induced energy separation correctly predicts the qualitative characteristics of the total temperature distributions measured in and around the shear layers, and anticipates the observed effects of flow Mach number and flow nonuniformities on the energy separation. An important consequence of vortex-induced energy separation suggested by the results is that unsteady vortical structures can be detected by taking point measurements of the total temperature in the flowfield. Vortex-induced energy separation also becomes important in problems involving heat transfer to or from a flow inhabited by unsteady vortices. Author

A92-23802*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
LEADING EDGE VELOCITY FIELD OF AN OSCILLATING AIRFOIL IN COMPRESSIBLE DYNAMIC STALL
R. D. VANDYKEN and M. S. CHANDRASEKHARA (NASA, Ames Research Center, Moffett Field; U.S. Navy-NASA Joint Institute of Aeronautics; U.S. Naval Postgraduate School, Monterey, CA) AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992. 11 p. Research supported by U.S. Army and USAF. refs
(AIAA PAPER 92-0193)

Phase-averaged mean-velocity and turbulence data are obtained and analyzed for the leading-edge region of an oscillating airfoil under compressibility conditions. A two-component laser-Doppler velocimetry system was used to make the measurements. Results are compared for the two Mach numbers 0.3 and 0.4 at a reduced frequency of 0.05 with varying airfoil angles of attack. For a Mach number of 0.3, a separation bubble is present on the airfoil throughout the oscillation cycle and no dynamic stall occurs as the peak angle of attack is below the static stall angle. However, a slight imprint of vortical structures is seen in the shear layer enveloping the bubble at the top of the cycle, a result confirmed also by the vorticity contours and in agreement with the earlier stroboscopic schlieren studies. When the Mach number is 0.4, dynamic stall occurs with its origin in the break-up of the separation bubble. Turbulence intensities in the bubble were found to be very large. Author

A92-23803#
NAVIER-STOKES COMPUTATION OF AIRFOIL IN STALL USING ALGEBRAIC REYNOLDS-STRESS MODEL
LARS DAVIDSON and ARTHUR RIZZI (Centre Europeen de Recherche et de Formation Avancee en Calcul Scientifique, Toulouse, France) AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992. 12 p. refs
(AIAA PAPER 92-0195) Copyright

Results of a computational study tracing low-speed flow over an airfoil in stall are presented. The mean-flow equations are solved by a code that is a standard explicit Runge-Kutta time-marchng cell-centered finite-volume technique using central differencing. Good agreement with the observed stall was obtained after an algebraic Reynolds stress model was implemented. The k and epsilon equations are calculated implicitly using hybrid central/upwind differencing. The resulting discretized linearized equations in both coordinate directions are solved by a tri-diagonal matrix procedure. 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. C.A.B.

A92-23804#
STUDY OF ROLE OF UNSTEADY SEPARATION IN FORMATION OF DYNAMIC STALL VORTEX
K. N. GHIA, J. YANG, G. A. OSSWALD, and U. GHIA (Cincinnati, University, OH) AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992. 19 p. Research supported by Ohio Supercomputing Center. refs
(Contract AF-AFOSR-90-0249)
(AIAA PAPER 92-0196) Copyright

An unsteady Navier-Stokes analysis is presently extended to allow active control during modulated suction/injection to manage the energetic dynamic stall vortex. Four different flow configurations are studied which are defined by Re of either 10,000 or 45,000, and either with or without modulated suction/injection. The results thus obtained are compared with a set of experimental data for constant pitch-up motion. In all cases, leading edge suction and trailing edge injection suitable for managing the evolution of the dynamic stall vortex were obtained through numerical experimentation. O.C.

N92-15964# Royal Aircraft Establishment, Farnborough (England).
THE EFFECT OF ROUNDING THE LEADING EDGES ON THE CHARACTERISTICS OF SEPARATED FLOW PAST DELTA WINGS OF LOW ASPECT RATIO
S. B. ZAKHAROV Nov. 1990 15 p Transl. into ENGLISH from TsAGI Uchenye Zapiski, (Moscow, USSR) v. 13, no. 4, 1982 p 1-9 Original language document was announced in IAA as A83-37551
(RAE-LIB-TRANS-2164; BR305194; AD-A242212) Copyright
Avail: NTIS HC/MF A03

The elongated-body approximation is used to analyze the separated flow of an ideal fluid past delta wings of low aspect ratio with blunt leading edges. The numerical method used is based on a mathematical model of inviscid separation with a smooth surface. Calculations are performed of symmetric flow around wings whose traverse cross sections are ellipses of small relative thickness. An analysis is presented of the effects of the location of the separation line, the blunting of the edges, and wing thickness on the configuration of the vortex sheet and the overall aerodynamic characteristics of the wing. Author

N92-15965*# Stanford Univ., CA. Dept. of Aeronautics and Astronautics.
ANALYSIS OF A DUSTY WALL JET
HOCK-BIN LIM and LEONARD ROBERTS Dec. 1991 19 p Sponsored by NASA. Ames Research Center
(NASA-CR-189759; NAS 1.26:189759; JIAA-TR-105) Avail: NTIS HC/MF A03 CSCL 01/1

An analysis is given for the entrainment of dust into a turbulent radial wall jet. Equations are solved based on incompressible flow of a radial wall jet into which dust is entrained from the wall and transported by turbulent diffusion and convection throughout the flow. It is shown that the resulting concentration of dust particles in the flow depends on the difference between the applied shear stress at the surface and the maximum level of shear stress that the surface can withstand (varies as rho(sub d)a(sub g)D) i.e., the pressure due to the weight of a single layer of dust. The analysis

is expected to have application to the downflow that results from helicopter and VTOL aircraft. Author

N92-15966*# MCAT Inst., San Jose, CA.
CONTROL OF UNSTEADY SEPARATED FLOW ASSOCIATED WITH THE DYNAMIC PITCHING OF AIRFOILS Progress Report
SAJEER AHMED Dec. 1991 63 p
(Contract NCC2-637)
(NASA-CR-189758; NAS 1.26:189758) Avail: NTIS HC/MF A04 CSCL 01/1

Although studies have been done to understand the dependence of parameters for the occurrence of deep stall, studies to control the flow for sustaining lift for a longer time has been little. To sustain the lift for a longer time, an understanding of the development of the flow over the airfoil is essential. Studies at high speed are required to study how the flow behavior is dictated by the effects of compressibility. When the airfoil is pitched up in ramp motion or during the upstroke of an oscillatory cycle, the flow development on the upper surface of the airfoil and the formation of the vortex dictates the increase in lift behavior. Vortex shedding past the training edge decreases the lift. It is not clear what is the mechanism associated with the unsteady separation and vortex formation in present unsteady environment. To develop any flow control device, to suppress the vortex formation or delay separation, it is important that this mechanism be properly understood. The research activities directed toward understanding these questions are presented and the results are summarized. Author

N92-15967*# Sverdrup Technology, Inc., Brook Park, OH.
DEVELOPMENT OF AN ANALYTICAL METHOD TO PREDICT HELICOPTER MAIN ROTOR PERFORMANCE IN ICING CONDITIONS Final Report
RANDALL K. BRITTON 1 Jan. 1992 26 p Presented at the 30th Aerospace Sciences Meeting and Exhibit, Reno, NV, 6-9 Jan. 1992; sponsored by AIAA
(Contract NAS3-25266)
(NASA-CR-189110; E-6779; NAS 1.26:189110; AIAA-92-0418)
Avail: NTIS HC/MF A03 CSCL 01/1

Historically, certification of a helicopter for flight into known icing conditions was a problem. This is because of the current emphasis on flight testing for verification of system performance. Flight testing in icing conditions is difficult because, in addition to being dangerous and expensive, many times conditions which are sought after cannot be readily found in nature. The problem is compounded for helicopters because of their small range in comparison to many fixed wing aircraft. Thus, helicopters are forced to wait for conditions to occur in a certain region rather than seeking them out. These and other drawbacks to flight testing prompted extreme interest in developing validated alternatives to flight testing. One such alternative is theoretical prediction. It is desirable to have the ability to predict how a helicopter will perform when subjected to icing conditions. Herein, calculations are restricted to the main rotor, and are illustrated. The computational tool used to obtain performance is the lifting line analysis of B65. B65 incorporates experimental data into data banks in order to determine the section lift, drag, and moment characteristics of various airfoils at different Mach numbers and angles of attack. The local flow angle is calculated at user specified radial locations. This flow angle, along with the local Mach number is then cross referenced with the airfoil tables to obtain the local section characteristics. The local characteristics are then integrated together to obtain the entire rotor attributes. Once the clean performance is known, characterization of the type and shape of ice which accretes on the rotor blades is obtained using the analysis of LEWICE. The Interactive Boundary Layer (IBL) method then calculates the 2-D characteristics of the iced airfoil for input into the airfoil data bank of B65. Calculations are restricted to natural ice shedding and it is assumed that no de-icing takes place. Once the new lift, drag, and moment characteristics are known for the entire blade radius, this information is fed into B65, where the iced performance is then calculated. Author

N92-15968*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
PREDICTION OF ICE ACCRETION ON A SWEPT NACA 0012 AIRFOIL AND COMPARISONS TO FLIGHT TEST RESULTS
ANDREW L. REEHORST 1992 60 p Presented at the 30th Aerospace Sciences Meeting and Exhibit, Reno, NV, 6-9 Jan. 1992; sponsored by AIAA
(NASA-TM-105368; E-6746; NAS 1.15:105368; AIAA-92-0043)
Avail: NTIS HC/MF A04 CSCL 01/1

In the winter of 1989-90, an icing research flight project was conducted to obtain swept wing ice accretion data. Utilizing the NASA Lewis Research Center's DHC-6 DeHavilland Twin Otter aircraft, research flights were made into known icing conditions in Northeastern Ohio. The icing cloud environment and aircraft flight data were measured and recorded by an onboard data acquisition system. Upon entry into the icing environment, a 24 inch span, 15 inch chord NACA 0012 airfoil was extended from the aircraft and set to the desired sweep angle. After the growth of a well defined ice shape, the airfoil was retracted into the aircraft cabin for ice shape documentation. The ice accretions were recorded by ice tracings and photographs. Ice accretions were mostly of the glaze type and exhibited scalloping. The ice was accreted at sweep angles of 0, 30, and 45 degrees. A 3-D ice accretion prediction code was used to predict ice profiles for five selected flight test runs, which include sweep angle of zero, 30, and 45 degrees. The code's roughness input parameter was adjusted for best agreement. A simple procedure was added to the code to account for 3-D ice scalloping effects. The predicted ice profiles are compared to their respective flight test counterparts. This is the first attempt to predict ice profiles on swept wings with significant scalloped ice formations. Author

N92-15969*# Texas Univ., Austin. Dept. of Mechanical Engineering.
EXPERIMENTAL STUDY OF A VORTEX SUBJECTED TO IMPOSED STRAIN Final Report
RONALD L. PANTON and KIRK E. STIFLE Aug. 1991 42 p
(Contract NAG2-389)
(NASA-CR-189757; NAS 1.26:189757) Avail: NTIS HC/MF A03 CSCL 01/1

An experimental project was undertaken to investigate the character of vortex breakdown with particular regard to the waveguide theories of vortex breakdown. A rectangular wing based on the NACA 0012 airfoil was used to produce a trailing vortex which convected downstream without undergoing breakdown. Dye marked the vortex location. A disturbance was then introduced onto the vortex using a small moving wire to 'cut' the vortex. The development of upstream and downstream propagating disturbance waves was observed and the propagation velocities measured. The downstream traveling wave produced a structure similar in appearance to a vortex breakdown. The upstream wave produced a moving, swirling, turbulent region that was not a vortex breakdown. The waves moving in either direction have the same swirl velocity profiles but quite different axial velocity profiles. The upstream disturbance (turbulence) moved into a flow with an axial velocity profile that had a wake-like defect in the core region. The downstream moving vortex breakdown moved into a flow with a jet-like overshoot in the core region. The fact that no breakdown was observed for the wake-like defect and breakdown was observed for the jet-like overshoot is not consistent with computational fluid dynamics (CFD) calculations. Although there are not a lot of examples, CFD results show breakdown for both types of profiles. The longitudinal and swirl velocity profiles were documented by Laser Doppler Velocimeter (LDV) measurement. Wave velocities, swirl angles, and swirl parameters are reported. Author

N92-15970 ESDU International Ltd., London (England).
A METHOD OF ESTIMATING A FLOW BREAKDOWN BOUNDARY FOR AEROFOILS AND SWEPT WINGS IN TRANSONIC FLOWS
Oct. 1991 37 p

(ESDU-91021; ISBN-0-85679-783-9; ISSN-0141-4356) Avail: ESDU

A method is given of estimating the boundary beyond which as either lift coefficient or Mach number is increased, the turbulent boundary layer on the upper surface separates from the foot of the shock to the trailing edge. Features of experimental pressure distribution are found to correlate with the onset of flow breakdown. In both methods (also ESDU 81020), it was found that those same features of a pressure distribution calculated by techniques that do not model separation could be used similarly. In this case, the bubble length is found to be a function of local Mach number and momentum thickness at the shock location, while the point of reattachment was found to correlate with features of the adverse rear gradient. Using those features, a step-by-step procedure for predicting the flow breakdown boundary is presented and was checked against experimental data for airfoils, and wings with quasi-two-dimensional flow. Two comprehensive worked examples show the use of the method. It is believed to predict the boundary with a rms error of 0.04 in lift coefficient when the Mach number is increasing or within 0.01 in Mach number when the lift coefficient is increasing. ESDU

N92-15971 ESDU International Ltd., London (England).
CONTRIBUTION OF FIN AND TAILPLANE TO SIDEFORCE AND YAWING MOMENT DERIVATIVES DUE TO SIDESLIP AT SUPERSONIC SPEEDS AT LOW ANGLES OF ATTACK
Nov. 1991 36 p
(ESDU-91031; ISBN-0-85679-794-4; ISSN-0141-397X) Avail: ESDU

ESDU 91031 presents a method for estimating the derivatives based on apparent mass calculations that allow for interference effects of body, wing, and tailplane on the fin. The method is modified as a result of comparisons with experimental data drawn from the literature for mid and low wing or tailplane position for which the theory tends to overestimate the sideforce. The method factors the lift-curve slope of an isolated surface for the interference effects, and values for that may be found from ESDU 70012. To establish the yawing moment, the sideforce is assumed to act at the aerodynamic center, which is also predicted using ESDU 70012. The method applies to a single fin in the plane of symmetry and body-mounted tailplane; however, recommendations are made on how it may be extended to treat fin-mounted tailplanes which in fact only make small contributions to these derivatives. It applies for angles of attack less than five degrees and angles of sideslip less than four degrees. The behavior of the derivatives up to angles of attack of 20 degrees is illustrated in a particular case and compared with predictions from an extended theory. Sketches show the comparison of predicted with experimental results drawn from the literature; agreement is found to be within 15 percent, which is in any case the anticipated tolerance on values of lift-curve slope from ESDU 70012. ESDU

N92-15972 ESDU International Ltd., London (England).
SIMPLIFIED METHOD FOR THE PREDICTION OF AEROFOIL EXCRESCENCE DRAG MAGNIFICATION FACTOR FOR TURBULENT BOUNDARY LAYERS AT SUBCRITICAL MACH NUMBERS
Nov. 1991 25 p
(ESDU-91028; ISBN-0-85679-790-1; ISSN-0141-397X) Avail: ESDU

A method based on the Nash and Bradshaw equation extended for the effects of compressibility is given. To evaluate the equation, both the pressure distribution and the development of the momentum thickness are required. At an early design stage it is unlikley that the boundary layer development will be known, and so the method due to Spence, modified for compressibility, is used to calculate momentum thickness. That ensures compatibility with the derivation of the Nash and Bradshaw equation and provides a method for wholly turbulent boundary layers that is independent of Reynolds number. The Nash and Bradshaw equation has been compared with BVGKE calculations and found to agree within five percent for subcritical flow. Comparisons of using three other turbulent boundary layer models in place of the Spence method gave results within three percent of those obtained by the method used here provided boundary layer transition was within 0.1 of chord from the leading edge and the excrescence was at least 0.1 of chord aft of transition. A FORTRAN program of the method is available on disc as ESDUpac 9128, and information on the input and output format is included together with a number of example calculations illustrating its use. ESDU

N92-15973 ESDU International Ltd., London (England).
EXCRESCENCE DRAG MAGNIFICATION FACTORS AT THE DRAG-RISE CONDITION FOR AEROFOILS WITH A SPECIFIED FORM OF UPPER-SURFACE PRESSURE DISTRIBUTION
Nov. 1991 60 p
(ESDU-91029; ISBN-0-85679-791-X; ISSN-0141-397X) Avail: ESDU

Data are given for the chordwise variation of the magnification factor on the upper and lower surfaces of a family of airfoils designed to combine a high drag-rise Mach number with a high lift coefficient for given thickness/chord ratio. (The geometry and pressure distribution at the design condition are described in ESDU 71020 and profile drag data are given in ESDU 67011.) The data are typical of airfoils designed for that purpose and were obtained using the program of ESDU 91028. They are presented in tables together with normalized values of local flow properties and boundary layer momentum thickness on both airfoil surfaces, and also graphically. The influence of systematic variations of thickness/chord ratio, design Mach number, and extent of upper surface roof top are discussed. A worked example illustrates the use of both the tabulated and graphical data in conjunction with excrescence drag data for grooves in uniform flow from ESDU 75028. ESDU

N92-15974*# Tennessee Univ. Space Inst., Tullahoma. Center for Space Transportation and Applied Research.
A WALL INTERFERENCE ASSESSMENT/CORRECTION SYSTEM Semiannual Report No. 1, Jun. - Dec. 1991
C. F. LO, J. C. ERICKSON, and N. ULBRICH Dec. 1991 25 p
(Contract NAG2-733)
(NASA-CR-189785; NAS 1.26:189785) Avail: NTIS HC/MF A03 CSCL 01/1

The Hackett method (a Wall Pressure Signature Method) was selected to be adapted for the 12 ft Wind Tunnel WIAC system. This method uses limited measurements of the static pressure at the wall, in conjunction with the solid wall boundary condition, to determine the strength and distribution of singularities representing the test article. The singularities are used in term for estimating wall interference at the model location. Hackett's method will have to be formulated for application to the unique geometry of the 12 ft tunnel. The WIAC code will be validated by conducting numerically simulated experiments rather than actual wind tunnel experiments. The simulations will be used to generate both free air and confined wind tunnel flow fields for each of the test articles over a range of test configurations. Specifically the pressure signature at the test section wall will be computed for the confined case to provide the simulated 'measured' data. These data will serve as the input for the WIAC method. The performance of the WIAC method then may be evaluated by comparing the corrected parameters with those for the free air simulation. Author

N92-15975# Naval Postgraduate School, Monterey, CA.
HOT-WIRE SURVEYS IN THE VORTEX WAKE DOWNSTREAM OF A THREE-PERCENT FIGHTER AIRCRAFT MODEL AT HIGH ANGLES OF ATTACK M.S. Thesis
WILLIAM D. FRINK, JR. Dec. 1990 65 p
(AD-A241869) Avail: NTIS HC/MF A04 CSCL 01/1

A low-speed wind tunnel investigation was conducted to examine the vortex wake downstream of a three-percent scale model of the YF-17 lightweight fighter prototype at high angles of attack. The study was in support of NASA Ames Research Center's wind tunnel investigation of a full scale F/A-18 as part of NASA's High Alpha Technology Program. Smoke flow visualization was used to locate the downstream vortex wake. Hot-wire surveys were taken through the vortex at two stations; one directly aft of

the model and the other at a station three model lengths downstream of the model. The effect of adding a fence to the leading edge extension (LEX) was studied. Power spectra from the hot-wire were recorded for the survey station directly aft of the model. Results show that peak turbulent fluctuation at this station occurred at 25 deg angle of attack; lateral turbulent fluctuation greatly diminished at the far downstream station; and the addition of the LEX fence shifted energy content of turbulence toward higher frequencies. GRA

N92-17114# Air Force Inst. of Tech., Wright-Patterson AFB, OH.
AN EXPERIMENTAL INVESTIGATION OF LEADING EDGE VORTICAL FLOW ABOUT A DELTA WING DURING WING ROCK M.S. Thesis
MICHAEL D. NELSON Dec. 1991 200 p
(AD-A243363; AFIT/CI/CIA-91-066) Avail: NTIS HC/MF A09 CSCL 01/1

The primary objective of this research was to further investigate the dynamic motion of an 80 deg delta wing during wing rock in both a water and wind tunnel. Both vortical flow data and wing motion data were recorded using a video-based motion analysis system. *This system provided adequate means to nonintrusively* measure dynamic data. The data revealed hysteresis differences between the wind tunnel and water tunnel tests. Hysteresis in the rolling moment coefficient versus bank or roll angle, during water tunnel testing, traveled in the direction opposite to the wind tunnel results. Visualization of the water tunnel vortical flowfields provided quantified right and left vortex locations at specific roll angles during wing rock. The contribution to the rolling moment based on these vortex positions was analyzed. Results show a decrease in rolling moment before reaching the maximum roll amplitude and an increase in rolling moment after passing through the maximum roll angle. Added mass experiments were also conducted in the wind tunnel. The wind tunnel rolling moment was 15 times larger than water tunnel results, due to the difference in densities of the mediums. Although dynamic similitude was not achieved between the two fluids, a foundation for further investigation has been laid. GRA

N92-17222# Virginia Polytechnic Inst. and State Univ., Blacksburg. Dept. of Aerospace and Ocean Engineering.
AN EXPERIMENTAL STUDY OF A TURBULENT WING-BODY JUNCTION AND WAKE FLOW Technical Report, 1 Jun. 1989 - 31 Aug. 1991
J. L. FLEMING, R. L. SIMPSON, and W. J. DEVENPORT 1 Sep. 1991 198 p
(Contract N00014-89-J-1275; N00014-90-J-1909)
(AD-A243388; VPI-AOE-179) Avail: NTIS HC/MF A09 CSCL 20/4

Extensive hot-wire measurements were conducted in incompressible turbulent flow around a wing-body junction. Measurements were performed adjacent to the body and up to 11.56 chord lengths downstream of the body. Junction wake flow entered an adverse pressure gradient region approximately 6 chord lengths downstream. This region's geometry approximated the aft portion of an aircraft fuselage or a submersible's hull. Body geometry was formed by joining a 3:2 elliptic nose to a NACA 0020 tail section at their respective maximum thickness locations. Measurements were taken with approach flow conditions of Re sub theta = 6,300, and delta/T = .513, where T is maximum body thickness. Results clearly show the characteristic horseshoe vortex flow structure, which is elliptically shaped, with del(W)/del Y forming the primary component of streamwise vorticity. Near wall measurements show a thin layer of highly concentrated vorticity, underneath and opposite in sign to the primary vortex, which is created by the wall no-slip condition. Development of flow distortions and associated vorticity distributions are highly dependent on the geometry-induced pressure gradients and resulting flow skewing directions. A quantity known as the 'distortion function' was used to separate distortive effects of secondary flow from those of the body and the local 2-D boundary layer. The distortion function revealed that adverse pressure gradient flow distortions grew primarily because of increasing boundary layer thickness. GRA

N92-17281# Aeronautical Research Labs., Melbourne (Australia).
SURFACE PRESSURE MEASUREMENTS ON THE WING OF A WIND TUNNEL MODEL DURING STEADY ROTATION
C. A. MARTIN and G. J. BRIAN Jul. 1991 84 p
(AD-A243047; ARL-FLIGHT-MECH-TM-443; DODA-AR-006-614)
Avail: NTIS HC/MF A05 CSCL 01/1

Wind tunnel measurements were conducted to determine the nature of the pressure distribution over the wing of a model of a basic training aircraft for a range of angles of attack and rotation rates representative of aircraft spinning conditions. The tests were carried out as part of a collaborative program organized through The Technical Cooperation Programme and were conducted in the Spin Research Facility at the NASA Langley Research Center. Software for displaying the surface pressure distributions was developed at the Aeronautical Research Laboratory. This report presents pressure coefficient data obtained during the program, in both numerical and graphical form. GRA

N92-17303# Old Dominion Univ., Norfolk, VA.
THE SOLUTION OF A SINGULAR INTEGRAL EQUATION ARISING FROM A LIFTING SURFACE THEORY FOR ROTATING BLADES Ph.D. Thesis
MARK H. DUNN Aug. 1991 155 p Original contains color illustrations
Avail: NTIS HC/MF A08; 11 functional color pages

A technique is presented for the solution of a linear, two dimensional, singular, Volterra integral equation of the first kind. The integral equation is derived from the basic equations of linearized acoustics and models the lifting force experienced by an infinitesimally thin surface moving tangent to itself. As a particular application, the motion of modern high speed aircraft propellers (Advanced Technology Propellers) is considered. The *unknown propeller blade surface pressure distribution is* approximated by a piecewise constant function and the integral equation is solved numerically by the method of collocation. Certain simplifying assumptions applied to the propeller blade model lead to a radical reduction in complexity of the solution methodology. Author

N92-17339# Naval Postgraduate School, Monterey, CA.
FLOW VISUALIZATION AND WAKE ANALYSIS FOR STANDARD AND MODIFIED CONFIGURATIONS OF THE AN/ALQ-78 ANTENNA POD M.S. Thesis
JAMES F. SMALL Mar. 1991 158 p
(AD-A243552) Avail: NTIS HC/MF A08 CSCL 20/4

A low-speed wind tunnel investigation was conducted to compare the aerodynamic flow field characteristics for standard and modified configurations of a 20 percent scale model of the AN/ALQ-78 electronic support measures system antenna pod. The modification consisted of replacing the standard quasi-conically shaped radome with a cylindrical radome and adapter collar. The research was requested by the Naval Air Systems Command (NAVAIRSYSCOM) as part of a risk and feasibility assessment in preparation for possible full-scale flight tests of the modified configuration. Wake flow visualization was conducted to determine the general characteristics of the flow field. Base pressure measurements were made to assess three-dimensional effects. The presence of coherent vortex shedding in the wake was investigated using a cross-probe constant temperature hot-film anemometer and spectrum analyzer. The Reynolds number varied from 40,000 to 6 x 10(exp 5) with the upper value approximately equal to one-eighth that of the full-scale pod in flight. Asymmetric vortex shedding was visualized in the wakes of both configurations at subcritical Reynolds numbers. The modified configuration exhibited a pronounced region of quasi-two-dimensional flow during wake visualization and base pressure tests, indicating a significant increase in the aerodynamic forces acting on the pod structure.

Spectral analysis of the hot-film output confirmed the presence of coherent vortex shedding in the wakes of both models at subcritical Reynolds numbers. Author (GRA)

N92-17347*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
EXPERIMENTAL ICE SHAPE AND PERFORMANCE CHARACTERISTICS FOR A MULTI-ELEMENT AIRFOIL IN THE NASA LEWIS ICING RESEARCH TUNNEL
BRIAN M. BERKOWITZ, MARK G. POTAPCZUK, BAHMAN S. NAMDAR, and TAMMY J. LANGHALS (Sverdrup Technology, Inc., Brook Park, OH.) Dec. 1991 323 p
(Contract NAS3-25266)
(NASA-TM-105380; E-6767; NAS 1.15:105380) Avail: NTIS HC/MF A14 CSCL 01/1

A study of the ice accretion patterns and performance of characteristics of a multi-element airfoil was undertaken at the NASA-Lewis Icing Research Tunnel. Several configurations were examined to determine the ice shape and performance characteristics. The testing included glaze, rime, and mixed icing regimes. Tunnel cloud conditions were set to correspond to those typical of the operating environment for commercial transport aircraft. Measurements acquired included ice profile tracings and aerodynamic forces both during the accretion process and in a post-accretion evaluation over a range of angle of attack. Substantial ice accretions developed on the main wing, flaps, and slat surfaces. Force measurements indicate severe performance degradation, especially near CL max, for both light and heavy ice accretion. Frost was seen on the lower surface of the airfoil which was found to contribute significantly to the force components.
Author

N92-17404# Army Natick Research and Development Command, MA.
TRAJECTORY ANALYSIS OF THE G-11 FAMILY OF CLUSTERED PARACHUTES TO DETERMINE MINIMUM ALTITUDE Final Report, Jul. 1990 - Aug. 1991
STEVEN KUNZ Nov. 1991 25 p
(Contract DA PROJ. 1E4-64804-D-279)
(AD-A243375; NATICK/TR-92/005) Avail: NTIS HC/MF A03 CSCL 01/2

The U.S. Air Force is interested in determining the minimum altitude at which an aircraft can approach a drop zone and deploy an airdrop system to deliver cargo without its becoming damaged. Lower altitudes will reduce the exposure of aircraft to hostile fire, but being too low will result in the destruction of the cargo. The objective of this report is to determine the minimum altitude at which the cargo may be safely delivered. This was accomplished by analyzing trajectory data for airdrop systems using the G-11 parachute. It was found that the first point (time) at which cargo can be safely landed occurs when the cargo velocity reaches its first minimum total velocity, incident with the first maximum backswing orientation of the system. This criterion was used to determine the statistical mean of the altitude loss. The importance of variability is discussed as it relates to the determination of a safety factor. GRA

N92-17509*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
STRUCTURAL DYNAMICS DIVISION RESEARCH AND TECHNOLOGY ACCOMPLISHMENTS FOR F.Y. 1991 AND PLANS FOR F.Y. 1992
ELEANOR C. WYNNE Jan. 1992 205 p
(NASA-TM-104188; NAS 1.15:104188) Avail: NTIS HC/MF A10 CSCL 01/1

The work under each technical area is described in terms of highlights of accomplishments during the past year and highlights of plans for the current year as they relate to 5 year plans for each technical area. This information will be useful in program coordination with other government organizations and industry in areas of mutual interest. The structural dynamics division consist of the following branches: configuration aeroelasticity; unsteady aerodynamics; aeroservoelasticity; landing and impact dynamics; and spacecraft dynamics. Author

N92-17547*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
USER GUIDE FOR WIACX: A TRANSONIC WIND-TUNNEL WALL INTERFERENCE ASSESSMENT AND CORRECTION PROCEDURE FOR THE NTF
JAVIER A. GARRIZ and KARA J. HAIGLER Jan. 1992 67 p
(Contract NAS1-18585)
(NASA-TM-104168; NAS 1.15:104168) Avail: NTIS HC/MF A04 CSCL 01/1

A three dimensional transonic Wind-tunnel Interference Assessment and Correction (WIAC) procedure developed specifically for use in the National Transonic Facility (NTF) at NASA Langley Research Center is discussed. This report is a user manual for the codes comprising the correction procedure. It also includes listings of sample procedures and input files for running a sample case and plotting the results. Author

N92-17681# George Washington Univ., Washington, DC.
THE EFFECT OF FREESTREAM TURBULENCE ON THE VORTICAL FLOW OVER A DELTA WING M.S. Thesis
ANTHONY EUGENE WASHBURN Dec. 1990 248 p
Avail: NTIS HC/MF A11

An experimental investigation of the effect of freestream turbulence on the vortical flow over a 76 deg sharp edged delta wing at low Reynolds numbers was conducted. The investigation also considered the effect of test section type and model support system on the aerodynamic loads of the wing. The freestream turbulence intensities were increased from a baseline less than 0.1 percent to 7.5 percent by placing a grid upstream of the model. The angle of attack was varied from -6 deg to 40 deg for sideslip angles between 0 deg and 20 deg in Reynolds numbers of 0.5 x 10(exp 6) x 10(exp 6), and 1.0 x 10(exp 6), based on root chord. Off-body and surface flow visualization were used to demonstrate the turbulence effect on the vortex topology, path, and burst position as well as boundary layer transition. A non-intrusive infrared transition measurement technique was employed to support the surface flow visualization transition results. Force and moment data were taken to quantify freestream turbulence and Reynolds number effects on the aerodynamic loads. Aerodynamic load dependence on model installation was evaluated by testing the model in three closed test sections and one open test section with both sting and post mounts. Small Kelvin-Helmholtz type vortical structures in the leading edge vortex shear layer and hysteresis in burst and loads were seen with the baseline turbulence. The vortices and burst positions were unsteady in the high turbulence case and hysteresis in both burst positions and loads seemed to be eliminated. The secondary separation lines on the surface of the delta wing moved closer to the leading edge in the presence of the high turbulence indicating a turbulent boundary layer. The turbulence decreased the loads near the maximum lift angle. The aerodynamic loads are very dependent on model mounting and test section configuration with differences in maximum lift as great as 20 percent. Author

N92-17755# National Aerospace Lab., Tokyo (Japan). Aircraft Aerodynamics Div.
RESULTS OF MEASURED TEMPERATURE DISTRIBUTION ON AN ADIABATIC WING MODEL WITH RADIATION THERMOMETER [HOSHA ONDOKEI NIYORU DANNETSUYOKU MOKEIJO NO ONDO BUNPU SOKUTEI SHIKEN KEKKA]
HIDEO SAWADA, AKIRA KOIKE, KOICHI SUZUKI, YUKIO KOMATSU, SEIGO NAKAMURA, and SHIGEO BABA Jul. 1989 31 p In JAPANESE
(NAL-TM-610; ISSN-0452-2982; JTN-92-80246) Avail: NTIS HC/MF A03

In order to evaluate the influence of the wind tunnel difference upon the wind tunnel test result, it is necessary to evaluate the influence of the disturbance of the stream upon the boundary layer, detachment area, and disturbance area on the wind tunnel

model. It is necessary to measure the transition point of boundary layer on the wing. As there is a close relationship between the boundary layer and the temperature distribution of the wing, it is effective to examine the temperature distribution on the wing in order to study the stream on the wing. This paper describes the measurement of the temperature distribution on an adiabatic wing model by the non-contact thermometer and shows the observation results on the shockwave location, detachment area, and transition point location on the wing. Author (NASDA)

N92-17849# Manchester Univ. (England). Aeronautical Engineering Group.
BOUNDARY-LAYER TRANSITION AND HEAT TRANSFER ON SLENDER DELTA WINGS
D. I. A. POLL 1989 21 p Previously announced in IAA as A91-21194
(AERO-REPT-8904; ETN-92-90913) Avail: NTIS HC/MF A03

The problem of boundary layer transition via three different mechanisms (attachment line contamination, cross flow instability and tripping by isolated roughness elements) is considered in the context of flow over a slender delta wing. Existing knowledge of the transition mechanisms is summarized and estimates of the shape of the resulting transition fronts are made by linking the phenomena to the topography of the flow at the edge of the boundary layer. Simple relations are presented for the estimation of leading edge heating at small angles of incidence and wing center line heating at large angles of incidence. ESA

N92-17874# Midwest Research Inst., Golden, CO. National Renewable Energy Lab.
DYNAMIC STALL ON WIND TURBINE BLADES
C. P. BUTTERFIELD, D. SIMMS, G. SCOTT, and A. C. HANSEN (Utah Univ., Salt Lake City.) Dec. 1991 9 p Presented at the 21st American Wind Energy Association Conference: Windpower 1991, Palm Springs, CA, 24-27 Sep. 1991
(Contract DE-AC02-83CH-10093)
(DE92-001157; NREL/TP-257-4510; CONF-9109112-7) Avail: NTIS HC/MF A02

Dynamic loads must be predicted accurately in order to estimate the fatigue life of wind turbines operating in turbulent environments. Dynamic stall contributes to increased dynamic loads during normal operation of all types of horizontal-axis wind turbine (HAWT's). This report illustrates how dynamic stall varies throughout the blade span of a 10 m HAWT during yawed and unyawed operating conditions. Lift, drag, and pitching moment coefficients during dynamics stall are discussed. Resulting dynamic loads are presented, and the effects of dynamic stall on yaw loads are demonstrated using a yaw loads dynamic analysis (YAWDYN). DOE

03

AIR TRANSPORTATION AND SAFETY

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

A92-21684
EVOLUTION OF EJECTION SYSTEMS [RAZVITIE AVIATSIONNYKH SREDSTV SPASENIIA]
ALEKSANDR G. AGRONIK and LAZAR' I. EGENBURG Moscow, Izdatel'stvo Mashinostroenie, 1990, 255 p. In Russian. refs
Copyright

The history and the current status of ejection systems and parachutes are reviewed. In particular, attention is given to the general design of parachutes used for the crew bailout in emergency, parachutes used in airdrop operations, and parachutes for ejection seat stabilization. The typical designs and operation of ejection seats are examined in detail, and trends in the development of jettison systems are discussed. V.L.

A92-22158#
STUDY OF THEORETICAL AND WIND TUNNEL RESULTS ON FLIGHT PERFORMANCE DEGRADATION DUE TO LEADING EDGE RIME ICE ACCRETION
ROBERT C. GRIFFITHS and KENNETH D. KORKAN (Texas A & M University, College Station) AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992. 11 p. refs
(AIAA PAPER 92-0038) Copyright

The paper presents a new computational methodology for predicting the aerodynamic performance characteristics of an airfoil. A new low-speed airfoil, designated the SM701 was designed using the EPPLER airfoil program system (APS), where the APC was used for the clean airfoil configuration, while a combination EPPLER-LEWICE code was used for the airfoil leading edge iced conditions. The theoretical results were verified by a comparison with results of wind tunnel experiments. It was found that the coupling of the LEWICE and the EPPLER analyses was successful; however, there were basic deficiencies with the theoretical predictions of the lift coefficient and the maximum lift coefficient values. I.S.

A92-22159#
DEVELOPMENT OF A THREE-DIMENSIONAL ICING CODE - COMPARISON WITH EXPERIMENTAL SHAPES
T. HEDDE and D. GUFFOND (ONERA, Chatillon, France) AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992. 11 p. refs
(AIAA PAPER 92-0041) Copyright

A 3D icing model has been developed. It starts with a 3D potential flow calculation followed by the droplets trajectories. It derives the heat transfer coefficient from the thermal boundary layer calculation on a rough wall. The runback trajectories are calculated from the wall streamlines. Hence, the thermodynamic balance is done, and the ice shape is obtained. The potential flow, the heat transfer coefficient and the ice shapes are compared with 2D experiments. The 3D code is compared to the 2D one on 2D ice shapes. On an infinite swept wing, it can be seen that the corrected 2D code may predict the local catch efficiency but not the ice shape. Author

A92-23172
NO END TO INCIDENTS IN AIRSPACE? III [LUFTZWISCHENFAELLE UND KEIN ENDE? III]
JOACHIM F. BENTZIEN Zeitschrift fuer Luft- und Weltraumrecht (ISSN 0340-8329), vol. 40, Dec. 1991, p. 366-385. In German. refs
Copyright

Legal aspects of incidents of unauthorized aircraft straying into foreign airspace are discussed. Investigations by the foreign state, the punishment of pilots, and the confiscation of cargo are discussed. Diplomatic reactions in a number of individual incidents are reviewed. C.D.

A92-23302
INDUSTRIAL MEASUREMENT OF MICROPHYSICAL PARAMETERS - APPLICATION TO NATURAL AND SIMULATED ICING CLOUDS [MESURE INDUSTRIELLE DES PARAMETRES MICROPHYSIQUES - APPLICATION AUX NUAGES GIVRANTS NATURELS ET SIMULES]
J.-F. GAYET (Clermont-Ferrand II, Universite, France), G. BOMMELAER (Centre d'Essais des Propulseurs, Saclay, France), and F. RETIF (Aerospatiale, Direction des Essais en Vol, Toulouse, France) L'Onde Electrique (ISSN 0030-2430), vol. 72, Jan.-Feb. 1992, p. 21-25. In French. refs
Copyright

Instrumentation necessary for the measurement of microphysical parameters during icing tests performed in natural or in simulated cloudes produced in wet wind tunnels is considered. The parameters which govern the icing intensity are the liquid water content and the droplet diameter. The microphysical probes used for the icing tests are described, and the accuracy obtained for the microphysical parameters is discussed. Attention is given

to microphysical measurements performed during the ATR-72 aircraft icing flight tests and during the control of the simulated clouds produced in the CEPr wet wind tunnel. L.M.

A92-23754#
A THEORETICAL ANALYSIS UTILIZING THE LEWICE AND EPPLER NUMERICAL ANALYSES TO PREDICT FLIGHT PERFORMANCE DEGRADATION UNDER ICING CONDITIONS
ROBERT C. GRIFFITHS (Texas A & M University, College Station) AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992. 8 p. refs
(AIAA PAPER 92-0134) Copyright

The LEWICE and EPPLER numerical-analysis codes have been used to investigate the flight-performance degradation of low-speed airfoils under icing conditions. Linkage between the two codes was achieved through the direct implementation by EPPLER of the new iced airfoil coordinates output from LEWICE. The aerodynamic characteristics of greatest interest encompassed lift, drag, and moment about the quarter-chord point; attention was given to the maximum lift coefficient and its influence on the stall speed of iced aircraft. These theoretical data are found to match with trends in wind tunnel data for a NACA 0012 airfoil. O.C.

A92-23777#
EXAMINATION OF A NUMERICAL ICING-SEVERITY SCALE
RICHARD K. JECK (FAA, Technical Center, Atlantic City, NJ) AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992. 14 p. refs
(AIAA PAPER 92-0164)

The present feasibility study for a numerical severity scale descriptive and predictive of aircraft icing conditions aloft proceeds by developing a trial scale whose divisions are proportional to the increments of liquid water content averaged over conventional reference distances of 17.4 and 2.6 n. mi., respectively, in stratiform and convective clouds. The intensity levels are thereby rendered proportional to ice-accretion quantities on a fixed-diameter rotating cylinder that serves as a standard reference or test probe. Simple adjustment rules can then be applied to take temperature and dropsize effects on icing intensity into account. O.C.

A92-23778#
DETERMINATION OF LIQUID WATER CONTENT IN THE AEDC ENGINE TEST CELLS
SCOTT BARTLETT, MIKE STRINGFIELD, and TOM TIBBALS (Sverdrup Technology, Inc., Arnold AFB, TN) AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992. 9 p. refs
(AIAA PAPER 92-0165)

The altitude engine test cells at the Arnold Engineering Development Center are capable of simulating atmospheric icing conditions. The test cells are used to conduct tests in the direct-connect and free-jet modes. A key icing simulation parameter is the cloud liquid water content. The liquid water content setting at AEDC considers two factors, the bulk value and the spatial distribution of the liquid water across a specific region of interest. The techniques used to determine the bulk value from measurable quantities of injected water flow rate, test cell air mass flow rate, total air temperature, and static and total air pressure are discussed. The technique for evaluation of the spatial distribution of the liquid water content using ice thickness measurements is discussed. A recent development in automation of the ice thickness measurement process with ultrasonic transducers is described. The use of the ultrasonic technology removes several errors associated with the time-honored method of manually measuring ice thickness. Author

N92-15978# National Transportation Safety Board, Washington, DC. Office of Aviation Safety.
AIRCRAFT ACCIDENT REPORTS: BRIEF FORMAT US CIVIL AND FOREIGN AVIATION ISSUE NUMBER 2 OF 1989 ACCIDENTS
18 Dec. 1990 417 p
(PB90-916902; NTSB/AAB-90/02) Avail: NTIS HC/MF A18; paper copy also available on Standing Order, deposit account required (minimum deposit $100 US, Canada, and Mexico; all others $200) CSCL 01/3

Selected aircraft accident reports are presented in Brief Format which occurred in the U.S. civil and foreign aviation operations during 1989. Approximately 200 General Aviation and Air Carrier accidents contained in the publication represent a random selection. The publication is issued irregularly, approximately 15 times a year. The Brief Format represents the facts, conditions, circumstances, and probable cause(s) for each accident. Author

N92-15979# National Transportation Safety Board, Washington, DC. Office of Aviation Safety.
AIRCRAFT ACCIDENT REPORTS: BRIEF FORMAT US CIVIL AND FOREIGN AVIATION ISSUE NUMBER 3 OF 1989 ACCIDENTS
18 Dec. 1991 417 p
(PB90-916903; NTSB/AAB-90/03) Avail: NTIS HC/MF A18; Paper copy also available on Standing Order, deposit account required (minimum deposit $100 US, Canada, and Mexico; all others $200) CSCL 01/3

Selected aircraft accident reports are presented in Brief Format occurring in U.S. civil and foreign aviation operations during 1989. Approximately 200 General Aviation and Air Carrier accidents contained in the publication represent a random selection. The publication is issued irregularly, approximately 15 times a year. The Brief Format represents the facts, conditions, circumstances, and probable cause(s) for each accident. Author

N92-16986# Wichita State Univ., KS. National Inst. for Aviation Research.
WICHITA STATE UNIVERSITY 1986 AVIATION SAFETY RESEARCH PROJECTS Final Report
JOHN J. HUTCHINSON Dec. 1991 28 p
(Contract DTFA03-86-C-00041)
(DOT/FAA/CT-91/4) Avail: NTIS HC/MF A03

The proposal which the National Institute for Aviation Research (NIAR) at the Wichita State University (WSU) submitted to the Federal Aviation Administration (FAA) on May 23, 1986, proposed aviation safety research efforts in four areas: crashworthiness; electro-impulse deicing; stall/spin prevention; software reliability. Specific research topics were selected on the basis of a review of FAA research interests, the specialized expertise of WSU research interests, and discussions held with FAA personnel at the FAA Technical Center in Atlantic City and at WSU. The research carried out under this contract is now complete. In addition to the research activities undertaken during the period of this contract, the NIAR has completed construction on a 74,000-square-foot building which houses the activities and laboratories of the institute. Extensive equipment has been purchased as part of this contract and is now housed in the institute building. Moreover, the FAA support for equipment has been used to match State of Kansas equipment grants and has resulted in several well equipped laboratories. This research has involved 13 faculty members and 14 students. The NIAR is now positioned for sustained research as well as advanced training of graduate students in a wide range of technical disciplines related to aviation safety. Publications resulting from their research efforts are listed by area. Summaries of research are given in the areas of crashworthiness, energy absorbing mechanisms, computational crash dynamics analysis, electro-impulse deicing, aerodynamic data on stall/spin prevention, and software reliability assessment in aviation systems. Author

N92-17133# National Transportation Safety Board, Washington, DC.
AIRCRAFT ACCIDENT REPORTS: BRIEF FORMAT. US CIVIL AND FOREIGN AVIATION ISSUE NUMBER 4 OF 1989 ACCIDENTS
18 Dec. 1990 414 p
(PB90-916904; NTSB/AAB-90/04) Avail: NTIS HC/MF A18; paper copy available on Standing Order, deposit account required (minimum deposit $100 US, Canada, and Mexico; all others

$200). Single copies also available in paper copy or microfiche CSCL 01/3

Presented here in brief format are selected aircraft accident reports relating to U.S. civil and foreign aviation operations during calendar year 1989. The approximately 200 general aviation and air carrier accidents contained here represent a random selection. The facts, conditions, circumstances, and probable causes for each accident are given. Author

N92-17149# Federal Aviation Administration, Atlantic City, NJ.
EFFECTIVENESS OF AN ONBOARD WATER SPRAY SYSTEM DURING AN OXYGEN ENRICHED CABIN FIRE
TIMOTHY MARKER and BRUCE DOWNIE (Rutgers Univ., New Brunswick, NJ.) Dec. 1991 33 p
(DOT/FAA/CT-TN91/51) Avail: NTIS HC/MF A03

Three full-scale fire tests were conducted in a modified DC-10 fuselage to determine the effectiveness of an onboard water spray system in reducing the hazardous effects of an oxygen enriched postcrash cabin fire. Two fuel fire tests were conducted in which pressurized oxygen was introduced into the cabin interior in the vicinity of a pool fire which was adjacent to a fuselage opening. Water was sprayed throughout the cabin during some of the two oxygen fed fire tests in order to determine the benefits of using an onboard spray system. For comparison, a third test was performed using the identical pool fire adjacent to the fuselage opening without the introduction of oxygen into the cabin in order to establish 'baseline' data. The interior of the fuselage was realistically furnished in the area adjacent to the fuel and was fully instrumented to measure the various fire hazards. Temperature profiles, smoke levels, gas concentrations and heat flux were monitored throughout the fuselage during the tests. Photographic and video recordings visually documented the progress of the fire. The results showed the water spray to be an effective method for increasing the chances of survival in the event of an oxygen enriched fire by significantly prolonging the period of time that the cabin environment remains habitable. Author

N92-17213# National Transportation Safety Board, Washington, DC.
AIRCRAFT ACCIDENT REPORT: NORTHWEST AIRLINES, INC., FLIGHTS 1482 AND 299. RUNWAY INCURSION AND COLLISION, DETROIT METROPOLITAN/WAYNE COUNTY AIRPORT, ROMULUS, MICHIGAN, DECEMBER 3, 1990
25 Jun. 1991 178 p
(PB91-910405; NTSB/AAR-91/05) Avail: NTIS HC/MF A09; paper copy also available on Standing Order, deposit account required (Minimum deposit $100 US, Canada, and Mexico; all others $200). Single copies also available in paper copy or microfiche CSCL 01/3

The runway collision of two Northwest Airlines aircraft on a runway at the Detroit Metropolitan/Wayne County Airport, Romulus, Michigan, on December 3, 1990 is explained. The safety issues discussed are airport marking and lighting, cockpit resource management, air traffic control procedures in low visibility conditions, flight attendant procedures during evacuations, and the design of the DC-9 tailcone emergency release system. Safety recommendations concerning these issues were made to the Federal Aviation Administration, the Detroit Metropolitan/Wayne County Airport, and Northwest Airlines, Inc. Author

N92-17217# Naval Postgraduate School, Monterey, CA.
ESCAPE STRATEGIES FOR TURBOPROP AIRCRAFT IN A MICROBURST WINDSHEAR M.S. Thesis
RICHARD B. BOBBITT Mar. 1991 247 p
(AD-A243090) Avail: NTIS HC/MF A11 CSCL 01/2

A quantitative analysis was carried out on the performance of turboprop aircraft within a microburst windshear. The objective of the analysis was to provide specific flight procedures for optimal navigation through the windshear. The microburst windshear model uses in the analysis embodied the severe characteristics of the microburst encountered by Delta Flight 191 during an approach to landing at Dallas/Ft. Worth, 2 Aug. 1985. Different escape strategies were tested using the flight performance characteristics of the U.S. Navy's P-3 'Orion' and T-44 'Pegasus' aircraft. The three flight phases investigated were approach to landing, takeoff, and the low altitude ASW mission. Results from the analysis were coupled with the pilot's view point from which conclusions were drawn. The results of the analysis support a constant-pitch-angle escape procedure. The same procedural steps can be used for both aircraft in any configuration or situation with the difference being the degree of pitch to employ. The conclusions are in a format for integrating specific microburst escape procedures within the NATOPS programs for the P-3 and T-44. GRA

N92-17259# Beltran, Inc., Brooklyn, NY.
DEVELOPMENT OF FUEL NEUTRALIZING AGENTS TO PREVENT FLASHBACK ON AIRCRAFT FIRES Final Report, Aug. 1987 - Sep. 1989
MICHAEL R. BELTRAN and CONSTANCE SIMO May 1991 178 p
(Contract F08635-87-C-0302)
(AD-A242828; AFESC/ESL-TR-90-60) Avail: NTIS HC/MF A09 CSCL 21/4

The object of this study was to explore chemical modification of extinguishants currently used against postcrash fuel fed fires to inhibit reignition, i.e., improve 'burnback' control, without compromising the efficacy of flame knockdown. A formulation was developed as an additive to AFFF, for delivery during fire extinguishment which succeeded in 16-inch laboratory trials, but not to the same extent in 6-foot field tests. Several causes were considered and reformulation recommended. Three other approaches, each with formulations, also showed potential for significant reduction of fuel reignition if administered subsequent to flame knockdown by AFFF. One permits resealing by AFFF, another, instant emulsification of water and JP-4, and a third, gelling of the fuel. GRA

N92-17478# Dayton Univ., OH.
EXPLICIT FINITE ELEMENT METHOD FOR TRANSPARENCY IMPACT ANALYSIS Final Technical Report, Sep. 1988 - Sep. 1990
R. A. BROCKMAN and T. W. HELD Jun. 1991 176 p
(Contract F33600-88-D-0414)
(AD-A243527; UDR-TR-90-114; WL-TR-91-3006) Avail: NTIS HC/MF A09 CSCL 01/2

This report documents new analytical methods for the solution of soft-body impact problems, including birdstrike. The approach is based on explicit finite element techniques which allow for very detailed material modeling and make efficient use of the current generation of supercomputers. The most important improvements in the present work over previous efforts are in the areas of soft-body impact loading, material modeling, and treatment of layered wall constructions. Impact loads are obtained directly by including the impacting body in the finite element model, eliminating the need for ad hoc loading models. Both the transparency and the soft body materials may be rate-sensitive, exhibit nonlinear bulk behavior, and may fail during the finite element solution. Methods have been developed to make commercial graphics software (PATRAN) deal correctly with failed elements for results output. An improved model of laminated shells is included in the plate and shell element so that each layer of a multilayered transparency need not be modeled with distinct elements, even when soft interlayers are present. The methods described have been implemented in an explicit finite element code X3D. User and programmer information are included in the report as appendices. Applications described in the report include two standard test problems and an F-16 birdstrike simulation. GRA

N92-17587# Wichita State Univ., KS. National Inst. for Aviation Research.
PROGRAM PLANS: AVIATION SAFETY RESEARCH
WILLIAM H. WENTZ and JOHN J. HUTCHINSON Dec. 1991 40 p
(Contract DTFA03-90-C-00050)
(NIAR-91-30) Avail: NTIS HC/MF A03

In the event of an engine failure, provision for containment of

moving parts is desired to prevent secondary damage of structural members and aircraft mechanical systems including possible damage to adjacent engines. This problem was addressed by large engine manufacturers to various degrees and with various analysis procedures. Currently, the wide variety of approaches in use, combined with the absence of a data base of experimental results, make the problem of developing certification standards difficult. The research collected, analyzed, and organized information on design procedures for rotor containment and the effectiveness of designs. The objective was to enable development of the most appropriate and workable standards possible. The specific elements of this study included: (1) reviewing current FAA regulations or standards addressing rotor containment; (2) reviewing existing literature on design for containment, reports of accident investigations, and test stand engine failure data; (3) contacting engine manufacturers and determining what design methods are currently employed and propulsion departments of airframe manufacturers to determine containment problems; (4) assessing effectiveness of computational codes for realistically predicting containment capabilities; and (5) presenting results of this study in a format designed to guide the development of certification standards. Author

N92-17985*# Massachusetts Inst. of Tech., Cambridge. Flight Transportation Lab.

AN INVESTIGATION OF AIR TRANSPORTATION TECHNOLOGY AT THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY, 1990-1991

ROBERT W. SIMPSON *In* NASA. Langley Research Center, Joint University Program for Air Transportation Research, 1990-1991 p 3-9 Dec. 1991

Avail: NTIS HC/MF A09 CSCL 01/3

Brief summaries are given of research activities at the Massachusetts Institute of Technology (MIT) under the sponsorship of the FAA/NASA Joint University Program. Topics covered include hazard assessment and cockpit presentation issues for microburst alerting systems; the situational awareness effect of automated air traffic control (ATC) datalink clearance amendments; a graphical simulation system for adaptive, automated approach spacing; an expert system for temporal planning with application to runway configuration management; deterministic multi-zone ice accretion modeling; alert generation and cockpit presentation for an integrated microburst alerting system; and passive infrared ice detection for helicopter applications. Author

N92-17986*# Massachusetts Inst. of Tech., Cambridge. Dept. of Aeronautics and Astronautics.

EXPERIMENTAL INVESTIGATION OF PASSIVE INFRARED ICE DETECTION FOR HELICOPTER APPLICATIONS

ADAM DERSHOWITZ and R. JOHN HANSMAN, JR. *In* NASA. Langley Research Center, Joint University Program for Air Transportation Research, 1990-1991 p 11-18 Dec. 1991 Previously announced in IAA as A91-19402

(Contract NAG3-927)

Avail: NTIS HC/MF A09 CSCL 01/3

A technique is proposed to remotely detect rotor icing on helicopters. Using passive infrared (IR) thermometry, it is possible to detect the warming caused by latent heat released as supercooled water freezes. During icing, the ice accretion region on the blade leading edge will be warmer than the uniced trailing edge, resulting in a chordwise temperature profile characteristic of icing. Preliminary tests were conducted on a static model in the NASA Icing Research Tunnel for a variety of wet (glaze) and dry (rime) ice conditions. The characteristic chordwise temperature profiles were observed with an IR thermal video system and confirmed with thermocouple measurements. A prototype detector system was built consisting of a single point IR pyrometer. Experiments were run on a small scale rotor model. Again, the characteristic chordwise temperature profiles were observed during icing, and the IR system was able to remotely detect icing. Based on the static and subscale rotor tests, the passive IR technique is promising for rotor ice detection. Author

N92-17987*# Massachusetts Inst. of Tech., Cambridge. Dept. of Aeronautics and Astronautics.

DETERMINISTIC MULTI-ZONE ICE ACCRETION MODELING

K. YAMAGUCHI, R. JOHN HANSMAN, JR., and MICHAEL KAZMIERCZAK (Cincinnati Univ., OH.) *In* NASA. Langley Research Center, Joint University Program for Air Transportation Research, 1990-1991 p 19-28 Dec. 1991 Previously announced in IAA as A91-19209 Sponsored in part by NSF

(Contract NAG3-666; NGL-22-009-640)

Avail: NTIS HC/MF A09 CSCL 01/3

The focus here is on a deterministic model of the surface roughness transition behavior of glaze ice. The initial smooth/rough transition location, bead formation, and the propagation of the transition location are analyzed. Based on the hypothesis that the smooth/rough transition location coincides with the laminar/turbulent boundary layer transition location, a multizone model is implemented in the LEWICE code. In order to verify the effectiveness of the model, ice accretion predictions for simple cylinders calculated by the multizone LEWICE are compared to experimental ice shapes. The glaze ice shapes are found to be sensitive to the laminar surface roughness and bead thickness parameters controlling the transition location, while the ice shapes are found to be insensitive to the turbulent surface roughness. Author

N92-17988*# Massachusetts Inst. of Tech., Cambridge. Dept. of Aeronautics and Astronautics.

ALERT GENERATION AND COCKPIT PRESENTATION FOR AN INTEGRATED MICROBURST ALERTING SYSTEM

CRAIG WANKE and R. JOHN HANSMAN, JR. *In* NASA. Langley Research Center, Joint University Program for Air Transportation Research, 1990-1991 p 29-39 Dec. 1991 Previously announced in IAA as A91-19207

(Contract NGL-22-009-640; BARR-10-119)

Avail: NTIS HC/MF A09 CSCL 01/3

Alert generation and cockpit presentation issues for low level wind shear (microburst) alerts are investigated. Alert generation issues center on the development of a hazard criterion which allows integration of both ground based and airborne wind shear detection systems to form an accurate picture of the aviation hazard posed by a particular wind shear situation. A methodology for the testing of a hazard criteria through flight simulation has been developed, and has been used to examine the effectiveness and feasibility of several possible criteria. Also, an experiment to evaluate candidate graphical cockpit displays for microburst alerts using a piloted simulator has been designed. Author

N92-17990*# Ohio Univ., Athens. Avionics Engineering Center.

INVESTIGATION OF AIR TRANSPORTATION TECHNOLOGY AT OHIO UNIVERSITY, 1990-1991

ROBERT W. LILLEY *In* NASA. Langley Research Center, Joint University Program for Air Transportation Research, 1990-1991 p 51-54 Dec. 1991

Avail: NTIS HC/MF A09 CSCL 01/3

The status of the Joint University Program is given. Brief synopsis of some areas of research follow. The study of spectrum efficient methods for transmitting weather information to aircraft has resulted in definition of an improved amplitude and phase modulation process which permits reutilization of voice channels for both voice and data. The system is being implemented for testing. Multisensor navigation systems introduce increased flexibility and performance for aviation, at the expense of increased complexity. Insuring a high level of system reliability and integrity requires that faults not only be detected, but also isolated to specific elements, so that the remaining capabilities of the system may be used with confidence. An algorithm was developed. The JUP has served as a vehicle for reporting work accomplished in evoked potential vision tracking experiments to determine the engineering parameters of this input and control method. Application of GPS in an interferometric mode permits accurate measurement of differential motion; aircraft attitude may be determined using GPS only, with multiple antennas. Author

N92-17995*# Princeton Univ., NJ. Dept. of Mechanical and Aerospace Engineering.
INVESTIGATION OF AIR TRANSPORTATION TECHNOLOGY AT PRINCETON UNIVERSITY, 1990-1991
ROBERT F. STENGEL *In* NASA. Langley Research Center, Joint University Program for Air Transportation Research, 1990-1991 p 103-112 Dec. 1991
Avail: NTIS HC/MF A09 CSCL 01/3

The Air Transportation Technology Program at Princeton University is a program that emphasizes graduate and undergraduate student research. The program proceeded along six avenues during the past year: microburst hazards to aircraft, intelligent failure tolerant control, computer-aided heuristics for piloted flight, stochastic robustness of flight control systems, neural networks for flight control, and computer-aided control system design. Author

N92-17996*# Princeton Univ., NJ. Dept. of Mechanical and Aerospace Engineering.
TARGET PITCH ANGLE FOR THE MICROBURST ESCAPE MANEUVER
SANDEEP S. MULGUND *In* NASA. Langley Research Center, Joint University Program for Air Transportation Research, 1990-1991 p 113-125 Dec. 1991
Avail: NTIS HC/MF A09 CSCL 01/3

The objective of this study was to investigate the constant pitch attitude strategy as a possible non-precision maneuver for recovery from inadvertent wind shear encounters. The Wind Shear Training Aid published by the FAA recommends that upon encountering a severe wind shear, the pilot should apply maximum thrust and rotate the aircraft to an initial pitch target angle of 15 degrees. The 15 degrees target was identified through rigorous analyses using six-degree-of-freedom flight simulators and microburst models representative of actual accident cases. It was found that 15 degrees was an effective target for a wide range of shears, and was generally applicable to most jet transports. This work was undertaken to examine the issue of recovery performance in wind shear of other classes of aircraft - notably turboprop commuters and propeller-driven general aviation planes. It should be possible to postulate a target pitch angle (TPA) for such aircraft, as well. Author

N92-17999*# Cornell Univ., Ithaca, NY.
OPTIMAL AIRCRAFT PERFORMANCE DURING MICROBURST ENCOUNTER
MARK L. PSIAKI and ROBERT F. STENGEL (Princeton Univ., NJ.) *In* NASA. Langley Research Center, Joint University Program for Air Transportation Research, 1990-1991 p 155-161 Dec. 1991 Previously announced in IAA as A91-29787
(Contract NGL-31-001-252)
Avail: NTIS HC/MF A09 CSCL 01/3

The effects of microburst characteristics on the optimal penetration performance of jet transport and general aviation aircraft are presented. The purpose is to determine the best possible performance that can be achieved in a broad range of microbursts. A secondary goal is to illustrate good strategies for dealing with a range of microbursts during takeoff and landing. Over 1100 optimal trajectories were computed for two aircraft types flying through idealized microbursts using a Successive Quadratic Programs trajectory optimization algorithm. Contours of safety metrics are plotted as functions of the length scales, magnitudes, and locations of horizontal wind shears and vertical downdrafts. These performance contours show three length-scale regimes for optimal microburst penetration. At short length scales, hazards usually associated with gustiness predominate (e.g., high normal load factor, rotational upset). At intermediate length scales, a degraded ability to maintain flight path and/or vertical velocity poses the most serious threat. At very long microburst length scales, excessive touchdown velocities may result. The ability to transit a microburst successfully also varies strongly with microburst location. The results show that both aircraft types could penetrate some very severe microbursts if optimal control histories were followed. Nevertheless, these control strategies assume perfect prior knowledge of the wind, and practical limits to successful encounter with real-time control capabilities would be lower. The optimally controlled jet transport can successfully penetrate higher intensity microbursts than can the general aviation aircraft. Author

04

AIRCRAFT COMMUNICATIONS AND NAVIGATION

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

A92-21325
REPORT OF THE WORKING GROUP FUTURE CNS SYSTEMS - APPLICATIONS AND IMPACT ON THE GERMAN AIR TRANSPORT SYSTEM [BERICHT DER ARBEITSGRUPPE ZUKUENFTIGE CNS-SYSTEME - ANWENDUNGEN UND AUSWIRKUNGEN AUF DAS DEUTSCHE LUFTVERKEHRSSYSTEM]
H. MENSEN, J.-U. KOCH, and R. SCHWENK (Deutsche Lufthansa AG, Frankfurt am Main, Federal Republic of Germany) Ortung und Navigation (ISSN 0474-7550), no. 3, 1991, p. 275-478. In German. refs

The activities of the working group Future CNS Systems in its study of the German air transport system are reviewed. The group's investigation of the state of air safety infrastructure is addressed, and planning activities of the Future Air Navigation Systems organization and international organizations such as ICAO and Eurocontrol are examined. The working group's hierarchy of goals is discussed in detail. An investigation of the promising 'Secondary Radar Mode S' and satellite-supported navigation systems for the German air transport system is reviewed, and an evaluation of the two systems is presented. C.D.

A92-21466
GPS INTEGRATED SYSTEM APPLICATION IN AIRCRAFT APPROACH LANDING
XIN YUAN, JIANYE LIU, and YONGXI NI (Nanjing Aeronautical Institute, People's Republic of China) Nanjing Aeronautical Institute, Journal (ISSN 1000-1956), vol. 23, Dec. 1991, p. 1-8. In Chinese. refs

This paper investigates the potential of using a GPS/SINS/RA integrated system for precise aircraft landings. An integrating scheme is presented, and the dynamic model is established with the application of the Kalman-filter technique. The simulation for the integrated-system performance is carried out, using a GPS simulator, considering a guide-slope inclination of 3 deg for aircraft landings. Simulation results indicate that the GPS/SINS/RA integrated system can satisfy the requirements of positioning accuracy for precision approach landing as specified by ICAO on the condition that the GPS receiver use the P code or the C/A code and works in the differential mode aided by pseudo-satellite technology. Author

A92-21683
PROCESSING AND DISPLAYING RADIO NAVIGATION DATA [OBRABOTKA I OTOBRAZHENIE RADIONAVIGATSIONNOI INFORMATSII]
LEONID S. BELIAEVSKII, VLADIMIR S. NOVIKOV, and PETR V. OLIANIUK Moscow, Izdatel'stvo Radio i Sviaz', 1990, 232 p. In Russian. refs
Copyright

State-of-the-art methods of processing and displaying radio navigation data and the principal data processing algorithms used in radio navigation systems are reviewed. Topics discussed include the selection and grouping of information parameters in radio navigation systems; spatial-temporal processing of radio navigation data; multiprocessor computer systems for solving navigation problems; and monitoring of the technical condition of radio

navigation systems. Consideration is also given to the psychological aspects of data perception and navigation data display systems. V.L.

A92-22087
THE STUDY OF CONSTANT VALUE THRESHOLDS OF FDI IN STRAPDOWN INERTIAL NAVIGATION
GUANG-QU YI (Beijing University of Aeronautics and Astronautics, People's Republic of China) and FEN WU (Chinese Aeronautical Radio Electronics Research Institute, Shanghai, People's Republic of China) IN: Symposium Gyro Technology 1990, Stuttgart, Federal Republic of Germany, Sept. 25, 26, 1990, Proceedings. Stuttgart/Duesseldorf, Federal Republic of Germany, Universitaet Stuttgart/Deutsche Gesellschaft fuer Ortung und Navigation, 1990, p. 2.0-2.13. refs

A parity vector is used to determine the reliability of the Strapdown Inertial Navigation System. Based on the generalized likelihood test, a group of parity equations is deduced and a parity vector irrelevant to flight attitude is obtained. The Kalman filter method is used to estimate and compensate for the errors affecting parity vector, and the compensated parity vector is employed to detect and isolate faults in the redundant system. The constant threshold is used to detect and isolate instrument faults. As the threshold value is small and constant, it lowers the level of soft failures of the redundant system that can be detected, which overcomes many weaknesses of dynamic threshold, effectively lowers failure probability, and enhances the system's failure detection ability. C.A.B.

A92-22088
THE LISA 6000 - A HIGHLY INTEGRATED IRS/GPS NAVIGATION SYSTEM
T. K. ALLEN (Litton Italia S.p.A., Pomezia, Italy) and W. G. DALZELL IN: Symposium Gyro Technology 1990, Stuttgart, Federal Republic of Germany, Sept. 25, 26, 1990, Proceedings. Stuttgart/Duesseldorf, Federal Republic of Germany, Universitaet Stuttgart/Deutsche Gesellschaft fuer Ortung und Navigation, 1990, p. 3.0-3.20.

This paper reports on the strategy for the development of a fully Schuler tuned IRS system, with an embedded 5 channel PPS GPS receiver in VLSI technology, and the design approach which was chosen for the integration. The results of the simulation work are discussed as well as relevant system tests completed on the prototype systems. The paper concludes that the results obtained demonstrate that high performance under dynamics can be achieved in a tightly coupled, physically integrated unit weighting less than 10 kg and consuming less than 70 W. Author

A92-23296
POTENTIAL IMPACT OF FANS - FAR-REACHING AND POSITIVE
N. J. G. OSTIGUY (International Civil Aviation Organization, Air Navigation Bureau, Montreal, Canada) ICAO Journal (ISSN 0018-8778), vol. 46, Dec. 1991, p. 7-9.
Copyright

The Future Air Navigation System (FANS) is discussed in terms of its capabilities for communications, navigation, and surveillance (CNS) as well as air-traffic management (ATM). Reference is given to interoperability with existing navigation-satellite systems such as Glonass and the Inmarsat for the support of aeronautical mobile communications. An implementation plan for the FANS concept is outlined with specific attention given to present designs related to the CNS/ATM system. The adoption of FANS is intended to be evolutionary since it requires major changes to the existing CNS and ATM environments. A timetable is proposed for FANS implementation between the present and 2015 that allows for a gradual transition and the dismantling of redundant or unnecessary systems. The FANS system can provide enhanced traffic safety, more precise ATM, and an increase in airspace capacity. C.C.S.

A92-23297
TRANSITION TO COOPERATIVE ATM SYSTEM REQUIRES COMMITMENT
G. A. PAULSON (Civil Aviation Authority, National Air Traffic Services, London, England) ICAO Journal (ISSN 0018-8778), vol. 46, Dec. 1991, p. 10-13.
Copyright

The incompatibility of existing European ATC systems is emphasized to argue the necessity for an improved air-traffic management (ATM) system and the conditions for successful implementation. An enhanced system for several countries suggests the existence of compatible engineering systems and interfaces, standardized operating procedures, and political commitment to integration of ATC systems into one ATM scheme. A strategy for the implementation phase is described called the Enhanced ATM and Mode-S Implementation in Europe which exploits air-ground digital-data-interchange technology to provide a closely coupled air-ground environment. C.C.S.

A92-23298
FANS IMPLEMENTATION PLANNING UNDER WAY IN CANADA
RON NORTH (Transport Canada, Aviation Group, Ottawa) ICAO Journal (ISSN 0018-8778), vol. 46, Dec. 1991, p. 22, 23.
Copyright

The transition to the Future Air Navigation System (FANS) in Canada is described both in terms of the related activities and their potential benefits. A VHF-based air-ground data link is described which presently incorporates an electronic readback for comparison with automated ATC data. The VHF data link can also support automatic dependent surveillance which is being developed to enhance the northern airspace display system as required for the FANS project. The Canadian automated air-traffic system is also identified as an efficient and cost-effective addition to support the FANS network. C.C.S.

A92-23967
REFLECTIONS OFF AIRCRAFT AND THE SHAPE OPTIMIZATION OF A RIDGED WAVEGUIDE
S. R. H. HOOLE and SAKUNTHALA SIRIKUMARAN (Harvey Mudd College, Claremont, CA) (IEEE Biennial Conference on Electromagnetic Field Computation, 4th, Toronto, Canada, Oct. 22-24, 1990) IEEE Transactions on Magnetics (ISSN 0018-9464), vol. 27, Sept. 1991, p. 4150-4153. Research supported by Southern California Edison Center for Excellence in Electrical Systems. refs
Copyright

The analysis of TE and TM waves traveling down a guide is a well-known art. However, it is the inverse problem that is more relevant in industrial design. That is, for a given cut-off frequency or attenuation limit, to synthesize the guide. The methodology for solving this inverse problem is laid down and demonstrated using a ridged guide as example. The procedure relies on defining an object function and minimizing it using its gradients with respect to the parameters of design interest. I.E.

A92-23984
FINITE ELEMENT ANALYSIS OF LARGE WAVELENGTH ANTENNA RADOME PROBLEMS FOR LEADING EDGE AND RADAR PHASED ARRAYS
MARK J. POVINELLI (GE Aerospace, Utica, NY) and JOHN D'ANGELO (General Electric Co., Schenectady, NY) (IEEE Biennial Conference on Electromagnetic Field Computation, 4th, Toronto, Canada, Oct. 22-24, 1990) IEEE Transactions on Magnetics (ISSN 0018-9464), vol. 27, Sept. 1991, p. 4299-4302. refs
Copyright

A method for determining the RF performance from antenna radome configurations based on a frequency-domain finite-element method is presented. The application of this analysis on the design of antenna arrays in aircraft leading edges and radar radomes is discussed. The modeled antenna array elements can be driven with arbitrary amplitude and phase weighting for sidelobe tapering and phased steering of the pattern. The understanding of near-field radiation and coupling interactions is an important design aid.

Physical phenomena such as resonances are observed in the predicted near-field results. I.E.

N92-15980# Computer Resource Management, Inc., Herndon, VA.
MONITORING OPERATIONAL CONCEPT
WILLIAM TRENT, THOMAS PICKERELL, and HAROLD NELSON, JR. Oct. 1991 46 p
(Contract DTFA01-91-Y-01004)
(DOT/FAA/SE-91/3; NAS-SR-133) Avail: NTIS HC/MF A03

A requirement for the National Airspace System (NAS) is to provide a variety of monitoring services to its users, as identified in the NAS System Requirement Specification (NASSRS). This document presents a concept of operations for monitoring. It describes monitoring capabilities and shows the relationships between subsystems, facilities, information, and operators/users. It is intended to provide a common perspective for personnel involved in monitoring services, assist in determining whether monitoring procedures meet formal requirements, and support coordination among the organizations involved. This concept, and the other seven operational concepts, will complete the description o the system requirements as described in the NASSRS. The eight operational concepts are: Communications Navigation; Monitoring Maintenance and System Effectiveness; Air Defense; Flight Planning; and Traffic Control and Airspace Management. Author

N92-15981# Federal Aviation Administration, Atlantic City, NJ.
VALIDATION AND VERIFICATION FLIGHT TEST FOR TCAS-2 LOGIC CHANGES (MOPS CHANGE 6) Technical Report, Apr. - Jun. 1989
KATHRYN M. CIARAMELLA and MICHAEL C. PETRI Dec. 1991 125 p
(DOT/FAA/CT-TN91/46) Avail: NTIS HC/MF A06

A series of 24 two aircraft encounters were designed and executed to validate and verify the Change 6 Traffic Alert and Collision Avoidance System (TCAS)-II collision avoidance logic of February 1989. These tests were performed with several aircraft equipped with varying configurations of TCAS and Mode C. Technical Center pilots performed all of the logic test encounters. Technical Center and TCAS manufacturer company pilots performed the TCAS coordination test encounters. Industry pilots performed a pilot evaluation of the logic changes through execution of a subset of the encounters. The logic flight tests demonstrated that the computer simulations of the encounters were accurate. The Change 6 logic successfully resolved all tested encounters, including those which would have resulted in 'advisory invalid' enunciations in the Change 5 logic. The pilots generally accepted maneuvers suggested by TCAS as safe and appropriate for the flight geometries. The pilots did suggest improvements to the TCAS display logic, and many of these improvements were incorporated into the final Change 6 logic of September 1989. The encounters have been updated to include all changes included in the final Change 6 logic in the event that additional flight tests are desired. Author

N92-15983# Federal Aviation Administration, Atlantic City, NJ.
JOINT FEDERAL AVIATION ADMINISTRATION (FAA)/CIVIL AVIATION AUTHORITY (CAA) MICROWAVE LANDING SYSTEM (MLS) AREA NAVIGATION (RNAV) FLIGHT EVALUATIONS Technical Note, Sep. 1990
BARRY BILLMANN, MICHAEL MAGROGAN, CLIFFORD MACKIN, and ROBERT PURSEL Aug. 1991 69 p
(Contract FAA-T0707A)
(DOT/FAA/CT-TN91/17) Avail: NTIS HC/MF A04

A series of flight evaluations were conducted to validate recommendations made at the 13th All Weather Operations Panel (AWOP) Meeting of the International Civil Aviation Organization (ICAO). The recommendations addressed permissible Microwave Landing System (MLS) azimuth antenna offsets from the primary runway by permissible parallel secondary runway locations, and the use of standard distance measuring equipment for computed centerline operations. In all cases, flight data validated the recommendations. Additionally, subject pilots expressed strong support for the advanced procedures they flew. Although not an objective of the evaluation, interoperability of MLS equipment manufactured in five different countries was demonstrated. Author

N92-17512*# Douglas Aircraft Co., Inc., Long Beach, CA.
ASSESSMENT OF COCKPIT INTERFACE CONCEPTS FOR DATA LINK RETROFIT Final Report
HUGH W. MCCAULEY, WILLIAM L. MILES, JOHN P. DWYER, and JEFFERY B. ERICKSON Jan. 1992 107 p
(Contract NAS1-18028)
(NASA-CR-187615; NAS 1.26:187615) Avail: NTIS HC/MF A06 CSCL 01/4

The problem is examined of retrofitting older generation aircraft with data link capability. The approach taken analyzes requirements for the cockpit interface, based on review of prior research and opinions obtained from subject matter experts. With this background, essential functions and constraints for a retrofit installation are defined. After an assessment of the technology available to meet the functions and constraints, candidate design concepts are developed. The most promising design concept is described in detail. Finally, needs for further research and development are identified. Author

N92-17568# National Research Council of Canada, Ottawa (Ontario). Inst. for Aerospace Research.
FLIGHT EVALUATION OF CURVED MLS PRECISION APPROACHES IN A TWIN OTTER AIRCRAFT, PHASE 2
J. B. CROLL Jul. 1991 26 p
(AD-A243025; IAR-AN-73; NRC-32149) Avail: NTIS HC/MF A03 CSCL 17/7

Phase 2 flight testing of curved, segmented approaches using a Microwave Landing System (MLS) was conducted on a Twin Otter aircraft belonging to the Canadian National Research Council's Institute for Aerospace Research (IAR). Precision guidance algorithms were developed for approaches with track angle changes exceeding 180 deg. Software development flights focussed on validating these algorithms and enhancing the existing electromechanical flight director to ease the pilot workload in tracking the curved segments. A limited number of pilot evaluations confirmed that with an enhanced lateral flight director, these approaches could be flown satisfactorily regardless of the magnitude of the track angle changes. Observations were made on approach design and wind effects on curved segment tracking. GRA

N92-17707# Department of the Navy, Washington, DC.
METHOD OF GUIDING AN IN-FLIGHT VEHICLE TO A DESIGNED FLIGHT PATH Patent Application
ROGER L. GRAY, inventor (to Navy) 27 Feb. 1991 17 p
(AD-D015061; US-PATENT-APPL-SN-708991;
NAVY-CASE-73256) Avail: NTIS HC/MF A03 CSCL 17/7

This patent application relates generally to guidance techniques and more particularly to a method of guiding an in-flight vehicle from its initial flight path at target acquisition to a desired flight path prior to target interception. A method of using two diverts in combination to guide an in-flight vehicle from its initial flight path at target acquisition to a desired flight path prior to target interception is provided. The two diverts are of known and different magnitudes. The magnitude of an initial projected miss at a closest approach to the target is used to determine the order and timing of the two diverts. At the completion of the second divert, the vehicle is on the desired flight path which may be either a collision or offset course trajectory as required by the vehicle's terminal guidance law. GRA

N92-17844 ESDU International Ltd., London (England).
EXAMPLE OF STATISTICAL TECHNIQUES APPLIED TO AUTOLAND TOUCHDOWN DISPERSION (CONFIDENCE INTERVALS FOR NORMAL AND SKEW DISTRIBUTIONS)
Oct. 1991 11 p

(ESDU-91019; ISBN-0-85679-781-2; ISSN-0141-4054) Avail: ESDU

This data item illustrates certain aspects of statistical analysis introduced in ESDU 91017 applied to autoland touchdown dispersion. Two sets of data are analyzed, one for the standard 3 deg glide slope and one for a STOL glide slope of 7.5 deg with modified control laws. Each set consisted of 1480 points giving frequency of touchdown in various 100 ft intervals from the thresholds. The data are analyzed to establish the mean touchdown distance, the probability of touching down either short or long (200 ft before or 3000 ft beyond the threshold) and the touchdown distance three standard deviations beyond the mean touchdown point. The Chi Squared Test applied to the first set of data shows a high confidence that they are normal, and so the required results are obtained by plotting the percentage cumulative frequency data against touchdown distance using normal probability graph paper. When the Chi Squared Test is applied to the second data set, the confidence in their normality is found to be only 19 pct. A transformation of the data is therefore tried, taking the logarithm of the touchdown distance which greatly increases the confidence in normality established by the Chi Squared Test. ESDU

N92-17994*# Ohio Univ., Athens.
GPS INTERFEROMETRIC ATTITUDE AND HEADING DETERMINATION: INITIAL FLIGHT TEST RESULTS
FRANK VANGRAAS and MICHAEL BRAASCH *In* NASA. Langley Research Center, Joint University Program for Air Transportation Research, 1990-1991 p 79-100 Dec. 1991
(Contract NGR-36-009-017)
Avail: NTIS HC/MF A09 CSCL 17/7

Attitude and heading determination using GPS interferometry is a well-understood concept. However, efforts have been concentrated mainly in the development of robust algorithms and applications for low dynamic, rigid platforms (e.g., shipboard). This paper presents results of what is believed by the authors to be the first realtime flight test of a GPS attitude and heading determination system. The system is installed in Ohio University's Douglas DC-3 research aircraft. Signals from four antennas are processed by an Ashtech 3DF 24-channel GPS receiver. Data from the receiver are sent to a microcomputer for storage and further computations. Attitude and heading data are sent to a second computer for display on a software generated artificial horizon. Demonstration of this technique proves its candidacy for augmentation of aircraft state estimation for flight control and navigation as well as for numerous other applications. Author

05

AIRCRAFT DESIGN, TESTING AND PERFORMANCE

Includes aircraft simulation technology.

A92-21007
SYSTEM-IDENTIFICATION OF AIRPLANES USING THE 'ESTIMATION BEFORE MODELLING' TECHNIQUE
K.-O. PROSKAWETZ (Deutsche Automobilgesellschaft, Brunswick, Federal Republic of Germany) Zeitschrift fuer Flugwissenschaften und Weltraumforschung (ISSN 0342-068X), vol. 15, Dec. 1991, p. 401-407. In German. refs
(Contract DFG-SFB-212)
Copyright

The 'estimation before modeling' method has been applied here for system-identification of a twin engine propeller aircraft using a multipoint model with six degrees of freedom. This method has essential advantages compared to system-identification using complete simulation models and allows even the identification of comprehensive and complex models by reasonable computer effort. Author

A92-21010
BERIEV BE-42 - A UNIQUE JET-PROPELLED SEAPLANE [BERIEV BE-42 - EINZIGES STRAHLFLUGBOOT DER WELT]
ULRICH WILKE Luft- und Raumfahrt (ISSN 0173-6264), vol. 12, Nov.-Dec. 1991, p. 26, 27. In German.
Copyright

A technical evaluation is given of the Soviet flying boat Beriev Be-42. The overall design and the construction of the Be-42 are described. The tasks of the Be-42 are briefly addressed. C.D.

A92-21011
AIRBUS A340 - THE FIRST PHASE OF FLIGHT TESTING [AIRBUS A340 - ERSTE PHASE DER FLUGERPROBUNG]
Luft- und Raumfahrt (ISSN 0173-6264), vol. 12, Nov.-Dec. 1991, p. 28-30. In German.
Copyright

The successful first phase of flight testing of the Airbus A340 is briefly reviewed. Stall tests, vibration tests, and lightning strike tests are reviewed. The performance of onboard equipment during these tests is described. C.D.

A92-21013
TECHNOLOGY FOR TOMORROW - DO 228 WITH LAMINAR WINGS [TECHNOLOGIE FUER MORGEN - DO 228 MIT LAMINARFLUEGEL]
Luft- und Raumfahrt (ISSN 0173-6264), vol. 12, Nov.-Dec. 1991, p. 36-41. In German.
Copyright

The development of laminar profiles on the wings of the Do 228 aircraft to reduce the frictional resistance to flight is discussed. The construction and measurement of the 'laminar glove' of the Do 228 are described. Plans for testing the system are examined. C.D.

A92-21312
A THEORY FOR MECHANICAL FLIGHT CONTROL LINKAGES
I. TAPOSU (Institute of Aviation, Bucharest, Romania) Revue Roumaine des Sciences Techniques, Serie de Mecanique Appliquee (ISSN 0035-4074), vol. 36, Sept.-Dec. 1991, p. 305-315. refs

A general theory is presented for the dynamics and kinematics of mechanical flight control linkages. The hypotheses and limitations of the model used are briefly examined, and the reference systems are identified. Calculations are then made of the deflection angles, angular velocities, angular accelerations, and forces along the rods and reactions from the joints. The mathematical model proposed here can be extended to different cases and readily implemented in computer software. V.L.

A92-21470
THE RESPONSE OF A HELICOPTER TO WINDSHEAR
YI ZHANG and XINYU XU (Nanjing Aeronautical Institute, People's Republic of China) Nanjing Aeronautical Institute, Journal (ISSN 1000-1956), vol. 23, Dec. 1991, p. 37-44. In Chinese. refs

The response of a helicopter to windshear is investigated using a logarithmic windshear model. The effect of windshear parameters on helicopter stability roots is analyzed using a linear windshear model. Particular attention is given to the rigid blade flapping motion of an articulated rotor with a blade hinge offset from the center of rotation and a spring about the flap hinge. The trim data, the stability characteristic roots, and the response of the helicopter to windshear for a helicopter model have been calculated. O.G.

A92-21734
CONDOR, AN ALL-ELECTRIC AIRPLANE
Aerospace Engineering (ISSN 0736-2536), vol. 12, Jan. 1992, p. 27-30.
Copyright

The Condor autonomously piloted vehicle (APV) conducts its flight-management functions through digital avionics as it flies a preprogrammed mission stored in its onboard computers. The selection of an all-electric design for this APV was predicated on the often -80 C stratospheric environment, which precluded use

of hydraulic fluids; electromechanical actuators were able to operate very efficiently at these temperatures. Weight savings accrued to the replacement of hydraulic tubing with electrical wiring. The Condor's propulsion-system control is furnished by a control electronics unit which takes input from a variety of sensors to drive seven continuous actuators and a solenoid valve. O.C.

A92-21836
EVOLUTIONARY UPGRADE AND APPLICATION OF THE C-130H SIMPLE-CYCLE REFRIGERATION SYSTEM
DAN MATULICH and RANDY FINSTAD (Allied-Signal Aerospace Co., Torrance, CA) SAE, International Conference on Environmental Systems, 21st, San Francisco, CA, July 15-18, 1991. 13 p. refs
(SAE PAPER 911439) Copyright

This paper addresses evolutionary improvements that have been made to aircraft environmental control system (ECS) equipment, using the C-130 ECS as an example. The paper traces the history of the C-130 aircraft and its variations and describes changes made to the ECS equipment to keep up with increased cooling demand. In particular, the paper discusses improvements to the C-130 simple-cycle refrigeration unit and, to a lesser extent, to the ECS as a whole. These advances have been applied to requirements for upgrading both the basic C-130H airplane and the Special Operations configuration. The ECS improvements involve cooling performance, structural integrity, and reliability/maintainability enhancements. Author

A92-21839
THERMAL MANAGEMENT OF HYPERSONIC AIRCRAFT USING NONCRYOGENIC FUELS
DOUGLAS E. WIESE (McDonnell Aircraft Co., Saint Louis, MO) SAE, International Conference on Environmental Systems, 21st, San Francisco, CA, July 15-18, 1991. 17 p. refs
(SAE PAPER 911443) Copyright

A study has been conducted to establish the Mach number limits of noncryogenic fuels used for manned hypersonic cruise missions. This paper specifically presents results for hydrocarbon fuels similar to JP-7. Both heat sink capacity and propulsive energy properties of the fuels are considered. The analysis approach uses an aircraft sizing program to predict aircraft performance and dynamic thermal models of the aircraft and Thermal Management Systems (TMS) to determine the fuel's ability to meet requirements over the mission profile. Crew station, avionics, secondary power, engine, and aerodynamic heat loads are accounted for in the analysis. The maximum Mach number capability for conventional JP-7 is determined. Thermal properties needed for advanced JP fuels to attain higher Mach numbers are also presented. Author

A92-21925
FLIGHT TEST INVESTIGATION OF THE WAKE VORTICES GENERATED BY HELICOPTERS
KEITH J. BIEHL, STEPHEN A. TEAGER (FAA, Technical Center, Atlantic City, NJ), and JOSEPH J. TYMCZYSZYN (FAA, International Wake Vortex Symposium, Washington, DC, Oct. 29-31, 1991) Cockpit (ISSN 0742-1508), Oct.-Dec. 1991, p. 5-22. refs
Copyright

Helicopter wake vortices were probed by small airplanes to acquire direct assessment of vortex danger as a function of distance behind the generating helicopter. The flight tests were planned to provide data for establishing ATC separation criteria and for comparison with theoretical calculations. Ground based tests indicate a very high vortex hazard from helicopters and therefore imply very large separation distances for safe IFR flight behind rotorcraft. These tests are deemed valid and useful as they represent an accurate duplication and analysis of real-world wake vortex hazards of helicopters in forward flight. R.E.P.

A92-22160*# National Academy of Sciences - National Research Council, Washington, DC.
DEVELOPMENT OF AN IMPROVED MODEL FOR RUNBACK WATER ON AIRCRAFT SURFACES
KAMEL M. AL-KHALIL (National Research Council, Washington, DC), THEO G. KEITH, JR., and KENNETH J. DE WITT (Toledo, University, OH) AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992. 14 p. Research sponsored by U.S. National Research Council and NASA. refs
(AIAA PAPER 92-0042) Copyright

A computer simulation for 'running wet' and evaporative aircraft anti-icing systems is developed. The model is based on the analysis of the liquid water film which forms in the regions of direct impingement and, then, breaks up near the impingement limits into rivulets. The wetness factor distribution resulting from the film breakup and the rivulet configuration on the surface are predicted using a stability analysis theory and the laws of mass energy conservation. The solid structure is modeled as a multiple layer wall. The anti-icing system modeled is of the thermal type utilizing hot air and/or electrical heating elements embedded within the wall layers. Experimental observations revealing some of the basic physics of the water flow on the surface are presented. Detailed qualitative documentation of the tests are given. Several numerical examples are considered, and the effect of some of the involved parameters on the system performance are investigated. Author

A92-22472
A PARAMETRIC STUDY OF THE AEROELASTIC STABILITY OF A BINARY WING-WITH-ENGINE NACELLE FLUTTER SYSTEM IN INCOMPRESSIBLE FLOW
H. FOERSCHING and A. SENFT (DLR, Institut fuer Aeroelastik, Goettingen, Federal Republic of Germany) Aeronautical Journal (ISSN 0001-9240), vol. 95, Dec. 1991, p. 359-369. refs
Copyright

A systematic parametric investigation of the flutter behavior of a binary wing-with-engine nacelle system in inviscid incompressible flow is performed. The equations of motion in coupled bending and torsion are initially set up and the aerodynamic model for the calculation of the motion-induced unsteady airloads is described. The aeroelastic stability equations are then derived in non-dimensional form and the procedure used for the numerical solution of these equations is outlined. For a typical large commercial aircraft configuration, numerical results are presented for a variety of systematic parameter variations with special emphasis on the effects of the location of the elastic axis and the motion-induced unsteady airloads on the engine nacelle. Author

A92-22473
INTERNATIONAL STANDARDISATION OF REGULATIONS FOR GUST LOADING CALCULATIONS
J. M. SAUCRAY, C. ARTIGUES, G. SQUEGLIA (Aerospatiale, Toulouse, France), and J. GUILLOT (Toulouse, Institut National des Sciences Appliquees, France) Aeronautical Journal (ISSN 0001-9240), vol. 95, Dec. 1991, p. 370-378. refs
Copyright

Calculation methods are presented for the preliminary dimensioning, substantiation, and certification of aircraft for gust loading airworthiness, as well as for the assessment of advancements made in recent years on the bases of aircraft response studies and comparisons of their results with calculated loads. The current international regulatory requirements are broadly directed toward standardization, thanks to the insistence of both the airworthiness authorities and the aeronautical industry. Attention is given to the airworthiness-discrete tuned gust method. O.C.

A92-22474
GUST EFFECTS ON A FLEXIBLE AIRCRAFT
P. SANTINI and P. GASBARRI (Roma I, Universita, Rome, Italy) Aeronautical Journal (ISSN 0001-9240), vol. 95, Dec. 1991, p. 379-384. refs
Copyright

An investigation is conducted of the influence of the structural stiffness of aircraft on their response to atmospheric turbulence, comparing unsteady and quasi-steady aerodynamics. Attention is given to the power spectral density approach, for which the turbulence power spectrum must be given; aircraft response is then evaluated via the classical theory of random vibrations. Pade's

approximation, the integral equation of motion, is noted to be reducible to a differential system which is more computationally tractable. O.C.

A92-22709
RELATING ECONOMICS TO DESIGN PARAMETERS THROUGH A CRITERION FUNCTION
DANIEL P. SCHRAGE (Georgia Institute of Technology, Atlanta) Vertiflite (ISSN 0042-4455), vol. 38, Jan.-Feb. 1992, p. 24-27. refs
Copyright

The 'productivity index' and 'utilization' criteria can be included in a criterion function in order to relate economics to design parameters. The weights assigned to these criteria should evolve from the first two steps of the decision support process. On the basis of recently observed civil and military sector emphasis, more weight is likely to be given to the utilization criterion and to its relationship to direct operating costs. A flowcharted breakdown is presented for the relationships among the criteria and design parameters. O.C.

A92-22710
MCDONNELL DOUGLAS' NEW LIGHT TWIN HELICOPTER - THE MDX
DEAN C. BORGMAN (McDonnell Douglas Helicopter Co., Mesa, AZ) Vertiflite (ISSN 0042-4455), vol. 38, Jan.-Feb. 1992, p. 28-30.
Copyright

The MDX helicopter has been designed through the use of CADAM techniques based on the UG II system. UG II is shared by a world-wide network of MDX subcontractors which communicate directly with each others' computers. A critically important feature of UG II is its Electronic Development Fixture, which replaces the conventional engineering mockup with computer memory-stored design data; this enables project engineers to assemble all components that are fully surfaced in three dimensions in order to ascertain how they fit. This feature also allows verification of whether maintenance personnel can look into the helicopter to conduct the requisite inspections. O.C.

A92-22712
COLD-CYCLE PRESSURE-JET HELICOPTERS - VENTURES, DESIGNS, AND DEVELOPMENTS. II - DESIGN
EUGENE K. LIBERATORE Vertiflite (ISSN 0042-4455), vol. 38, Jan.-Feb. 1992, p. 67-80.
Copyright

Propulsion-system configurational and performance details are presented from four major efforts to develop compressor discharge-driven 'cold-cycle' tipjet helicopters. These propulsion systems were based on either the free-shaft output of turboprop engines (whose exhaust jet could be used for yaw control), or turbine-engine compressor bleed. Attention is given to inlet guide-vane control of compressor loading, the rotor-head configuration and blade-retention system, and hollow (internally pressurized) rotor blade designs of both Al-alloy and composite laminate type. O.C.

A92-23768*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
EXPERIMENTAL STUDY OF PYLON GEOMETRIES FOR TRANSPORT AIRCRAFT
DINESH A. NAIK (Vigyan, Inc., Hampton, VA), ANTHONY M. INGRALDI, and ODIS C. PENDERGRAFT, JR. (NASA, Langley Research Center, Hampton, VA) AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992. 14 p. refs
(Contract NAS1-17919)
(AIAA PAPER 92-0153) Copyright

Pylon cross-sectional geometries that are intended to reduce propulsion system installation drag were investigated on a 1/17th-scale low-wing transport model in the NASA Langley 16-Foot Transonic Tunnel. The basic design philosophy for these pylons was to alleviate flow acceleration without introducing severe adverse pressure gradients near the pylon/wing junction. This was achieved by means of a gradually, diverging pylon with maximum thickness occurring at the wing trailing edge. The pylon closure occurs aft of the wing trailing edge. The force, surface pressure and surface flow visualization data obtained support this concept. Author

A92-23781#
A FLIGHT TEST STUDY TO DETERMINE AIRCRAFT PROPULSIVE EFFICIENCY AND AERODYNAMIC DRAG USING TWO PARAMETER IDENTIFICATION METHODS AND LOCK'S PROPELLER MODEL
TERRY TAYLOR, GEORGE BENNETT, DONNA COBLE, KENNETH HALL, and PHILIP BRIDGES (Mississippi State University, Mississippi State) AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992. 16 p. refs
(AIAA PAPER 92-0170) Copyright

Two parameter identification techniques have been developed to extract and predict aircraft performance characteristics from steady state flight test data. One method uses a simple gradient search technique, while the other uses an extended Kalman filter technique to process flight test data. Both methods use Lock's propeller model to determine propeller thrust. The parameters identified by these techniques include five curve fit coefficients to describe the propeller thrust along with the Oswald efficiency factor and the zero lift drag coefficient. A comparison of the method using data from level speed-power and constant blade angle flight test maneuvers show that the Kalman technique converges more rapidly for computer-generated data and that both methods have convergence problems in the propeller drag terms when actual flight test data are used. C.D.

A92-23782#
IDENTIFICATION OF AERODYNAMIC EFFECTIVENESS AND INTERFERENCE EFFECTS OF DIRECT-LIFT-CONTROL FLAPS FROM FLIGHT DATA
R. V. JATEGAONKAR (DLR, Institut fuer Flugmechanik, Brunswick, Federal Republic of Germany) AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992. 10 p. refs
(Contract DFG-SFB-212)
(AIAA PAPER 92-0171) Copyright

A maximum likelihood parameter estimation method for nonlinear systems has been applied to flight data of the research aircraft ATTAS. The emphasis is on modeling and identification of: (1) dynamics and nonlinearities of actuation systems for the direct-lift-control flaps, and (2) their aerodynamic effectiveness and other influences. These specially designed flaps provide an additional longitudinal control suitable for in-flight simulation or load alleviation investigations. The identification results indicate that under aerodynamic loads the possible maximum flap deflections are severely limited. The flight estimated aerodynamic characteristics are compared with those predicted by wind tunnel and analytical methods. It is found that the direct-lift-control flaps are aerodynamically somewhat less effective than designed for. More importantly, the transit time lag in the downwash generated due to flap deflections affects significantly the dynamic pitching motion. Furthermore, it leads to certain additional unsymmetrical and interference effects. Author

A92-23814#
FLIGHT TEST VALIDATION OF TOW TARGET TRAJECTORY PREDICTIONS
P. RICHARDSON, A. CENKO, and W. ANGERMANN (U.S. Navy, Naval Air Development Center, Warminster, PA) AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992. 11 p. refs
(AIAA PAPER 92-0209)

A recently developed tow target launch trajectory prediction code was previously validated with wind tunnel data and limited flight test data. A recent series of flight tests has resulted in a significant quantity of flight test data to allow a more complete validation of the trajectory program. Discussions of the inputs to the code and comparisons of predicted trajectories to the flight test data are presented. Author

A92-24178
THE DEVELOPMENT AND TEST OF THERMOPLASTIC COMPOSITE SPEED BRAKE
C.-L. ONG and H. CHIN (Aeronautical Research Laboratory, Taichung, Republic of China) IN: Development and design with advanced materials. Amsterdam, Netherlands and New York, Elsevier, 1990, p. 27-49. refs
Copyright

A graphite fiber-reinforced PEEK-matrix composite material system has been used to manufacture an aircraft speed brake's laminate skin, while the brake's complex z-shaped spars were formed from graphite-reinforced epoxy. Although the design allowable data for the speed brake was verified by coupon tests of the components, static structural testing was also conducted; failure modes were found to be buckling and delamination near the brake's attachment points. A weight-saving of 13 percent relative to the metallic structure replaced was achieved. O.C.

A92-24192
DESIGN AND TESTING LEADING TO CERTIFICATION OF THE AIRBUS A340 NOSE LANDING GEAR DOORS
R. F. H. WOODBERRY, A. MULE (Canadair, Inc., Saint Laurent, Canada), and M. THOMAS (Aerospatiale, Division Avions, Toulouse, France) IN: Development and design with advanced materials. Amsterdam, Netherlands and New York, Elsevier, 1990, p. 301-307.
Copyright

The nose landing composite door gears of the Airbus A340 airplane are fabricated with a NOMEX honeycomb core with carbon fiber/epoxy resin facings and metal hinges. Details are presented of the testing required with respect to materials, detection of flaws, definition of allowable properties, repairs, static strength, and durability from operational service. A correlation between analyses and testing are required for certification. It is demonstrated that composite component carrying significant loads requires a large amount of fundamental test data for design, analysis and certifications. Author

N92-15986*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Center, Edwards, CA.
PILOTED SIMULATION STUDY OF A BALLOON-ASSISTED DEPLOYMENT OF AN AIRCRAFT AT HIGH ALTITUDE
JAMES MURRAY, TIMOTHY MOES, KEN NORLIN, JEFFREY BAUER, ROBERT GEENEN, BRYAN MOULTON (PRC Kentron, Inc., Edwards, CA.), and STEPHEN HOANG Jan. 1992 33 p Proposed for presentation at the Sixth Workshop on Civilian and Military Needs for Automated Instrument Platforms in the 1990s and Beyond, Association for Unmanned Vehicle Systems, Silicon Valley Chapter, Menlo Park, Ca, 28-30 Jan. 1992
(NASA-TM-104245; H-1785; NAS 1.15:104245) Avail: NTIS HC/MF A03 CSCL 01/3

A piloted simulation was used to study the feasibility of a balloon assisted deployment of a research aircraft at high altitude. In the simulation study, an unmanned, modified sailplane was carried to 110,000 ft with a high altitude balloon and released in a nose down attitude. A remote pilot controlled the aircraft through a pullout and then executed a zoom climb to a trimmed, 1 g flight condition. A small parachute was used to limit the Mach number during the pullout to avoid adverse transonic effects. The use of small rocket motor was studied for increasing the maximum attainable altitude. Aerodynamic modifications to the basic sailplane included applying supercritical airfoil gloves over the existing wing and tail surfaces. The aerodynamic model of the simulated aircraft was based on low Reynolds number wind tunnel tests and computational techniques, and included large Mach number and Reynolds number effects at high altitude. Parametric variations were performed to study the effects of launch altitude, gross weight, Mach number limit, and parachute size on the maximum attainable stabilized altitude. A test altitude of approx. 95,000 ft was attained, and altitudes in excess of 100,000 ft was attained. Author

N92-15987 ESDU International Ltd., London (England).
ENERGY HEIGHT METHOD FOR FLIGHT PATH OPTIMISATION. ADDENDUM A: NUMERICAL METHOD SUITABLE FOR RAPID USE ON IBM PC COMPATIBLE COMPUTERS
Sep. 1991 10 p
(ESDU-91016-ADD; ISBN-0-85679-778-2; ISSN-0141-4054)
Avail: ESDU

A method is suggested of speeding up the calculation of the optimum flight path by the energy height method of ESDU 90012. Although programming the graphical methods used is possible, it is quicker to apply a simple linear search routine to seek minimum df/dH sub e (where f is the parameter to be minimized, e.g., time or fuel, and H sub e is energy height) along contours of constant energy height. A feasible flight envelope for the search is first established (taking account of, e.g., maximum design speed and altitude, buffet boundary, the requirement that thrust must exceed drag, etc). Then a choice of initial velocity increment is made to establish the region of the minimum and the increment is then progressively reduced as smaller and smaller regions are searched to locate the minimum with a required accuracy. The use of linear search technique is only necessary because two minima may exist; if it is known there is only one minimum, the use of a Fibonacci search routine is recommended and explained. The method is illustrated using the worked examples in ESDU 90012; one is minimum time to a given speed and height for a supersonic combat aircraft and the other is minimum fuel to a given speed and height for a subsonic transport aircraft. ESDU

N92-15988 ESDU International Ltd., London (England).
ESTIMATION OF AIRBORNE PERFORMANCE IN LANDING
Oct. 1991 46 p Supersedes ESDU-Perf-EG6/3
(ESDU-91032; ESDU-PERF-EG6/3; ISBN-0-85679-793-6; ISSN-0141-4054) Avail: Issuing Activity

Methods for estimating airborne distance for fixed-wing aircraft are given. The time taken is estimated as a function of the change in rate of sink between the screen and touch-down using a correlation developed from measured data for landings without significant float. This is directed towards certification style landings of transport aircraft, but some guidance is given for cases with significant float as well. A further empirical correlation allows an independent assessment of the time taken and of the speed loss during the maneuver to be made from the energy equation; the correlation provides the average value of drag minus thrust, again depending on whether there is a significant float or not. The ranges of aircraft types and flight conditions for which data were available are tabulated and cover a wide range of weights, geometry, approach angles and powerplants (turbo-jet, turbo-fan and turbo-prop). The correction of still air distance for the effect of wind and wind gradient is discussed. The geometric relationships that result if the path is prescribed to be some combination of circular arc and straight-line segments are given. Three worked examples illustrate the use of the method to determine the distance. ESDU

N92-15990# Air Force Inst. of Tech., Wright-Patterson AFB, OH. School of Engineering.
INVESTIGATION OF ADVANCED AIRCRAFT PERFORMANCE MEASURES OF MERIT INCLUDING NEW AGILITY METRICS M.S. Thesis
BRUCE A. FOX Sep. 1991 142 p
(AD-A242016; AFIT/GAE/ENY/91S-3) Avail: NTIS HC/MF A07 CSCL 01/3

Advanced aircraft performance measures of merit have been proposed and individually analyzed by various researchers. These metrics have been consolidated into a single computer code as part of this research effort. This code was used to study the relationships between the advanced metrics, aircraft design metrics and an aircraft's trajectory performance. The study found a linear relationship existed between the advanced metrics and the design metrics. This relationship was used to quantify the required levels of the advanced metrics which would give desired changes in

trajectory performance. The results showed that advanced metrics could be applied only to very specific trajectory maneuvers. GRA

N92-17071*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.
AIRCRAFT GROUND TEST AND SUBSCALE MODEL RESULTS OF AXIAL THRUST LOSS CAUSED BY THRUST VECTORING USING TURNING VANES
STEVEN A. JOHNSON Washington Jan. 1992 29 p (NASA-TM-4341; H-1743; NAS 1.15:4341) Avail: NTIS HC/MF A03 CSCL 01/3

The NASA-Dryden F/A-18 high alpha research vehicle was modified to incorporate three independently controlled turning vanes located aft of the primary nozzle of each engine to vector thrust for pitch and yaw control. Ground measured axial thrust losses were compared with the results from a 14.25 pct. cold jet model for single and dual vanes inserted up to 25 degs into the engine exhaust. Data are presented for nozzle pressure ratios of 2.0 and 3.0 and nozzle exit areas of 253 and 348 sq in. The results indicate that subscale nozzle test results properly predict trends but underpredict the full scale results by approx. 1 to 4.5 pct. in thrust loss. Author

N92-17153# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). Flight Mechanics Panel.
ROTORCRAFT SYSTEM IDENTIFICATION
Oct. 1991 257 p Lecture series held in Ottobrunn, Fed. Republic of Germany, 4-5 Nov. 1991, in Rome, Italy, 7-8 Nov. 1991, and in College Park, MD, 13-14 Nov. 1991
(AGARD-LS-178; ISBN-92-835-0640-5; AD-A244248) Copyright Avail: NTIS HC/MF A12; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

Owing to the highly coupled flight dynamic behavior of rotorcraft configurations, long term interdisciplinary scientific knowledge combined with practical flight test experience is required to use system identification and mathematical modeling tools in the most efficient way. This lecture series is intended to establish an improved dialogue between government organizations, research institutions, and industry in order to apply these tools more routinely in rotorcraft system design, development, and evaluation. This lecture series is supported by a unique flight test data set which was specially generated and analyzed within a recent working group in the Flight Mechanics Panel of Advisory Group for Aerospace Research & Development (AGARD) on Rotorcraft System Identification (WB 18). This lecture series, sponsored by the Flight Mechanics Panel of AGARD, was implemented by the Consultant and Exchange Program.

N92-17154# Glasgow Univ. (Scotland). Dept. of Electronics and Electrical Engineering.
DESIGN OF EXPERIMENTS
DAVID J. MURRAY-SMITH and GARETH D. PADFIELD (Royal Aerospace Establishment, Bedford, England) *In* AGARD, Rotorcraft System Identification 8 p Oct. 1991
Copyright Avail: NTIS HC/MF A12; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

The planning and conduct of flight experiments is a critically important part of the system identification process. Factors such as the choice of test input signal and the duration of the experiment can have a major influence on the quality of the identification results. Other factors such as the quality of flightcrew and groundcrew briefings and the availability of online monitoring facilities also greatly influence the effectiveness of any flight testing program. Inevitably there is a trade-off between performance and flight safety which must be taken fully into account at all stages of identification flight trials and influences the experiment design process and test matrix in a very significant way. Other important practical constraints arise in experiment design, especially when test input signals have to be applied manually by the pilot. An outline of the forms of test input most commonly used for identification is included, and an account of methods of experimental design is provided in which the value of a frequency-domain approach is emphasized. Author

N92-17155# Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, Brunswick (Germany, F.R.). Inst. fuer Flugmechanik.
INSTRUMENTATION AND DATA PROCESSING
JUERGEN KALETKA *In* AGARD, Rotorcraft System Identification 18 p Oct. 1991
Copyright Avail: NTIS HC/MF A12; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

The quality of measured flight test data is critically important to system identification. Inaccurate or kinematically inconsistent data can lead to identification of an incorrect model or inability to obtain convergence of the estimation solution. Therefore, this lecture concentrates on instrumentation and data processing aspects from a system identification point of view. It is mainly based on the work of the Advisory Group for Aerospace Research & Development (AGARD) Working Group WG-18 on Rotorcraft System Identification who concentrated on the identification of 6 degrees of freedom models. In addition, rotor blade instrumentation needed for the determination of extended models with explicit rotor degrees of freedom is addressed. Author

N92-17157# Toronto Univ. (Ontario). Inst. for Aerospace Studies.
IDENTIFICATION TECHNIQUES: MODEL STRUCTURE AND TIME DOMAIN METHODS
JAAP H. DELEEUW *In* AGARD, Rotorcraft System Identification 9 p Oct. 1991
Copyright Avail: NTIS HC/MF A12; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

An overview is given of rotorcraft system identification techniques used by WG 18. The selection of model structure is considered. Here, special emphasis is given to ensuring that the model structure is appropriate to the intended model application. For example, simple decoupled first-order models that characterize the helicopter dynamics over a limited frequency range may be suitable for handling-qualities applications, while coupled 6-DoF models suitable for a broader range are needed for piloted simulation. At the other end of the complexity spectrum are models needed for use in advanced high-bandwidth rotorcraft flight control system design that must consider the coupled fuselage/rotor/airmass dynamics. Both nonparametric model structures (frequency-responses) and parametric model structures (transfer functions and state-space equations) are considered in the two sections dealing with identification techniques. The next step in the identification problem definition is the formulation of the criterion or 'cost' function. Once the model structure and cost function have been defined, the model is identified from the input/output time-history data using either time-domain or frequency-domain methods. The final step in system identification is referred to as 'model verification.' Here the extracted model is driven with flight data not used in the identification process to ensure the correctness of the identification procedure, and the utility of the model in predicting control responses rather than simply matching them. Author

N92-17158# Army Aviation Systems Command, Moffett Field, CA. Aeroflightdynamics Directorate.
IDENTIFICATION TECHNIQUES: FREQUENCY DOMAIN METHODS
MARK B. TISCHLER *In* AGARD, Rotorcraft System Identification 4 p Oct. 1991
Copyright Avail: NTIS HC/MF A12; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

The starting point in frequency-domain identification methods is the conversion of time-based data to frequency-based data. This conversion, which is a batch and non-iterative process, involves a considerable amount of data conditioning not required for time-domain methods. However, once the frequency-domain data base is completed, the computational burden of the parameter nonlinear search is considerably reduced. Also, there are some

important benefits of formulating the cost function in the frequency-domain. An overview of frequency-domain methods used by WG 18 members is presented. Author

N92-17159# Glasgow Univ. (Scotland). Dept. of Electronics and Electrical Engineering.
MODELLING ASPECTS AND ROBUSTNESS ISSUES IN ROTORCRAFT SYSTEM IDENTIFICATION
DAVID J. MURRAY-SMITH *In* AGARD, Rotorcraft System Identification 9 p Oct. 1991

The concept of robustness is examined and discussed in the context of rotorcraft system identification and modeling. A classification of robustness issues is proposed involving experimental design aspects, identification techniques, model structure estimation, parameter estimation and the robustness of the complete mathematical model resulting from the application of identification processes. Associated tests of robustness are proposed and a set of special recommendations is presented for each of the aspects considered. Within these recommendations particular emphasis is placed on the need for a good user interface which fully exploits the use of computer graphics and for reliable tools for the assessment of model structure. The need for preliminary flight tests to characterize the dynamics of the system and thus guide the design of identification experiments is also emphasized. A further recommendation is that design criteria should be established for verification inputs. Author

N92-17160# McDonnell-Douglas Helicopter Co., Mesa, AZ.
ASSESSMENT OF ROTORCRAFT SYSTEM IDENTIFICATION AS APPLIED TO THE AH-64
DEV BANERJEE and JEFF W. HARDING *In* AGARD, Rotorcraft System Identification 25 p Oct. 1991

Flight test data from the U.S. Army/McDonnell Douglas AH-64 Apache attack helicopter was provided to the AGARD FMP Working Group 18 (WG-18) on Rotorcraft System Identification. Results from the application of system identification techniques on the data by several members are compared. The data are processed by the WG members to assure consistency and remove identified measurement biases. Various time domain identification procedures ranging from linear regression to maximum likelihood are used to identify coupled six degrees of freedom rigid body models. Stability and control derivative estimates and model eigenvalues are compared. Diagonal terms in the models are consistently identified while coupling derivative estimates vary widely. Eigenvalues associated with the slower modes (phugoid and spiral) are not consistently identified due to the limited 12 second record length of the available data. Roll convergence and Dutch roll models are consistent between the models. All the models do a good job of predicting primary axis response, however, improved correlation is achieved by eliminating insensitive stability and control derivatives from the parameter sets. Author

N92-17161# Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, Brunswick (Germany, F.R.). Inst. fuer Flugmechanik.
BO 105 IDENTIFICATION RESULTS
JUERGEN KALETKA *In* AGARD, Rotorcraft System Identification 50 p Oct. 1991

BO 105 flight test data generated particularly for system identification purposes were provided to the AGARD Working Group WG-18 on Rotorcraft System Identification. The accomplishments are summarized of the WG for the data consistency analyses, and the identification and verification results for 6 degrees of freedom models. The individually applied approaches are described and representative results are presented. It is shown that the flight test data were appropriate for use of system identification. The discussion of the identification and verification results show that there are significant differences depending upon the applied identification technique. The identification is addressed of higher order models and some results are presented which were obtained for an extended model with rotor degrees of freedom. Author

N92-17162# Royal Aerospace Establishment, Bedford (England). Aerospace Div.
SA 330 PUMA IDENTIFICATION RESULTS
GARETH D. PADFIELD *In* AGARD, Rotorcraft System Identification 38 p Oct. 1991

The SA 330 Puma test data provided by the RAE were analyzed with a variety of different identification techniques by six of the participating organizations in AGARD Flight Mechanics Panel Working Group 18. The results of this work are presented. A detailed study of the data kinematic consistency conducted by the RAE is included, highlighting some of the difficulties that can be encountered, even with high quality measurements, and ways of overcoming them. The results of the six degrees of freedom identification are discussed in terms of the conventional rigid body modes of motion. Author

N92-17163# McDonnell-Douglas Helicopter Co., Mesa, AZ.
INDUSTRY VIEW ON ROTORCRAFT SYSTEM IDENTIFICATION
DEV BANERJEE and JEFF W. HARDING *In* AGARD, Rotorcraft System Identification 4 p Oct. 1991

An industry perspective on rotorcraft system identification is presented based on responses from eight major rotorcraft manufacturers to a questionnaire sent out by the AGARD FMP Working Group 18 on Rotorcraft System Identification. Several manufacturers are implementing system identification techniques for model validation and flight control law development. Concerns over costly data requirements and nonstandardized procedures are echoed. An example of the application of system identification for design support at McDonnell Douglas Helicopter Co. is discussed. Author

N92-17164# Royal Aerospace Establishment, Bedford (England). Aerospace Div.
APPLICATION AREAS FOR ROTORCRAFT SYSTEM IDENTIFICATION: SIMULATION MODEL VALIDATION
GARETH D. PADFIELD and RONALD W. DUVAL (Advanced Rotorcraft Technology, Inc., Mountain View, CA.) *In* AGARD, Rotorcraft System Identification 39 p Oct. 1991

The role of system identification in the validation of rotorcraft simulation models is examined in terms of the overall 'functional' fidelity and individual component 'physical' fidelity. Validation acceptance criteria are discussed in terms of modeling range and accuracy for the three fundamental flight mechanics problems - trim, stability, and response. Model development and upgrading are described as a natural part of validation, and the role that system identification can play in highlighting model deficiencies is discussed. An example from a six-degree-of-freedom analysis is presented to illustrate validation and the merits of model distortion analysis in identifying deficiencies. Results from a more detailed analysis of the SA 330 blade flapping dynamics are presented to illustrate physical validation. Author

N92-17165# Army Aviation Systems Command, Moffett Field, CA. Aeroflightdynamics Directorate.
SYSTEM IDENTIFICATION METHODS FOR HANDLING-QUALITIES EVALUATION
MARK B. TISCHLER *In* AGARD, Rotorcraft System Identification 9 p Oct. 1991

System identification methods for rotorcraft handling-qualities studies are discussed in this paper. A key factor that is responsible

for the successful application of system identification techniques in the handling-qualities community is the relative simplicity of the models which are desired for pilot-in-the-loop analyses as compared to the full 6 Degree Of Freedom (DOF) models required for most other applications. Generally, these analyses consider only the on-axis, single-input/single-output response of the pilot/vehicle system. The extracted vehicle model may be nonparametric, such as a frequency-response, or a low-order parametric model, such as a transfer function, or a simplified decoupled state-space representation. Both time- and frequency-domain methods have been widely used for these applications and are discussed in this paper. The requirements for flight testing, data analyses, and modeling for handling-qualities applications of system identification are contrasted with the requirements for extracting multi-input/multi-output state-space models for flight mechanics purposes. Typical handling qualities analysis results are illustrated using the WG 18 databases for the BO-105 and AH-64 helicopters. Author

N92-17234# Aeronautical Research Labs., Melbourne (Australia).
MODIFICATION OF JINDIVIK AIR INTAKE DUCT WITH AN AUXILIARY INTAKE STATIC AERODYNAMIC TESTS
A. M. ABDEL-FATTAH Aug. 1991 37 p
(AD-A243002; ARL-PROP-TM-460; DODA-AR-006-600) Avail: NTIS HC/MF A03 CSCL 21/5

Results are presented for an R and D program to improve the take-off performance of the Jindivik target aircraft. The engine air intake duct of Jindivik is aerodynamically optimised for altitude and high subsonic cruise, and scope for its modification, for improved performance at take-off, was limited to the incorporation of an auxiliary intake system which is deployed only during take-off and is closed in flight. The auxiliary intake concept was explored experimentally with a 1/4 scale model of a Jindivik air intake duct, and involved both static testing and tests with forward speeds in the wind tunnel. This report covers the aerodynamic aspects of the static phase of the program, at which conditions substantial improvements in pressure recovery with acceptable levels of flow distortion at the engine face have been demonstrated for simple intake modifications. GRA

N92-17266# Aeronautical Research Labs., Melbourne (Australia).
WIND LOADS ON A MIRAGE III O AIRCRAFT MOUNTED ABOVE A GROUND PLANE
P. A. HERMSEN Aug. 1991 21 p
(AD-A243004; ARL-FLIGHT-MECH-TM-434; DODA-AR-006-590) Avail: NTIS HC/MF A03 CSCL 01/1

Measurements were made in ARL Salisbury's Low Speed Tunnel on a 1/72 scale model of a Mirage III O aircraft to determine steady wind loads when mounted above a ground plane. The six component data cover 360 deg in azimuth, and roll and pitch angles of -20, O, and +20 degs. GRA

N92-17300# Naval Postgraduate School, Monterey, CA.
A WING ROCK MODEL FOR THE F-14A AIRCRAFT M.S. Thesis
STEVEN R. WRIGHT 1992 86 p
(AD-A243109) Avail: NTIS HC/MF A05 CSCL 01/3

An investigation of inertial coupling and its contribution to wing rock in the F-14A aircraft has been conducted. Wind tunnel data was used to obtain the stability parameters for angles of attack from zero to 25 degrees, after which linear and nonlinear analyses of the equations of motion were completed. The linearized analysis of the uncoupled longitudinal and lateral-directional equations was included to provide a baseline for comparison with the fully coupled, nonlinear equations. In both cases, the equations of motion were solved numerically and time history traces produced to illustrate aircraft response. Results indicate that a stable short period mode can feed damping energy into an unstable dutch roll mode via the coupling of the equations to produce a stable limit cycle very similar to those experienced in the aircraft. Numerous suggestions for follow-on research are presented. GRA

N92-17313# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (Germany, F.R.). Hubschrauber und Flugzeuge.
AERODYNAMIC DEVELOPMENT OF THE X-31 AIRCRAFT FOR THE HIGH ANGLE OF ATTACK REGION
WERNER KRAUS May 1991 38 p
(MBB-FE211-S-PUB-452; ETN-92-90620) Copyright Avail: NTIS HC/MF A03

The X-31 high agility airplane is designed to operate well at high angles of attack. The aircraft is designed to have natural aerodynamic stability about all three axes in the entire angle of attack range, except at small angles of attack, where the aircraft is unstable in pitch for performance reasons. In critical regions in which natural stability cannot be contained, the control power required to achieve stability is provided to the appropriate axis by artificial control, still leaving sufficient control for power maneuvers. The results of the wind tunnel development program are presented. Additional wind tunnel tests in a spin tunnel are presented. ESA

N92-17316*# Ohio State Univ., Columbus. ElectroScience Lab.
AUTOMATED COMPOSITE ELLIPSOID MODELLING FOR HIGH FREQUENCY GTD ANALYSIS
K. Y. SZE, R. G. ROJAS, F. T. KLEVENOW, and J. T. SCHEICK Sep. 1991 188 p
(Contract NAG1-1058)
(NASA-CR-189853; NAS 1.26:189853; REPT-722792-2) Avail: NTIS HC/MF A09 CSCL 01/3

The preliminary results of a scheme currently being developed to fit a composite ellipsoid to the fuselage of a helicopter in the vicinity of the antenna location are discussed under the assumption that the antenna is mounted on the fuselage. The parameters of the close-fit composite ellipsoid would then be utilized as inputs into NEWAIR3, a code programmed in FORTRAN 77 for high frequency Geometrical Theory of Diffraction (GTD) Analysis of the radiation of airborne antennas. Author

N92-17513# Northrop Corp., Hawthorne, CA. Aircraft Div.
FINITE ELEMENT ANALYSIS OF ASTOVL FIGHTER STRUCTURE Interim Report, 1 Oct. 1988 - 1 Oct. 1989
J. A. HANGEN Dec. 1991 258 p
(Contract F33615-88-C-3205)
(AD-A243724; NOR-89-101; WL-TR-91-3104) Avail: NTIS HC/MF A12 CSCL 01/3

This report documents the static/dynamic and aeroelastic finite element model development and description used for the preliminary structural design and optimization of an Advanced Short Takeoff and Vertical Landing (ASTOVL) fighter structure. The model defined represents an Automated STructural Optimization System (ASTROS) compatible model initially developed from a NASTRAN finite element model. The generated data are for the purpose of enabling the repeat of the structural analysis and to independently analyze the structure in case of future structural or operational modifications to the aircraft. GRA

N92-17565# Aeronautical Research Labs., Melbourne (Australia).
GENERAL REQUIREMENTS AND TECHNIQUES FOR COMPONENT FATIGUE LIFE SUBSTANTIATION IN AUSTRALIAN SERVICE HELICOPTERS
K. F. FRASER Jun. 1991 54 p
(AD-A242881; ARL-PROP-R-187; DODA-AR-006-619) Avail: NTIS HC/MF A04 CSCL 20/11

An Australian Defense Force requirement has been defined to provide in-country capability to support component fatigue life substantiation in selected Australian fleet helicopters, with initial application to the S-70A-9 Black Hawk helicopter operated by the Australian Army. The implications of this requirement are examined, and the need to assess the severity of the spectrum of normal missions for the selected aircraft fleet is supported. Justification for a program to assess mission severity from measurements of flight regime recognition data and loads in selected components in a sample of fleet aircraft, is provided. A program to substantiate the fatigue lives of selected Black Hawk helicopter components,

subject to significant in-service loads, is outlined. The general requirements of airborne and ground data systems required in support of the program are examined. GRA

N92-17843 ESDU International Ltd., London (England).
EXAMPLE OF STATISTICAL TECHNIQUES APPLIED TO CRUISE PERFORMANCE GUARANTEES (STUDENT'S T DISTRIBUTION)
Oct. 1991 5 p
(ESDU-91018; ISBN-0-85679-780-4; ISSN-0141-4054) Avail: ESDU

This data item illustrates certain aspects of statistical analysis introduced in ESDU 91017 in relation to cruise specific air range. Before issuing guarantees to a customer, flight tests were carried out around the guarantee point to verify the specific air range that could be claimed without a risk of triggering a penalty. Because the first sample of data obtained was small, it is analyzed using Student's t distribution but is found, at the chosen confidence level, to indicate an unacceptable performance. A further sample of values were therefore measured with a view to improving the prediction accuracy. Data from the two samples are first checked with the F Variance Ratio Test to establish that they may be coalesced. The samples are then combined and Student's t distribution applied again. The results are still unsatisfactory but the comment is made that one point is clearly outside the general dispersion of the data. The deviation from the pooled mean is noted but it is explained that if the result cannot be faulted on sound engineering grounds it must stand and the conclusions drawn must be accepted. ESDU

N92-17847 ESDU International Ltd., London (England).
VARIABILITY OF STANDARD AIRCRAFT PERFORMANCE PARAMETERS
Oct. 1991 8 p
(ESDU-91020; ISBN-0-85679-782-0; ISSN-0141-4054) Avail: ESDU

This data item presents data on the variability of civil aircraft and engine performance quantities drawn from a report of the ICAO Standing Committee on Performance, and also more recent information on the variability of turbo-fan engine performance quantities. These latter data are given as ranges of uncertainty and are converted to the ICAO form of a standard deviation using information from ESDU 91017. The variability data are then used to calculate the variability of takeoff climb gradient. The methods of ESDU 91017 are again used, this time to calculate the overall variability arising from the cumulative effects of the individual variabilities in drag, thrust, and weight. ESDU

06

AIRCRAFT INSTRUMENTATION

Includes cockpit and cabin display devices; and flight instruments.

A92-21074* McDonnell-Douglas Research Labs., Saint Louis, MO.
EXPERIMENTAL INVESTIGATION OF TERMINAL SHOCK SENSORS FOR MIXED-COMPRESSION INLETS
MIKLOS SAJBEN, JOHN F. DONOVAN, and MARTIN J. MORRIS (McDonnell Douglas Research Laboratories, Saint Louis, MO) Journal of Propulsion and Power (ISSN 0748-4658), vol. 8, Jan.-Feb. 1992, p. 168-174. Previously cited in issue 17, p. 2718, Accession no. A90-40560. refs
(Contract NAS3-25446)
Copyright

A92-22000
HIGH COSTS FORCE AVIONICS LINKS
BARRY MILLER Interavia Aerospace Review (ISSN 0020-6512), vol. 47, Jan. 1992, p. 45-53.
Copyright

This review shows that the high costs required to perfect commercial flight decks are shaping alliances and risk-sharing ventures of avionics manufacturers. Some examples cited include the development of MD-12 FBW controls (Honeywell/GE), flight deck needs of new and retrofit aircraft (Collins/Smiths), and avionics suite for IL-96M (Collins/Ilyushin). Attention is given to some of the new avionic suites under development including electronic flight instrument systems, laser inertial reference, centralized fault display systems, fiber optic data bus, and a fault-tolerant air data inertial reference system. R.E.P.

A92-23040
A PARALLEL ARCHITECTURE ADAPTED TO ONBOARD MULTIEXPERT SYSTEMS [UNE ARCHITECTURE PARALLELE ADAPTEE AUX SYSTEMES MULTI-EXPERTS EMBARQUES]
J.-C. HEUDIN (Sodima, S.A., Les Ulis, France) and A. GILLES (Dassault Aviation, Saint-Cloud, France) Revue Scientifique et Technique de la Defense (ISSN 0994-1541), 3rd Quarter, 1991, 1991, p. 7-11. In French. refs
Copyright

A architecture suitable for onboard real-time AI is being designed within the framework of Daussault Aviations's Electronic Copilot project. The knowledge-based system is organized around a set of integrated expert modules running concurrently on a dedicated multiprocessor architecture based on a custom AI RISC microprocessor. The application is designed using a KOS (knowledge-based operating system) expert system shell. The paper describes the software and hardware architectures that have been designed to confront the challenge posed by an embedded real-time concurrent AI system operating in the combat environment of the next decade. L.M.

N92-15991*# Douglas Aircraft Co., Inc., Long Beach, CA.
IDENTIFICATION OF HIGH-LEVEL FUNCTIONAL/SYSTEM REQUIREMENTS FOR FUTURE CIVIL TRANSPORTS Final Report
JAY R. SWINK and RICHARD T. GOINS Jan. 1992 151 p
(Contract NAS1-18028)
(NASA-CR-189561; NAS 1.26:189561) Avail: NTIS HC/MF A08 CSCL 01/4

In order to accommodate the rapid growth in commercial aviation throughout the remainder of this century, the Federal Aviation Administration (FAA) is faced with a formidable challenge to upgrade and/or modernize the National Airspace System (NAS) without compromising safety or efficiency. A recurring theme in both the Aviation System Capital Investment Plan (CIP), which has replaced the NAS Plan, and the new FAA Plan for Research, Engineering, and Development (RE&D) rely on the application of new technologies and a greater use of automation. Identifying the high-level functional and system impacts of such modernization efforts on future civil transport operational requirements, particularly in terms of cockpit functionality and information transfer, was the primary objective of this project. The FAA planning documents for the NAS of the 2005 era and beyond were surveyed; major aircraft functional capabilities and system components required for such an operating environment were identified. A hierarchical structured analysis of the information processing and flows emanating from such functional/system components were conducted and the results documented in graphical form depicting the relationships between functions and systems. Author

N92-17128*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.
FAILURE DETECTION AND FAULT MANAGEMENT TECHNIQUES FOR FLUSH AIRDATA SENSING SYSTEMS
STEPHEN A. WHITMORE, TIMOTHY R. MOES, and CORNELIUS T. LEONDES (Washington Univ., Seattle.) Washington Jan. 1992 22 p Presented at the Aerospace Sciences Meeting, Reno, NV, 6-9 Jan. 1992; sponsored by AIAA
(NASA-TM-4335; H-1780; NAS 1.15:4335) Avail: NTIS HC/MF A03 CSCL 01/4

A high-angle-of-attack flush airdata sensing system was installed and flight tested on the F-18 High Alpha Research Vehicle at NASA-Dryden. This system uses a matrix of pressure orifices arranged in concentric circles on the nose of the vehicle to determine angles of attack, angles of sideslip, dynamic pressure, and static pressure as well as other airdata parameters. Results presented use an arrangement of 11 symmetrically distributed ports on the aircraft nose. Experience with this sensing system data indicates that the primary concern for real-time implementation is the detection and management of overall system and individual pressure sensor failures. The multiple port sensing system is more tolerant to small disturbances in the measured pressure data than conventional probe-based intrusive airdata systems. However, under adverse circumstances, large undetected failures in individual pressure ports can result in algorithm divergence and catastrophic failure of the entire system. How system and individual port failures may be detected using chi sq. analysis is shown. Once identified, the effects of failures are eliminated using weighted least squares. Author

N92-17221# Research Triangle Inst., Research Triangle Park, NC.

AGSSS: THE AIRBORNE GRAPHICS SOFTWARE SUPPORT SYSTEM; AN ADA/PHIGS-BASED DISPLAY EDITOR FOR THE RAPID DEVELOPMENT OF COCKPIT DISPLAY SOFTWARE SYSTEMS Final Report, Sep. 1987 - Sep. 1990

R. J. MONTOYA, TIMOTHY L. TURNER, DONNA M. JEWELL, JAMES V. AANSTOOS, and RAMASUBRAMANIAN SURESH Sep. 1991 91 p

(Contract F33615-87-C-1531)

(AD-A243224; RTI/3966/00-01F; WL-TR-91-1042) Avail: NTIS HC/MF A05 CSCL 12/5

Over the past decade, the performance of digital graphics systems has increased several-fold. At the same time, the size of the hardware has been reduced and high performance airborne systems are now feasible. As a result, complex, three dimensional, pictorial, real time display formats can now be supported. Unfortunately, the increase in display complexity results in a significant increase in the software requirements. Additionally, dynamic displays, such as used in avionics, have a two part software problem. First, the display format and all its elements must be explicitly defined. Second, the connection must be established to the rest of the avionics. Overall, graphics software development is a truly time and labor intensive task. The goal of the AGSSS is to provide a graphics software development support environment. The AGSSS consists of four parts: the Graphics Editor for creating the format program, the Actions Editor for creating the driver software for the display dynamics, the Display Test Manager which allows the user to test the new software within the workstation, and the Display Program Integrator which creates the final software source modules tuned to the target system hardware. GRA

N92-17989*# Massachusetts Inst. of Tech., Cambridge. Dept. of Aeronautics and Astronautics.

COCKPIT DISPLAY OF HAZARDOUS WEATHER INFORMATION

R. JOHN HANSMAN, JR. and CRAIG WANKE *In* NASA. Langley Research Center, Joint University Program for Air Transportation Research, 1990-1991 p 41-48 Dec. 1991 Previously announced as N90-20929 Previously announced in IAA as A89-25591

(Contract NAG1-690; NGL-22-009-640; BARR-10-119)

Avail: NTIS HC/MF A09 CSCL 01/3

Information transfer and display issues associated with the dissemination of hazardous weather warnings are studied in the context of wind shear alerts. Operational and developmental wind shear detection systems are briefly reviewed. The July 11, 1988 microburst events observed as part of the Denver Terminal Doppler Weather Radar (TDWR) operational evaluation are analyzed in terms of information transfer and the effectiveness of the microburst alerts. Information transfer, message content and display issues associated with microburst alerts generated from ground based sources (Doppler Radar, Low Level Wind Shear Alert System, and Pilot Reports) are evaluated by means fo pilot opinion surveys and part task simulator studies. Author

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.

A92-21012

PRATT & WHITNEY PW300 FOR GENERAL AVIATION [PRATT & WHITNEY PW300 FUER DIE ALLGEMEINE LUFTFAHRT]

Luft- und Raumfahrt (ISSN 0173-6264), vol. 12, Nov.-Dec. 1991, p. 32-34. In German.

Copyright

The small Pratt & Whitney PW300 turbofan jet engine for long-distance business jets is described. The development of the engine is reviewed, its design and mode of operation are described, and marketing efforts are briefly addressed. Results to date show that the engine has met its objectives. Further development possibilities of the engine are considered. C.D.

A92-21071

PREDICTION OF PERIODIC LOADINGS ON SINGLE ROTATION PROPFAN WITH OFF-AXIS INFLOW

SHIH H. CHEN (Rockwell International Corp., Rocketdyne Div., Canoga Park, CA) Journal of Propulsion and Power (ISSN 0748-4658), vol. 8, Jan.-Feb. 1992, p. 144-150. Previously cited in issue 20, p. 3093, Accession no. A89-47024. refs

Copyright

A92-21078

METHOD FOR THE PREDICTION OF SUPERSONIC COMPRESSOR BLADE PERFORMANCE

C. FREEMAN (Rolls-Royce, PLC, Derby, England) and N. A. CUMPSTY (Cambridge, University, England) Journal of Propulsion and Power (ISSN 0748-4658), vol. 8, Jan.-Feb. 1992, p. 199-208. refs

Copyright

A simple model is used to calculate the flow in compressor blades with supersonic relative inlet flow. The method addresses the common irreversible deceleration and compression that takes place when a shock stands ahead of the blade leading edge: it does not attempt to describe the process when inverse camber in the forward part is used to decelerate the flow before the shock. The one-dimensional model utilizes the conservation of stagnation enthalpy, mass flow, and momentum in the inlet region. The momentum equation is applied in the direction parallel to the blade surface at inlet, and one of the fundamental simplifications adopted is that the projected area of the blades gives such a small force in this direction that a very simple approximation for it suffices. The model is able to predict the loss creation in the inlet region. The levels of calculated loss agree well with measured values when the Mach numbers are sufficiently high for the inlet loss to dominate. Furthermore, the correct trends of loss with incidence and blade speed are predicted. The method predicts other trends usually seen in measurements: the narrowing of the useful operating range between choke and flow instability (surge) as blade speed is increased and a steepening of the surge line at the higher speeds. Author

A92-21080

ROLE OF DYNAMIC SIMULATION IN FIGHTER ENGINE DESIGN AND DEVELOPMENT

S. J. KHALID (Pratt and Whitney Group, West Palm Beach, FL) Journal of Propulsion and Power (ISSN 0748-4658), vol. 8, Jan.-Feb. 1992, p. 219-226. Previously cited in issue 20, p. 3091,

Accession no. A89-46854. refs
(Contract F33657-84-C-2014; F33657-79-C-0541)
Copyright

A92-21745
AN INVESTIGATION OF FUEL NOZZLES FOR COMBUSTION PERFORMANCE
HONGMING WANG, ZHONG QUAN, and XIAOHUA GAN (Air Force PR China, Aeronautical Engineering Research Institute, People's Republic of China) Journal of Propulsion Technology (ISSN 1001-4055), Dec. 1991, p. 36-41. In Chinese.

In this paper, three types of fuel nozzle, different in atomization principle, are separately tested on a jet engine combustion apparatus to examine their performance. These nozzles are characterized by pressure-swirl, airblast, and air-assist pressure-swirl. Experiments show that changing in combustor inlet air velocity can slightly improve exit temperature profile, when nozzles is used. The pressure-swirl atomizer has the features of good ignition and flame stabilization, but lower combustion efficiency and higher exit extreme temperature. Compared with the pressure-swirl atomizer, the airblast atomizer has higher combustion efficiency, better ignition at high air velocity and poorer ignition at low air velocity, and poor lean fuel-extinction limit. The air-assist pressure-swirl atomizer has higher combustion effeciency, better ignition and flame stabilization, and an easy control of the exit extreme temperature. Author

A92-22126#
RESEARCH ON SUPERSONIC COMBUSTION
F. S. BILLIG (Johns Hopkins University, Laurel, MD) AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992. 21 p. refs
(AIAA PAPER 92-0001) Copyright

A development history is presented for the supersonic combustion-related research efforts which led to the definition of the scramjet propulsion system for hypersonic flight. The study of precombustion shock trains and the modeling thus derivable serves to frame the characterization of the range of scramjet system flows. The results of flowfield calculations based on such modeling are compared with experimental measurements obtained in supersonic combustors, in order to identify remaining problem in the current development status of scramjet design tools. O.C.

A92-22136#
RECENT ADVANCEMENTS IN TURBOMACHINERY FORCED RESPONSE ANALYSES
ROBERT E. KIELB and HSIAO-WEI D. CHIANG (GE Aircraft Engines, Cincinnati, OH) AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992. 9 p. refs
(AIAA PAPER 92-0012) Copyright

The flow-defect, unsteady blade-load, and blade-response steps of forced response analysis for turbomachinery are presented and evaluated. It is judged that wake modeling improvements are required at both the empirical and computational levels. The primary CFD requirements lie in the realm of turbulence modeling, since shock structure and strength are dependent on shock interactions with the boundary layer. While tuned blade response models are highly refined, improvements are required for mistuned blade response modeling. O.C.

A92-22137#
THE POSITION OF THE UNSTEADY FLOW COMPUTATION IN THE COMPRESSOR AND TURBINE DESIGN AND ANALYSIS PROCESS
GEORGES KARADIMAS (SNECMA, Moissy-Cramayel, France) AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992. 11 p. refs
(AIAA PAPER 92-0015) Copyright

An evaluation is made of the development status and consequentiality of unsteady flow-simulating CFD techniques applicable in advanced gas turbine compressor and turbine stage design. The maximization of aircraft gas turbine thrust/weight performance and reliability while minimizing acquisition and maintenance costs fundamentally depends on the ability to anticipate the effects of unsteady aeromechanical phenomena. Attention is given to blade flutter and forced vibration, stator/rotor interactions, flow instabilities and distortions, and the evolution of CFD techniques to date. O.C.

A92-22482* Washington Univ., Seattle.
INVESTIGATION OF HYPERSONIC RAMJET PROPULSION CYCLES USING A RAM ACCELERATOR TEST FACILITY
A. P. BRUCKNER, G. CHEW, J. A. DE TURENNE, and B. DUNMIRE (Washington, University, Seattle) IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 12 p. Research supported by Olin Corp. refs
(Contract NAG1-327; NAG1-1061; F08635-89-C-0196)
(IAF PAPER 91-275) Copyright

Experimental research on hypersonic propulsion using a ram accelerator test facility is presented. The gasdynamics of the ram accelerator has been studied experimentally in a 38-mm bore facility over the Mach number range of 2.5 to 8.5, using methane- and ethylene-based propellant mixtures. Three different propulsive modes, centered on the Chapman-Jouguet (C-J) detonation speed of the combustible gas, have been experimentally observed. Projectiles have been accelerated smoothly from velocities below to above the C-J speed within a single propellant mixture. Author

A92-23816#
3D NAVIER-STOKES ANALYSIS FOR A TIP LEAKAGE FLOW IN A LOW ASPECT RATIO TURBINE
DOCHUL CHOI (Textron Defense Systems, Everett, MA) AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992. 9 p. Research sponsored by Textron Lycoming. refs
(AIAA PAPER 92-0395) Copyright

A computational investigation has been performed using a 3D Navier-Stokes solver to study the details of flow through a tip clearance gap of a Low Aspect Ratio Turbine (LART). The code solves Navier-Stokes equations and Coakley's q-omega turbulence model equations with viscous sublayer resolution, using a low-Reynolds-number turbulence model. Tip leakage flow through a 0.013 in gap, about 1 percent of span, between rotating blades and stationary shroud has been well resolved, including fine-scale viscous motions such as vena contracta and separation on the blade tip. To identify the effects of the leakage flow, the solution was compared with computational results of a no tip-gap case. Author

A92-23817*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
A COMPUTATIONAL INVESTIGATION OF MIXING AND REACTING FLOWS IN SUPERSONIC COMBUSTORS
D. W. RIGGINS (Missouri-Rolla, University, Rolla) and C. R. MCCLINTON (NASA, Langley Research Center, Hampton, VA) AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992. 18 p. refs
(AIAA PAPER 92-0626) Copyright

Results of the numerical simulation of 15 degree downstream helium injection into a unconfined Mach 6 airstream are presented. Both details of downstream mixing and mean flow are in good agreement with experimental data. Results of the numerical simulation of similar hydrogen injection into a high enthalpy (Mach 17) confined Mach 6 airstream are presented with favorable comparison to experimental plume structure and wall data. The low enthalpy inflow from the unconfined case was then provided to the high enthalpy geometry in order to study the feasibility of using low enthalpy simulations of mixing for scramjet flight performance estimation. Results indicate that the mixing is substantially lower for the high enthalpy case but can be shown to appropriately scale using the inflow velocity. Production and decay of axial vorticity, cross-flow velocities, and the mean-flow velocities of these confined flows are then related and discussed to illustrate the effect of residence time on jet mixing. Author

N92-15992# Department of the Navy, Washington, DC.
UNDERWATER TURBOJET ENGINE Patent Application
RAAFAT H. GURGUIS, inventor (to Navy) 1 Jul. 1991 12 p
(AD-D015017; US-PATENT-APPL-SN-724079) Avail: NTIS HC/MF A03 CSCL 21/5

This invention relates generally to turbojet engines and more particularly to such engines employing liquid as a motive flow medium. It is an important object of the present invention to provide an engine of the foregoing type which is more suitable for underwater applications, where light weight, small size, high power output and high speeds are essential. In accordance with the present invention, the motive working liquid conducted through the engine also acts as an oxidizer reacting with the fuel on contact, as does air in conventional turbojet engines. Further in accordance with the present invention the fuel is either in liquid or solid form. The motive liquid according to different embodiments of the invention is pure water, sea water having impurities or any other liquid capable of reacting with the fuel on contact. GRA

N92-15993*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
SUPERSONIC PROPULSION SIMULATION BY INCORPORATING COMPONENT MODELS IN THE LARGE PERTURBATION INLET (LAPIN) COMPUTER CODE
GARY L. COLE and JACQUES C. RICHARD Dec. 1991 33 p
(NASA-TM-105193; E-6494; NAS 1.15:105193) Avail: NTIS HC/MF A03 CSCL 21/5

An approach to simulating the internal flows of supersonic propulsion systems is presented. The approach is based on a fairly simple modification of the Large Perturbation Inlet (LAPIN) computer code. LAPIN uses a quasi-one dimensional, inviscid, unsteady formulation of the continuity, momentum, and energy equations. The equations are solved using a shock capturing, finite difference algorithm. The original code, developed for simulating supersonic inlets, includes engineering models of unstart/restart, bleed, bypass, and variable duct geometry, by means of source terms in the equations. The source terms also provide a mechanism for incorporating, with the inlet, propulsion system components such as compressor stages, combustors, and turbine stages. This requires each component to be distributed axially over a number of grid points. Because of the distributed nature of such components, this representation should be more accurate than a lumped parameter model. Components can be modeled by performance map(s), which in turn are used to compute the source terms. The general approach is described. Then, simulation of a compressor/fan stage is discussed to show the approach in detail. Author

N92-17011# Deacon Research, Palo Alto, CA.
LASER BASED, NON-INTRUSIVE MEASUREMENT SYSTEM FOR ANALYSIS OF JET ENGINE FLOWS Final Technical Report, 8 Aug. 1990 - 8 Mar. 1991
A. OKEEFE Oct. 1991 36 p
(Contract F33615-90-C-2077)
(AD-A242398; WL-TR-91-2108) Avail: NTIS HC/MF A03 CSCL 21/2

This document summarizes an effort to establish the feasibility of a technique which will allow the remote determination of the local flow velocity, temperature and density of selected species present in the combustion and exhaust flows of hydrocarbon fueled scram jet engine test facilities. We have developed a data acquisition system which is capable of high speed date collection (several kHZ) for time periods of many seconds before pausing for data transfer. This program demonstrated a system prototype with a 16 millisecond capacity on a high speed combustor flow and demonstrated that the local flow speed, temperature, and density can be recovered from the data. This data was used to estimate the potential signal levels which might be attained on the test facilities and discuss how this approach might be configured and optimized on the quartz-walled test flow being developed there. GRA

N92-17061*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
SAFETY CONSIDERATIONS IN TESTING A FUEL-RICH AEROPROPULSION GAS GENERATOR
R. JAMES ROLLBUHLER and DAVID D. HULLIGAN (Sverdrup Technology, Inc., Brook Park, OH.) 1991 9 p Presented at the Combustion Fundamentals and Applications Meeting, Nashville, TN, 21-24 Apr. 1991; sponsored by the Combustion Inst.
(NASA-TM-105258; E-5976; NAS 1.15:105258) Avail: NTIS HC/MF A02 CSCL 21/5

A catalyst containing reactor is being tested using a fuel-rich mixture of Jet A fuel and hot input air. The reactor product is a gaseous fuel that can be utilized in aeropropulsion gas turbine engines. Because the catalyst material is susceptible to damage from high temperature conditions, fuel-rich operating conditions are attained by introducing the fuel first into an inert gas stream in the reactor and then displacing the inert gas with reaction air. Once a desired fuel-to-air ratio is attained, only limited time is allowed for a catalyst induced reaction to occur; otherwise the inert gas is substituted for the air and the fuel flow is terminated. Because there presently is not a gas turbine combustor in which to burn the reactor product gas, the gas is combusted at the outlet of the test facility flare stack. This technique in operations has worked successfully in over 200 tests. Author

N92-17204# Wright Lab., Wright-Patterson AFB, OH.
PROCEEDINGS OF THE USAF STRUCTURAL INTEGRITY PROGRAM CONFERENCE Final Report, 11 - 13 Dec. 1990
THOMAS D. COOPER and JOHN W. LINCOLN Aug. 1991 1064 p Conference held in San Antonio, TX, 11-13 Dec. 1990
(Contract AF PROJ. 2418)
(AD-A242943; WL-TR-91-2071) Avail: NTIS HC/MF A99 CSCL 21/5

The purpose of this 1990 Conference was to bring together technical personnel in DOD and the aerospace industry who are involved in the various technologies required to ensure the structural integrity of aircraft gas turbine engines, airframes, and other mechanical systems. It provided a forum to exchange ideas and share new information relating to the critical aspects of durability and damage tolerance technology for aircraft systems. GRA

N92-17546*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
EXPERIMENTS AND ANALYSIS CONCERNING THE USE OF EXTERNAL BURNING TO REDUCE AEROSPACE VEHICLE TRANSONIC DRAG Ph.D. Thesis - Maryland Univ., 1991
CHARLES J. TREFNY Jan. 1992 294 p
(NASA-TM-105397; E-6789; NAS 1.15:105397) Avail: NTIS HC/MF A13 CSCL 21/5

The external combustion of hydrogen to reduce transonic drag was investigated. A control volume analysis is developed and indicates that the specific impulse performance of external burning is competitive with other forms of airbreathing propulsion and depends on the fuel-air ratio, freestream Mach number, and the severity of the base drag. A method is presented for sizing fuel injectors for a desired fuel-air ratio in the unconfined stream. A two-dimensional Euler analysis is also presented which indicates that the total axial force generated by external burning depends on the total amount of energy input and is independent of the transverse and streamwise distribution of heat addition. Good agreement between the Euler and control volume analysis is demonstrated. Features of the inviscid external burning flowfield are discussed. Most notably, a strong compression forms at the sonic line within the burning stream which may induce separation of the plume and prevent realization of the full performance potential. An experimental program was conducted in a Mach 1.26 free-jet to demonstrate drag reduction on a simple expansion ramp geometry, and verify hydrogen-air stability limits at external burning conditions. Stable combustion appears feasible to Mach number of between 1.4 and 2 depending on the vehicle flight trajectory. Drag reduction is demonstrated on the expansion ramp at Mach 1.26; however, force levels showed little dependence on fuel

pressure or altitude in contrast to control volume analysis predictions. Various facility interference mechanisms and scaling issues were studied and are discussed. Author

N92-17552# General Electric Co., Cincinnati, OH. Aircraft Engine Business Group.
QUALIFICATION TEST REPORT. FUEL PUMP TEST STAND 3C3965G05
J. E. MOSS Oct. 1991 113 p
(Contract F33657-84-C-2011)
(AD-A242929; QTR-CDRL-29087) Avail: NTIS HC/MF A06
CSCL 13/11

The purpose of this report is to summarize the results of the qualification testing performed on the 3C3965G05 fuel pump test stand at Tinker Air Force Base. The 3C3965G05 fuel pump test stand was designed for the USAF by General Electric Aircraft Engines, Cincinnati, Ohio. It was designed to test the F101-GE-102, F110-GE-100, F108-CF-100, F118-GE-100, and F110-GE-129 fuel pumps and subassemblies. The objective of the testing program was to qualify the test stand for the F110-GE-129 main fuel pump. In so doing, the test stand was required to duplicate results obtained on the UUT manufacturer's test stand within tolerance limits established by ESO Design Engineering with concurrence from Evendale C and A Engineering. After test stand modification and prior to qualification demonstration, the stand was subjected to an engineering evaluation by the GE stand test engineer. GRA

N92-17729# Naval Postgraduate School, Monterey, CA.
AN ANALYSIS OF THE AIRCRAFT ENGINE COMPONENT IMPROVEMENT PROGRAM (CIP): A LIFE CYCLE COST APPROACH M.S. Thesis
CHRIS J. BORER Dec. 1990 125 p
(AD-A243346) Avail: NTIS HC/MF A06 CSCL 21/5

Increasing budgetary constraints have prompted actions to reduce the maintenance cost of current naval aircraft. This thesis examines the Aircraft Engine Component Improvement Program (CIP), its impact on these cost at the organizational and intermediate levels of maintenance, and savings from these improvements. The objectives of the research were to identify current life cycle cost (LCC) models used by the Navy and/or the other services to determine CIP benefits, to validate on-going LCC-oriented computer programs. This thesis is organized into areas covering CIP objectives and considerations, system effectiveness, reliability, LCC and related data and models, aircraft data used for LCC, CIP/LCC computer models, return on investment (ROI) analysis program of the F-14A TF30-P-414A engine improvement, conclusions and recommendations. Based on the ROI analysis and ECIFR reports, the engine improvement program has been cost effective. GRA

N92-17855# National Aerospace Lab., Tokyo (Japan). Aeroengine Div.
HYDROGEN FUELED SUBSONIC-RAM-COMBUSTOR MODEL TESTS FOR AN AIR-TURBO-RAM ENGINE
TAKASHI TAMARU, KAZUO SHIMODAIRA, TAKASHI SAITOH, HIDESHI YAMADA, and SHOUJI HORIUCHI Apr. 1990 14 p
Previously announced in IAA as A90-12529
(NAL-TR-1064T; ISSN-0389-4014; JTN-92-80298) Avail: NTIS HC/MF A03

This paper deals with a basic study to facilitate the design of the hydrogen fueled subsonic ram combustor. Three types of flame holders, scaled 1/10 of the estimated actual size, were investigated to evaluate the performance for severe inlet conditions of hypersonic flight. Unidimensional analysis with total pressure at the exit and the static pressure on the duct wall gave the gas temperature and the Mach number of the combustion gas. Analysis of sampled gas at the exit gave radial profiles of equivalence ratio, combustion efficiency and so on. These results indicate that the fuel rich zone over stoichiometry must be avoided for the fuel preparation to attain the best combustion efficiencies near the stoichiometric mixture condition which is required for the engine in hypersonic flight. Author (NASDA)

08

AIRCRAFT STABILITY AND CONTROL

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

A92-21006
A NEW METHOD FOR INCREASING MAXIMUM FLIGHT ENDURANCE [EINE NEUE METHODE ZUR STEIGERUNG DER MAXIMAL-FLUGDAUER]
GOTTFRIED SACHS (Muenchen, Technische Universitaet, Munich, Federal Republic of Germany) Zeitschrift fuer Flugwissenschaften und Weltraumforschung (ISSN 0342-068X), vol. 15, Dec. 1991, p. 393-400. In German. refs
Copyright

A method for increasing flight endurance is presented which consists essentially of a periodic, optimal adjustment of variable wing camber. The problem is formulated as a periodic optimal control, and optimality conditions are set up based on the minimum principle. The optimal control law for the camber adjustment is derived and given in a form which simplifies the theoretical and calculative task and affords a clear physical interpretation. C.D.

A92-21178* Textron Bell Helicopter, Fort Worth, TX.
SYNTHESIS OF A HELICOPTER FULL-AUTHORITY CONTROLLER
M. W. HEIGES (Bell Helicopter Textron, Inc., Fort Worth, TX), P. K. A. MENON (NASA, Ames Research Center, Moffett Field, CA; Georgia Institute of Technology, Atlanta), and D. P. SCHRAGER (Georgia Institute of Technology, Atlanta) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 15, Jan.-Feb. 1992, p. 222-227. Research sponsored by U.S. Army. Previously cited in issue 23, p. 3617, Accession no. A89-52547. refs
Copyright

A92-21180
AIRCRAFT FLIGHT CONTROLS DESIGN USING OUTPUT FEEDBACK
B. L. STEVENS (Georgia Institute of Technology, Smyrna), F. L. LEWIS (University of Texas at Arlington, Fort Worth), and F. AL-SUNNI (Georgia Institute of Technology, Atlanta) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 15, Jan.-Feb. 1992, p. 238-246. Research supported by Georgia Institute of Technology. refs
Copyright

An approach is given for designing compensators of specified structure for shaping the closed-loop step response that uses linear quadratic output-feedback techniques. This approach results in controllers that take advantage of the wealth of experience in aircraft controls design. The correct initial conditions for determining the output-feedback gains are not uniformly distributed as is traditionally assumed, but are shown to be explicitly given in terms of the step command magnitude. Arbitrary systems are treated, not only those with integrators in the forward paths, by adding a term to the performance index that weights the steady-state error. Necessary conditions are derived that may be used in a gradient-based routine to determine the optimal control gains. Author

A92-21301
CONTROL SURFACES CORRELATION IN DLC MANEUVERS
M. M. NITA and B. TEODORESCU (Polytechnic Institute, Bucharest, Romania) Revue Roumaine des Sciences Techniques, Serie de Mecanique Appliquee (ISSN 0035-4074), vol. 36, Jan.-Apr. 1991, p. 3-10. refs

The correlation of aircraft control surfaces is examined with reference to direct lift control (DLC) maneuverability. In particular, the elevator-canard correlation is considered, and expressions for the correlation coefficient are derived for three typical DLC maneuvers: longitudinal attitude variation during rectilinear

horizontal uniform flight, transition from rectilinear to curvilinear flight at constant angle of attack, and curvilinear flight with constant longitudinal attitude. V.L.

A92-21307
CONTROL SURFACES CORRELATION IN DSFC MANEUVERS
M. M. NITA and B. TEODORESCU (Polytechnic Institute, Bucharest, Romania) Revue Roumaine des Sciences Techniques, Serie de Mecanique Appliquee (ISSN 0035-4074), vol. 36, May-Aug. 1991, p. 187-193. refs

The correlation of control surfaces is investigated analytically for direct side-force control (DSFC) maneuvers. In particular, the correlation between the rudder, ailerons, and an auxiliary control surface (canard) is analyzed, and expressions are derived for the correlation coefficients. Consideration is given to three typical DSFC maneuvers: azimuth angle variation during wing-level rectilinear flight, wing-level curvilinear translation, and wing-level symmetrical turn. V.L.

A92-21311
SOME CONSIDERATIONS ON MODELING FLIGHT VEHICLES MOVEMENT
M. M. NITA, P. PARVU (Polytechnic Institute, Bucharest, Romania), and V. CHELARU (Research Center, Ploiesti, Romania) Revue Roumaine des Sciences Techniques, Serie de Mecanique Appliquee (ISSN 0035-4074), vol. 36, Sept.-Dec. 1991, p. 297-304. refs

Several models for the dynamics of flight vehicles are presented which assume that a flight vehicle is a rigid body and allow for different types of rotations. The models examined use Euler's angles, quaternions, and flight vehicle angles (rather than attitude angles). The relative advantages and disadvantages of each of the approaches are discussed. V.L.

A92-22143*# Stanford Univ., CA.
AIRCRAFT CONTROL AT HIGH-ALPHA BY TANGENTIAL BLOWING
ZEKI Z. CELIK and LEONARD ROBERTS (Stanford University, CA) AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992. 18 p. refs
(Contract NCC2-55)
(AIAA PAPER 92-0021) Copyright

An experimental study has been undertaken to investigate the possibility of using tangential blowing to provide control forces and moments on a delta wing-forebody combination at high angles of attack. The present model can utilize the blowing separately on the wing and forebody. This research emphasizes the effect of blowing on the aerodynamics of the state of the art model by using: (1) flow visualization (smoke-flow visualization using a laser sheet), and (2) force and moment measurements. Experiments revealed that the effect of the blowing on a body-wing combination differs in several respects compared to that of wing alone or body alone. Force and moment measurements on the present model showed that the asymmetric blowing from the fuselage creates larger side force, rolling and yawing moments compared to blowing from the wing. In the presence of the forebody, the effectiveness of the rolling moment generated by blowing from the wing is reduced. Author

A92-22144*# Eidetics International, Inc., Torrance, CA.
FOREBODY VORTEX CONTROL WITH MINIATURE, ROTATABLE NOSE-BOOM STRAKES
CARLOS J. SUAREZ, GERALD N. MALCOLM (Eidetics International, Inc., Torrance, CA), and T. T. NG (Toledo, University, OH) AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992. 16 p. refs
(Contract NAS1-19289)
(AIAA PAPER 92-0022) Copyright

Experiments have been conducted in water and wind tunnel facilities to investigate the effectiveness of using rotatable miniaturized forebody nose-boom strakes to manipulate and control fighter aircraft forebody vortices at moderate to high angles of attack to provide potential aerodynamic control power in yaw. Water tunnel tests including flow visualization and yaw moment measurements were conducted on several different models of the F-16 fighter. Wind tunnel force and moment tests investigated the effects of several nose-boom strake configurations on an isolated 1/8th-scale X-29A forebody model. The primary variables of interest were strake size, configuration and roll angle orientation on the nose-boom. Both experiments showed clearly that small nose-boom strakes can be very effective in controlling the forebody vortex flowfield. Different degrees of flow asymmetry can be obtained by rotating a single or a pair of small strakes located on the nose-boom. With large fixed forebody strakes, such as those on the X-29A configuration, the effectiveness of the nose-boom strakes is significantly reduced. Author

A92-22161*# California Univ., Davis.
QUANTITATIVE FEEDBACK THEORY (QFT) APPLIED TO THE DESIGN OF A ROTORCRAFT FLIGHT CONTROL SYSTEM
R. A. HESS (California, University, Davis) and P. J. GORDER AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992. 12 p. refs
(Contract NCC2-624)
(AIAA PAPER 92-0044) Copyright

Quantitative Feedback Theory describes a frequency-domain technique for the design of multi-input, multi-output control systems which meet time or frequency domain performance criteria when specified uncertainty exists in the linear description of the vehicle dynamics. Quantitative Feedback Theory is applied to the design of the longitudinal flight control system for a linear uncertain model of the AH-64 rotorcraft. In this model, the uncertainty is assigned, and is assumed to be attributable to actual uncertainty in the dynamic model and to the changes in the vehicle aerodynamic characteristics which occur near hover. The model includes an approximation to the rotor and actuator dynamics. The design example indicates the manner in which handling qualities criteria may be incorporated into the design of realistic rotorcraft control systems in which significant uncertainty exists in the vehicle model. Author

A92-22162#
COMBINED H(2)/H(INFINITY) OPTIMAL CONTROL DESIGN APPLIED TO AN ADVANCED FIGHTER AIRCRAFT
KLIFFTON M. BLACK (Texas, University, Arlington), ANDREW G. SPARKS, SIVA S. BANDA, and HSI-HAN YEH (USAF, Flight Dynamics Laboratory, Wright-Patterson AFB, OH) AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992. 10 p. refs
(Contract F49620-86-C-0127)
(AIAA PAPER 92-0045) Copyright

Some practical aspects of designing a controller that minimizes a mixed H(2) and H(infinity) system norm are considered. Two approaches to the problem of selecting the many design variables are presented: an ad hoc procedure with 'diagonal' weighting matrices, and a novel extension of the well known linear quadratic Gaussian synthesis with loop transfer recovery to the mixed H(2)/H(infinity) optimal control problem. A linearized 4th order lateral model of an advanced fighter aircraft having three inputs and three outputs is used to illustrate the details. Numerical solutions to the resulting system of three coupled Riccati equations are obtained using an effective new algorithm that is based upon rewriting one of the equations in a Liapunov form. Author

A92-22163#
INTEGRATED FLIGHT CONTROL LAW SYNTHESIS FOR AN AEROELASTIC FORWARD-SWEPT WING AIRCRAFT
KAPSCONG RO, JEWEL B. BARLOW, and GYUNGHYUN BAE (Maryland, University, College Park) AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992. 12 p. refs
(AIAA PAPER 92-0046) Copyright

The aeroelastic forward-swept wing aircraft is a highly relaxed static stability aircraft with strong coupling between flight mechanic and structural dynamic modes. This coupling causes a dynamic instability known as the body freedom flutter. Since the aircraft is unstable, the rigid-body flight control system is mandatory. In

addition, due to body freedom flutter phenomenon an active elastic control system is a strong design alternative to provide satisfactory elastic stability for high speed flight or with wing mounted store. Two ways are possible to design these control systems. One is to separately design a rigid-body and elastic control system, and the other is to design a single integrated control system to achieve both rigid and elastic stability. Regardless of these design approaches, various uncertainties in the design model are inevitable so that the candidate control law is required to be robust with respect to such uncertainties. In this paper, the optimal output linear quadratic regulator, and the linear quadratic Gaussian with loop transfer recovery technique are applied to design both separated and integrated control system. Author

A92-22164#
USE OF NEURAL NETWORKS IN CONTROL OF HIGH ALPHA MANEUVERS
J. E. STECK and K. ROKHSAZ (Wichita State University, KS) AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992. 8 p. refs
(AIAA PAPER 92-0048) Copyright

A method is presented by which an appropriately constructed artificial neural network can be 'trained' to predict the force and moment coefficients of a 70 degree sweep delta wing during a high angle of attack excursion. The angle of attack time history is a sinusoidal motion from 0 degrees to 90 degrees and returning to 0 degrees. Experimental data is used to train the network, and it is demonstrated that the network has indeed learned to model the behavior of the delta wing over a range of frequencies of this type of angle of attack time history. The longitudinal equations of motion for a delta wing aircraft are integrated for three sinusoidal angle of attack time histories using the predicted network aerodynamic data. This integration generates the longitudinal control deflection time histories required to produce these maneuvers. An exploration is then made as to whether a second artificial neural network can be trained as a neural stick gearing for such maneuvers. This is investigated by attempting to train a network to associate each required control deflection time history with a specified stick position schedule. Author

A92-22520
EVALUATION METHOD OF LONGITUDINAL STATIC STABILITY OF TAILLESS AIRPLANE
SHIGENORI ANDO and HIROSHI KAJITA Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 40, no. 456, 1992, p. 14-22. In Japanese. refs

Static longitudinal stability of tailless airplane is evaluated theoretically with two methods. One is the quasi-strip (or modified strip) method, and the other is a lifting-surface theory (DLM). Computation is made on the basis of available data of Northrop XB-35. Both methods agree with each other only qualitatively; of course, results of DLM should be much more reliable. Allowable limit of longitudinal CG position may be almost comparable with that of conventional airplanes. The airplane efficiency factor, e, relating to induced drag, is computed which is also satisfactory at least for cruising configuration. Author

A92-23382
A NEW METHOD FOR CALCULATION OF HELICOPTER MANEUVERING FLIGHT
YIHUA CAO and ZHENG GAO (Nanjing Aeronautical Institute, People's Republic of China) Nanjing Aeronautical Institute, Journal (English Edition), vol. 8, Oct. 1991, p. 16-24. Research supported by National Education Committee. refs

In this paper a set of nonlinear equations governing the helicopter in maneuvering flight are developed and solved based on finite difference methods for evaluating the extreme value of function. The inverse solution technique is improved and from it a good result of the sample calculation of level turn maneuver is obtained. Beginning with a set of prescribed flight conditions, this method calculates first the flight path, velocity and other kinematic parameters and then the control displacement, flight attitude and the load factor for a helicopter during the maneuvering. Author

N92-17019*# Georgia Inst. of Tech., Atlanta.
PERIODIC TRIM SOLUTIONS WITH HP-VERSION FINITE ELEMENTS IN TIME Final Report, Jul. 1989 - Dec. 1991
Dec. 1991 15 p
(Contract NAG1-1027)
(NASA-CR-189778; NAS 1.26:189778) Avail: NTIS HC/MF A03 CSCL 01/3

Finite Element in Time has been proven to be a powerful alternative solving strategy for the rotor craft trim problem. Additionally, Finite Element Method in Time has been developed in various versions like time-marching framework, Galerkin framework, Rayleigh-Ritz framework, and mixed formulation. Recently, this method was applied to the rotorcraft trim problem to obtain linearized solutions. The rotorcraft trim problem consists of trying to find a period solution for period-coefficient, differential equations subject to side constraints where certain force and momentum balance equations are forced to be equal to zero. There are free (or trim) parameters that are chosen to meet these side constraints. This project aims at expanding the application, in terms of the rotorcraft trim problem, from a linearized solution to nonlinear solution. Author

N92-17096# Air Force Inst. of Tech., Wright-Patterson AFB, OH. School of Engineering.
DEVELOPMENT OF HIGH ANGLE OF ATTACK CONTROL LAWS FOR AN UNSTABLE, NON-MINIMUM PHASE AIRCRAFT USING VARIATIONS OF THE QUANTITATIVE FEEDBACK TECHNIQUE M.S. Thesis
MARK A. MCCLURE Dec. 1991 244 p
(AD-A243698; AFIT/GE/ENG/91D-39) Avail: NTIS HC/MF A11 CSCL 01/4

This thesis discusses the application of variations of the quantitative feedback technique to a control problem with unstable, nonminimum phase plants. The X-29A research aircraft is used as the basis for developing a set of representative linearized aircraft dynamics models, which are modified to allow for the use of differential canard control inputs for enhanced maneuverability at extreme angles of attack. A specialized design approach is presented to develop frequency dependent weighting matrices, and the shortcomings of traditional methods are discussed. Four independent longitudinal compensators are developed by first designing loop transmission functions. Discussion is provided that addresses the limitations imposed on the designer by the numerous right half plane poles and zeros of the effective plants. The optimal blending method is applied in one case to achieve a marginally stable system for a virtually impossible problem. Prefilters are designed and their effects on closed-loop time responses are discussed. The singular-G method is used to improve the achievable stability characteristics of a multi-input multi-output lateral-directional controller. The optimal blending method is then applied to develop an optimal loop transmission function. Finally, the required steps for completing the MIMO design are presented to aid future research efforts. GRA

N92-17166# Army Aviation Systems Command, Moffett Field, CA. Aeroflightdynamics Directorate.
SYSTEM IDENTIFICATION REQUIREMENTS FOR HIGH-BANDWIDTH ROTORCRAFT FLIGHT CONTROL SYSTEM DESIGN
MARK B. TISCHLER *In* AGARD, Rotorcraft System Identification 12 p Oct. 1991 Previously announced in IAA as A90-45333
Copyright Avail: NTIS HC/MF A12; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

The application of system identification methods to high-bandwidth rotorcraft flight control system design is examined. Flight test and modeling requirements are illustrated using flight test data from a BO-105 hingeless rotor helicopter. The proposed approach involves the identification of nonparametric frequency-response models, followed by parametric (transfer function and state space) model identification. Results for the BO-105 show the need for including coupled body/rotor flapping and lead-lag dynamics in the identification model structure to allow the accurate prediction of control system bandwidth limitations.

Lower-order models are useful for estimating nominal control system performance only when the flight data used for the identification are bandlimited to be consistent with the frequency range of applicability of the model. The flight test results presented in this paper are consistent with theoretical studies by previous researchers. Author

N92-17243# United Technologies Research Center, East Hartford, CT.
LOADING AND VIBRATION REDUCTION THROUGH ACTIVE AERODYNAMIC CONTROL Quarterly Progress Report, 13 Jun. - 13 Sep. 1991
JOHN C. SIMONICH 13 Sep. 1991 14 p
(Contract N00014-91-C-0148)
(AD-A242321; UTRC-R91-970089-01) Avail: NTIS HC/MF A03
CSCL 20/11

The objective of this work is to provide active aerodynamic control concepts for reducing unsteady lift and moments in propulsor blades. These unsteady forces are responsible for vibration and noise during an encounter with an incident gust. This effort represents an extension of a recent UTRC breakthrough in which active aerodynamic control was used to reduce noise generated during a two dimensional (2-D) blade-gust interaction. The associated reductions in unsteady blade surface pressures responsible for the noise reduction will be evaluated under the current program. Also, an analytical effort will generate a computer code for predicting surface pressures created by an actively controlled flap system and will estimate the required flap motion to cancel the unsteady lift. This work will extend the UTRC 2-D expertise in active aerodynamic control to a three dimensional (3-D) capability. This will be done by analytically investigating the effect of a swept gust interacting with an actively controlled, segmented flap to control the bending moment as well as the lift. Also, an exploratory experimental study on the effects of a swept gust encountering a 2-D non-segmented flap will be performed. In summary, this study will provide the Navy with concepts for active aerodynamic control for reducing unsteady blade loads responsible for structural vibration. GRA

N92-17442# Naval Postgraduate School, Monterey, CA.
MULTIPLE INPUT SLIDING MODE CONTROL FOR AUTONOMOUS DIVING AND STEERING OF UNDERWATER VEHICLES M.S. Thesis
TODD D. HAWKINSON Dec. 1990 214 p
(AD-A241935) Avail: NTIS HC/MF A10 CSCL 13/10

Design and analysis of multiple input autopilots using sliding modes in order to achieve accurate horizontal and vertical plane control of an autonomous underwater vehicle over a wide variation of speeds is presented. The simulated vehicle is equipped with two (fore and aft) sets of dive planes and two sets of rudders. In addition, two vertical and two horizontal thrusters are provided for control during low speed or hovering operations. The entire range of vehicle speeds from zero speed hovering to full speed ahead is divided into regions depending on control efficiency. Thrusters are used for low speed hovering, control surfaces for transition speeds. Linear quadratic regulator optimal control techniques coupled with the robustness properties of sliding mode control are utilized to provide the necessary control reversal which occurs during the transition from cruise to hover mode. Constant disturbances arising from underwater currents are effectively compensated resulting in accurate path keeping. As a consequence of the multiple input control methodology developed in this work, it is shown that both path and orientation accuracy can be achieved in moderate cross current environments. Finally, reduced order observers are designed in order to account for sensor absence or malfunction. GRA

N92-17748# Air Force Inst. of Tech., Wright-Patterson AFB, OH. School of Engineering.
A ROBUST DIGITAL FLIGHT CONTROL SYSTEM FOR AN UNFANNED RESEARCH VEHICLE USING DISCRETE QUANTITATIVE FEEDBACK THEORY M.S. Thesis
DONALD J. LACEY, JR. Dec. 1991 190 p
(AD-A243638; AFIT/GE/ENG/91D-33) Avail: NTIS HC/MF A09
CSCL 01/3

This thesis describes application of digital multiple-input multiple-output (MIMO) Quantitative Feedback Theory (QFT) technique to the design of a three axis rate controller for the Lambda Unmanned Research Vehicle. The resulting robust controller performs well throughout the flight envelope without gain scheduling. It results from research done at the Air Force Institute of Technology. The Lambda URV was designed by the Control Systems Development Branch of the Wright Laboratory at Wright-Patterson AFB, OH for flight testing aircraft control hardware and software. The flight control system is built using a small perturbation linear model developed from flight test data. The actuators, also modelled from aircraft test data, are second order in roll and pitch and first order in yaw. Nineteen separate plants are used to represent the flight envelope of the aircraft resulting from variations in speed, altitude, center of gravity location, and weight. The sample rate is 50 Hertz. The pitch channel is decoupled from the lateral-directional resulting in a single-input single-output (SISO) system for the pitch channel and a two-by-two MIMO system for the lateral-directional channel. The design employs the Nichols Chart and is accomplished in the w'-domain. GRA

N92-17917# National Aerospace Lab., Tokyo (Japan). Flight Research Div.
IDENTIFICATION OF THE STABILITY AND CONTROL DERIVATIVES OF A DLC-FLAP SYSTEM FOR VSRA
YUKICHI TSUKANO, TAKATSUGU ONO, and KAZUTOSHI ISHIKAWA 3 Apr. 1991 18 p In JAPANESE; ENGLISH summary
(NAL-TR-1116; ISSN-0389-4010) Avail: NTIS HC/MF A03

Flight tests were conducted using the Variable Stability and Response Airplane (VSRA) in order to identify the stability and control derivatives for a Direct Lift Control (DLC) flap system. The frequency response method was selected, with a pure sinusoidal input being applied to the DLC flaps. Response from a linear system model consisting of the stability and control derivatives was compared with other flight test response data to determine general inputs. The resulting derivatives were subsequently verified. Additionally, the control capability of the DLC flaps was estimated by the control derivatives and compared with wind tunnel test data. Author

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.

A92-21125
AIRPORT TERMINALS
CHRISTOPHER J. BLOW (Scott, Brownrigg, and Turner, England) Oxford, England and Stoneham, MA, Butterworth-Heinemann, Ltd., 1991, 199 p. refs
Copyright

The review of terminal facilities refers to a number of existing and new terminals around the globe within the context of their significance and the politics of their design. Terminal-design principles are defined in relation to the issues of capacity, airport master planning, and specific functional types of airport terminals. A taxonomy of aircraft-terminal forms is developed which includes basic terminals with either remote aircraft or mobile lounges, linear terminals, single vs. multiple piers, single vs. multiple satellites, multiple linear units, and hybrid forms. Specific criticisms of landside factors, design details, external airside factors, and terminal redevelopment lead to a proposed methodological approach to terminal design. With extensive illustrations of examples of terminal

design this overview represents a comprehensive design guide and critical resource for ground planning in the airport and aerospace industries. C.C.S.

A92-21749
NOISE CONTROL USED FOR TURBOJET ENGINE TEST BENCH
JUJUN ZHAO (31st Research Institute, People's Republic of China) Journal of Propulsion Technology (ISSN 1001-4055), Dec. 1991, p. 60-68. In Chinese. refs

A detailed discussion is presented on the noise making propagation and its characteristic at a turbojet engine test bench. A comparison is made of various design of noise control. The noise-reduction performance of a thick or a thin plate assembly which consists of a bilayer metal plate unit with multiple tiny holes is also given. With useful first-hand data, the noise-reduction effect of a device on wide-frequency-band, 140 dB (A), noise made during engine test is discussed. Author

A92-21922
THE FALSTAFF PROGRAM - A STANDARD SPECTRUM FOR SIMULATING THE SERVICE LOADING OF AIRCRAFT WITH PREVAILING MANEUVER LOADS [PROGRAM FALSTAFF - STANDARDNI SPEKTRUM PRO SIMULACI PROVOZNIHO ZATIZENI LETOUNU S PREVAZUJICIM MANEVROVYM ZATIZENIM]
JIRI FIDRANSKY Zpravodaj VZLU (ISSN 0044-5355), no. 5, 1991, p. 233-241. In Czech. refs
Copyright

The use of service loading simulation programs for fatigue testing is discussed with particular reference to the FALSTAFF standard spectrum. Service loading data for different fighter aircraft are compared with the loading history of a jet flight simulator. The final program sequence includes data for 200 flights and is repeated continuously. The generation of peak/through sequences in particular flights is described, and a method for reducing the peak/through cycles per flight is presented. This makes it possible to reduce the time required for fatigue tests. V.L.

A92-22634
FLIGHT SIMULATION AND ITS APPLICATION
KOICHI MATSUSHIMA Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 39, no. 454, 1991, p. 586-595. In Japanese. refs

Classifications of flight simulation are outlined. Mathematical and physical models are given, and concepts for the flight simulator and in-flight simulator are discussed. Application of simulation to the Space Shuttle is described. Y.P.Q.

A92-23761#
PRELIMINARY LASER INDUCED FLUORESCENCE MEASUREMENTS IN SEVERAL FACILITIES IN PREPARATION FOR APPLICATION TO STUDIES IN THE HIGH ENTHALPY SHOCK TUNNEL GOETTINGEN (HEG)
W. H. BECK, C. DANKERT, G. EITELBERG, and G. GUNDLACH (DLR, Institut fuer Experimentelle Stroemungsmechanik, Goettingen, Federal Republic of Germany) AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992. 11 p. Research supported by ESA. refs
(AIAA PAPER 92-0143) Copyright

The LIF technique will be used to examine the gas flows around models located in the test section of the high enthalpy shock tunnel (HEG) in Goettingen, at present undergoing qualification trails. Concentrations of NO (in 2D) (and latter O atoms (1D)) and an NO internal temperature will be measured. A completely automated apparatus consisting of three lasers and image capturing systems has been constructed. This system has been tested on a heated cell, on a vacuum wind tunnel, and on an arc-driven wind tunnel. Results from these tests are presented. The role of quenching in applying the LIF technique to HEG gas flows (which are not in chemical equilibrium) and an ongoing shock tube study are described briefly. Author

A92-23805#
REALISTIC REAL-TIME GROUND TESTING
JAMES BENDER, JEFF PERLEY, DAVE NEURAUTER (Sparta, Inc., Flight Support Div., Lancaster, CA), and L. J. GRAHAM (Science Applications International Corp., Lancaster, CA) AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992. 10 p. refs
(AIAA PAPER 92-0197) Copyright

Advancements in computer hardware and software have facilitated the realistic testing of aircraft in a cost-effective and controllable ground test environment. The extent to which a data-processing facility is fully integrated directly affects the efficiency of operations and the quality of results. A modular approach to facility development will allow phased development of facility subsystems as budgets allow, and facilitate future modular upgrades as technological advancements and test requirement revisions are incorporated. O.C.

A92-23810*# National Aeronautics and Space Administration, Washington, DC.
OPERATION AND DESIGN CONSIDERATIONS FOR UNSTEADY DATA ACQUISITION WITH PC-BASED SYSTEMS IN HIGH REYNOLDS NUMBER HYPERSONIC FLOWFIELDS
M. J. FLANAGAN, JR. (Ohio State University, Columbus) AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992. 8 p. Research supported by NASA. refs
(AIAA PAPER 92-0204) Copyright

Operation and design considerations for personal-computer-based data acquisition are analyzed, and a system is created that is portable, inexpensive, and capable of high-frequency response. This system performed well when given an extensive analysis of the characteristics of the radio-frequency noise in the test environment. The system architecture is well-suited for support of high-frequency data acquisition from both pressure transducers and high-frequency-response thermocouple gauges. As configured, the system provides a data resolution of approximately 0.09 psia and 0.56 F. Considering the constraints placed upon this design, this data resolution is acceptable. The $5000 budget did require use of an existing PC and rental of signal-conditioning equipment. Author

N92-15998*# Physical Sciences, Inc., Andover, MA.
AEROTHERMODYNAMIC RADIATION STUDIES Final Report
K. DONOHUE, W. G. REINECKE, D. ROSSI, W. J. MARINELLI, R. H. KRECH, and G. E. CALEDONIA Sep. 1991 71 p
(Contract NAS9-18172)
(NASA-CR-185666; NAS 1.26:185666; PSI-2093/TR-1143) Avail: NTIS HC/MF A04 CSCL 14/2

We have built and made operational a 6 in. electric arc driven shock tube which alloys us to study the non-equilibrium radiation and kinetics of low pressure (0.1 to 1 torr) gases processed by 6 to 12 km/s shock waves. The diagnostic system allows simultaneous monitoring of shock radiation temporal histories by a bank of up to six radiometers, and spectral histories with two optical multi-channel analyzers. A data set of eight shots was assembled, comprising shocks in N2 and air at pressures between 0.1 and 1 torr and velocities of 6 to 12 km/s. Spectrally resolved data was taken in both the non-equilibrium and equilibrium shock regions on all shots. The present data appear to be the first spectrally resolved shock radiation measurements in N2 performed at 12 km/s. The data base was partially analyzed with salient features identified. Author

N92-17097# Air Force Inst. of Tech., Wright-Patterson AFB, OH.
IMPLEMENTATION OF AN OBJECT-ORIENTED FLIGHT SIMULATOR D.C. ELECTRICAL SYSTEM ON A HYPERCUBE ARCHITECTURE M.S. Thesis
GUY R. BOOTH Dec. 1991 148 p
(AD-A243700; AFIT/GCE/ENS/91D-01) Avail: NTIS HC/MF A07 CSCL 05/9

The Software Engineering Institute developed an object-oriented paradigm for flight simulators based on the concept

of mapping the behavior of physical objects from an aircraft into an object-oriented software architecture. This mapping is a semi-formal method that maps objects to a hierarchy that has three logical layers: objects, systems, and executives. The paradigm was developed with the idea of implementing the derived simulation design on a parallel or distributed computer architecture, but no explicity design features are provided for implementing the design on a parallel computer. This research addresses the issue of determining what extensions (if any) are required to implement a parallel version of the D.C. Electrical System Simulation (DESS) that the SEI developed as an example on using their paradigm. The parallel DESS design is implemented and tested using Ada on an Intel iPSC/2 Hypercube. An analysis of the performance of the simulation is presented, and some conclusions are made about implementing a parallel design based on the SEI Object-Oriented Paradigm for Flight Simulators. Author (GRA)

N92-17260# Army Engineer Waterways Experiment Station, Vicksburg, MS. Geotechnical Lab.
ALTERNATE/MODIFIED BINDERS FOR ASPHALT AIRFIELD PAVEMENTS Final Report, Jan. 1986 - Sep. 1988
GARY L. ANDERTON Nov. 1990 162 p
(Contract MIPR-N-86-28; MIPR-N-87-5; MIPR-N-88-15; AF PROJ. 2673)
(AD-A242829; AFESC/ESL-TR-89-40) Avail: NTIS HC/MF A08 CSCL 13/3

This report documents a laboratory research effort to determine the effects of asphalt modifiers and alternate binders on asphalt airfield pavements. The modified binders were tested to determine their potential for reducing pavement deformation distresses, improving rheological properties, reducing asphalt contents, and improving the asphalt pavement's heat resistant capabilities under jet engine blasts. An intensive literature search was performed during the first year of the study to gather all of the available information on the modifiers currently available. This information was used to choose 14 test materials, which were tested in the laboratory during the second year of the study. Data resulting from these tests were used to choose the five most promising test materials, which were evaluated further in the third and final year of the study by more detailed laboratory tests. All laboratory mix specimens were made with the same aggregate gradations and under as near identical conditions as possible. An AC-20 grade of asphalt cement was chosen as the base asphalt for all modified asphalt blends. Asphalt mix testing consisted of indirect tensile, resilient modulus and unconfined creep-rebound tests. Asphalt binder test included kinematic viscosity, Brookfield viscosity, penetration, resiliency, and chromatography. GRA

N92-17297# Aeronautical Research Labs., Melbourne (Australia).
STAGNATION AND DYNAMIC PRESSURE LIMITS FOR THE S1 WIND TUNNEL
DAVID A. PIERENS Sep. 1991 30 p
(AD-A242989; ARL-FLIGHT-MECH-TM-435; DODA-AR-006-591)
Avail: NTIS HC/MF A03 CSCL 14/2

The ARL-Salisbury S1 wind tunnel is a closed circuit, continuous, variable pressure wind tunnel, with a Mach number range of 0.35 to 1.0 and 1.4 to 2.8. The nominal dimensions of the tunnel's working section are 380 mm x 380 mm. Although the tunnel has been in operation for many years, no attempt has been made to experimentally investigate and establish the operational pressure limits. Thus, it is not uncommon for new experimenters to request running conditions which the tunnel cannot achieve. This is further complicated by new temperature and current limits being adopted in 1985 after a main monitor failure. Therefore, a series of wind tunnel test runs were carried out in order to provide a reliable guide, outlining the running conditions which the S1 wind tunnel can safely achieve. This report outlines the absolute maximum pressure and the recommended maximum operating pressures for the S1 wind tunnel. The pressure limits calculated in this report were obtained from actual wind tunnel data records. GRA

N92-17756# National Aerospace Lab., Tokyo (Japan). Advanced Aircraft Research Group.
IMPROVEMENT OF DATA PROCESSING SYSTEM FOR GUST WIND TUNNEL DATA ACQUISITION PART: SYSTEM CONVERSION FROM OFF-LINE TO ON-LINE PROCESSING [TOPPU FUDO DETA SHORI SOCHI (DETA SHUSHUBU) NO KAISHU: KEISOKU SHISUTEMU NO ONRAINKA]
TOSHIMI FUJITA, AKIHITO IWASAKI, and HIROTOSHI FUJIEDA Jul. 1989 60 p In JAPANESE
(NAL-TM-611; ISSN-0452-2982; JTN-92-80247) Avail: NTIS HC/MF A04

The data acquisition part of the gust wind tunnel in National Aerospace Laboratory has been changed from the OKITAC-4300 off-line processing system to the ECLIPSE MV/7800 XP on-line processing system. At the same time, the primary data processing system has been updated with quick look display to conduct wind tunnel tests more efficiently. The new system enables the great improvement of wind tunnel test efficiency and data productivity as follows: (1) human operation errors in the wind tunnel test can be prevented; (2) repetition of the same test caused by inferior or abnormal data can be avoided; and (3) turn around time from data acquisition until data processing can be cut down from a day or hourly time scale to minutes or seconds.
Author (NASDA)

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.

A92-21023* Colorado Univ., Boulder.
SIMULATION OF GRM DRAG COMPENSATION SYSTEM
PETER G. ANTREASIAN (Colorado, University, Boulder), JOHN B. LUNDBERG, and BOB E. SCHUTZ (Texas, University, Austin) Journal of the Astronautical Sciences (ISSN 0021-9142), vol. 39, Oct.-Dec. 1991, p. 487-518. Research supported by University of Texas. refs
(Contract NAG5-528)
Copyright

NASA's Geopotential Research Mission (GRM) was proposed in 1986 for globally determining the earth's gravitational and magnetic fields with high precision via full earth coverage polar-orbit satellites. In the GRM system, at least one of the two satellites was required to be stationed in a low-altitude, 160-km orbit subject to atmospheric drag effects that could both corrupt gravity measurements and reduce the satellite's lifetime. The Disturbance Compensation System, 'DISCOS', was incorporated to select a drag-free orbit during the active portion of GRM satellite operations by firing thrusters that offset the effects of disturbances. A drag-free thruster algorithm has been created to simulate the DISCOS system; simulation results are presented. O.C.

A92-22632
SPACEPLANE SYSTEM STUDIES
MASATAKA MAITA Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 39, no. 454, 1991, p. 571-579. In Japanese. refs

Basic system concepts of Japanese spaceplane research and development are presented. The single stage to orbit system of the spaceplane is illustrated. The hypersonic airbreathing propulsion system is addressed. Y.P.Q.

A92-23746*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
SHUTTLE INFRARED LEESIDE TEMPERATURE SENSING (SILTS) EXPERIMENT - STS-35 AND STS-40 PRELIMINARY RESULTS
DAVID A. THROCKMORTON, E. V. ZOBY (NASA, Langley Research Center, Hampton, VA), JAMES C. DUNAVANT (Lockheed Engineering and Sciences Co., Hampton, VA), and DAVID L. MYRICK (Vigyan Research Associates, Inc., Hampton, VA) AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992. 14 p. refs
(AIAA PAPER 92-0126) Copyright

Preliminary results from the STS-35 and STS-40 flight of the Shuttle Infrared Leeside Temperature Sensing (SILTS) experiment aboard the Shuttle Orbiter Columbia are presented. Infrared images are shown in false-color indicating the level and distribution of surface temperature over the vehicle's leeside fuselage during entry. Features evident in the imagery are related to their causative aerodynamic flow phenomena. Quantitative comparisons of the infrared image data with in situ temperature measurements obtained with thermocouples located at the aerodynamic surface of the thermal protection materials are presented. Author

A92-23753#
SHUTTLE ENTRY AIR DATA SYSTEM - AN EXPERIMENTAL INVESTIGATION OF CALIBRATION FOR ASCENT FLIGHT
TIMOTHY J. WOESTE (Cincinnati, University, OH) AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992. 10 p. refs
(AIAA PAPER 92-0133) Copyright

An investigation into the calibration of the Shuttle Entry Air Data System (SEADS) has been conducted for the purpose of obtaining angle of attack and sideslip during ascent powered flight. The calibration methodology involves modeling a modified Newtonian pressure distribution, corrected for interference, around the orbiter nosecap. Due to the lack of ascent configuration wind tunnel data resolution near the nosecap, the Ascent Air Data System (AADS) was used as a calibrator. The calibration curves were then used to reduce data from future Shuttle flights. Results from this calibration show that vehicle attitude can be determined to within six-tenths degree of pitch and sideslip when compared with the AADS. Calibration curves were then developed using data from two SEADS flights, and the comparison with the AADS system was improved to within one-half degree. Additional flights of the SEADS system should provide more flight calibration data and increase the accuracy of the ascent data reduction method. This paper details the calibration methodology and also presents the results of the calibration when applied to STS-28 and STS-32. Author

N92-16012*# Flight Mechanics and Control, Inc., Hampton, VA.
STS-40 DESCENT BET PRODUCTS: DEVELOPMENT AND RESULTS Final Report
KEVIN F. OAKES, JAMES S. WOOD, and JOHN T. FINDLAY Nov. 1991 8 p
(Contract NAS1-18937)
(NASA-CR-189570; NAS 1.26:189570) Avail: NTIS HC/MF A02 CSCL 22/2

Descent Best Estimate Trajectory (BET) Data were generated for the final Orbiter Experiments Flight, STS-40. This report discusses the actual development of these post-flight products: the inertial BET, the Extended BET, and the Aerodynamic BET. Summary results are also included. The inertial BET was determined based on processing Tracking and Data Relay Satellite (TDRSS) coherent Doppler data in conjunction with observations from eleven C-band stations, to include data from the Kwajalein Atoll and the usual California coastal radars, as well as data from five cinetheodolite cameras in the vicinity of the runways at EAFB. The anchor epoch utilized for the trajectory reconstruction was 53,904 Greenwich Mean Time (GMT) seconds which corresponds to an altitude at epoch of approximately 708 kft. Atmospheric data to enable development of an Extended BET for this mission were upsurped from the JSC operational post-flight BET. These data were evaluated based on Space Shuttle-derived considerations as well as model comparisons. The Aerodynamic BET includes configuration information, final mass properties, and both flight-determined and predicted aerodynamic performance estimates. The predicted data were based on the final pre-operational databook, updated to include flight determined incrementals based on an earlier ensemble of flights. Aerodynamic performance comparisons are presented and correlated versus statistical results based on twenty-two previous missions. Author

N92-16973*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
STS-41 SPACE SHUTTLE MISSION REPORT
DAVID W. CAMP, D. M. GERMANY, and LEONARD S. NICHOLSON Nov. 1990 26 p
(NASA-TM-105479; NAS 1.15:105479; NSTS-08194) Avail: NTIS HC/MF A03 CSCL 22/2

The STS-41 Space Shuttle Program Mission Report contains a summary of the vehicle subsystem activities on this thirty-sixth flight of the Space Shuttle and the eleventh flight of the Orbiter vehicle, Discovery (OV-103). In addition to the Discovery vehicle, the flight vehicle consisted of an External Tank (ET) (designated as ET-39/LWT-32), three Space Shuttle main engines (SSME's) (serial numbers 2011, 2031, and 2107), and two Solid Rocket Boosters (SRB's), designated as BI-040. The primary objective of the STS-41 mission was to successfully deploy the Ulysses/inertial upper stage (IUS)/payload assist module (PAM-S) spacecraft. The secondary objectives were to perform all operations necessary to support the requirements of the Shuttle Backscatter Ultraviolet (SSBUV) Spectrometer, Solid Surface Combustion Experiment (SSCE), Space Life Sciences Training Program Chromosome and Plant Cell Division in Space (CHROMEX), Voice Command System (VCS), Physiological Systems Experiment (PSE), Radiation Monitoring Experiment - 3 (RME-3), Investigations into Polymer Membrane Processing (IPMP), Air Force Maui Optical Calibration Test (AMOS), and Intelsat Solar Array Coupon (ISAC) payloads. The sequence of events for this mission is shown in tabular form. Summarized are the significant problems that occurred in the Orbiter subsystems during the mission. The official problem tracking list is presented. In addition, each Orbiter problem is cited in the subsystem discussion. Author

N92-17167*# Rockwell International Corp., Downey, CA. Space Transportation Systems Div.
RESULTS OF THE SPACE SHUTTLE VEHICLE ASCENT AIR DATA SYSTEM PROBE CALIBRATION TEST USING A 0.07-SCALE EXTERNAL TANK FOREBODY MODEL (68T) IN THE AEDC 16-FOOT TRANSONIC WIND TUNNEL (IA-310), VOLUME 1
J. G. R. COLLETTE Nov. 1991 642 p Prepared in cooperation with Chrysler Corp., New Orleans, LA
(Contract NAS9-17840)
(NASA-CR-167696; NAS 1.26:167696; DMS-DR-2547-VOL-1)
Avail: NTIS HC/MF A99 CSCL 22/2

A recalibration of the Space Shuttle Vehicle Ascent Air Data System probe was conducted in the Arnold Engineering Development Center (AEDC) transonic wind tunnel. The purpose was to improve on the accuracy of the previous calibration in order to reduce the existing uncertainties in the system. A probe tip attached to a 0.07-scale External Tank Forebody model was tested at angles of attack of -8 to +4 degrees and sideslip angles of -4 to +4 degrees. High precision instrumentation was used to acquire pressure data at discrete Mach numbers ranging from 0.6 to 1.55. Pressure coefficient uncertainties were estimated at less than 0.0020. Data is given in graphical and tabular form. Author

N92-17214*# Rockwell International Corp., Downey, CA. Space Transportation Systems Div.
RESULTS OF THE SPACE SHUTTLE VEHICLE ASCENT AIR DATA SYSTEM PROBE CALIBRATION TEST USING A 0.07-SCALE EXTERNAL TANK FOREBODY MODEL (68T) IN THE AEDC 16-FOOT TRANSONIC WIND TUNNEL (IA-310), VOLUME 2

J. G. R. COLLETTE Nov. 1991 685 p Prepared in cooperation with Chrysler Corp., New Orleans, LA
(Contract NAS9-17840)
(NASA-CR-167697; NAS 1.26:167697; DMS-DR-2547-VOL-2)
Avail: NTIS HC/MF A99 CSCL 22/2

A recalibration of the Space Shuttle Vehicle Ascent Air Data System probe was conducted in the Arnold Engineering and Development Center (AEDC) transonic wind tunnel. The purpose was to improve on the accuracy of the previous calibration in order to reduce the existing uncertainties in the system. A probe tip attached to a 0.07-scale External Tank Forebody model was tested at angles of attack of -8 to +4 degrees and sideslip angles of -4 to +4 degrees. High precision instrumentation was used to acquire pressure data at discrete Mach numbers ranging from 0.6 to 1.55. Pressure coefficient uncertainties were estimated at less than 0.0020. Additional information is given in tabular form.
Author

N92-17325# Charles River Analytics, Inc., Cambridge, MA.
AN ALTERNATIVE CONCEPT FOR AEROASSISTED ORBIT TRANSFERS
PAUL G. GONSALVES, SCOTT M. ALLEN, and ALPER K. CAGLAYAN Aug. 1991 77 p
(Contract DAAH01-91-C-R061)
(AD-A243409; TR-R90222) Avail: NTIS HC/MF A05 CSCL 17/7

The primary results of this study are identification of possible new applications of aeroassisted orbital transfers to LightSat/TacSats and the feasibility evaluation of an on-line neural network implementation of an atmospheric trajectory/guidance scheme. AOT scenarios involve 2 distinct categories: on-orbit multiple-pass 'soft maneuvers' and the single-pass deep penetration into the atmosphere 'hard maneuver'. Due to propellant limitations, the soft maneuver is very conducive to address LightSac/TacSat orbital transfer requirements. Possible soft-maneuvers include inclination and perigee location stationkeeping. Hard maneuvers are more conducive to situations requiring a greater amount of maneuverability, e.g., emergency relocation of a satellite. Associated with each class of AOTs are a set of relevant vehicle and mission requirement parameters, which help define the overall feasibility of AOTs. Chief among these parameters is perigee altitude. Perigee altitude determines the amount of atmospheric density available to perform on-orbit maneuvers. Since density decreases exponentially with altitude, AOTs are not feasible beyond a perigee altitude of 200 km. Lower perigee altitudes come with detrimental effects of shorter orbital lifetimes. This can be ameliorated via more eccentric orbits. Among the relevant vehicle parameters are satellite mass, reference area, and aerodynamic efficiency. Trade-off studies were performed for two specific soft maneuvers: plane change and rotation of line of apsides.
GRA

N92-17350*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
ADVANCED FLIGHT SOFTWARE RECONFIGURATON
BRYAN PORCHER *In* NASA, Washington, Beyond the Baseline 1991: Proceedings of the Space Station Evolution Symposium. Volume 2: Space Station Freedom, Part 2 p 1021-1036 Sep. 1991
Avail: NTIS HC/MF A20 CSCL 22/2

Information is given in viewgraph form on advanced flight software reconfiguration. Reconfiguration is defined as identifying mission and configuration specific requirements, controlling mission and configuration specific data, binding this information to the flight software code to perform specific missions, and the release and distribution of the flight software. The objectives are to develop, demonstrate, and validate advanced software reconfiguration tools and techniques; to demonstrate reconfiguration approaches on Space Station Freedom (SSF) onboard systems displays; and to interactively test onboard systems displays, flight software, and flight data.
Author

N92-17754# National Aerospace Lab., Tokyo (Japan). Aerodynamics Div.
WEIGHT EVALUATION AND SENSITIVITY ANALYSIS FOR SPACE PLANE. PART 2: TSTO Report No. 1 [UCHU OHKANKI NO JURYO HYOKA TO KANDO KAISEKI (SONO 2): TSTO]
MASAO SHIROUZU Feb. 1989 19 p In JAPANESE
(NAL-TM-602-PT-2; ISSN-0452-2982; JTN-92-80241) Avail: NTIS HC/MF A03

Reported here is the weight evaluation and sensitivity analysis of a two stage to orbit (TSTO) type spaceplane. The major purpose of this analysis is to get the basic data which is necessary to determine the configuration of the spaceplane. Those data are used in wind tunnel tests. As the result of weight evaluation, it is confirmed that the TSTO is more feasible than single stage to orbit (SSTO). The further analysis leads to the basic specification of TSTO as follows: total weight is 350 tons; the booster wing area is 583 square meters; and the orbiter length is 39.5 meters. As for sensitivity analysis, the following parameters are checked: orbiter lift-off weight, orbiter separation condition, lift-off wing load, and cruising range. As the result of sensitivity analysis, it is confirmed that the orbiter velocity on separation and the engines which can be used in high Mach number condition are the important factors which enable the TSTO type spaceplane.
Author (NASDA)

11

CHEMISTRY AND MATERIALS

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

A92-21003
COMPARATIVE STUDY OF FATIGUE IN VARIOUS MATERIALS AND DESIGNS UNDER SONIC LOADING [VERGLEICHENDE UNTERSUCHUNG ZUR ERMUEDUNG VERSCHIEDENER MATERIALIEN UND BAUWEISEN UNTER BELASTUNG DURCH SCHALL]
K. KOENIG (Deutsche Airbus GmbH, Bremen, Federal Republic of Germany) Zeitschrift fuer Flugwissenschaften und Weltraumforschung (ISSN 0342-068X), vol. 15, Dec. 1991, p. 373-378. In German.
Copyright

Vibration tests of a number of designs and materials were conducted, and the results are compared. It is concluded that, next to classical aluminum, CFK is the best material with regard to sonic fatigue. CFRP and CFRP/GFRP can produce better results than alumimum only if either aluminum stringers of greater strength than those tested here are used or if riveted CFRP stringers are used. The use of doublers between skin and stringers results in the most striking design improvement reported here. A loose doubler is more effective than a chemically milled doubler.
C.D.

A92-21052
SIMULTANEOUS COHERENT ANTI-STOKES RAMAN SPECTROSCOPY MEASUREMENTS IN HYDROGEN-FUELED SUPERSONIC COMBUSTION
TORGER J. ANDERSON and ALAN C. ECKBRETH (United Technologies Research Center, East Hartford, CT) Journal of Propulsion and Power (ISSN 0748-4658), vol. 8, Jan.-Feb. 1992, p. 7-15. Previously cited in issue 06, p. 788, Accession no. A90-19713. refs
(Contract F33615-86-C-2695)
Copyright

A92-21327
DEVELOPMENT AND TRIBOLOGICAL PROPERTIES OF NEW CYCLOTRIPHOSPHAZENE HIGH TEMPERATURE LUBRICANTS FOR AIRCRAFT GAS TURBINE ENGINES

BASSAM S. NADER, KISHORE K. KAR, TED A. MORGAN, CHESTER E. PAWLOSKI, and WENDELL L. DILLING (Dow Chemical Co., Midland, MI) (STLE, Annual Meeting, 46th, Montreal, Canada, Apr. 29-May 2, 1991) STLE Tribology Transactions (ISSN 0569-8197), vol. 35, Jan. 1992, p. 37-44. refs
Copyright

A number of substituted aryloxycyclotriphosphazenes were synthesized and studied, with the objective of meeting the lubricant requirements of the Integrated High Performance Turbine Engine Technology (IHPTET) initiative. These compounds were evaluated for pour point, oxidative stability, and lubricity behavior. Further property evaluations were performed on a leading candidate fluid, bis(4-fluorophenoxy)-tetrakis(3-trifluoromethylphenoxy) phazene, code-named X-1P. The results of this study are discussed, along with comparative data of other leading commercial high temperature fluids. Author

A92-21490
CREEP-FATIGUE CRACK GROWTH IN JETHETE M152 AT 550 C UNDER MIXED MODE CONDITIONS
T. H. HYDE and A. C. CHAMBERS (Nottingham, University, England) Journal of Strain Analysis for Engineering Design (ISSN 0309-3247), vol. 27, Jan. 1992, p. 49-57. Research supported by SERC and Rolls-Royce, PLC. refs
Copyright

Creep-fatigue tests were carried out on Jethete M152 at 550 C under mode-I, mode-II, and mixed-mode (K(I)/K(II) approximately equal to 1.6) conditions. The results were correlated and compared with corresponding fatigue and creep data. The results indicated that damage due to creep caused a larger increase in fatigue-crack-growth rate than a simple superposition model predicts. Also, creep appeared to have a more dominant influence than fatigue on crack-growth direction. Author

A92-22133#
LASER DIAGNOSTICS FOR VELOCITY MEASUREMENTS IN SUPERSONIC COMBUSTING ENVIRONMENTS
L. P. GOSS, T. H. CHEN, D. G. SCHOMMER (Systems Research Laboratories, Inc., Dayton, OH), and A. S. NEJAD (USAF, Wright Laboratory, Wright-Patterson AFB, OH) AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992. 8 p. refs
(Contract F33615-88-C-2832)
(AIAA PAPER 92-0008)

Two-photon photolysis of propane-air mixtures is investigated as a possible source of tag species for velocity measurements. Emission spectra of the propane photofragments indicate the presence of the C2, and CN (with the addition of air). Emission at 216 nm is speculated to be from a primary fragment and varies linearly with propane concentration. Emission from the photofragments is shown to be dependent upon the local air-to-fuel ratio. Chemical lifetime measurements of the CN- and CH-radical photo-fragments indicate a lifetime of 3-5 microseconds. These photo-fragments can be utilized as tag species in flowfields above 50 m/s. Author

A92-22754
APPLICATIONS OF IMI 834 IN AEROENGINES - A COLLABORATIVE IMI/MTU PROGRAMME
M. A. DAEUBLER, D. HELM (MTU Motoren- und Turbinen-Union Muenchen GmbH, Munich, Federal Republic of Germany), and D. F. NEAL (IMI Titanium, Ltd., Birmingham, England) IN: Titanium 1990: Products and applications; Proceedings of the International Conference, Buena Vista, FL, Sept. 30-Oct. 3, 1990. Vol. 1. Dayton, OH, Titanium Development Association, 1990, p. 78-87. refs
Copyright

The high (about 600 C) service temperature Ti alloy designated IMI 834 is weldable and exhibits greater mechanical strength, fatigue strength, creep resistance and refined microstructure, relative to current Ti alloys; it is accordingly an attractive candidate for high pressure/temperature compressor disk applications. Attention is presently given to the alloying variations, thermomechanical treatments, and heat treatments applied in order to tailor an optimal alloy of this type for compressor disk use. The influence of microstructure on tensile strength, creep resistance, and low-cycle fatigue behavior is also noted, and the dominant influence of quench rate (following solution heat-treatment) on both microstructure and properties is emphasized. O.C.

A92-22755
MECHANICAL AND FRACTURE BEHAVIOUR OF TI-6AL-2SN-4ZR-2MO-0.1SI ALLOYS
BILAL DOGAN and KARL-HEINZ SCHWALBE (GKSS-Forschungszentrum, Institut fuer Werkstoff-Forschung, Geesthacht, Federal Republic of Germany) IN: Titanium 1990: Products and applications; Proceedings of the International Conference, Buena Vista, FL, Sept. 30-Oct. 3, 1990. Vol. 1. Dayton, OH, Titanium Development Association, 1990, p. 89-98. refs
Copyright

An investigation is conducted of two Ti-6242-Si alloys respectively having a lamellar and an equiaxed microstructure, in order to ascertain the effects of microstructure on deformation and fracture behavior. Microstructural observations were made on fracture surfaces and sectioned side surfaces of fractured tensile, creep, impact, and fracture-toughness specimens tested at temperatures up to 500 C. The tensile strength of the lamellar microstructure material was slightly higher than that of the equiaxed material, at both room temperature and 500 C; the tensile ductility of the lamellar material was lower at room temperature. O.C.

A92-22757
TI-6AL-4V FORGINGS WITH ENHANCED FATIGUE CHARACTERISTICS FOR ENGINE AND AIRFRAME APPLICATIONS
G. W. KUHLMAN (Aluminum Company of America, Forging Div., Cleveland, OH), A. K. CHAKRABARTI (Alcoa Laboratories, Alcoa Center, PA), and S. R. SEAGLE (RMI Titanium Co., Niles, OH) IN: Titanium 1990: Products and applications; Proceedings of the International Conference, Buena Vista, FL, Sept. 30-Oct. 3, 1990. Vol. 1. Dayton, OH, Titanium Development Association, 1990, p. 111-119. refs
Copyright

Using both standard and special-composition Ti-6Al-4V alloy samples, forging and thermomechanical-processing (TMP) sequences have been executed to achieve enhanced low and high cycle fatigue lives. In addition to obtaining first-tier room temperature and elevated temperature tensile properties and elevated temperature fracture toughness, attention is given to improvements in such important fatigue-related characteristics as stress- and strain-controlled low cycle fatigue and smooth and notched high cycle fatigue. It is found that the use of both standard and controlled compositions in conjunction with TMP techniques leads to an enhancement of low cycle fatigue lives by a factor of 3, while high cycle fatigue properties are improved by as much as 30 percent. O.C.

A92-22758
THE COMPATIBILITY AND TRADEOFFS OF TITANIUM AND COMPOSITES
O. E. NELSON (Oregon Metallurgical Corp., Albany) IN: Titanium 1990: Products and applications; Proceedings of the International Conference, Buena Vista, FL, Sept. 30-Oct. 3, 1990. Vol. 1. Dayton, OH, Titanium Development Association, 1990, p. 120-130.
Copyright

An effort is made to identify specific applications where Ti alloys are selected for their compatibility with polymer-matrix composite materials, in such realms as airframes and engine structures, with a view to cases in which Ti alloys demonstrably outperform both alternative metals and advanced composites. Attention is also given to cases of successful substitution of Ti alloy by a composite material; these are found to involve either radical weight-savings or stealth as the primary considerations guiding material selection, by contrast to the composite-compatibility uses of Ti alloys, in which corrosion-resistance and thermal expansion coefficient-matching were the dominant concerns. O.C.

A92-22760
THE BETA-CEZ - A HIGH PERFORMANCE TITANIUM ALLOY FOR AEROSPACE ENGINES
B. PRANDI, J. F. WADIER (Compagnie Europeenne du Zirconium, Centre de Recherches, Ugine, France), F. SCHWARTZ, P. E. MOSSER (SNECMA, Gennevilliers, France), and A. VASSEL (ONERA, Chatillon, France) IN: Titanium 1990: Products and applications; Proceedings of the International Conference, Buena Vista, FL, Sept. 30-Oct. 3, 1990. Vol. 1. Dayton, OH, Titanium Development Association, 1990, p. 150-159. Research supported by Service Technique des Programmes Aeronautiques. refs
Copyright

Beta-CEZ, a Ti-base (Ti-5Al-2Sn-4Zr-4Mo-2Cr-1Fe) alloy with high tensile strength and toughness as well as excellent creep resistance in service temperatures of as much as 450 C, has been developed with a view to such medium-high temperature applications as aircraft gas turbine compressor disks. Beta-CEZ ingots are forged in the beta-field between 1050 and 1100 C; a second transformation occurs in the alpha-beta field, which occurs in the vicinity of 850 C. An account is given of thermomechanical treatment results. O.C.

A92-22767
INFLUENCE OF LONG TIME EXPOSURE AT ELEVATED TEMPERATURES IN AIR ON MECHANICAL PROPERTIES OF THE HIGH TEMPERATURE TITANIUM ALLOY IMI 834
M. A. DAEUBLER and D. HELM (MTU Motoren- und Turbinen-Union Muenchen GmbH, Munich, Federal Republic of Germany) IN: Titanium 1990: Products and applications; Proceedings of the International Conference, Buena Vista, FL, Sept. 30-Oct. 3, 1990. Vol. 1. Dayton, OH, Titanium Development Association, 1990, p. 244-255. refs
Copyright

An investigation is conducted of the effects of surface oxidation and microstructure instability on the mechanical properties of IMI 834, a novel Ti alloy envisioned as applicable to gas turbine compressor components with service temperatures of the order of 600 C. Attention is given to the case of an IMI 834 bimodal microstructure combining about 10 percent primary alpha phase embedded in a fine lamellar alpha/beta matrix; samples were tested at 600 C in air for 500 hrs with a view to tensile strength, ductility, low cycle fatigue strength, creep strength, and fracture toughness. The threshold temperature at which the detrimental effects of surface oxidation cease to be negligible is investigated. O.C.

A92-22771
IMPROVING THE PROPERTIES OF TITANIUM ALLOYS BY ION IMPLANTATION
PIRAN SIOSHANSI (Spire Corp., Bedford, MA) IN: Titanium 1990: Products and applications; Proceedings of the International Conference, Buena Vista, FL, Sept. 30-Oct. 3, 1990. Vol. 1. Dayton, OH, Titanium Development Association, 1990, p. 300-307. refs
Copyright

The 'Ionguard' ion-implantation process for the enhancement of Ti alloys' wear, corrosion-resistance, and other surface properties has found use in orthopedic implant, ball valve, turbine blade, specialty fastener, and threaded component applications. The application of the Ironguard process to finished components does not jeopardize their dimensional integrity or surface finish. Ironguard is, moreover, a low-temperature process which leaves the bulk properties of products unaffected. Nitrogen is often used as an implant by the process; attention is given to results obtained for the Ti-6Al-4V alloy. O.C.

A92-23418
WEIGHT ESTIMATING GUIDE FOR ADVANCED COMPOSITES
J. W. BURNS (LTV Aerospace and Defense Co., Aircraft Products Div., Dallas, TX) Weight Engineering (ISSN 0583-9270), vol. 51, Fall 1991, p. 49-60. refs
Copyright

An effort is made to identify a majority of factors on graphite/epoxy aircraft structural component design which remain problematic, with a view to the formulation of weight-estimation guidelines for several of the design drivers of a recent aircraft-development program. The general guidelines thus obtained are useful in determining minimum gages required for impact damage, lightning strike, and birdstrikes. The data should be compared with gages required for the flight loads and the most severe sizing that were included in the initial weight estimate. Integral fuel tanks using graphite/epoxy are easily underestimated unless allowances are made for fasteners and plumbing accessories. O.C.

N92-16128# Oak Ridge National Lab., TN.
CERAMIC TECHNOLOGY FOR ADVANCED HEAT ENGINES PROJECT
D. R. JOHNSON Jul. 1991 552 p
(Contract DE-AC05-84OR-21400)
(DE92-002397; ORNL/TM-11859) Avail: NTIS HC/MF A24

Significant accomplishments in fabricating ceramic components for advanced heat engine programs have provided evidence that the operation of ceramic parts in high temperature engine environments is feasible. However, these programs have also demonstrated that additional research is needed in materials and processing development, design methodology, and database and life prediction before industry will have a sufficient technology base from which to produce reliable cost effective ceramic engine components commercially. An assessment of needs was completed, and a five year project plan was developed with extensive input from private industry. The project approach includes determining the mechanisms controlling reliability, improving processes for fabricating existing ceramics, developing new materials with increased reliability, and testing these materials in simulated engine environments to confirm reliability. Although this is a generic materials project, the focus is on the structural ceramics for advanced gas turbine and diesel engines, ceramic bearings and attachments, and ceramic coatings for thermal barrier and wear applications in these engines. To facilitate the rapid transfer of this technology to US industry, the major portion of the work is being done in the ceramic industry, with technological support from government laboratories, other industrial laboratories, and universities. This project is managed by ORNL for the Office of Transportation Technologies, Office of Transportation Materials, and is closely coordinated with complementary ceramics tasks funded by other DOE offices, NASA, DOD, and industry. DOE

N92-17004*# Old Dominion Univ., Norfolk, VA. Dept. of Civil Engineering.
POLYMER INFILTRATION STUDIES Progress Report, 16 Sep. - 31 Dec. 1991
JOSEPH M. MARCHELLO Jan. 1992 23 p
(Contract NAG1-1067)
(NASA-CR-189773; NAS 1.26:189773) Avail: NTIS HC/MF A03 CSCL 11/3

The preparation is reported of carbon fiber composites using advanced polymer resins. Current and ongoing research activities include: powder towpreg process; weaving, braiding and stitching dry powder prepreg; advanced tow placement; and customized ATP towpreg. The goal of these studies is to produce advanced composite materials for automated part fabrication using textile and robotics technology in the manufacture of subsonic and supersonic aircraft. Author

N92-17070*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
HIGH-TEMPERATURE DURABILITY CONSIDERATIONS FOR HSCT COMBUSTOR
NATHAN S. JACOBSON Washington Jan. 1992 19 p
(NASA-TP-3162; E-6343; NAS 1.60:3162) Avail: NTIS HC/MF A03 CSCL 11/3

The novel combustor designs for the High Speed Civil Transport will require high temperature materials with long term environmental stability. Higher liner temperatures than in conventional combustors and the need for reduced weight necessitates the use of advanced ceramic matrix composites. The combustor environment is defined at the current state of design, the major degradation routes are

discussed for each candidate ceramic material, and where possible, the maximum use temperatures are defined for these candidate ceramics. Author

N92-17310# Messerschmitt-Boelkow-Blohm G.m.b.H., Ottobrunn (Germany, F.R.). Hubschrauber und Flugzeuge.
RAPID REPAIR OF INTEGRALLY STIFFENED CARBON FIBRE COMPOSITE STRUCTURES BY BOLTED ALUMINIUM ELEMENTS
J. VILSMEIER and G. GUENTHER 22 May 1991 12 p
(MBB-FE202-S-PUB-0453-A; ETN-92-90616) Copyright Avail: NTIS HC/MF A03

Integrally stiffened carbon fiber composite structures, which are representative for dominantly shear and compression loaded skins of forward fuselages of modern fighter aircraft, are repaired using bolted aluminum elements. The design criteria for the repairs and the carbon fiber skin are described. The panels are tested for static and residual strength after spectrum fatigue loading. It is shown that the goal of recovering the ultimate design strength of the structure is achieved for both static and residual strength. ESA

N92-17653# Pratt and Whitney Aircraft, West Palm Beach, FL.
FATIGUE IN SINGLE CRYSTAL NICKEL SUPERALLOYS Progress Report, 16 Sep. - 15 Nov. 1991
15 Nov. 1991 8 p
(Contract N00014-91-C-0124)
(AD-A243453; PWA-FR21998-1) Avail: NTIS HC/MF A02
CSCL 11/6

This program investigates the behavior of single crystal airfoil materials. The fatigue initiation processes in single crystal materials are significantly more complicated and involved than fatigue initiation and subsequent behavior of a (single) macrocrack in conventional, isotropic, materials. In cast single crystal nickel alloys, two basic fracture modes, crystallographic and non-crystallographic, are seen in combination. They occur in varying proportions depending upon temperature and stress state. Crystallographic orientation with respect to applied load also affects the proportion of each and influences the specific crystallographic planes and slip directions involved. Mixed mode fracture is observed under monotonic as well as cyclic conditions. GRA

N92-17682# General Electric Co., Schenectady, NY. Engineering Systems Lab.
LOCAL EXTINCTION MECHANISMS IN NON-PREMIXED TURBULENT COMBUSTION Final Report, 1 May 1988 - 30 Jun. 1990
S. M. CORREA and A. GULATI 31 Aug. 1991 78 p
(Contract F49620-88-C-0066)
(AD-A242027; AFOSR-91-0871TR) Avail: NTIS HC/MF A05
CSCL 21/2

The goal of this research was a quantitative understanding of turbulence-chemistry interactions pertinent to future aeropropulsion combustors. For example: (1) flameout and relight in turbine combustors are related to interactions of turbulence with chain-branching reactions; (2) hydrogen burnout in supersonic combustors is related to interactions with recombination reactions; and (3) emissions of NO(x), CO, smoke, and other observables are related to nonequilibrium in the populations of intermediate species such as oxyhydrogen radicals and C(x)H(y). A bluff-body stabilized turbulent diffusion flame, time-and space-resolved laser Raman measurements of major species, and a nonequilibrium computational fluid mechanics code were applied to the problem. Principal conclusions include: (1) turbulent jet flames are being abandoned in the search for more intensely turbulent flames; (2) an axisymmetric bluff-body stabilized turbulent diffusion flame burner is a reasonable choice for combustion research at high Reynolds numbers, approaching blowoff; (3) Raman scattering for measurements of major species and temperature can be extended into the sooting/chemiluminescent environment of methane flames--space and time resolved Raman scattering measurements were made in bluff-body stabilized CO/H2/N2 and CH4 flames at conditions approaching blowoff; (4) a thermochemical submodel based on partial equilibrium in the oxyhydrogen radical pool was developed for the 27.5 percent CO/32.3 percent H2/40.2 percent N2-air system; (5) calculations compare favorably with with the Raman data; (6) work on pdf transport/Monte Carlo methods in recirculation-stabilized flames has begun; and (7) the range of turbulence-chemistry interactions in combustion has been quantified, in an attempt to gauge the universality of turbulence-chemistry models. GRA

N92-17932# Air Force Inst. of Tech., Wright-Patterson AFB, OH.
THE EFFECT OF PHYSICAL AGING ON THE CREEP RESPONSE OF A THERMOPLASTIC COMPOSITE Ph.D. Thesis
ROBERT L. HASTIE, JR. 26 Jun. 1991 242 p
(AD-A243600; AFIT/CI/CIA-91-017D) Avail: NTIS HC/MF A11
CSCL 11/4

The effect of thermoreversible physical aging on the linear viscoelastic creep properties of a thermoplastic composite was investigated. Radel X/IM7, an amorphous composite material considered for use in the next generation high speed transport aircraft, was studied. The operating environment for the aircraft material will be near 188 C (370 F) with a service life in excess of 60,000 hours at temperature. Accurate predictions of the viscoelastic properties of the material are essential to insure that design strength and stiffness requirements are met for the entire service life. The effect of physical aging on the creep response was studied using momentary tensile creep tests conducted at increasing aging times following a rapid quench from above the glass transition temperature T(sub g) to a sub-T(sub g) aging temperature. GRA

12

ENGINEERING

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

A92-21079* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
STUDIES OF THE EFFECTS OF CURVATURE ON DILUTION JET MIXING
JAMES D. HOLDEMAN (NASA, Lewis Research Center, Cleveland, OH), RAM SRINIVASAN, ROBERT S. REYNOLDS, and CRAIG D. WHITE (Allied-Signal Aerospace Co., Phoenix, AZ) Journal of Propulsion and Power (ISSN 0748-4658), vol. 8, Jan.-Feb. 1992, p. 209-218. refs
Copyright

An analytical program was conducted using both three-dimensional numerical and empirical models to investigate the effects of transition liner curvature on the mixing of jets injected into a confined crossflow. The numerical code is of the TEACH type with hybrid numerics; it uses the power-law and SIMPLER algorithms, an orthogonal curvilinear coordinate system, and an algebraic Reynolds stress turbulence model. From the results of the numerical calculations, an existing empirical model for the temperature field downstream of single and multiple rows of jets injected into a straight rectangular duct was extended to model the effects of curvature. Temperature distributions, calculated with both the numerical and empirical models, are presented to show the effects of radius of curvature and inner and outer wall injection for single and opposed rows of cool dilution jets injected into a hot mainstream flow. Author

A92-21085
EFFECTS OF SIDEWALL DISTURBANCES ON THE SUPERSONIC MIXING LAYER

N. T. CLEMENS and M. G. MUNGAL (Stanford University, CA) Journal of Propulsion and Power (ISSN 0748-4658), vol. 8, Jan.-Feb. 1992, p. 249-251. Research sponsored by USAF. refs
Copyright

It is experimentally established that supersonic mixing enhancements can be obtained by means of vortex generators; it is also possible to conveniently generate similar effects by means of a sidewall shock-vortex generator (SWSVG). The SWSVG's advantages encompass the avoidance of mechanical devices on the splitter tip, the possibility of active control of timing and location of the layer perturbation, and straightforward cooling of the disturbance generator. Either corotating or contrarotating apparent vortices can be generated through the appropriate choice of the side for the generation of the disturbances. O.C.

A92-21216
LINEAR PANEL FLUTTER OF AN ELLIPTIC CYLINDRICAL SHELL

M. KOZAROV and T. VODENICHAROVA (Higher Institute of Architecture and Civil Engineering, Sofia, Bulgaria) Archive of Applied Mechanics (ISSN 0939-1533), vol. 61, Dec. 1991, p. 505-516. refs
Copyright

Panel flutter of an elliptic cylindrical shell exposed to an external supersonic air stream is investigated. Shallow cylindrical shell deformation theory and aerodynamic piston theory are used. The displacement function is expressed in two variants. A comparison between the results obtained by both versions is made. Numerical results for shells with different geometric parameters are shown. Hereby, the shell is considered as a system with two and with four degrees of freedom. The purpose of the investigation is to determine the variation of critical flutter Mach number with shell parameters. Author

A92-21330
DEVELOPMENT OF FILM RIDING FACE SEALS FOR A GAS TURBINE ENGINE

JOHN MUNSON (General Motors Corp., Allison Gas Turbine Div., Indianapolis, IN) and GLENN PECHT (John Crane, Inc., Morton Grove, IL) (STLE, Annual Meeting, 46th, Montreal, Canada, Apr. 29-May 2, 1991) STLE Tribology Transactions (ISSN 0569-8197), vol. 35, Jan. 1992, p. 65-70. refs
Copyright

Gas film riding seals have found wide acceptance in pipeline and process industry turbomachinery. The seals have not found many applications in either industrial or aircraft gas turbines, however. Gas turbine engines currently being designed will have higher compression ratios (greater than 30:1). The combination of increased pressure and more aggressive engine efficiency goals will severely tax the capability of present sealing systems. The film riding face seal (FRFS) has emerged as an attractive candidate for providing sealing for the hot high pressure engine compressor discharge air. Gas turbine relative surface velocity and temperature requirements in general, exceed those of other applications. In addition, the aerospace nature of the product imposes restrictions on the allowable size and weight of the seal. This paper describes development efforts currently under way to adapt the gas film riding face seal for the aircraft gas turbine engine. Also described are anticipated operational parameters for the next generation of engines, and challenges which need to be overcome to successfully apply these seals to these engines. Author

A92-21374
A PIEZOELECTRIC DROPLET GENERATOR FOR USE IN WIND TUNNELS

W. D. WARNICA, M. VAN REENEN, M. RENKSIZBULUT, and A. B. STRONG (Waterloo, University, Canada) Review of Scientific Instruments (ISSN 0034-6748), vol. 62, Dec. 1991, p. 3037-3046. Research supported by NSERC and Manufacturing Research Corporation of Ontario. refs
Copyright

The design of a compact piezoelectric droplet generator, developed for use in wind tunnels, is described. The droplet generator has a very small size (19-mm-diam) nozzle assembly which includes a cylindrical piezoelectric ceramic transducer, an interchangeable orifice, a charging ring, and deflection plates. The blocked area created by the assembly is less than 5 percent of a wind tunnel with an open cross-sectional area of 900 sq cm. Using this instrument, uniform droplets can be produced reliably over a large range of size and speed. I.S.

A92-21450
MEASUREMENT OF CONVECTIVE HEAT-TRANSFER COEFFICIENTS ON A WIND TUNNEL MODEL BY PASSIVE AND STIMULATED INFRARED THERMOGRAPHY

D. L. BALAGEAS, D. M. BOSCHER, and A. A. DEOM (ONERA, Chatillon, France) IN: Infrared technology XVI; Proceedings of the Meeting, San Diego, CA, July 11-13, 1990. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1990, p. 339-357. Research supported by DRET and Matra, S.A. refs
Copyright

Research conducted at ONERA to make quantitative infrared thermography operational and applicable to any 3D model is discussed. The problems of precise thermometry using this technique are considered, and the methodological and hardware choices made to obtain quantitative thermograms are described. The problem of determining the convective flows once the unsteady temperatures are known is addressed for two kinds of methods: classical passive thermography, in which only the heating due to convection is used, and active, or stimulated, thermography, in which the heat-transfer coefficients are calculated directly from the additional heating of the model by a radiation source, applied for short periods during the test. C.D.

A92-21472
FATIGUE LIFE ESTIMATION OF FASTENER HOLES WITHOUT LOAD TRANSFER

SHEN WU (Nanjing Aeronautical Institute, People's Republic of China) Nanjing Aeronautical Institute, Journal (ISSN 1000-1956), vol. 23, Dec. 1991, p. 51-57. In Chinese. refs

Cyclic stress and strain parameters are analyzed using the Neuber equation, and the fatigue life of fastener holes without load transfer is estimated using the Manson-Coffin strain fatigue equation. Data obtained are found to be in good agreement with results fatigue life tests on different fitting specimens of fasteners and fastener holes. It is concluded that the cyclic parameter analysis and the stress severity factor method are effective techniques for fatigue life estimation of a typical lower-wing structure. O.G.

A92-21691
A MULTI-LAYER NEURAL NETWORK CLASSIFIER FOR RADAR CLUTTER

CONG DENG and SIMON HAYKIN (McMaster University, Hamilton, Canada) IN: IJCNN - International Joint Conference on Neural Networks, San Diego, CA, June 17-21, 1990, Proceedings. Vol. 1. New York, Institute of Electrical and Electronics Engineers, Inc., 1990, p. I-241 to I-246. Research supported by Telecommunications Research Institute of Ontario. refs
Copyright

A multilayer neural network classifier has been successfully implemented on a Warp systolic computer for distinguishing several major categories of radar returns: target (aircraft), weather, birds, and ground. The experimental results show that the neural network method is better than the traditional statistical method, which gives an average rate of 81.8 percent for classifying target, weather, and birds, in the same SNR range. The design of this neural classifier also suggests that the preprocessing and postprocessing procedures based on some prior information about the input data are very important for enhancing the classification performance. I.E.

A92-21721
PAR-WIG PERFORMANCE PREDICTION DURING ACCELERATION FROM WATER-BORNE TO AIR-BORNE

SHIGENORI ANDO (Tokushima Bunri University, Japan) and

MICHIYO KATO (Nagoya University, Japan) Japan Society for Aeronautical and Space Sciences, Transactions (ISSN 0549-3811), vol. 34, Nov. 1991, p. 139-152. refs

Take-off performance is calculated for PAR-WIG which utilizes propeller-slipstream. For this purpose, a quick automatic computation scheme is developed for performance of 'engine-propeller combination system'. Example calculations are presented, which show that the hump drag is completely removed with PAR effect. It is noted that variable-geometry of wing-end-plates is desirable and variable-camber of main-wing is essential. Author

A92-21733
FLUID POWER DISTRIBUTION AND CONTROL
JAMES H. BRAHNEY Aerospace Engineering (ISSN 0736-2536), vol. 12, Jan. 1992, p. 21-26.
Copyright

Aircraft hydraulic systems require flexible plumbing to accommodate the motion about a pivot or linear reciprocation. Coiled tubing has proven to be the most effective approach for flexible plumbing installations for the past three decades. Most designers agree that significant advancements in coiled tubing technology will derive from its consideration as a structural system with identifiable critical areas. In a 'test-to-fail' reliability approach being studied, tests are conducted on a statistically significant number of specimens to failure in each of the primary cyclic-fatigue stress modes: bending, torsion, impulse, and burst. Attention is given to the roles of fittings and the character of advanced hydraulic fluids. O.C.

A92-21900
HISTORICAL DEVELOPMENT OF EDDY CURRENT TESTING IN AIRCRAFT MAINTENANCE
ROBERT D. SHAFFER (Foerster Instruments, Pittsburgh, PA) Materials Evaluation (ISSN 0025-5327), vol. 50, Jan. 1992, p. 76-79, 81, 82. refs
Copyright

The history of the historical development of eddy current testing is outlined, and the past and present problems in the aircraft maintenance applications are examined. Particular attention is given to the conductivity measurement and surface crack detection applications of eddy current in aircraft maintenance and the use of eddy current testing in the subsurface crack and corrosion detection. It is emphasized that the great sensitivity of eddy current to a variety of material and test variables may well be the method's greatest strength, and will enhance eddy current applications. I.S.

A92-21923
APPLICATION OF HOLOMORPHIC VECTORS THEORY IN THREE-DIMENSIONAL POTENTIAL FLOW PROBLEM
ZDENEK SKODA Zprava VZLU, no. Z-63, 1991, 9 p. refs
Copyright

A new theoretical approach to a 3D flow problem which is based on holomorphic vectors is presented. This approach makes it possible to obtain the velocity field without numerical differentiation and to keep the number of equations equal to the number of panels. The flow is described through holomorphic vectors and Cauchy-type 3D integrals. Properties of the latter are defined and used to find a solution by an iterative procedure applied to a single Fredholm integral equation. Expressions for evaluation of the velocity field are also obtained. O.G.

A92-22129#
DEVELOPMENT AND APPLICATION OF A PARTICLE IMAGE VELOCIMETER FOR HIGH-SPEED FLOWS
M. J. MOLEZZI and J. C. DUTTON (Illinois, University, Urbana) AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992. 13 p. Research supported by U.S. Army and University of Illinois. refs
(AIAA PAPER 92-0004) Copyright

A particle image velocimetry (PIV) system has been developed for use in high-speed separated air flows. The image acquisition system uses two 550 mJ/pulse Nd:YAG lasers and is fully controlled by a host Macintosh computer. The interrogation system is also Macintosh-based and performs interrogations at approximately 2.3 sec/spot and 4.0 sec/spot when using the Young's fringe and autocorrelation methods, respectively. The system has been proven in preliminary experiments using known-displacement simulated PIV photographs and a simple axisymmetric jet flow. Further results have been obtained in a transonic wind tunnel operating at Mach 0.4 to 0.5 (135 m/s to 170 m/s). PIV experiments were done with an empty test section to provide uniform flow data for comparison with pressure and LDV data, then with a two-dimensional base model, revealing features of the von Karman vortex street wake and underlying small scale turbulence. Author

A92-22130*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
DOPPLER GLOBAL VELOCIMETER MEASUREMENTS OF THE VORTICAL FLOW ABOVE A THIN DELTA WING
JIMMY W. USRY, JAMES F. MEYERS (NASA, Langley Research Center, Hampton, VA), and L. S. MILLER (Wichita State University, KS) AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992. 10 p. refs
(AIAA PAPER 92-0005)

Doppler global velocimetry, currently under development by NASA for the measurement of off-surface flow fields, will allow quantification of complex, 3D flow fields at video-camera rates and accomplish the simultaneous measurement of an entire flow field structure within the given plane. In order to assess the performance capabilities of the technique, velocity measurements of the vortical flow field above a thin, 75-deg delta wing were conducted at NASA-Langley and compared with results obtained via three-component laser velocimeter. The achievement of performance goals is confirmed. O.C.

A92-22195#
LASER-INITIATED CONICAL DETONATION WAVE FOR SUPERSONIC COMBUSTION. II
F. FENDELL, J. MITCHELL, R. MCGREGOR, K. MAGIAWALA, and M. SHEFFIELD (TRW Space and Technology Group, Redondo Beach, CA) AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992. 11 p. refs
(Contract F49620-90-C-0070)
(AIAA PAPER 92-0088) Copyright

Further theoretical studies are undertaken of the feasibility of an air-breathing supersonic combustor based on a stabilized, conically configured (oblique) detonation wave. The conical wave is the resultant of the interaction of a train of spherical detonation waves, each directly initiated by a very rapidly repeated pulsed laser, which is tightly focused on a fixed site in a steady uniform supersonic stream of combustible gaseous mixture. Here, the length of an axisymmetric (nearly conical) nozzle required to exhaust the reacted mixture at ambient-atmosphere pressure is estimated by a steady isentropic ideal-gas flow calculation. Then the thrust-to-drag ratio achievable with such a combustor for upper-atmospheric flight is roughly characterized. Finally, proof-of-principle laboratory experiments needed to establish the capacity of existing laser sources to achieve the direct initiation of detonation in hydrogen/air mixtures under conditions of practical interest are outlined. Author

A92-22196# Florida Univ., Gainesville.
EXPERIMENTAL INVESTIGATION OF A SUPERSONIC COMBUSTION FLOWFIELD EMPLOYING STAGED TRANSVERSE INJECTION BEHIND A REARWARD-FACING STEP
JOHN D. ABBITT, III, CORIN SEGAL (Florida, University, Gainesville), JAMES C. MCDANIEL, ROLAND H. KRAUSS, and ROBERT B. WHITEHURST (Virginia, University, Charlottesville) AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992. 17 p. refs
(Contract NAG1-795; NGT-50142)
(AIAA PAPER 92-0090) Copyright

An experimental investigation of a Mach 2 combustor has been conducted in order to characterize flow properties in a supersonic reacting flowfield. Hydrogen was injected transversely as staged, underexpanded jets behind a rearward facing step into a ducted Mach 2 air free stream. The effects of the chemical reaction on the supersonic flowfield was investigated using shadowgraphs, broadband flame emission photography, and planar laser-induced fluorescence of OH. The shadowgraphs indicated a strong affect of the heat release on the wave pattern in the combustor, with a significant increase in flowfield unsteadiness. The broadband flame emission photographs revealed large regions of no combustion in the vicinity of the fuel injectors where fuel/air mixing was insufficient to support combustion. These regions decreased in size as the free stream stagnation temperature was decreased for fixed hydrogen mass flow rate, consistent with an increase in the effective Q-ratio with combustion. The size of the zones containing OH in the planar fluorescence images also both increased as the main flow stagnation temperature was decreased. Reaction zones were found in the planar fluorescence images away from regions containing injectant in a non-reacting study of the same geometry, indicating that the pressure rise associated with the reaction forced a large redistribution of the fuel. Author

A92-22200#
NUMERICAL STUDIES OF SUPERSONIC/HYPERSONIC COMBUSTION
W. S. YOON and T. J. CHUNG (Alabama, University, Huntsville) AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992. 17 p. refs
(AIAA PAPER 92-0094) Copyright

This paper is concerned with the development of direct numerical simulations of turbulence interacting with shock waves and chemical reactions using unstructured adaptive finite element h-p methods. Reliable methods for resolving the complicated time and length scales involved in turbulence interacting with shock waves and chemical reactions are not yet available. Direct numerical simulations are here developed via Taylor-Galerkin finite element implicit scheme, with mesh refinements and spectral orders optimized such that errors are reduced where gradients of variables are large. Author

A92-22203#
A NUMERICAL STUDY OF ISOTHERMAL FLOWS OF A SLIT V-GUTTER
C. K. LIN, J. CHOU, Y. M. TSUEI (Chung-Shan Institute of Science and Technology, Republic of China), and D. LEE (National Cheng Kung University, Tainan, Republic of China) AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992. 8 p. refs
(AIAA PAPER 92-0100) Copyright

In this study, flowfields of a slit V-gutter are investigated numerically. The flow pattern can be significantly different from that of a conventional V-gutter. For a small slit height h, two separate recirculation bubbles are formed. A smaller bubble is anchored behind the inner gutter, a larger one follows. With a larger h, the smaller bubble grows and the larger one shrinks. As h increases further, the two bubbles merge to form a single recirculation zone. The magnitude and the angle of the slit velocity play important roles in determining the strength of the recirculation zone. These results are consistent with that observed experimentally by other authors. Author

A92-22299
OPPORTUNITIES FOR ADVANCED SPEECH PROCESSING IN MILITARY COMPUTER-BASED SYSTEMS
CLIFFORD J. WEINSTEIN (MIT, Lexington, MA) IEEE, Proceedings (ISSN 0018-9219), vol. 79, Nov. 1991, p. 1626-1641. Research supported by USAF and DARPA. Previously announced in STAR as N91-26412. refs
Copyright

This report presents a study of military applications of advanced speech processing technology which includes three major elements: (1) review and assessment of current efforts in military applications of speech technology, (2) identification of opportunities for future military applications of advanced speech technology; and (3) identification of problem areas where research in speech processing is needed to meet application requirements, and of current research thrusts which appear promising. The relationship of this study to previous assessments of military applications of speech technology is discussed, and substantial recent progress is noted. Curent efforts in military applications of speech technology which are highlighted include: (1) narrowband (2400 b/s) and very-low-rate (50-1200 b/s) secure voice communication; (2) voice/data integration in computer networks; (3) speech recognition in fighter aircraft, military helicopters, battle management, and air traffic control training systems; and (4) noise and interference removal for human listeners. Oppportunities for advanced applications are identified by means of descriptions of several generic systems which would be possible with advances in speech technology and in system integration. Author

A92-22346
PARALLEL ALGORITHMS FOR PANEL METHODS
TIM DAVID and GRAHAM BLYTH (Leeds, University, England) International Journal for Numerical Methods in Fluids (ISSN 0271-2091), vol. 14, Jan. 15, 1992, p. 95-108. refs
Copyright

A parallel algorithm for the solution of potential flow problems using the panel method of Hess and Smith and conjugate and bi-conjugate gradient techniques is presented. Analysis of the parallelism for the matrix solvers shows the algorithms to have scalable properties as the problem size grows indefinitely large. Speed-up and efficiency values are presented along with experimental and theoretical values for the optimum number of processors for maximum speed-up. It is envisaged that the parallel techniques presented here have applications using other boundary integral methods for solving engineering problems of a more complex nature. Author

A92-22523
AN ANALYSIS OF IMPACT RESISTANCE OF COMPOSITE FAN BLADE
TOSHIO MIYACHI, HIDEHITO OKUMURA, KUNIHIKO OHTAKE, and YASUSHI SOFUE Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 40, no. 456, 1992, p. 35-44. In Japanese. refs

An analysis of impact resistance of composite fan blades for turbofan engines has been conducted. Analytical models of composite blade of different sizes and materials were composed and impact resistance was evaluated by the analysis. The validity of the analytical model was confirmed by comparison of the analytical result with the experimental result of natural vibration of the titanium blade model of the same configuration as the composite blade models. The transient response produced by simulated bird strike on the blade model was analyzed with the finite element method which includes bird impact load model and geometrical nonlinearity. The validity of the analytical method was confirmed by comparing the analytical results with the experimental results of some impact tests of the titanium blade models. The results show that polymer matrix composite blades have much lower impact resistance than titanium blade and it is clear that the composite blade of same size as the titanium blade is entirely broken by the bird strike, and 1.65 and 2.06 times larger-size composite blades are partially broken by the bird strike. Author

A92-22785
COST EFFECTIVE SOLUTIONS FOR TITANIUM SHEET METAL FORMING
W. SWALE and R. SWALE (T.K.R. International, Ltd., Welwyn Garden City, England) IN: Titanium 1990: Products and applications; Proceedings of the International Conference, Buena Vista, FL, Sept. 30-Oct. 3, 1990. Vol. 2. Dayton, OH, Titanium Development Association, 1990, p. 875-887.
Copyright

Cost-effective solutions for titanium sheet metal forming have been developed and are being employed. Each forming process

has its particular niche role to play in manufacturing the wide range of products conceived for the aerospace industry. The choice of method, however, is best made in consultation between design and manufacturer to ensure that weight, cost and performance are optimized. It is not always the case that the greatest savings come from redesigning a multipart fabrication in order to produce it as a complex on piece Superplastically Formed item but the in-service record of such components has been excellent with design allowables regularly exceeded by considerable margins. It follows, therefore, as confidence in and flexibility of the processes continue to increase so the opportunities for exploiting the benefits of titanium sheet will continue. Author

A92-22796 National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, MD.
RESONANT CRYOGENIC CHOPPER
LYMAN A. PAGE (Princeton University, NJ), EDWARD S. CHENG (NASA, Goddard Space Flight Center, Greenbelt, MD), and STEPHAN S. MEYER (MIT, Cambridge, MA) Applied Optics (ISSN 0003-6935), vol. 31, Jan. 1, 1992, p. 95-100. refs
(Contract NAGW-1841)
Copyright

An account is given of the design features, construction, and performance of a both mechanically and thermally robust, resonant cryogenic chopper operating at 4.2 K. The chopper can occult a 2.54-cm aperture at 4.5 Hz, with approximately 1-mW dissipation. The controllability of the stator and rotor magnetic fields facilitates performance optimization and the determination of any possible interference effects. Attention is given to long-term amplitude stability determinations. O.C.

A92-22879
RELIABILITY GROWTH OF COOLERS FOR ADVANCED OPTICAL SYSTEMS AND INSTRUMENTS
GERALD R. PRUITT (Hughes Aircraft Co., Electron Dynamics Div., Torrance, CA) IN: Cryogenic optical systems and instruments IV; Proceedings of the Meeting, San Diego, CA, July 10-12, 1990. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1990, p. 311-324.
Copyright

Results of reliability cycle testing of rotary drive Stirling cycle coolers are reviewed for the 1988-1990 timeframe. Four cooler models (7014H-1, 7014H-2, 7004H-2, and 7022H) have been subjected to rigorous reliability cycle testing per military usage requirements, accumulating 50,000 hours of operation with only 9 failures. Reliability demonstrations under severe environmental conditions show that mean-time-to-failure has increased from 300-1000 h to 1500-3000 h. It is concluded that this reliability growth has resulted in a family of miniature cryogenic coolers capable of satisfying system reliability requirements. O.G.

A92-23109
AN ANALYSIS OF IMPACT RESISTANCE OF COMPOSITE BLADES FOR TURBO-FAN ENGINES
T. MIYACHI, H. OKUMURA, K. OHTAKE, and Y. SOFUE (National Aerospace Laboratory, Chofu, Japan) IN: Achievement in composites in Japan and the United States; Proceedings of the 5th Japan-U.S. Conference on Composite Materials, Tokyo, Japan, June 24-27, 1990. Tokyo, Japan Society for Composite Materials, 1990, p. 87-94. refs
Copyright

An analysis of impact response of composite fan blades of turbo-fan engines is conducted. The validity of analytical model and analytical method were confirmed by comparing the analytical results with the experimental results of natural vibration and impact response of the titanium-alloy blade of the same configuration of one of the composite blades. The results show that the polymer-matrix composite blade cannot endure a 1.5-lb bird strike which is one of the requirements of the airworthiness standards. To endure the bird strike, it is suggested that application of metal-matrix composites and/or superhybrid structures is necessary. Author

A92-23111
NONLINEAR TRANSIENT ANALYSIS OF COMPOSITE ATP BLADE MODEL
HIDEHITO OKUMURA, KUNIHIKO OHTAKE, AKINORI OGAWA, RYOSAKU HASHIMOTO (National Aerospace Laboratory, Chofu, Japan), TOSHIHIRO KAWASHIMA, YASUYUKI TANAKA, and TADASHI NATUMURA (Ishikawajima-Harima Heavy Industries Co., Ltd., Mizuho, Japan) IN: Achievement in composites in Japan and the United States; Proceedings of the 5th Japan-U.S. Conference on Composite Materials, Tokyo, Japan, June 24-27, 1990. Tokyo, Japan Society for Composite Materials, 1990, p. 103-110. refs
Copyright

A computational simulation for the transient response problem of the composite ATP blade model subjected to local impact loading with foreign objects is presented using geometrically nonlinear finite element analysis. In this numerical study, two remarkable things were found. One is that initial deformation patterns of plate model due to impact on local region are similar to higher order vibrational eigenmodes. Another thing is that existence of flexural edge wave in the region of the leading edge and the trailing edge of the ATP blade model was confirmed for the first time in computer simulations. It was found that delaminations of the leading edge in experimental results presented in the literature were related to this edge wave propagation along the free boundary. Author

A92-23114
STATIC AEROELASTIC TAILORING OF COMPOSITE AIRCRAFT SWEPT WINGS MODELLED AS THIN-WALLED BEAM STRUCTURES
LIVIU LIBRESCU and OHSEOP SONG (Virginia Polytechnic Institute and State University, Blacksburg) IN: Achievement in composites in Japan and the United States; Proceedings of the 5th Japan-U.S. Conference on Composite Materials, Tokyo, Japan, June 24-27, 1990. Tokyo, Japan Society for Composite Materials, 1990, p. 141-149. refs
Copyright

The aeroelastic divergence instability of swept-wing structures fabricated from anisotropic composite materials is analyzed with a novel structural model. The model is based on a thin-walled anisotropic composite beam and incorporates nonclassical effects including: warping inhibition, secondary warping effects, transverse shear deformation, and anisotropy in the materials that make up the structure layers. The governing equations and boundary conditions are set forth, and a numerical example shows the effects of ply angle, transverse shear deformation, and secondary warping on the divergence speed. The model is found to be effective and yield important conclusions regarding the enhancement of aeroelastic response characteristics that are of value in designing structures made of advanced composite materials. C.C.S.

A92-23167
FORCED VIBRATION OF RECTANGULAR LAMINATED PLATES WITH MATERIAL DAMPING
K. N. CHO, C. W. BERT, and A. G. STRIZ (Oklahoma, University, Norman) IN: Achievement in composites in Japan and the United States; Proceedings of the 5th Japan-U.S. Conference on Composite Materials, Tokyo, Japan, June 24-27, 1990. Tokyo, Japan Society for Composite Materials, 1990, p. 661-669. refs
Copyright

An extended higher-order individual-layer theory is presented for determining the frequency response of laminated plates with material damping. This theory approximates the in-plane and thickness normal displacements by third- and second-order functions of each layer's thickness coordinate, respectively. The theory treats each layer separately and satisfies the displacement continuity and stress equilibrium conditions along the interfaces between adjacent layers. In the present analysis, all materials are considered as viscoelastic with complex forms for moduli and Poisson's ratios. All plate edges are assumed to be simply supported without axial force. In the numerical results, parametric studies are shown for the effects of varying the material loss

tangents and for unconstrained and constrained arrangements including a high-damping viscoelastic layer. Author

A92-23269
EFFICIENT EVALUATION OF THE FLEXIBILITY OF TAPERED I-BEAMS ACCOUNTING FOR SHEAR DEFORMATIONS
L. VU-QUOC (Florida, University, Gainesville) and P. LEGER (McGill University, Montreal, Canada) International Journal for Numerical Methods in Engineering (ISSN 0029-5981), vol. 33, Feb. 15, 1992, p. 553-566. refs
(Contract NSF MSS-89-09153; NSF MSS-90-57602; NSERC-OGPIN-006)
Copyright

The principle of complementary virtual work is used to evaluate numerically the flexibility matrix of tapered I-beams accounting for shear deformations. Equilibrium considerations of the top and bottom fibers reveal that the shear stress is not equal to zero at these locations. To correct for this non-vanishing shear, a statically admissible shear stress field is considered by assuming a parabolic distribution of shear stress which takes nonzero values at the top and bottom fibers such that the global equilibrium is satisfied within the assumed stress profile. The flexibility matrices of the proposed tapered I-beam finite element with different slopes are generated using numerical integration based on Gauss quadrature. The results are compared to full-blown shell finite element models, and stepped beam models constituted by a series of uniform beam elements, to illustrate the effectiveness of the proposed method. Author

A92-23299
EXPERIMENTAL MEASUREMENT OF THE VORTEX DEVELOPMENT DOWNSTREAM OF A LOBED FORCED MIXER
W. A. ECKERLE (Cummins Engine Co., Inc., Columbus, IN), H. SHEIBANI, and J. AWAD (Clarkson University, Potsdam, NY) ASME, Transactions, Journal of Engineering for Gas Turbines and Power (ISSN 0742-4795), vol. 114, Jan. 1992, p. 63-71. refs
(ASME PAPER 90-GT-27) Copyright

The mixing processes downstream from a 'forced mixer' generating large-scale axial vorticity that causes primary and secondary flows to mix rapidly with low loss are experimentally investigated. Interior mean and fluctuating velocities were nonintrusively measured using a two-component LDV system for 1:1 and 1:2 velocity ratios. The wake structure is found to figure a three-step process; turbulent mixing in the first step of the mixing process is critically important for the homogeneous mixing of the two streams. Both the mean secondary motion and the turbulent mixing occurring after vortex breakdown need to be considered in mixer performance prediction. O.C.

A92-23300* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
FACTORS INFLUENCING THE EFFECTIVE SPRAY CONE ANGLE OF PRESSURE-SWIRL ATOMIZERS
S. K. CHEN, A. H. LEFEBVRE (Purdue University, West Lafayette, IN), and J. ROLLBUHLER (NASA, Lewis Research Center, Cleveland, OH) ASME, Transactions, Journal of Engineering for Gas Turbines and Power (ISSN 0742-4795), vol. 114, Jan. 1992, p. 97-103. refs
Copyright

The spray cone angles produced by several simplex pressure-swirl nozzles are examined using three liquids whose viscosities range from 0.001 to 0.012 kg/ms (1 to 12 cp). Measurements of both the visible spray cone angle and the effective spray cone angle are carried out over wide ranges of injection pressure and for five different values of the discharge orifice length/diameter ratio. The influence of the number of swirl chamber feed slots on spray cone angle is also examined. The results show that the spray cone angle widens with increase in injection pressure but is reduced by increases in liquid viscosity and/or discharge orifice length/diameter ratio. Variation in the number of swirl chamber feed slots between one and three has little effect on the effective spray cone angle. Author

A92-23301
EFFECTS OF IONIZING AND NONIONIZING RADIATION ON AIRCRAFT [EFFETS DES RAYONS IONISANTS ET NON IONISANTS SUR LES AERONEFS]
P. MORIN (DGA, Issy-les-Moulineaux, France) L'Onde Electrique (ISSN 0030-2430), vol. 72, Jan.-Feb. 1992, p. 9-11. In French.
Copyright

It is pointed out that a nuclear explosion has a two-fold effect on electronic components due to X-rays and gamma-rays and to the electromagnetic wave generated. The present study shows the influence of the combination of these two types of effects on an aircraft whose action as a Faraday shield is reduced by the use of composite materials. It is noted that helicopters are especially vulnerable to such effects because of their technology. The difficulties involved in performing comprehensive tests have led to the use of mathematical models combined with partial tests. L.M.

A92-23385
PREDICTION OF LOW CYCLE FATIGUE LIFE OF ENGINE CASES
TANG XU and YINHE FAN (Nanjing Aeronautical Institute, People's Republic of China) Nanjing Aeronautical Institute, Journal (English Edition), vol. 8, Oct. 1991, p. 41-50. refs

A prediction method of low-cycle fatigue life of engine cases based on the local stress-strain approach is introduced. The suggestion for determining the case load spectrum is proposed, and the determination of equivalent strains under the multidirectional stress state is described, so that the curve of strain amplitude-fatigue life determined under the single direction stress state may be adaptive to the problems under the multidirectional stress state. According to the flight characteristics, the safety life calculation method of engine cases is represented. Finally, it is proved via the examples that the method introduced possesses high accuracy. The method is more convenient and is an effective life-prediction one. Author

A92-23750#
DYNAMICS OF AN AIRCRAFT-TOWED BODY DURING RELEASE
MARK C. DOTY (Virginia Polytechnic Institute and State University, Blacksburg) AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992. 10 p. refs
(AIAA PAPER 92-0130) Copyright

A study is presented of the dynamic characteristics of a towed body during release from an aircraft. The towed body's trajectory relative to the aircraft is the most important aspect of its motion. If the body swings too far, it may strike the towing aircraft. To simulate the trajectory, governing equations are derived and a numerical simulation is performed. The effects of damping are investigated using this simulation. The accuracy of the simulation is measured by comparison with a wind tunnel experiment. To scale future wind tunnel studies, scaling laws are developed to relate wind tunnel results to full scale applications. Author

A92-23826* National Aeronautics and Space Administration, Washington, DC.
SPACE CRYOGENICS WORKSHOP, 10TH, CLEVELAND, OH, JUNE 18-20, 1991, PROCEEDINGS
Workshop sponsored by NASA. Cryogenics (ISSN 0011-2275), vol. 32, no. 2, 1992, 186 p. For individual items see A92-23827 to A92-23853.
Copyright

The present workshop on cryogenics discusses the anomalous on-orbit behavior of the Cosmic Background Explorer Dewar, the SHOOT orbital operations, cooling options for Astromag, and space IR telescope facility mission and cryogenic design. Attention is given to the design of a spaceworthy adiabatic demagnetization refrigerator, the evaluation of metal hydride compressors for applications in Joule-Thomson cryocoolers, diaphragm Stirling cryocooler developments, and a computer simulation model for Stirling refrigerators. Topics addressed include low-gravity thermal stratification of liquid helium on SHOOT, a screening program to

select a resin for gravity probe-B composites, a simplified generic cryostat thermal model for predicting cryogen mass and lifetime, and the effect of gas mass flux on cryogenic liquid jet breakup. Also discussed are damping criteria for thermal acoustic oscillations in slush and liquid hydrogen systems, an STS-based cryogenic fluid management experiment, and the design and testing of a cryogenic mixer pump. P.D.

A92-23835
EVALUATION OF METAL HYDRIDE COMPRESSORS FOR APPLICATIONS IN JOULE-THOMSON CRYOCOOLERS
R. C. BOWMAN, JR., B. D. FREEMAN (Aerojet, Electronic Systems Div., Azusa, CA), and J. R. PHILLIPS (Harvey Mudd College, Claremont, CA) (Space Cryogenics Workshop, 10th, Cleveland, OH, June 18-20, 1991, Proceedings. A92-23826 08-31) Cryogenics (ISSN 0011-2275), vol. 32, no. 2, 1992, p. 127-137. refs
Copyright

The Joule-Thomson expansion of hydrogen gas offers the potential for efficient and reliable cryocoolers to produce temperatures between 10 and 50 K. A critical component of the development of these devices is the metal-hydride storage bed that provides a nonmechanical method to compress the hydrogen gas via the reversible absorption by the appropriate metals or alloys. The influences of the thermophysical properties of these metal hydrides as well as compressor design constraints on the performance potentials of hydrogen sorption refrigerators are examined. A thermodynamics model is used to calculate the impact of operational parameters such as input/output pressure ratios and bed temperature on system efficiency. Detailed comparisons are reported for a compressor which utilizes vanadium metal as the sorbent for either hydrogen or deuterium where the unusually large isotope differences between VH(x) and VD(x) are considered. Author

A92-23837
COMPUTER SIMULATION MODEL FOR LUCAS STIRLING REFRIGERATORS
S. W. K. YUAN, I. E. SPRADLEY, P. M. YANG, and T. C. NAST (Lockheed Missiles and Space Co., Inc., Research and Development Div., Palo Alto, CA) (Space Cryogenics Workshop, 10th, Cleveland, OH, June 18-20, 1991, Proceedings. A92-23826 08-31) Cryogenics (ISSN 0011-2275), vol. 32, no. 2, 1992, p. 143-148. refs
Copyright

Attention is given to a third-order nodal network model for Stirling refrigerators, with emphasis on the validation of this model against experimental results for the Lucas Stirling refrigerators. Excellent agreement was found between the two. The predicted compressor pressure-vs-volume (P-V) diagram of the Lucas refrigerator is shown. The pressure decreases due to the assumed initial start-up conditions and the subsequent redistribution of mass inside the model. Comparison of the predicted converged compressor P-V curve with the experimental data is plotted. The shapes of both curves are similar, and the areas inside the P-V curves are nearly the same (about 25 W). Excellent agreement is found between the predicted Q(input)/Q(net) and the experimental results. Remarkable predictions were given on the PV work, net cooling, power input, temperature, and pressure distributions throughout the system. The model was also proven to be useful in performing parametric studies, e.g., varying frequency and stroke. P.D.

A92-24176
DEVELOPMENT AND DESIGN WITH ADVANCED MATERIALS
GEORGE C. SIH, ED. (Lehigh University, Bethlehem, PA), SUONG V. HOA, ED. (Concordia University, Montreal, Canada), and JERZY T. PINDERA, ED. (Waterloo, University, Canada) Amsterdam, Netherlands and New York, Elsevier, 1990, 341 p. In English and French. For individual items see A92-24177 to A92-24193.
(ISBN 0-444-88706-7) Copyright

The present conference on topics in the characterization of composites, composite joints and structures, biomaterials, and composite fracture and fatigue, gives attention to the influence of thermal-mechanical interaction on material characterization, the thermomicrohardness analysis of glassy materials, the temperature-dependence of the viscoelastic behavior of PEEK resin and composites, the effect of through-the-thickness holes on the tensile strength of thick laminates, and the effect of microstructure on the response of composite tubes. Also discussed are a FEM model for porous implants, the replacement of articular cartilage with a thermoplastic elastomer, the selection of GRP composites for naval ship structures, and methods for crack-growth testing in gas turbine engine disk materials. O.C.

A92-24186
RESPONSE OF SYMMETRICALLY LAMINATED RECTANGULAR PLATES SUBJECTED TO HEATING
K. S. SIVAKUMARAN (McMaster University, Hamilton, Canada) IN: Development and design with advanced materials. Amsterdam, Netherlands and New York, Elsevier, 1990, p. 167-182. Research supported by NSERC. refs
Copyright

In the present geometrically nonlinear analysis for the response of symmetrically laminated composite material plates that are subjected to thermal fields and aerodynamic loading, inertia and transverse shear effects are ignored but the governing equations used encompass thermomechanical coupling effects. Attention is given to boundary conditions for loosely clamped edges; results are obtained which correspond to increasing aerodynamic forces and thermal fields, indicating the sensitivity of the stress and displacement fields to the class of laminated plates under consideration. O.C.

A92-24193
REVIEW OF METHODS FOR CRACK GROWTH TESTING IN GAS TURBINE ENGINE DISC MATERIALS
M. D. RAIZENNE (National Aeronautical Establishment, Ottawa, Canada) IN: Development and design with advanced materials. Amsterdam, Netherlands and New York, Elsevier, 1990, p. 309-320. refs
Copyright

With the implementation of gas turbine engine disk lifing criteria based on damage tolerance design, a need for accurate crack propagation data exists. A review of engine disk critical flaw size geometries indicates that non-standard specimens are best suited for obtaining crack propagation data for engine disk applications. Crack length measurements can be taken using optical, compliance or resistance foil techniques, but the most suitable method for elevated test temperatures is the potential drop technique. Examples of two gas turbine-related test programs employing damage tolerance testing are discussed. Author

N92-16174 Department of the Navy, Washington, DC.
PULSED FIELD SYSTEM FOR DETECTING THE PRESENCE OF A TARGET IN A SUBSURFACE ENVIRONMENT Patent
CLARENCE F. RAMSTEDT, inventor (to Navy) 18 Jun. 1991 8 p Filed 23 Apr. 1979
(AD-D015074; US-PATENT-5,025,218;
US-PATENT-APPL-SN-032815; US-PATENT-CLASS-324-334)
Avail: US Patent and Trademark Office CSCL 17/6

In a method and apparatus for searching a subsurface environment to detect the presence of a target therein, an electromagnetic field is emitted which comprises successive electromagnetic pulses of selected duty cycle with the time interval between pulses comprising a zero emission interval and a sampling interval. The sampling interval follows the zero emission interval, and the polarity of the pulses of the emitted field alternate at a selected alternating frequency. The emitted field is projected into the environment from a selected location, and the electromagnetic field proximate to the selected location is sampled during each of the sampling intervals to provide a train of proximate field samples. The train of proximate field samples is spectrum analyzed to determine whether or not the field proximate to the selected location contains a component having a frequency which is equal to the alternating frequency. Author (GRA)

N92-16181# Scientech, Inc., Idaho Falls, ID.
HIGH INTENSITY RADIATED FIELDS (HIRF) PROJECT PLAN
MICHAEL S. GLYNN, JERRY T. BLAIR, and M. MARX HINTZE Sep. 1991 45 p
(Contract DTFA03-89-A-000111)
(DOT/FAA/CT-TN91/1) Avail: NTIS HC/MF A03

Addressed here is the Federal Aviation Administration's approach to High Intensity Radiated Fields (HIRF) affecting the aviation community. Near- and far-term tasks are described. Deliverables, program management, scheduling, and cost issues are discussed. Author

N92-16225# Queensland Univ., Brisbane (Australia). Dept. of Civil Engineering.
FLOW AROUND TWO CIRCULAR CYLINDERS ARRANGED PERPENDICULAR TO EACH OTHER
T. A. FOX Dec. 1990 36 p
(PB91-238279; RR-CE126; ISBN-0-86776-418-X) Avail: NTIS HC/MF A03 CSCL 20/4

The flow around two smooth circular cylinders arranged perpendicular to each other was examined through flow visualization in a water tunnel facility. The configuration was immersed in a steady, low-turbulence, uniform flow at Reynolds numbers of 1 times 10,000 and 2 times 1000 (based on cylinder diameter and freestream velocity). The effect of cylinder spacing was examined up to a distance of five diameters between axes. The observations corroborate the findings of a wind tunnel study previously performed by the author and provide further details of the complex regimes that occur at the center of the geometry. Author

N92-16243* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
ATMOSPHERIC PRESSURE FLOW REACTOR: GAS PHASE CHEMICAL KINETICS UNDER TROPOSPHERIC CONDITIONS WITHOUT WALL EFFECTS Patent
STEVEN L. KOONTZ, inventor (to NASA) and DENNIS D. DAVIS, inventor (to NASA) 31 Dec. 1991 6 p Filed 2 Dec. 1988
(NASA-CASE-MSC-21384-1; US-PATENT-5,077,015; US-PATENT-APPL-SN-279170; US-PATENT-CLASS-422-83; US-PATENT-CLASS-422-93; US-PATENT-CLASS-422-176; INT-PATENT-CLASS-H01N-1/26; INT-PATENT-CLASS-H01N-17/00) Avail: US Patent and Trademark Office CSCL 20/4

A flow reactor for simulating the interaction in the troposphere is set forth. A first reactant mixed with a carrier gas is delivered from a pump and flows through a duct having louvers therein. The louvers straighten out the flow, reduce turbulence and provide laminar flow discharge from the duct. A second reactant delivered from a source through a pump is input into the flowing stream, the second reactant being diffused through a plurality of small diffusion tubes to avoid disturbing the laminar flow. The commingled first and second reactants in the carrier gas are then directed along an elongated duct where the walls are spaced away from the flow of reactants to avoid wall interference, disturbance or turbulence arising from the walls. A probe connected with a measuring device can be inserted through various sampling ports in the second duct to complete measurements of the first and second reactants and the product of their reaction at selected XYZ locations relative to the flowing system.
Official Gazette of the U.S. Patent and Trademark Office

N92-16265*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
BRUSH SEAL LEAKAGE PERFORMANCE WITH GASEOUS WORKING FLUIDS AT STATIC AND LOW ROTOR SPEED CONDITIONS
JULIE A. CARLILE, ROBERT C. HENDRICKS, and DENNIS A. YODER 1992 9 p Proposed for presentation at the 37th International Gas Turbine and Aeroengine Congress and Exposition, Cologne, Germany, 1-4 Jun. 1992; sponsored by the American Inst. of Mechanical Engineers
(NASA-TM-105400; E-6796; NAS 1.15:105400) Avail: NTIS HC/MF A02 CSCL 20/4

The leakage performance of a brush seal with gaseous working fluids at static and low rotor speed conditions was studied. The leakage results are included for air, helium, and carbon dioxide at several bristle/rotor interferences. Also, the effects of packing a lubricant into the bristles and also of reversing the pressure drop across the seal were studied. Results were compared to that of an annular seal at similar operating conditions. In order to generalize the results, they were correlated using corresponding state theory. The brush seal tested had a bore diameter of 3.792 cm (1.4930 in), a fence height of 0.0635 cm (0.025 in), and 1800 bristles/cm circumference (4500 bristles/in circumference). Various bristle/rotor radial interferences were achieved by using a tapered rotor. The brush seal reduced the leakage in comparison to the annular seal, up to 9.5 times. Reversing the pressure drop across the brush seal produced leakage rates approx. the same as that of the annular seal. Addition of a lubricant reduced the leakage by 2.5 times. The air and carbon dioxide data were successfully correlated using corresponding state theory. However, the helium data followed a different curve than the air and carbon dioxide data. Author

N92-16281# Pacific Northwest Lab., Richland, WA.
CALIBRATION DATA FOR IMPROVED CORRECTION OF UVW PROPELLER ANEMOMETERS
J. R. CONNELL (Colorado State Univ., Fort Collins.) and V. R. MORRIS Oct. 1991 33 p
(Contract DE-AC06-76RL-01830)
(DE92-002935; PNL-7824) Avail: NTIS HC/MF A03

Wind turbine test programs sponsored by the US DOE in the late 1980s called for measurement of three-dimensional turbulent wind with an accuracy not previously required. The Pacific Northwest Laboratory identified the need for more complete, more highly resolved, and more accurate calibrations to provide the new level of measurement capability. The UVW propeller anemometer, became the object of a unique calibration effort at a large wind tunnel at Colorado State University. A UVW anemometer, with all three propellers active, was installed in the wind tunnel on a digitally stepped two-axis rotary platform placed just below the tunnel floor. The azimuth and elevation of the anemometer in a steady wind at each of a selected set of speeds was stepped through a complete test program using a digital computer as controller and a digital data acquisition system to sample and filter the data. Tests were run using polypropylene and carbon fiber propellers. In addition, the effects of attaching 'shaft extensions' to the polypropylene propellers were measured. Calibrations for the polypropylene four-blade propeller provide an improved level of detail and repeatability. The UVW propeller anemometer is quite accurate at all wind angles and speeds to be experienced in wind energy studies, including winds blowing at right angles to the axis of rotation of a propeller. The new correction factors derived from these data eliminate previous difficulties in accuracy and speed of data reduction from voltages to wind speed components. Calibration data for a carbon fiber thermoplastic propeller are presented with resolution similar to that for the polypropylene propellers. DOE

N92-16283*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
EVALUATION OF ELECTROLYTIC TILT SENSORS FOR MEASURING MODEL ANGLE OF ATTACK IN WIND TUNNEL TESTS
DOUGLAS T. WONG Washington Feb. 1992 36 p Presented at the International Conference on Instrumentations for Aerodynamic Simulation Facilities, Rockville, MD, 28-31 Oct. 1991
(NASA-TM-4315; L-16938; NAS 1.15:4315) Avail: NTIS HC/MF A03 CSCL 14/2

The results of a laboratory evaluation of electrolytic tilt sensors as potential candidates for measuring model attitude or angle of attack in wind tunnel tests are presented. The performance of eight electrolytic tilt sensors was compared with that of typical servo accelerometers used for angle-of-attack measurements. The

areas evaluated included linearity, hysteresis, repeatability, temperature characteristics, roll-on-pitch interaction, sensitivity to lead-wire resistance, step response time, and rectification. Among the sensors being evaluated, the Spectron model RG-37 electrolytic tilt sensors have the highest overall accuracy in terms of linearity, hysteresis, repeatability, temperature sensitivity, and roll sensitivity. A comparison of the sensors with the servo accelerometers revealed that the accuracy of the RG-37 sensors was on the average about one order of magnitude worse. Even though a comparison indicates that the cost of each tilt sensor is about one-third the cost of each servo accelerometer, the sensors are considered unsuitable for angle-of-attack measurements. However, the potential exists for other applications such as wind tunnel wall-attitude measurements where the errors resulting from roll interaction, vibration, and response time are less and sensor temperature can be controlled. Author

N92-16325# Helsinki Univ. of Technology, Otaniemi (Finland). Lab. of Thermal Engineering.
ANALYSIS OF EULER'S AND STRESS TENSOR METHODS FOR CALCULATING POWER CONSUMPTION OF HIGH SPEED CENTRIFUGAL FANS AND TURBOCOMPRESSORS
M. J. LAMPINEN and K. G. ERIKSSON 1990 31 p
(DE92-728396; TKK-KO/LTK-49) Avail: NTIS HC/MF A03

The aim of our research has been the investigation of two different calculation methods for power consumption of radial high speed fans and turbocompressors. We have studied the use of the angular momentum equation, called ruler's method, and the use of the blade loading equation, called the stress tensor method. We have derived formulae, based on theoretical analyses, for the stress tensor calculation method and compared the results achieved with ruler's method on a theoretical level and also in practice. In order to make these two methods coincide, the boundary layers should be considered carefully, and simple algebraic wall functions should not be used. We have also introduced a local efficiency concept by which the performance of an impeller can be more carefully analyzed. Representative numerical examples are presented. DOE

N92-16326# Helsinki Univ. of Technology, Otaniemi (Finland). Lab. of Thermal Engineering.
CALCULATION OF LOCAL POWER CONSUMPTIONS AND EFFICIENCIES OF CENTRIFUGAL FANS AND TURBOCOMPRESSORS
M. J. LAMPINEN and K. G. ERIKSSON 1991 27 p
(DE92-728402; TKK-KO/LTK-62) Avail: NTIS HC/MF A03

A theoretical study is presented of calculation methods for determining local power consumptions and efficiencies of radial fans and turbocompressors. The use of the angular momentum equation, Euler's method, and the use of the stress tensor method are analyzed. A modified formula for ruler's method is derived, which is accurate for viscous flows. A new local efficiency concept is introduced, by which the performance can be evaluated in different parts of the impeller. A representative numerical example of the use of the theory is presented. DOE

N92-16336*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
ENGINE PANEL SEALS FOR HYPERSONIC ENGINE APPLICATIONS: HIGH TEMPERATURE LEAKAGE ASSESSMENTS AND FLOW MODELLING
BRUCE M. STEINETZ, RAJAKKANNU MUTHARASAN, GUANG-WU DU, JEFFREY H. MILLER, and FRANK KO (Drexel Univ., Philadelphia, PA.) 1992 14 p Proposed for presentation at the Fourth International Symposium on Transport Phenomena and Dynamics of Rotating Machinery, Honolulu, HI, 5-8 Apr. 1992; sponsored by the Pacific Center of Thermal-Fluids Engineering
(Contract NAS3-25266)
(NASA-TM-105260; E-6545; NAS 1.15:105260) Avail: NTIS HC/MF A03 CSCL 11/1

A critical mechanical system in advanced hypersonic engines is the panel-edge seal system that seals gaps between the articulating horizontal engine panels and the adjacent engine splitter walls. Significant advancements in seal technology are required to meet the extreme demands placed on the seals, including the simultaneous requirements of low leakage, conformable, high temperature, high pressure, sliding operation. In this investigation, the seal concept design and development of two new seal classes that show promise of meeting these demands will be presented. These seals include the ceramic wafer seal and the braided ceramic rope seal. Presented are key elements of leakage flow models for each of these seal types. Flow models such as these help designers to predict performance-robbing parasitic losses past the seals, and estimate purge coolant flow rates. Comparisons are made between measured and predicted leakage rates over a wide range of engine simulated temperatures and pressures, showing good agreement. Author

N92-16978# David Taylor Research Center, Bethesda, MD. Ship Hydromechanics Dept.
COMPUTATION OF THE HYDRODYNAMIC FORCES AND MOMENTS ON A BODY OF REVOLUTION WITH AND WITHOUT APPENDAGES
YOUNG S. HONG Aug. 1991 54 p
(AD-A243033; DTRC/SHD-1003-06) Avail: NTIS HC/MF A04
CSCL 20/4

An analytical method was developed to predict the hydrodynamic forces and moments developed on a body of revolution with and without appendages. The appendages included a bridge fairwater, sternplanes, and rudders. It was assumed that the body was either translating with an angle of attack of up to 20 deg or rotating with an angular velocity. Calculations were performed by using the analytical method for four different bodies of revolution and comparisons were made with available experimental data. Potential flow was used to determine the inviscid contribution to the hydrodynamic forces and moments. The viscous contribution to the hydrodynamic forces and moments was determined by assuming that there was no flow separation due to the axial flow, and that the flow separation on the leeward side of the body due to the crossflow was independent of the offsets of the body, the angle of attack, the angular velocity, and the forward speed. It was assumed that the angle at which the flow separates, as measured from the stagnation point, was 110 deg at the stern and 170 deg at the bow for the body at angle of attack and 160 deg for the body with an angular velocity. GRA

N92-17002*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
APPLICATION OF PROGRAM LAURA TO PERFECT GAS SHOCK TUBE FLOWS: A PARAMETRIC STUDY
K. F. MITTERER, R. A. MITCHELTREE, and P. A. GNOFFO Jan. 1992 23 p
(NASA-TM-104190; NAS 1.15:104190) Avail: NTIS HC/MF A03
CSCL 20/4

The Langley Aerothermodynamic Upwind Relaxation Algorithm (LAURA) was originally developed to solve steady-flow problems. The desire to validate the algorithm with shock tube experimental data motivated the development of a time-accurate version of the LAURA code. The current work presents a test of the Algorithm. Computational results are compared with the exact solution for a simple shock tube case. The parameters examined are Courant number, relaxation sweeps, grid spacing, and the inviscid relaxation factor. The results of the study indicate that LAURA is capable of producing accurate solutions when appropriate values are used for each parameter. Author

N92-17006*# Lockheed Aeronautical Systems Co., Burbank, CA.
HEAT FLUX SENSOR RESEARCH AND DEVELOPMENT: THE COOL FILM CALORIMETER Final Report, 25 Jan. 1990
A. ABTAHI and P. DEAN 30 Jun. 1990 72 p
(Contract NAS1-18570)
(NASA-CR-189789; NAS 1.26:189789; LR-31824) Avail: NTIS HC/MF A04 CSCL 14/2

The goal was to meet the measurement requirement of the NASP program for a gauge capable of measuring heat flux into a

'typical' structure in a 'typical' hypersonic flight environment. A device is conceptually described that has fast response times and is small enough to fit in leading edge or cowl lip structures. The device relies heavily on thin film technology. The main conclusion is the description of the limitations of thin film technology both in the art of fabrication and in the assumption that thin films have the same material properties as the original bulk material. Three gauges were designed and fabricated. Thin film deposition processes were evaluated. The effect of different thin film materials on the performance and fabrication of the gauge was studied. The gauges were tested in an arcjet facility. Survivability and accuracy were determined under various hostile environment conditions. Author

N92-17024# Air Force Inst. of Tech., Wright-Patterson AFB, OH. School of Engineering.
MODEL IDENTIFICATION AND CONTROL SYSTEM DESIGN FOR THE LAMBDA UNMANNED RESEARCH VEHICLE M.S. Thesis
GERALD A. SWIFT Sep. 1991 245 p
(AD-A241859; AFIT/GAE/ENY/91S-4) Avail: NTIS HC/MF A11 CSCL 01/3

Research for this thesis centered on the Lambda Unmanned Research Vehicle (URV), an asset of the Flight Dynamics Directorate, Wright Laboratory Patterson AFB. The following tasks were accomplished: (1) a linear, state-space, small perturbation model was developed for both the longitudinal and lateral directional dynamics of the vehicles, and (2) pitch rate roll rate, and yaw rate flight controllers were designed using classical and multivariable feedback methods. The parameters of the linear, state space, small perturbation model were estimated from actual flight test data. Digital Datcom was first used to estimate stability and control derivatives from the vehicle's geometry. Maximum likelihood estimation was then used to adjust the Datcom derivatives so that the estimated state time histories matched the actual state time histories recorded during flight. Pitch rate, roll rate, and yaw rate controller designs were developed using classical feedback methodology characterized by single input, single output, open loop transfer function techniques. The controller designs were repeated using the Linear Quadratic Gaussian with Loop Transfer Recovery (LOG/LTR) multivariable feedback approach. GRA

N92-17033*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
EXPERIENCES AT LANGLEY RESEARCH CENTER IN THE APPLICATION OF OPTIMIZATION TECHNIQUES TO HELICOPTER AIRFRAMES FOR VIBRATION REDUCTION
T. SREEKANTA MURTHY (Lockheed Engineering and Sciences Co., Hampton, VA.) and RAYMOND G. KVATERNIK Dec. 1991 17 p Presented at the American Helicopter Society National Technical Specialists' Meeting on Rotorcraft Structures, Williamsburg, VA, 29-31 Oct. 1991
(NASA-TM-104193; NAS 1.15:104193) Avail: NTIS HC/MF A03 CSCL 20/11

A NASA/industry rotorcraft structural dynamics program known as Design Analysis Methods for VIBrationS (DAMVIBS) was initiated at Langley Research Center in 1984 with the objective of establishing the technology base needed by the industry for developing an advanced finite-element-based vibrations design analysis capability for airframe structures. As a part of the in-house activities contributing to that program, a study was undertaken to investigate the use of formal, nonlinear programming-based, numerical optimization techniques for airframe vibrations design work. Considerable progress has been made in connection with that study since its inception in 1985. This paper presents a unified summary of the experiences and results of that study. The formulation and solution of airframe optimization problems are discussed. Particular attention is given to describing the implementation of a new computational procedure based on MSC/NASTRAN and CONstrained function MINimization (CONMIN) in a computer program system called DYNOPT for the optimization of airframes subject to strength, frequency, dynamic response, and fatigue constraints. The results from the application of the DYNOPT program to the Bell AH-1G helicopter are presented and discussed. Author

N92-17034*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
THE NASA/INDUSTRY DESIGN ANALYSIS METHODS FOR VIBRATIONS (DAMVIBS) PROGRAM: ACCOMPLISHMENTS AND CONTRIBUTIONS
RAYMOND G. KVATERNIK Dec. 1991 37 p Presented at the American Helicopter Society National Technical Specialists' Meeting on Rotorcraft Structures, Williamsburg, VA, 29-31 Oct. 1991
(NASA-TM-104192; NAS 1.15:104192) Avail: NTIS HC/MF A03 CSCL 20/11

A NASA Langley-sponsored rotorcraft structural dynamics program, known as Design Analysis Methods for VIBrationS (DAMVIBS), has been under development since 1984. The objective of this program was to establish the technology base needed by the industry to develop an advanced finite-element-based dynamics design analysis capability for vibrations. Under the program, teams from the four major helicopter manufacturers have formed finite-element models, conducted ground vibration tests, made test/analysis comparisons of both metal and composite airframes, performed 'difficult components' studies on airframes to identify components which need more complete finite-element representation for improved correlation, and evaluated industry codes for computing coupled rotor-airframe vibrations. Studies aimed at establishing the role that structural optimization can play in airframe vibrations design work have also been initiated. Five government/industry meetings were held in connection with these activities during the course of the program. Because the DAMVIBS Program is coming to an end, the fifth meeting included a brief assessment of the program and its benefits to the industry. Author

N92-17168# David Taylor Research Center, Bethesda, MD. Ship Hydromechanics Dept.
USE OF NAVIER-STOKES ANALYSIS IN SECTION DESIGN Final Report, Oct. 1988 - Oct. 1990
PHUC N. NGUYEN Dec. 1990 24 p
(Contract NR PROJ. RB2-3-C-22)
(AD-A242074; DTRC/SHD-1262-04) Avail: NTIS HC/MF A03 CSCL 01/1

The Navier-Stokes analysis method and a design technique based on conformal mapping are combined to develop new 2-D thick sections. The Eppler-Somers design technique allows for fast design of arbitrary section shape. The well-validated David Taylor Navier-Stokes code is used to optimize the thickness of the section. From previous experimental results, the turbulence characteristics in the near-wake region correlate with the pressure spectra on the trailing edge of a 2-D lifting surface. Therefore, the turbulent kinetic energy, and the Reynolds shear stress are used as design parameters to develop new 2-D sections. Minimizing these parameters is assumed to provide desirable boundary layer and wake characteristics. The characteristics of one new section are compared with those of a baseline section to demonstrate the new foil design method. GRA

N92-17216# Air Force Systems Command, Brooks AFB, TX.
TESTING AND EVALUATION OF THE VANNER ELECTRICAL INVERTERS, MODELS 24-1500 AND SP 00112 Final Report, Oct. 1990 - Jan. 1991
THOMAS E. PHILBECK, JR. and PHILIP J. PREEN Oct. 1991 19 p
(AD-A241914; AL-TR-1991-0094) Avail: NTIS HC/MF A03 CSCL 10/2

The United States Air Force Military Airlift Command (MAC) provides aeromedical airlift for Department of Defense personnel. Two aircraft, the C-130 and C-141, are primarily used for the transport of cargo, but may also be configured for aeromedical use. Neither aircraft have 110-120 volt alternating current (VAC)/60 Hz power required for medical equipment items. Inverters,

manufactured by Vanner Incorporated of Hilliard, OH, were selected to provide the needed power. Initially a Model 24-1500, and later a Model SP 00112 were submitted to the Armstrong Laboratory's Aeromedical Research Function at Brooks AFB, TX, for testing and evaluation. Modifications must be made to comply with MIL-STD 461, Category Ale and MIL-STD 810D. Only tested medical equipment may be operated off the Vanner. Only the 4.57 m (15 ft) 4 ga cable can be used to power the Vanner. The Vanner was fitted with a remote switch bypass plug. At least 10.2 cm (4 in.) of clearance must be provided all around the Vanner. Tiewraps must be inspected for deterioration or displacement. Provided these requirements are met, the Vanner can be an effective device to provide 120-VAC for powering some medical equipment items on C-130 and C-141 aircraft. Author (GRA)

N92-17258# Army Lab. Command, Fort Monmouth, NJ. Electronics Technology and Devices Lab.
LOW-NOISE OSCILLATORS FOR AIRBORNE RADAR APPLICATIONS
RAYMOND L. FILLER and JOHN R. VIG Oct. 1991 21 p
(Contract DA PROJ. 1L1-62705-AH-94)
(AD-A242264; SLCET-TR-91-26) Avail: NTIS HC/MF A03
CSCL 17/9

Vibration induced phase noise can change the probability of detection of moving target indicator (MTI) radar from near 100 percent to zero. Oscillators that are capable of meeting the requirements of MTI radar systems in a quiet environment are readily available. In the vibrating environments of airborne platforms, however, the phase noise of oscillators degrades very significantly. For example, a 10 MHz crystal oscillator may have a phase noise of -140 dBc/Hz, 100 Hz from the carrier. Assuming a typical one part per billion per g acceleration sensitivity, this phase noise degrades to -93 dBc/Hz under a 0.1 sq g/Hz random vibration at 100 Hz away from the carrier. If there is a 1 g sinusoidal vibration at 100 Hz, there will be a pair of -86 dBc spectral lines superimposed on the signal. Of course, upon multiplication to 10 GHz, the phase noise increases by at least another 60 dB. This report reviews the causes and effects of acceleration sensitivity of bulkwave quartz crystal resonators, and the methods that reduce or compensate for that sensitivity. Most of what is discussed is equally relevant to surface acoustic wave (SAW), shallow bulk acoustic wave (SBAW), dielectric resonator oscillators (DRO), and other types of oscillators. Author (GRA)

N92-17344# Max-Planck-Inst. fuer Stroemungsforschung, Goettingen (Germany, F.R.).
DEVELOPMENT OF AN ELECTRONIC HIGH SPEED CAMERA SYSTEM FOR THE QUANTITATIVE ANALYSIS OF UNSTEADY FLOWS
BERNWARD BRETTHAUER 1991 75 p In GERMAN; ENGLISH summary
(MPIS-100/1991; ISSN-0374-1257; ETN-92-90624) Avail: NTIS HC/MF A04

A high speed camera system, based on eight CCD cameras and the Cranz-Scharolin priciple, was developed for the quantitative analysis of unsteady flows. Light emitting diodes were used for illumination. Interferograms were taken from experiments concerned with vortex airfoil interaction, showing the generation of local stagnation points by this interaction. The camera generates high quality pictures suitable for quantitative analysis using an image processing system which was improved for this purpose. The system allows the recognition of weak compression waves. ESA

N92-17387# Applied Research Lab., State College, PA.
BASIC HYDRODYNAMICS Final Report
G. C. LAUCHLE 4 Dec. 1991 10 p
(Contract N00014-87-K-0196; N00014-91-J-1646)
(AD-A243513; PSU/ARL-TM-91-299) Avail: NTIS HC/MF A02
CSCL 20/4

Basic hydrodynamic studies in turbomachinery and hydrodynamic drag reduction have been conducted. In the turbomachinery thrust area, the overall objective is to develop an improved understanding of the complex three-dimensional flows typical of incompressible rotor and stator flows; this effort has been primarily computational in nature. The second thrust area is axisymmetric turbulent flow drag reduction through microbubble injections. The third thrust area objective is to assess experimentally the effects of wall suction of turbulent boundary layer skin friction with possible applications to drag reduction. A fourth thrust area was a combined analytical and experimental study on laminar boundary layer/particle interaction physics. GRA

N92-17629# Hughes Aircraft Co., El Segundo, CA. Electro-Optical and Data Systems Group.
THERMALLY REGENERATIVE FUEL CELLS Final Report
F. A. LUDWIG, A. KINDLER, and J. MCHARDY Oct. 1991 6 p
(Contract N00014-89-C-0071)
(AD-A242900) Avail: NTIS HC/MF A02 CSCL 10/3

The three phase project was undertaken to investigate solventless ionic liquids as possible working fluids for a new type of thermally regenerative fuel cell (TRFC). The heart of the new device, invented at Hughes Aircraft Company in 1983, is an electrochemical concentration cell where acid and base streams react to produce electrical energy. Thermal energy is then used to decompose the resulting salts and regenerate the cell reactants. In principle, a TRFC can be matched to any source of thermal energy simply by selecting working fluids with the appropriate regeneration temperature. However, aqueous working fluids (the focus of previous studies) impose limitations on both the operating temperatures and the achievable energy densities. It was the need to overcome these limitations that prompted the present investigation. Specific aims were to identify possible working fluids for TRFC systems with both low and high regeneration temperatures. A major advantage of our aqueous-fluid TRFC systems has been the ability to use hydrogen electrodes. The low activation and mass transfer losses of these electrodes contribute substantially to overall system efficiency. GRA

N92-17674*# National Aeronautics and Space Administration. Pasadena Office, CA.
THREE-STAGE SORPTION TYPE CRYOGENIC REFRIGERATION SYSTEM AND METHOD EMPLOYING HEAT REGENERATION Patent Application
STEVEN BARD, inventor (to NASA) and JACK A. JONES, inventor (to NASA) (Jet Propulsion Lab., California Inst. of Tech., Pasadena.) 22 Oct. 1991 21 p
(Contract NAS7-918)
(NASA-CASE-NPO-18366-1-CU; NAS 1.71:NPO-18366-1-CU; US-PATENT-APPL-SN-781520) Avail: NTIS HC/MF A03 CSCL 13/2

A three-stage sorption type cryogenic refrigeration system, each stage containing a fluid having a respectively different boiling point. Each stage includes a compressor in which a respective fluid is heated to be placed in a high pressure gaseous state. The compressor for that fluid which is heated to the highest temperature is enclosed by the other two compressors to permit heat to be transferred from the inner compressor to the surrounding compressors. The system may include two sets of compressors, each having the structure described above, with the interior compressors of the two sets coupled together to permit selective heat transfer therebetween, resulting in more efficient utilization of input power. NASA

N92-17757# National Aerospace Lab., Tokyo (Japan). Thermofluid Dynamics Div.
DISCUSSION FOR POSSIBILITY OF SOME AERODYNAMIC GROUND EFFECT CRAFT [ARU AERODAINAMIKKU GURAUNDO IFEKUTO KURAFUTO NO KANOSEI NIKANSURU ICHI KOSATSU]
YOSHIKAZU TANABE May 1990 32 p In JAPANESE
(NAL-TM-619; ISSN-0452-2982; JTN-92-80290) Avail: NTIS HC/MF A03

Some type of pleasant, convenient, safe, and economical transportation method to supplement airplane transportation is currently required. This paper proposes an Aerodynamic Ground

Effect Craft (AGEC) as this new transportation method, and studies its qualitative feasibility in comparison with present typical transportation methods such as transporter airplanes, flying boats, and linear motor cars which also have common characteristics of ultra low altitude cruising. Noteworthy points of AGEC are the effective energy consumption against transportation capacity (exergie) and the ultra low altitude cruising, which is relatively safer at the emergency landing than the subsonic airplane's body landing. Through AGEC has shorter cruising range and smaller transportation capacity, its transportation efficiency is superior to that of airplanes and linear motor cars. There is no critical difficulty in large sizing of AGEC, and AGEC is thought to be the very probable candidate which can supplement airplane transportation in the near future. Author (NASDA)

13

GEOSCIENCES

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

A92-22495
STUDIES ON THE EFFECT OF HIGH-FLYING AIR-TRAFFIC ON THE ATMOSPHERE
U. SCHUMANN and M. E. REINHARDT (DLR, Institut fuer Physik der Atmosphaere, Oberpfaffenhofen, Federal Republic of Germany) IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 12 p. refs
(IAF PAPER 91-737) Copyright

With respect to the effects of subsonic airtraffic at cruising altitude on the atmosphere, previous and ongoing studies are surveyed. Concentration increases for nitrogen oxides and water vapor are estimated which occur in the lower stratosphere, in the troposphere, over the north Atlantic, and in the trail of a single airliner. The increase in nitrogen oxide is large in comparison to background concentration and may cause considerable increase of tropospheric ozone. The global increase of water vapor concentration is small. However, satellite data and Lidar observations of contrails show that such contrails trigger additional cirrus clouds which may have climatological effects at least regionally. Author

A92-23008
PRECIPITATION DEVELOPMENT IN COLORADO FRONT RANGE SNOWSTORMS - 15 NOVEMBER 1987 CASE STUDY
ROY M. RASMUSSEN, ANDREW CROOK, and CATHY KESSINGER (NCAR, Boulder, CO) IN: 1990 Conference on Cloud Physics, San Francisco, CA, July 23-27, 1990, Preprints. Boston, MA, American Meteorological Society, 1990, p. 758-764. refs
Copyright

The structure, dynamics, and microphysics of a heavy snowstorm along the Colorado Front Range are discussed with particular attention given to the origin of the precipitation falling at Stapleton prior to the takeoff of flight 1713, which crashed on takeoff from Denver Stapleton International Airport on 15 November 1987. During the storm, heavy snowfall fell at Stapleton as a result of the snowbands becoming stationary, causing rapid icing of the exposed surfaces of flight 1713 while the aircraft was taxiing for takeoff. Supercooled liquid water was also present aloft, as well as strong vertical wind shear at low levels. O.G.

A92-23009
THE 1988 AUSTRALIAN WINTER STORMS EXPERIMENT - CASE STUDY: 6 AUGUST 1988
JORGEN B. JENSEN, SUNHEE LEE, RUSSELL O'BRIEN, CHARLES TIVENDALE, and ALEXIS B. LONG (CSIRO, Div. of Atmospheric Research, Aspendale, Australia) IN: 1990 Conference on Cloud Physics, San Francisco, CA, July 23-27, 1990, Preprints. Boston, MA, American Meteorological Society, 1990, p. 765-771. Research supported by Australian Water Research Association and NSF. refs
Copyright

Results of the 1988 Australian Winter Storms Experiment (AWSE) are analyzed to study orographic cloud and precipitation processes near the Thomson Reservoir. Observations are presented from the F-27 flight made on August 6 1988 during postfrontal conditions. Data obtained indicate that there are complex but possibly systematic interactions between airflow, cloud fields, and precipitation fields. A slow development of ice was observed in some parcels, and in other parcels there seem to be active ice multiplication processes. O.G.

N92-16458# Midwest Research Inst., Golden, CO. National Renewable Energy Lab.
A COMPARISON OF SPANWISE AERODYNAMIC LOADS ESTIMATED FROM MEASURED BENDING MOMENTS VERSUS DIRECT PRESSURE MEASUREMENTS ON HORIZONTAL AXIS WIND TURBINE BLADES
D. A. SIMMS and C. P. BUTTERFIELD Oct. 1991 11 p Presented at the 21st American Wind Energy Association Conference: Windpower '91, Palm Springs, CA, 24-27 Sep. 1991
(Contract DE-AC02-83CH-10093)
(DE92-001158; NREL/TP-257-4507; CONF-9109112-3) Avail: NTIS HC/MF A03

Two methods can be used to determine aerodynamic loads on a rotating wind turbine blade. The first is to make direct pressure measurements on the blade surface. This is a difficult process requiring costly pressure instrumentation. The second method uses measured flap bending moments in conjunction with analytical techniques to estimate airloads. This method, called ALEST, was originally developed for use on helicopter rotors and was modified for use on horizontal axis wind turbine blades. Estimating airloads using flap bending moments in much simpler and less costly because measurements can be made with conventional strain gages and equipment. This paper presents results of airload estimates obtained using both methods under a variety of operating conditions. Insights on the limitations and usefulness of the ALEST bending moment technique are also included. DOE

N92-17028# Massachusetts Inst. of Tech., Lexington. Lincoln Lab.
TERMINAL DOPPLER WEATHER RADAR TEST BED OPERATION, ORLANDO: JANUARY-JUNE 1990 Semiannual Report, 1 Jan. - 30 Jun. 1990
DAVID M. BERNELLA 4 Nov. 1991 112 p
(Contract F19628-90-C-0001; DTFA01-L-83-4-10579)
(AD-A242890; ATC-180) Avail: NTIS HC/MF A06 CSCL 17/9

This semiannual report for the Terminal Doppler Weather Radar program, sponsored by the Federal Aviation Administration (FAA), covers the period from 1 January 1990 through 30 June 1990. The principal activity of this period was the transport and reassembly of the FL-2 weather radar test site from Kansas City, MO to Orlando, FL and the change of radar frequency from S-band used in Kansas City to C-band for Orlando operations. Site operations to prepare the FL-2C radar site for summer testing began in January and continued through May, when testing began. This report describes the RF hardware, the data collection, the computer systems at site, and the networks between Orlando, FL and Lexington, MA. Also included are discussions of the microburst and gust front algorithm development, data collection, display terminals, and training for Air Traffic Control (ATC) supervisors and controllers. GRA

N92-17393*# National Center for Atmospheric Research, Boulder, CO. Atmospheric Technology Div.
MEETING REVIEW: AIRBORNE AEROSOL INLET WORKSHOP
DARREL BAUMGARDNER, BARRY HUEBERT, and CHUCK WILSON Jul. 1991 299 p Sponsored by NASA, Washington and NSF

(NASA-CR-189814; NAS 1.26:189814; PB91-233783; NCAR/TN-362+1A) Avail: NTIS HC/MF A13 CSCL 13/2

Proceedings from the Airborne Aerosol Inlet Workshop are presented. The two central topics of discussion were the role of aerosols in atmospheric processes and the difficulties in characterizing aerosols. The following topics were discussed during the working sessions: airborne observations to date; identification of inlet design issues; inlet modeling needs and directions; objectives for aircraft experiments; and future laboratory and wind tunnel studies. GRA

N92-17875# Midwest Research Inst., Golden, CO. National Renewable Energy Lab.

AN OVERVIEW: CHALLENGES IN WIND TECHNOLOGY DEVELOPMENT

R. W. THRESHER and S. M. HOCK Dec. 1991 10 p Presented at the 21st American Wind Energy Association Conference: Windpower 1991, Palm Springs, CA, 24-27 Sep. 1991

(Contract DE-AC02-83CH-10093)

(DE92-001190; NREL/TP-257-4518; CONF-9109112-8) Avail: NTIS HC/MF A02

Developing innovative wind turbine components and advanced turbine configurations is a primary focus for wind technology researchers. In their rush to bring these new components and systems to the marketplace, designers and developers should consider the lessons learned in the wind farms over the past 10 years. Experience has shown that a disciplined design approach is required that realistically accounts for the turbulence-induced loads, unsteady stall loading, and fatigue effects. This paper reviews past experiences and compares current modeling capabilities with experimental measurements in order to identify some of the knowledge gaps that challenge designers of advanced components and systems. DOE

15

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.

A92-21176

PARAMETRIC ROBUST CONTROL BY QUANTITATIVE FEEDBACK THEORY

OSITA NWOKAH (Purdue University, West Lafayette, IN), SUHADA JAYASURIYA (Texas A & M University, College Station), and YOSSI CHAIT (Massachusetts, University, Amherst) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 15, Jan.-Feb. 1992, p. 207-214. Research supported by General Motors Corp. refs

(Contract F49629-88-C-0053)

Copyright

The problem of performance robustness, especially in the face of significant parametric uncertainty, has been increasingly recognized as a predominant issue of engineering significance in many design applications. Quantitative feedback theory is very effective for dealing with this class of problems even when there exist hard constraints on closed-loop response. In this paper, single-input/single-output quantitative feedback theory is viewed formally as a sensitivity constrained multiobjective optimization problem whose solution cannot be obtained analytically but (when feasible) can be obtained graphically. In contrast to the more recent robust control methods where phase uncertainty information is often neglected, the direct use of parametric uncertainty and phase information in quantitative feedback theory results in a significant reduction in the cost of feedback. An example involving a standard quantitative feedback theory problem is included for completeness. Author

A92-21179

NONLINEAR AIRCRAFT TRACKING FILTER UTILIZING CONTROL VARIABLE ESTIMATION

D. J. MOOK and IN-MING SHYU (New York, State University, Buffalo) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 15, Jan.-Feb. 1992, p. 228-237. Previously cited in issue 21, p. 3305, Accession no. A90-47657. refs

Copyright

A92-21181* Princeton Univ., NJ.

PROBABILISTIC REASONING FOR INTELLIGENT WIND SHEAR AVOIDANCE

D. A. STRATTON and ROBERT F. STENGEL (Princeton University, NJ) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 15, Jan.-Feb. 1992, p. 247-254. Previously cited in issue 21, p. 3439, Accession no. A90-47690. refs

(Contract NAG1-834)

Copyright

A92-21191* Mississippi State Univ., Mississippi State.

OBSERVABILITY UNDER RECURRENT LOSS OF DATA

ROGELIO LUCK (Mississippi State University, Mississippi State), ASOK RAY (Pennsylvania State University, University Park), and YORAM HALEVI (Technion - Israel Institute of Technology, Haifa) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 15, Jan.-Feb. 1992, p. 284-287. refs

(Contract N00014-90-J-1513; NAG3-823)

Copyright

An account is given of the concept of extended observability in finite-dimensional linear time-invariant systems under recurrent loss of data, where the state vector has to be reconstructed from an ensemble of sensor data at nonconsecutive samples. An at once necessary and sufficient condition for extended observability that can be expressed via a recursive relation is presented, together with such conditions for this as may be related to the characteristic polynomial of the state transition matrix in a discrete-time setting, or of the system matrix in a continuous-time setting. O.C.

A92-23038

THE APPLICATION OF PARAMETER OPTIMISATION TECHNIQUES TO LINEAR OPTIMAL CONTROL SYSTEM DESIGN

C. FRANGOS and J. A. SNYMAN (Pretoria, University, Republic of South Africa) Automatica (ISSN 0005-1098), vol. 28, Jan. 1992, p. 153-157. refs

Copyright

A parameter optimization approach is used to automate the linear quadratic regulator (LQR) design procedure. A multivariable plus integral controller structure has been employed, and decoupled command tracking specifications in the time domain have been taken into account. Diagonal state weighting matrices, which satisfy the specifications, have been calculated using standard algorithms. The design methodology under consideration has the advantages of both optimal control and accommodation of additional design specifications. The method was applied to the design of a decoupled longitudinal control system for a vertical take-off-and-land aircraft. The Snyman (1983) algorithm was used in minimization procedure. O.G.

A92-23693

AI TECHNOLOGY AND APPLICATION DEVELOPMENT ON THE SHUTTLE PROJECT

DOC SHANKAR (IBM Corp., Houston, TX) IN: i-SAIRAS '90; Proceedings of the International Symposium on Artificial Intelligence, Robotics and Automation in Space, Kobe, Japan, Nov. 18-20, 1990. Tokyo, REN Associates, Inc., 1990, p. 185-188. refs

Projects related to artificial intelligence (AI) are reviewed that are designed to support Space Shuttle activities including applications concepts and technological developments. Specific descriptions are given of performance tests for flight software and hardware to analyze relevant applications. Reference is given to launch-abort analysis, shuttle hardware diagnostics, mission-data

determination, Shuttle/Spacelab interface diagnostics, cold start initialization, and software code reviews. AI technological developments include a real-time embedded expert system, knowledge acquisition, neural networks for improving productivity, automated program composition, software reengineering and AI coprocessors. Some of the AI expert systems are in use as production systems, and the areas for AI applications are growing. C.C.S.

N92-16605*# California Polytechnic State Univ., San Luis Obispo.
A CLIPS-BASED TOOL FOR AIRCRAFT PILOT-VEHICLE INTERFACE DESIGN
THOMAS D. FOWLER and STEVEN P. ROGERS (Anacapa Sciences, Inc., Santa Barbara, CA.) *In* NASA. Johnson Space Center, Second CLIPS Conference Proceedings, Volume 2 p 407-416 Sep. 1991
(Contract NAS2-13391)
Avail: NTIS HC/MF A13 CSCL 09/2

The Pilot-Vehicle Interface of modern aircraft is the cognitive, sensory, and psychomotor link between the pilot, the avionics modules, and all other systems on board the aircraft. To assist pilot-vehicle interface designers, a C Language Integrated Production System (CLIPS) based tool was developed that allows design information to be stored in a table that can be modified by rules representing design knowledge. Developed for the Apple Macintosh, the tool allows users without any CLIPS programming experience to form simple rules using a point and click interface. Author

N92-17130*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
THE MULTI-ATTRIBUTE TASK BATTERY FOR HUMAN OPERATOR WORKLOAD AND STRATEGIC BEHAVIOR RESEARCH
J. RAYMOND COMSTOCK, JR. and RUTH J. ARNEGARD (Old Dominion Univ., Norfolk, VA.) Jan. 1992 99 p
(NASA-TM-104174; NAS 1.15:104174) Avail: NTIS HC/MF A05 CSCL 09/2

The Multi-Attribute Task (MAT) Battery provides a benchmark set of tasks for use in a wide range of lab studies of operator performance and workload. The battery incorporates tasks analogous to activities that aircraft crewmembers perform in flight, while providing a high degree of experimenter control, performance data on each subtask, and freedom to use nonpilot test subjects. Features not found in existing computer based tasks include an auditory communication task (to simulate Air Traffic Control communication), a resource management task permitting many avenues or strategies of maintaining target performance, a scheduling window which gives the operator information about future task demands, and the option of manual or automated control of tasks. Performance data are generated for each subtask. In addition, the task battery may be paused and onscreen workload rating scales presented to the subject. The MAT Battery requires a desktop computer with color graphics. The communication task requires a serial link to a second desktop computer with a voice synthesizer or digitizer card. Author

N92-17438# BDM International, Inc., Arlington, VA.
AUTOMATED PLANNING WITH SPECIAL RELEVANCE TO ASSOCIATE SYSTEMS TECHNOLOGY AND MISSION PLANNING Final Report, May 1990 - Sep. 1991
PHILIP A. MERKEL, PAUL E. LEHNER, ROGER A. GEESEY, and JOHN B. GILMER Sep. 1991 132 p
(Contract MDA072-90-C-0039; ARPA ORDER 6707)
(AD-A241924; BDM/VSQ-91-0742-TR) Avail: NTIS HC/MF A07 CSCL 12/6

This report describes the results of work performed to establish the technical basis for a future R and D effort in mission planning technology. One known operational need is for aircrew decision aiding for dynamic replanning during the performance of modern military air missions where information flow, knowledge and detailed reasoning can radically alter the outcome. Artificial intelligence technologies have been applied to create associate concepts with automated planning being a key construct to aid decision making in time constrained, rapidly changing situations. Basic and advanced research programs such as Pilot's Associate, Rotorcraft Pilot's Associate and the Submarine Operational Automation System have each introduced relevant advances to meet service-specific needs. This report provides an overview of automated planning techniques followed by an applications and technology map. The material is supported by information on the relationships of automated planning to the techniques of mathematical optimization, decision theory, et. al. GRA

N92-17498# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). Guidance and Control Panel.
TECHNICAL EVALUATION REPORT ON THE 52ND SYMPOSIUM ON SOFTWARE FOR GUIDANCE AND CONTROL
DONALD E. DEWEY (Boeing Military Airplane Development, Seattle, WA.) Dec. 1991 41 p Symposium held in Thessaloniki, Greece, 7-10 May 1991
(AGARD-AR-302; ISBN-92-835-0647-2; CP-503) Copyright
Avail: NTIS HC/MF A03; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

A review is presented of some of the symposium sessions. The papers presented covered some of the following headings: tools and methods for a user's viewpoint; general requirements on software; integrated programs support environments; software requirements; design methods for real time software; ADA applications; and automated software generation approaches. Author

N92-17998*# Princeton Univ., NJ. Dept. of Mechanical and Aerospace Engineering.
NEURAL NETWORKS FOR AIRCRAFT SYSTEM IDENTIFICATION
DENNIS J. LINSE *In* NASA. Langley Research Center, Joint University Program for Air Transportation Research, 1990-1991 p 141-154 Dec. 1991
Avail: NTIS HC/MF A09 CSCL 09/2

Artificial neural networks offer some interesting possibilities for use in control. Our current research is on the use of neural networks on an aircraft model. The model can then be used in a nonlinear control scheme. The effectiveness of network training is demonstrated. Author

N92-18002*# Princeton Univ., NJ. Dept. of Mechanical and Aerospace Engineering.
TECHNICAL NOTES AND CORRESPONDENCE: STOCHASTIC ROBUSTNESS OF LINEAR TIME-INVARIANT CONTROL SYSTEMS
ROBERT F. STENGEL and LAURA R. RAY *In* NASA. Langley Research Center, Joint University Program for Air Transportation Research, 1990-1991 p 181-186 Dec. 1991
(Contract NGL-31-001-252)
Avail: NTIS HC/MF A09 CSCL 12/1

A simple numerical procedure for estimating the stochastic robustness of a linear time-invariant system is described. Monte Carlo evaluations of the system's eigenvalues allows the probability of instability and the related stochastic root locus to be estimated. This analysis approach treats not only Gaussian parameter uncertainties but non-Gaussian cases, including uncertain-but-bounded variation. Confidence intervals for the scalar probability of instability address computational issues inherent in Monte Carlo simulation. Trivial extensions of the procedure admit consideration of alternate discriminants; thus, the probabilities that stipulated degrees of instability will be exceeded or that closed-loop roots will leave desirable regions can also be estimated. Results are particularly amenable to graphical presentation. Author

16

PHYSICS

Includes physics (general); acoustics; atomic and molecular physics; nuclear and high-energy physics; optics; plasma physics; solid-state physics; and thermodynamics and statistical physics.

A92-21338
MAGNETOHYDRODYNAMIC BOUNDARY LAYER FLOW OVER A ROTATING DISK
TAKASHI WATANABE (Iwate University, Morioka, Japan) and TOSHIO OYAMA Zeitschrift fuer angewandte Mathematik und Mechanik (ISSN 0044-2267), vol. 71, no. 12, 1991, p. 522-524. refs
Copyright

The boundary layer flow of a rotating electrically conducting fluid on a rotating disk in the presence of a magnetic field is considered. The governing similarity equations are numerically solved using a finite-difference scheme. Numerical results are given for the velocity profiles and the displacement thickness for various values of the magnetic parameter. C.D.

A92-23563
DEVELOPMENT OF A COMBINED FAST METHOD FOR STUDYING THE PLANE MOTIONS OF RIGID BODIES IN THE ATMOSPHERE AROUND THE CENTER OF MASS IN THE PRESENCE OF PERTURBATIONS [O POSTROENII KOMBINIROVANNOGO BYSTRODEISTVUIUSHCHEGO METODA ISSLEDOVANIIA PLOSKOGO DVIZHENIIA V ATMOSFERE TVERDYKH TEL VOKRUG TSENTRA MASS PRI NALICHII VOZMUSHCHENII]
G. M. LOKHOV and S. I. PODZOROV Akademiia Nauk SSSR, Izvestiia, Mekhanika Tverdogo Tela (ISSN 0572-3299), Nov.-Dec. 1991, p. 3-10. In Russian. refs
Copyright

Second-order asymptotic approximations are obtained for cases where the motion of rigid bodies around the center of mass consists of rapid rotations or oscillations and where perturbations are present. The asymptotic approximations are used in a combined fast algorithm for calculating the motion of rigid bodies in the atmosphere in the presence of perturbations, implemented in a set of applied software, WARHED. The use of the algorithm makes it possible to reduce the calculation time by an order of magnitude in comparison with the continuous integration of a system of equations. V.L.

N92-16705*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
DETAILED NOISE MEASUREMENTS ON THE SR-7A PROPELLER: TONE BEHAVIOR WITH HELICAL TIP MACH NUMBER
JAMES H. DITTMAR and DAVID G. HALL (Sverdrup Technology, Inc., Brook Park, OH.) Dec. 1991 31 p
(NASA-TM-105206; E-6519; NAS 1.15:105206) Avail: NTIS HC/MF A03 CSCL 20/1

Detailed noise measurements were taken on the SR-7A propeller to investigate the behavior of the noise with helical tip Mach number and then to level off as Mach number was increased further. This behavior was further investigated by obtaining detailed pressure-time histories of data. The pressure-time histories indicate that a portion of the primary pressure pulse is progressively cancelled by a secondary pulse which results in the noise leveling off as the helical tip Mach number is increased. This second pulse appears to originate on the same blade as the primary pulse and is in some way connected to the blade itself. This leaves open the possibility of redesigning the blade to improve the cancellation; thereby, the propeller noise is reduced. Author

N92-16789# Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of High Energy.
SYSTEM OF CRYOGENIC SECURITY OF THE SUPERCONDUCTING ACCELERATOR OF RELATIVISTIC NUCLEI-NUCLOTRON
N. N. AGAPOV, V. I. LIPCHENKO, V. L. MAZARSKIJ, L. G. MAKAROV, and A. K. SUKHANOVA 1990 7 p In RUSSIAN; ENGLISH summary
(DE91-643289; JINR-R-8-90-481) Avail: NTIS HC/MF A02

The system of cryogenic security of the Nuclotron (superconducting accelerator of relativistic nuclei) is described. The system consists of three helium liquefiers KGU-16004/5. Refrigeration in each liquefier is performed by three preliminary cool-down turboexpanders and a vapor-liquid turboexpander. In this case the refrigeration of the KGU-1600/4.5 liquefiers reaches 1700 W. The system of gas preparation is composed of driers operating at the surrounding temperature. Purification from the admixtures of oxygen, nitrogen, neon, hydrogen and other gases is carried out in low-temperature blocks built in the helium liquefiers KGU-1600/4.5. To store the helium, there are ten 20 cu m receivers under a pressure of 3MPA. DOE

N92-17088# Air Force Inst. of Tech., Wright-Patterson AFB, OH. School of Engineering.
DESIGN OF A FIBER OPTIC IMAGE TRANSMISSION LINK M.S. Thesis
JUSTIN D. REDD Dec. 1991 82 p
(AD-A243686; AFIT/GE/ENG/91D-45) Avail: NTIS HC/MF A05 CSCL 20/6

An original design is presented for a fiber optic based digital image transmission link operating at a serial bit rate of 250 Mbits/Second. The link is designed as an integral part of an airborne infrared imaging system with particular emphasis on avoiding problems associated with aircraft electromagnetic interference (EMI). Unique features include simplicity (single PC board transmitter and receiver), low power, low cost (under $3,000), and use of the latest off-the-shelf components (including the Gazelle GA9011/GA9012 HOT ROD chip set). Theoretical modeling is used to predict a bit error rate of better than 10 to the minus 15th power, while actual measurements include transmission of over 10 to 13th power bits without any errors (measured bit error rate of at least 10 to the minus 13th power). Test results also show that the link is capable of transmitting 640 x 480 pixel (12 bits per pixel) images with no significant image degradation. GRA

N92-17506# Army Construction Engineering Research Lab., Champaign, IL.
HUMAN RESPONSE TO HELICOPTER NOISE: A TEST OF A-WEIGHTING Final Report
PAUL D. SCHOMER, BRIAN D. HOOVER, and LEE R. WAGNER Nov. 1991 89 p
(AD-A243719; CERL-TR-N-91/13) Avail: NTIS HC/MF A05 CSCL 01/3

Department of Defense and U.S. Army policy has long been to adjust measured helicopter noise levels upwards to account for the special character of helicopter noise in terms of human and community annoyance. In the United States, the A-weighted Day/Night Average Sound Level (DNL) descriptor is used most often for this purpose, but research has shown that it is not completely adequate. Also, many questions remain about human perception of, and response to, helicopter noise. This study is an extension of earlier research that tested human response to the noise of an Army UH-1H (Huey) helicopter flown over various indoor environments. This report documents a follow-up test using six different helicopters to replicate and expand on the earlier study. The data generally indicate that the A-weighted DNL is inadequate for assessing helicopter noise. The C-weighted scale was also tried and found inadequate. Helicopter noise measurement by either scale must be corrected to accurately correspond to human perceptions. Measuring indoors, the use of A-weighting to assess helicopter noise requires an offset that varies with helicopter

A-weighted sound exposure level (ASEL), and this offset varies for different helicopters. GRA

N92-17537# Navy Clothing and Textile Research Facility, Natick, MA.
THERMAL ENERGY TEST APPARATUS Technical Report, period ending 1974
N. F. AUDET Oct. 1991 33 p
(AD-A243526; NCTRF-187) Avail: NTIS HC/MF A03 CSCL 20/13

The Navy Clothing and Textile Research Facility (NCTRF) designed and fabricated a thermal energy test apparatus to permit evaluation of the heat protection provided by crash crew firefighter's proximity clothing materials against radiant and convective heat loads, similar to those found outside the flame zone of aircraft fuel fires. The apparatus employs electrically operated quartz lamp radiant heaters and a hot air convective heater assembly to produce the heat load conditions the materials to be subjected to, and is equipped with heat flux sensors of different sensitivities to measure the incident heat flux on the sample material as well as the heat flux transmitted by the sample. Tests of the apparatus have shown that it can produce radiant heat flux levels equivalent to those estimated to be possible in close proximity to large aircraft fuel fires, and can produce convective heat fluxes equivalent to those measured in close proximity to aircraft fuel fires at upwind and sidewind locations. Work was performed in 1974. GRA

17

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.

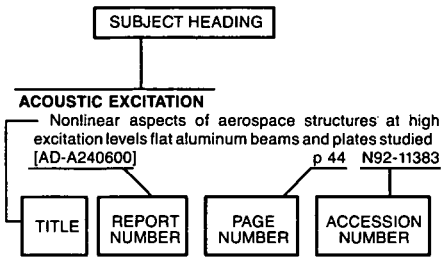
N92-17369# Naval Ocean Systems Center, San Diego, CA.
INFORMATION MANAGEMENT ENGINEERING (IME) LABORATORY: A DATABASE DEVELOPMENT FACILITY Final Report, FY 1985 - FY 1991
MARION G. CERUTI and RICHARD A. AUCLAIR Aug. 1991 21 p
(AD-A243191; NOSC-TD-2174) Avail: NTIS HC/MF A03 CSCL 12/7

An Information Management Engineering (IME) database development laboratory is described that features a VAX/Macintosh hardware suite and a menu driven user interface. The software system was created for, and is used by, database developers and database administrators who work with the Digital Equipment Corporation Virtual Memory Operating System (VMS) and the Oracle Database Management System. It was designed to accomplish a variety of database related tasks, including data input from magnetic tape, disk file management, database fill, data entry, data dictionary report generation, data quality analysis and validation, data reference inventory management, and user communications. This system was used to develop and enhance several command and control databases for the following projects: the OSIS Baseline Upgrade (OBU); the Maritime Defense Zone (MDZ); the Operations Support Group Prototype (OSGP); the Fleet Command Center Battle Management Program (FCCBMP) for CINCPACFLT at Pearl Harbor, HI; CINCPACAF Integrated Decision Support System (CIDSS) testing for CINCPACAF at Hicham Air Force Base, HI; the Mobile Systems Tactical Data Facility (MSTDF); and the Operational Support System (OSS). GRA

N92-17687# Naval Postgraduate School, Monterey, CA.
DEVELOPMENT OF A KNOWLEDGE BASE FOR USE IN AN EXPERT SYSTEM ADVISOR FOR AIRCRAFT MAINTENANCE SCHEDULING (ESAAMS) M.S. Thesis
MARK H. STONE, JR. Mar. 1991 100 p
(AD-A243435) Avail: NTIS HC/MF A05 CSCL 12/5

The Expert System Advisor for Aircraft Maintenance Scheduling (ESAAMS) was originally proposed to assist in the scheduling of discrepancies in a naval aviation squadron maintenance department. The development of a knowledge base for ESAAMS which will support the stated goals of the system is addressed. An overview of expert systems in general and specifically the ESAAMS system is presented as background information to the reader. A specific approach to acquiring, documenting, and storing the knowledge is suggested which will facilitate further development of the system prototype. Based on interviews with experienced maintenance controllers, an initial knowledge base is provided for use in the prototype system. Recommendations for further study based upon the findings discovered during this research are presented. GRA

Typical Subject Index Listing



The subject heading is a key to the subject content of the document. The title is used to provide a description of the subject matter. When the title is insufficiently descriptive of document content, a title extension is added, separated from the title by three hyphens. The accession number and the page number are included in each entry to assist the user in locating the abstract in the abstract section. If applicable, a report number is also included as an aid in identifying the document. Under any one subject heading, the accession numbers are arranged in sequence.

A

B

C

D

E

F

G

H

I

J

K

L

M

N

O

P

Q

R

S

T

U

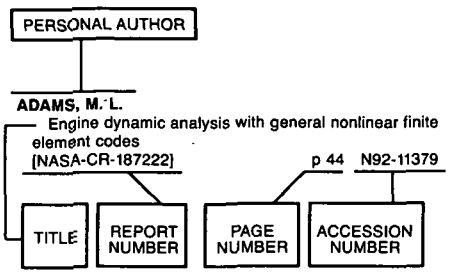
V

W

X

Y

Typical Personal Author Index Listing



Listings in this index are arranged alphabetically by personal author. The title of the document provides the user with a brief description of the subject matter. The report number helps to indicate the type of document listed (e.g., NASA report, translation, NASA contractor report). The page and accession numbers are located beneath and to the right of the title. Under any one author's name the accession numbers are arranged in sequence.

A

B

C

D

E

F

G

H

I

J

K

L

M

N

O

P

Q

R

S

T

U

V

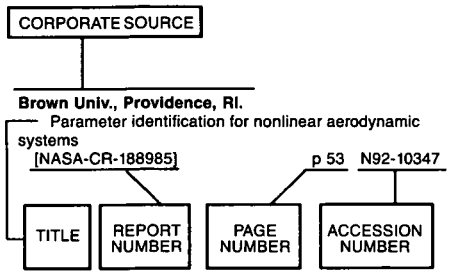
W

X

Y

Z

Typical Corporate Source Index Listing



Listings in this index are arranged alphabetically by corporate source. The title of the document is used to provide a brief description of the subject matter. The page number and the accession number are included in each entry to assist the user in locating the abstract in the abstract section. If applicable, a report number is also included as an aid in identifying the document.

F

G

H

I

J

L

M

N

O

P

Q

R

S

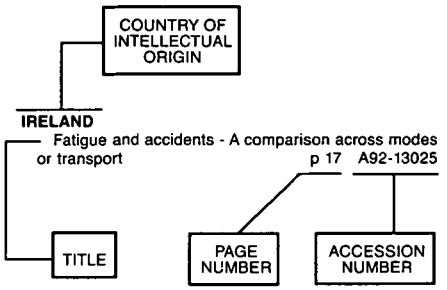
T

U

V

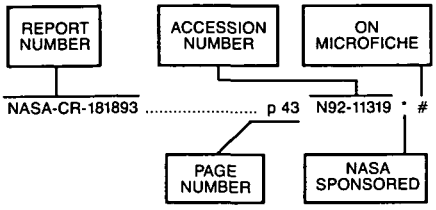
W

Typical Foreign Technology Index Listing



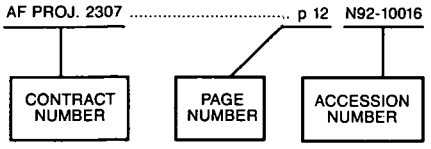
Listings in this index are arranged alphabetically by country of intellectual origin. The title of the document is used to provide a brief description of the subject matter. The page number and the accession number are included in each entry to assist the user in locating the citation in the abstract section. If applicable, a report number is also included as an aid in identifying the document.

Typical Report Number Index Listing



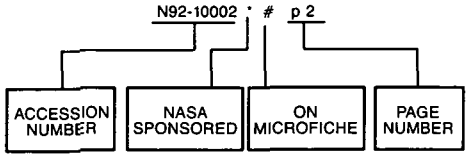
Listings in this index are arranged alphanumerically by report number. The page number indicates the page on which the citation is located. The accession number denotes the number by which the citation is identified. An asterisk (*) indicates that the item is a NASA report. A pound sign (#) indicates that the item is available on microfiche.

Typical Contract Number Index Listing



Listings in this index are arranged alphanumerically by contract number. Under each contract number, the accession numbers denoting documents that have been produced as a result of research done under the contract are shown. The accession number denotes the number by which the citation is identified in the abstract section. Preceding the accession number is the page number on which the citation may be found.

Typical Accession Number Index Listing



Listings in this index are arranged alphanumerically by accession number. The page number listed to the right indicates the page on which the citation is located. An asterisk (*) indicates that the item is a NASA report. A pound sign (#) indicates that the item is available on microfiche.

AVAILABILITY OF CITED PUBLICATIONS

IAA ENTRIES (A92-10000 Series)

Publications announced in *IAA* are available from the AIAA Technical Information Service as follows: Paper copies of accessions are available at $10.00 per document (up to 50 pages), additional pages $0.25 each. Standing order microfiche are available at the rate of $1.45 per microfiche for *IAA* source documents and $1.75 per microfiche for AIAA meeting papers.

Minimum air-mail postage to foreign countries is $2.50. All foreign orders are shipped on payment of pro-forma invoices.

All inquiries and requests should be addressed to: Technical Information Service, American Institute of Aeronautics and Astronautics, 555 West 57th Street, New York, NY 10019. Please refer to the accession number when requesting publications.

STAR ENTRIES (N92-10000 Series)

One or more sources from which a document announced in *STAR* is available to the public is ordinarily given on the last line of the citation. The most commonly indicated sources and their acronyms or abbreviations are listed below. If the publication is available from a source other than those listed, the publisher and his address will be displayed on the availability line or in combination with the corporate source line.

Avail: NTIS. Sold by the National Technical Information Service. Prices for hard copy (HC) and microfiche (MF) are indicated by a price code preceded by the letters HC or MF in the *STAR* citation. Current values for the price codes are given in the tables on NTIS PRICE SCHEDULES.

Documents on microfiche are designated by a pound sign (#) following the accession number. The pound sign is used without regard to the source or quality of the microfiche.

Initially distributed microfiche under the NTIS SRIM (Selected Research in Microfiche) is available at greatly reduced unit prices. For this service and for information concerning subscription to NASA printed reports, consult the NTIS Subscription Section, Springfield, VA 22161.

NOTE ON ORDERING DOCUMENTS: When ordering NASA publications (those followed by the * symbol), use the N accession number. NASA patent applications (only the specifications are offered) should be ordered by the US-Patent-Appl-SN number. Non-NASA publications (no asterisk) should be ordered by the AD, PB, or other *report number* shown on the last line of the citation, not by the N accession number. It is also advisable to cite the title and other bibliographic identification.

Avail: SOD (or GPO). Sold by the Superintendent of Documents, U.S. Government Printing Office, in hard copy. The current price and order number are given following the availability line. (NTIS will fill microfiche requests, as indicated above, for those documents identified by a # symbol.)

Avail: BLL (formerly NLL): British Library Lending Division, Boston Spa, Wetherby, Yorkshire, England. Photocopies available from this organization at the price shown. (If none is given, inquiry should be addressed to the BLL.)

Avail: DOE Depository Libraries. Organizations in U.S. cities and abroad that maintain collections of Department of Energy reports, usually in microfiche form, are listed in *Energy Research Abstracts.* Services available from the DOE and its depositories are described in a booklet, *DOE Technical Information Center - Its Functions and Services* (TID-4660), which may be obtained without charge from the DOE Technical Information Center.

Avail: ESDU. Pricing information on specific data, computer programs, and details on Engineering Sciences Data Unit (ESDU) topic categories can be obtained from ESDU International Ltd. Requesters in North America should use the Virginia address while all other requesters should use the London address, both of which are on the page titled ADDRESSES OF ORGANIZATIONS.

Avail: Fachinformationszentrum, Karlsruhe. Sold by the Fachinformationszentrum Energie, Physik, Mathematik GMBH, Eggenstein Leopoldshafen, Federal Republic of Germany, at the price shown in deutschmarks (DM).

Avail: HMSO. Publications of Her Majesty's Stationery Office are sold in the U.S. by Pendragon House, Inc. (PHI), Redwood City, CA. The U.S. price (including a service and mailing charge) is given, or a conversion table may be obtained from PHI.

Avail: NASA Public Document Rooms. Documents so indicated may be examined at or purchased from the National Aeronautics and Space Administration, Public Documents Room (Room 126), 600 Independence Ave., S.W., Washington, DC 20546, or public document rooms located at each of the NASA research centers, the NASA Space Technology Laboratories, and the NASA Pasadena Office at the Jet Propulsion Laboratory.

Avail: Univ. Microfilms. Documents so indicated are dissertations selected from *Dissertation Abstracts* and are sold by University Microfilms as xerographic copy (HC) and microfilm. All requests should cite the author and the Order Number as they appear in the citation.

Avail: US Patent and Trademark Office. Sold by Commissioner of Patents and Trademarks, U.S. Patent and Trademark Office, at the standard price of $1.50 each, postage free.

Avail: (US Sales Only). These foreign documents are available to users within the United States from the National Technical Information Service (NTIS). They are available to users outside the United States through the International Nuclear Information Service (INIS) representative in their country, or by applying directly to the issuing organization.

Avail: USGS. Originals of many reports from the U.S. Geological Survey, which may contain color illustrations, or otherwise may not have the quality of illustrations preserved in the microfiche or facsimile reproduction, may be examined by the public at the libraries of the USGS field offices whose addresses are listed in this Introduction. The libraries may be queried concerning the availability of specific documents and the possible utilization of local copying services, such as color reproduction.

Avail: Issuing Activity, or Corporate Author, or no indication of availability. Inquiries as to the availability of these documents should be addressed to the organization shown in the citation as the corporate author of the document.

FEDERAL DEPOSITORY LIBRARY PROGRAM

In order to provide the general public with greater access to U.S. Government publications, Congress established the Federal Depository Library Program under the Government Printing Office (GPO), with 53 regional depositories responsible for permanent retention of material, inter-library loan, and reference services. At least one copy of nearly every NASA and NASA-sponsored publication, either in printed or microfiche format, is received and retained by the 53 regional depositories. A list of the regional GPO libraries, arranged alphabetically by state, appears on the inside back cover. These libraries are *not* sales outlets. A local library can contact a Regional Depository to help locate specific reports, or direct contact may be made by an individual.

PUBLIC COLLECTION OF NASA DOCUMENTS

An extensive collection of NASA and NASA-sponsored publications is maintained by the British Library Lending Division, Boston Spa, Wetherby, Yorkshire, England for public access. The British Library Lending Division also has available many of the non-NASA publications cited in *STAR*. European requesters may purchase facsimile copy or microfiche of NASA and NASA-sponsored documents, those identified by both the symbols # and * from ESA – Information Retrieval Service European Space Agency, 8-10 rue Mario-Nikis, 75738 CEDEX 15, France.

STANDING ORDER SUBSCRIPTIONS

NASA SP-7037 supplements and annual index are available from the National Technical Information Service (NTIS) on standing order subscription as PB92-914100, at price code A04. Current values for the price codes are listed on page APP-5. Standing order subscriptions do not terminate at the end of a year, as do regular subscriptions, but continue indefinitely unless specifically terminated by the subscriber.

ADDRESSES OF ORGANIZATIONS

American Institute of Aeronautics and Astronautics
Technical Information Service
555 West 57th Street, 12th Floor
New York, New York 10019

British Library Lending Division,
Boston Spa, Wetherby, Yorkshire,
England

Commissioner of Patents and Trademarks
U.S. Patent and Trademark Office
Washington, DC 20231

Department of Energy
Technical Information Center
P.O. Box 62
Oak Ridge, Tennessee 37830

European Space Agency-Information Retrieval Service
ESRIN
Via Galileo Galilei
00044 Frascati (Rome) Italy

Engineering Sciences Data Unit International
P.O. Box 1633
Manassas, Virginia 22110

Engineering Sciences Data Unit International, Ltd.
251-259 Regent Street
London, W1R 7AD, England

Fachinformationszentrum Energie, Physik, Mathematik
GMBH
7514 Eggenstein Leopoldshafen
Federal Republic of Germany

Her Majesty's Stationery Office
P.O. Box 569, S.E. 1
London, England

NASA Center for AeroSpace Information
P.O. Box 8757
Baltimore, MD 21240-0757

National Aeronautics and Space Administration
Scientific and Technical Information Program (JTT)
Washington, DC 20546

National Technical Information Service
5285 Port Royal Road
Springfield, Virginia 22161

Pendragon House, Inc.
899 Broadway Avenue
Redwood City, California 94063

Superintendent of Documents
U.S. Government Printing Office
Washington, DC 20402

University Microfilms
A Xerox Company
300 North Zeeb Road
Ann Arbor, Michigan 48106

University Microfilms, Ltd.
Tylers Green
London, England

U.S. Geological Survey Library National Center
MS 950
12201 Sunrise Valley Drive
Reston, Virginia 22092

U.S. Geological Survey Library
2255 North Gemini Drive
Flagstaff, Arizona 86001

U.S. Geological Survey
345 Middlefield Road
Menlo Park, California 94025

U.S. Geological Survey Library
Box 25046
Denver Federal Center, MS914
Denver, Colorado 80225

NTIS PRICE SCHEDULES

(Effective October 1, 1991)

Schedule A
STANDARD PRICE DOCUMENTS AND MICROFICHE**

PRICE CODE	NORTH AMERICAN PRICE	FOREIGN PRICE
A01	$ 9.00	$ 18.00
A02	12.50	25.00
A03	17.00	34.00
A04-A05	19.00	38.00
A06-A09	26.00	52.00
A10-A13	35.00	70.00
A14-A17	43.00	86.00
A18-A21	50.00	100.00
A22-A25	59.00	118.00
A99	*	*
N01	60.00	120.00
N02	59.00	118.00
N03	20.00	40.00

Schedule E
EXCEPTION PRICE DOCUMENTS AND MICROFICHE**

PRICE CODE	NORTH AMERICAN PRICE	FOREIGN PRICE
E01	$11.00	$ 22.00
E02	14.00	28.00
E03	16.00	32.00
E04	19.00	38.00
E05	21.00	42.00
E06	24.00	48.00
E07	27.00	54.00
E08	30.00	60.00
E09	33.00	66.00
E10	36.00	72.00
E11	39.00	78.00
E12	43.00	86.00
E13	46.00	92.00
E14	50.00	100.00
E15	54.00	108.00
E16	59.00	118.00
E17	64.00	128.00
E18	69.00	138.00
E19	76.00	152.00
E20	88.00	176.00
E99	*	*

* Contact NTIS for price quote.

** Effective January 1, 1991, the microfiche copy of any new document entering the NTIS collection will be priced the same as the paper copy of the document.

IMPORTANT NOTICE

NTIS Shipping and Handling Charges

U.S., Canada, Mexico — ADD $3.00 per TOTAL ORDER

All Other Countries — ADD $4.00 per TOTAL ORDER

Exceptions — Does NOT apply to:

ORDERS REQUESTING NTIS RUSH HANDLING

ORDERS FOR SUBSCRIPTION OR STANDING ORDER PRODUCTS *ONLY*

NOTE: Each additional delivery address on an order requires a separate shipping and handling charge.

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
NASA SP-7037(278)		

4. Title and Subtitle	5. Report Date
Aeronautical Engineering A Continuing Bibliography (Supplement 278)	May 1992
	6. Performing Organization Code JTT
7. Author(s)	8. Performing Organization Report No.
	10. Work Unit No.
9. Performing Organization Name and Address NASA Scientific and Technical Information Program	11. Contract or Grant No.
	13. Type of Report and Period Covered Special Publication
12. Sponsoring Agency Name and Address National Aeronautics and Space Administration Washington, DC 20546	14. Sponsoring Agency Code

15. Supplementary Notes

16. Abstract

This bibliography lists 414 reports, articles and other documents introduced into the NASA scientific and technical information system in April 1992.

17. Key Words (Suggested by Author(s))	18. Distribution Statement
Aeronautical Engineering Aeronautics Bibliographies	Unclassified - Unlimited Subject Category - 01

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price *
Unclassified	Unclassified	134	A07/HC

*For sale by the National Technical Information Service, Springfield, Virginia 22161

FEDERAL REGIONAL DEPOSITORY LIBRARIES

ALABAMA

AUBURN UNIV. AT MONTGOMERY LIBRARY
Documents Dept.
7300 University Drive
Montgomery, AL 36117-3596
(205) 244-3650 FAX: (205) 244-0678

UNIV. OF ALABAMA
Amelia Gayle Gorgas Library
Govt. Documents
Box 870266
Tuscaloosa, AL 35487-0266
(205) 348-6046 FAX: (205) 348-8833

ARIZONA

DEPT. OF LIBRARY, ARCHIVES, AND PUBLIC RECORDS
Federal Documents
Third Floor State Capitol
1700 West Washington
Phoenix, AZ 85007
(602) 542-4121 FAX: (602) 542-4400; 542-4500

ARKANSAS

ARKANSAS STATE LIBRARY
State Library Services
One Capitol Mall
Little Rock, AR 72201
(501) 682-2869

CALIFORNIA

CALIFORNIA STATE LIBRARY
Govt. Publications Section
914 Capitol Mall - P.O. Box 942837
Sacramento, CA 94237-0001
(916) 322-4572 FAX: (916) 324-8120

COLORADO

UNIV. OF COLORADO - BOULDER
Norlin Library
Govt. Publications
Campus Box 184
Boulder, CO 80309-0184
(303) 492-8834 FAX: (303) 492-2185

DENVER PUBLIC LIBRARY
Govt. Publications Dept. BS/GPD
1357 Broadway
Denver, CO 80203
(303) 571-2135

CONNECTICUT

CONNECTICUT STATE LIBRARY
231 Capitol Avenue
Hartford, CT 06106
(203) 566-4971 FAX: (203) 566-3322

FLORIDA

UNIV. OF FLORIDA LIBRARIES
Documents Dept.
Library West
Gainesville, FL 32611-2048
(904) 392-0366 FAX: (904) 392-7251

GEORGIA

UNIV. OF GEORGIA LIBRARIES
Govt. Documents Dept.
Jackson Street
Athens, GA 30602
(404) 542-8949 FAX: (404) 542-6522

HAWAII

UNIV. OF HAWAII
Hamilton Library
Govt. Documents Collection
2550 The Mall
Honolulu, HI 96822
(808) 948-8230 FAX: (808) 956-5968

IDAHO

UNIV. OF IDAHO LIBRARY
Documents Section
Moscow, ID 83843
(208) 885-6344 FAX: (208) 885-6817

ILLINOIS

ILLINOIS STATE LIBRARY
Reference Dept.
300 South Second
Springfield, IL 62701-1796
(217) 782-7596 FAX: (217) 524-0041

INDIANA

INDIANA STATE LIBRARY
Serials/Documents Section
140 North Senate Avenue
Indianapolis, IN 46204
(317) 232-3678 FAX: (317) 232-3728

IOWA

UNIV. OF IOWA LIBRARIES
Govt. Publications Dept.
Washington & Madison Streets
Iowa City, IA 52242
(319) 335-5926 FAX: (319) 335-5830

KANSAS

UNIV. OF KANSAS
Govt. Documents & Map Library
6001 Malatt Hall
Lawrence, KS 66045-2800
(913) 864-4660 FAX: (913) 864-5380

KENTUCKY

UNIV. OF KENTUCKY LIBRARIES
Govt. Publications/Maps Dept.
Lexington, KY 40506-0039
(606) 257-3139 FAX: (606) 257-1563; 257-8379

LOUISIANA

LOUISIANA STATE UNIV.
Middleton Library
Govt. Documents Dept.
Baton Rouge, LA 70803
(504) 388-2570 FAX: (504) 388-6992

LOUISIANA TECHNICAL UNIV.
Prescott Memorial Library
Govt. Documents Dept.
305 Wisteria Street
Ruston, LA 71270-9985
(318) 257-4962 FAX: (318) 257-2447

MAINE

TRI-STATE DOCUMENTS DEPOSITORY
Raymond H. Fogler Library
Govt. Documents & Microforms Dept.
Univ. of Maine
Orono, ME 04469
(207) 581-1680

MARYLAND

UNIV. OF MARYLAND
Hornbake Library
Govt. Documents/Maps Unit
College Park, MD 20742
(301) 454-3034 FAX: (301) 454-4985

MASSACHUSETTS

BOSTON PUBLIC LIBRARY
Govt. Documents Dept.
666 Boylston Street
Boston, MA 02117
(617) 536-5400 ext. 226
FAX: (617) 267-8273; 267-8248

MICHIGAN

DETROIT PUBLIC LIBRARY
5201 Woodward Avenue
Detroit, MI 48202-4093
(313) 833-1440; 833-1409
FAX: (313) 833-5039

LIBRARY OF MICHIGAN
Govt. Documents Unit
P.O. Box 30007
Lansing, MI 48909
(517) 373-0640 FAX: (517) 373-3381

MINNESOTA

UNIV. OF MINNESOTA
Wilson Library
Govt. Publications Library
309 19th Avenue South
Minneapolis, MN 55455
(612) 624-5073 FAX: (612) 626-9353

MISSISSIPPI

UNIV. OF MISSISSIPPI
J.D. Williams Library
Federal Documents Dept.
106 Old Gym Bldg.
University, MS 38677
(601) 232-5857 FAX: (601) 232-5453

MISSOURI

UNIV. OF MISSOURI - COLUMBIA
Ellis Library
Govt. Documents
Columbia, MO 65201
(314) 882-6733 FAX: (314) 882-8044

MONTANA

UNIV. OF MONTANA
Maureen & Mike Mansfield Library
Documents Div.
Missoula, MT 59812-1195
(406) 243-6700 FAX: (406) 243-2060

NEBRASKA

UNIV. OF NEBRASKA - LINCOLN
D.L. Love Memorial Library
Documents Dept.
Lincoln, NE 68588
(402) 472-2562

NEVADA

UNIV. OF NEVADA
Reno Library
Govt. Publications Dept.
Reno, NV 89557
(702) 784-6579 FAX: (702) 784-1751

NEW JERSEY

NEWARK PUBLIC LIBRARY
U.S. Documents Div.
5 Washington Street - P.O. Box 630
Newark, NJ 07101-0630
(201) 733-7812 FAX: (201) 733-5648

NEW MEXICO

UNIV. OF NEW MEXICO
General Library
Govt. Publications Dept.
Albuquerque, NM 87131-1466
(505) 277-5441 FAX: (505) 277-6019

NEW MEXICO STATE LIBRARY
325 Don Gaspar Avenue
Santa Fe, NM 87503
(505) 827-3826 FAX: (505) 827-3820

NEW YORK

NEW YORK STATE LIBRARY
Documents/Gift & Exchange Section
Federal Depository Program
Cultural Education Center
Albany, NY 12230
(518) 474-5563 FAX: (518) 474-5786

NORTH CAROLINA

UNIV. OF NORTH CAROLINA - CHAPEL HILL
CB#3912, Davis Library
BA/SS Dept.—Documents
Chapel Hill, NC 27599
(919) 962-1151 FAX: (919) 962-0484

NORTH DAKOTA

NORTH DAKOTA STATE UNIV. LIBRARY
Documents Office
Fargo, ND 58105
(701) 237-8886 FAX: (701) 237-7138
In cooperation with Univ. of North Dakota, Chester Fritz Library
Grand Forks

OHIO

STATE LIBRARY OF OHIO
Documents Dept.
65 South Front Street
Columbus, OH 43266
(614) 644-7051 FAX: (614) 752-9178

OKLAHOMA

OKLAHOMA DEPT. OF LIBRARIES
U.S. Govt. Information Div.
200 NE 18th Street
Oklahoma City, OK 73105-3298
(405) 521-2502, ext. 252, 253
FAX: (405) 525-7804

OKLAHOMA STATE UNIV.
Edmon Low Library
Documents Dept.
Stillwater, OK 74078
(405) 744-6546 FAX: (405) 744-5183

OREGON

PORTLAND STATE UNIV.
Millar Library
934 SW Harrison - P.O. Box 1151
Portland, OR 97207
(503) 725-3673 FAX: (503) 725-4527

PENNSYLVANIA

STATE LIBRARY OF PENN.
Govt. Publications Section
Walnut St. & Commonwealth Ave. - P.O. Box 1601
Harrisburg, PA 17105
(717) 787-3752

SOUTH CAROLINA

CLEMSON UNIV.
Cooper Library
Public Documents Unit
Clemson, SC 29634-3001
(803) 656-5174 FAX: (803) 656-3025
In cooperation with Univ. of South Carolina, Thomas Cooper Library, Columbia

TENNESSEE

MEMPHIS STATE UNIV. LIBRARIES
Govt. Documents
Memphis, TN 38152
(901) 678-2586 FAX: (901) 678-2511

TEXAS

TEXAS STATE LIBRARY
United States Documents
P.O. Box 12927 - 1201 Brazos
Austin, TX 78711
(512) 463-5455 FAX: (512) 463-5436

TEXAS TECH. UNIV. LIBRARY
Documents Dept.
Lubbock, TX 79409
(806) 742-2268 FAX: (806) 742-1920

UTAH

UTAH STATE UNIV.
Merrill Library & Learning Resources Center, UMC-3000
Documents Dept.
Logan, UT 84322-3000
(801) 750-2684 FAX: (801) 750-2677

VIRGINIA

UNIV. OF VIRGINIA
Alderman Library
Govt. Documents
Charlottesville, VA 22903-2498
(804) 924-3133 FAX: (804) 924-4337

WASHINGTON

WASHINGTON STATE LIBRARY
Document Section
MS AJ-11
Olympia, WA 98504-0111
(206) 753-4027 FAX: (206) 753-3546

WEST VIRGINIA

WEST VIRGINIA UNIV. LIBRARY
Govt. Documents Section
P.O. Box 6069
Morgantown, WV 26506
(304) 293-3640

WISCONSIN

ST. HIST. SOC. OF WISCONSIN LIBRARY
Govt. Publications Section
816 State Street
Madison, WI 53706
(608) 262-2781 FAX: (608) 262-4711
In cooperation with Univ. of Wisconsin-Madison, Memorial Library

MILWAUKEE PUBLIC LIBRARY
Documents Div.
814 West Wisconsin Avenue
Milwaukee, WI 53233
(414) 278-2167 FAX: (414) 278-2137

National Aeronautics and
Space Administration
Code JTT
Washington, D.C.
20546-0001

Official Business

Penalty for Private Use, $300

BULK RATE
POSTAGE & FEES PAID
NASA
Permit No. G-27

POSTMASTER: If Undeliverable (Section 158 Postal Manual) Do Not Return