NASA SP-7037 (337)
December 2, 1996

AERONAUTICAL ENGINEERING

A CONTINUING BIBLIOGRAPHY WITH INDEXES

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Records are arranged in categories 1 through 19, the first nine coming from the Aeronautics division of *STAR*, followed by the remaining division titles. Selecting a category will link you to the collection of records cited in this issue pertaining to that category.

Indexes

Two indexes are available. You may use the **Find** command under the **Tools** menu while viewing the PDF file for direct match searching on any text string. You may also view the indexes provided, for searching on *NASA Thesaurus* subject terms and author names.

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Appendix

Select **Appendix** for important information about NASA Scientific and Technical Information (STI) Office products and services, including registration with the NASA Center for AeroSpace Information (CASI) for access to the NASA CASI TRS (Technical Report Server), and availability and pricing information for cited documents.

Typical Report Citation and Abstract

DOCUMENT ID NUMBER → **19960021053** NASA Langley Research Center, Hampton, VA USA. ← **CORPORATE SOURCE**

TITLE → **An Extended Compact Tension Specimen for Fatigue Crack Propagation and Fracture**

AUTHORS → Piascik, R. S., NASA Langley Research Center, USA; Newman, J. C., Jr., NASA Langley Research Center, USA; ← **AUTHORS' AFFILIATION**

PUBLICATION DATE → Mar. 1996, pp. 16; In English

CONTRACTS/GRANTS → Contract(s)/Grant(s): RTOP 538–02–10–01

REPORT NO.(S) → Report No.(s): NASA–TM–110243; NAS 1.15:110243; No Copyright; Avail: CASI A03, Hardcopy; A01, Microfiche ← **AVAILABILITY AND PRICE CODE**

ABSTRACT → An extended compact tension specimen, EC(T) has been developed for fatigue and fracture testing. Documented herein are stress-intensity factor and compliance expressions for the EC(T) specimen.

ABSTRACT AUTHOR → Author

SUBJECT TERMS → *Crack Propagation; Stress Intensity Factors; Fatigue (Materials)*

AERONAUTICAL ENGINEERING

A Continuing Bibliography (Suppl. 337)

DECEMBER 2, 1996

01
AERONAUTICS

19960045815 Foreign Broadcast Information Service, Washington, DC USA

Science and Technology - Central Eurasia: Research at the Central Aerohydrodynamics Institute, Series 3

Aug. 23, 1996; 193p; In English

Report No.(s): FBIS-UST-96-031; Copyright; Avail: Issuing Activity (Conact the Foreign Broadcast Information Service (U.S. Gov.-, P.O. Box 2604, Washington D.C. 20013-2604); (Non-U.S. Gov.- 5285 Port, Hardcopy, Microfiche

This FBIS (Foreign Broadcast Information Service) Report discusses the following aerohydrodynamic topics: Research (experiments and computations) on head for measuring downwash; (2) Characteristics of pneumatic measuring systems and methods for measuring continuously changing pressure; (3) Term (normal service life) prior to cracks formation and growth of small cracks in aircraft construction aluminum alloys; (4) Analysis of stability and controllability of aircraft with short longitudinal control arm; (5) Constructing optimum trajectories for the gliding of a flightcraft to a stipulated point with control reserve in prelanding maneuvering; (6) Determining aerodynamic moments from flight experiment data by moving mode method; (7) Harmonic analysis in main rotor theory; (8) Integration of singularities in problem of analysis of field of inductive velocities in plane of rotation of main rotor using disk theory; (9) N. Ye. Zhukoskiy formula for inductive velocity form main rotor outside plane of rotation averaged in a circle.

CASI

Aerodynamics; Downwash; Aircraft Structures; Pneumatics; Aircraft Control; Rotor Dynamics; Research and Development; Russian Federation

19960049773 Lockheed Martin Corp., Hampton, VA USA

CLMNANAL: A C++ program for application of the Coleman stability analysis to rotorcraft

Lance, Michael B., Lockheed Martin Corp., USA; Aug. 1996; 74p; In English

Contract(s)/Grant(s): NAS1-19000; RTOP 505-63-36-12

Report No.(s): NASA-CR-201592; NAS 1.26:201592; No Copyright; Avail: CASI; A04, Hardcopy; A01, Microfiche

This program is an adaptation of the theory of Robert P. Coleman and Arnold M. Feingold as presented in NACA Report 1351, 1958. This theory provided a method for the analysis of multiple-bladed rotor systems to determine the system susceptibility to ground resonance. Their treatment also provided a simple means for determining the required product of rotor and chassis damping factors to suppress the resonance. This C++ program is based on a FORTRAN 77 version of a similar code.

Author

Ground Resonance; Rotary Wing Aircraft; Aerodynamic Stability; Applications Programs (Computers)

19960049880 Foreign Broadcast Information Service, Washington, DC USA

FBIS report: Science and technology. Central Eurasia: Research at the Central Aerohydrodynamics Institute (TsAGI) 1995, Series 4 ***Final Report***

Sep. 16, 1996; 195p; Transl. into ENGLISH from various Central Eurasian articles; In English

Report No.(s): FBIS-UST-96-035; Copyright; Avail: Issuing Activity (FBIS, P.O. Box 2604, Washington, DC 20013-2604), Hardcopy, Microfiche

Translated articles cover the following topics: Calculation of Spectral Densities of Loads for Aircraft in Turbulent Atmosphere with Allowance for Nonstationary Nature of Aerodynamic Forces; Calculation of In-Flight Loading of Aircraft Airframe from Impact of Multidimensional Turbulence with Allowance for Operation of Automatic Control System; Constructing Statistical Model of Multidimensional Atmospheric Turbulence Loading Aircraft in Flight with Allowance for Influence of Automatic Control System; Determining Hydrostatic Pressure on Walls of Fuel Tank of Arbitrary Configuration; Finite Element Approach to Formation of Models for Calculating Static Loads; Assessments of Soundness of Reliability Computations; Research on Influence of Concentration of Stresses on Strength Under Repeated Loads; Automatic Control System and Loading of Aircraft; Research on Dynamic Loading of Il-86 Aircraft During Flight in Turbulent Atmosphere and During Landing; Experimental Studies of Panels and Transverse Bolt Joining of Skins Fabricated From Composite Materials; and Experi-

mental Study of Shear Strength of Structural Components Fabricated from Composite Materials.
CASI
Russian Federation; Research and Development; Technologies; Hydrodynamics; Aerodynamic Loads; Aerodynamic Forces; Stress Analysis

02
AERODYNAMICS

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

19960045736 Stanford Univ., Dept. of Aeronautics and Astronautics., CA USA
Experimental and computational investigation of lift-enhancing tabs on a multi-element airfoil
Ashby, Dale, Stanford Univ., USA; Jun. 1996; 232p; In English
Report No.(s): NASA-CR-201482; NAS 1.26:201482; JIAA-TR-116; Copyright Waived (NASA); Avail: CASI; A11, Hardcopy; A03, Microfiche

An experimental and computational investigation of the effect of lift enhancing tabs on a two-element airfoil was conducted. The objective of the study was to develop an understanding of the flow physics associated with lift enhancing tabs on a multi-element airfoil. A NACA 63(sub 2)-215 ModB airfoil with a 30 percent chord Fowler flap was tested in the NASA Ames 7 by 10 foot wind tunnel. Lift enhancing tabs of various heights were tested on both the main element and the flap for a variety of flap riggings. Computations of the flow over the two-element airfoil were performed using the two-dimensional incompressible Navier-Stokes code INS2D-UP. The computer results predict all of the trends in the experimental data quite well. When the flow over the flap upper surface is attached, tabs mounted at the main element trailing edge (cove tabs) produce very little change in lift. At high flap deflections. however, the flow over the flap is separated and cove tabs produce large increases in lift and corresponding reductions in drag by eliminating the separated flow. Cove tabs permit high flap deflection angles to be achieved and reduce the sensitivity of the airfoil lift to the size of the flap gap. Tabs attached to the flap training edge (flap tabs) are effective at increasing lift without significantly increasing drag. A combination of a cove tab and a flap tab increased the airfoil lift coefficient by 11 percent relative to the highest lift tab coefficient achieved by any baseline configuration at an angle of attack of zero percent and the maximum lift coefficient was increased by more than 3 percent. A simple analytic model based on potential flow was developed to provide a more detailed understanding of how lift enhancing tabs work. The tabs were modeled by a point vortex at the training edge. Sensitivity relationships were derived which provide a mathematical basis for explaining the effects of lift enhancing tabs on a multi-element airfoil. Results of the modeling effort indicate that the dominant effects of the tabs on the pressure distribution of each element of the airfoil can be captured with a potential flow model for cases with no flow separation.
Author
Aerodynamic Coefficients; Boundary Layer Separation; Incompressible Flow; Separated Flow; Tabs (Control Surfaces); Airfoils; Potential Flow; Pressure Distribution; Flaps (Control Surfaces); Lift Augmentation

19960045781 Old Dominion Univ., Research Foundation, Norfolk, VA USA
Variational Methods in Sensitivity Analysis and Optimization for Aerodynamic Applications ***Progress Report, Jun. 1996***
Ibrahim, A. H., Old Dominion Univ., USA; Hou, G. J.-W., Old Dominion Univ., USA; Tiwari, S. N., Principal Investigator, Old Dominion Univ., USA; Aug. 1996; 160p; In English
Contract(s)/Grant(s): NCC1-68
Report No.(s): NASA-CR-202167; NAS 1.26:202167; No Copyright; Avail: CASI; A08, Hardcopy; A02, Microfiche

Variational methods (VM) sensitivity analysis, which is the continuous alternative to the discrete sensitivity analysis, is employed to derive the costate (adjoint) equations, the transversality conditions, and the functional sensitivity derivatives. In the derivation of the sensitivity equations, the variational methods use the generalized calculus of variations, in which the variable boundary is considered as the design function. The converged solution of the state equations together with the converged solution of the costate equations are integrated along the domain boundary to uniquely determine the functional sensitivity derivatives with respect to the design function. The determination of the sensitivity derivatives of the performance index or functional entails the coupled solutions of the state and costate equations. As the stable and converged numerical solution of the costate equations with their boundary conditions are a priori unknown, numerical stability analysis is performed on both the state and costate equations. Thereafter, based on the amplification factors obtained by solving the generalized eigenvalue equations, the stability behavior of the costate equations is discussed and compared with the state (Euler) equations. The stability analysis of the costate equations suggests that the converged and stable solution of the costate equation is possible only if the computational domain of the costate equations is transformed to take into account the reverse flow nature of the costate equations. The application of the variational methods to aerodynamic shape optimization problems is demonstrated for internal flow problems at supersonic Mach number range. The study shows, that while maintaining the accuracy of the functional sensitivity derivatives within the reasonable range for engineering prediction purposes, the variational methods show a substantial gain in computational efficiency, i.e., computer

time and memory, when compared with the finite difference sensitivity analysis.
Author
Aerodynamic Configurations; Calculus of Variations; Boundary Conditions; Design Analysis; Equations of State; Euler Equations of Motion; Finite Volume Method; Internal Flow

19960047007 Old Dominion Univ., Dept. of Engineering Technology., Norfolk, VA USA
Experimental Optimization Methods for Multi-Element Airfoils ***Final Report, period ended 31 Aug. 1996***
Landman, Drew, Old Dominion Univ., USA; Britcher, Colin P., Old Dominion Univ., USA; Sep. 1996; 20p; In English
Contract(s)/Grant(s): NAG1-1750; NLPN-95-707; ODURF Proj. 160031
Report No.(s): NASA-CR-202213; NAS 1.26:202213; No Copyright; Avail: CASI; A03, Hardcopy; A01, Microfiche

A modern three element airfoil model with a remotely activated flap was used to investigate optimum flap testing position using an automated optimization algorithm in wind tunnel tests. Detailed results for lift coefficient versus flap vertical and horizontal position are presented for two angles of attack: 8 and 14 degrees. An on-line first order optimizer is demonstrated which automatically seeks the optimum lift as a function of flap position. Future work with off-line optimization techniques is introduced and aerodynamic hysteresis effects due to flap movement with flow on are discussed.
Author
Aerodynamic Coefficients; Angle of Attack; Airfoils; Flaps (Control Surfaces); Reynolds Number; Pressure Distribution; Computer Programs; Optimization

19960047050 NASA Ames Research Center, Moffett Field, CA USA
Numerical Study of Steady and Unsteady Canard-Wing-Body Aerodynamics
Eugene, L. Tu, NASA Ames Research Center, USA; Aug. 1996; 168p; In English
Contract(s)/Grant(s): RTOP 505-59-53
Report No.(s): NASA-TM-110394; A-961533; NAS 1.15: 110394; No Copyright; Avail: CASI; A08, Hardcopy; A02, Microfiche

The use of canards in advanced aircraft for control and improved aerodynamic performance is a topic of continued interest and research. In addition to providing maneuver control and trim, the influence of canards on wing aerodynamics can often result in increased maximum lift and decreased trim drag. In many canard-configured aircraft, the main benefits of canards are realized during maneuver or other dynamic conditions. Therefore, the detailed study and understanding of canards requires the accurate prediction of the non-linear unsteady aerodynamics of such configurations. For close-coupled canards, the unsteady aerodynamic performance associated with the canard-wing interaction is of particular interest. The presence of a canard in close proximity to the wing results in a highly coupled canard-wing aerodynamic flowfield which can include downwash/upwash effects, vortex-vortex interactions and vortex-surface interactions. For unsteady conditions, these complexities of the canard-wing flowfield are further increased. The development and integration of advanced computational technologies provide for the time-accurate Navier-Stokes simulations of the steady and unsteady canard-wing-body flox,fields. Simulation, are performed for non-linear flight regimes at transonic Mach numbers and for a wide range of angles of attack. For the static configurations, the effects of canard positioning and fixed deflection angles on aerodynamic performance and canard-wing vortex interaction are considered. For non-static configurations, the analyses of the canard-wing body flowfield includes the unsteady aerodynamics associated with pitch-up ramp and pitch oscillatory motions of the entire geometry. The unsteady flowfield associated with moving canards which are typically used as primary control surfaces are considered as well. The steady and unsteady effects of the canard on surface pressure integrated forces and moments, and canard-wing vortex interaction are presented in detail including the effects of the canard on the static and dynamic stability characteristics. The current study provides an understanding of the steady and unsteady canard-wing-body flowfield. Emphasis is placed on the effects of the canard on aerodynamic performance as well as the detailed flow physics of the canard-wing flowfield interactions. The computational tools developed to accurately predict the time-accurate flowfield of moving canards provides for the capability of coupled fluids-controls simulations desired in the detailed design and analysis of advanced aircraft.
Author
Canard Configurations; Unsteady Aerodynamics; Navier-Stokes Equation; Flow Distribution; Control Surfaces; Aircraft Configurations; Aerodynamic Configurations; Aerodynamic Characteristics; Wings

19960047109 Army Aviation Systems Command, Aeroflightdynamics Directorate., Hampton, VA USA
The AFDD International Dynamic Stall Workshop on Correlation of Dynamic Stall Models with 3-D Dynamic Stall Data
Tan, C. M., Army Aviation Systems Command, USA; Carr, L. W., Army Aviation Systems Command, USA; Jul. 1996; 96p; In English
Contract(s)/Grant(s): RTOP 505-59-52
Report No.(s): NASA-TM-110375; A-960632; NAS 1.15:110375; USAATCOM-TR-96-A-009; No Copyright; Avail: CASI; A05, Hardcopy; A01, Microfiche

A variety of empirical and computational fluid dynamics two-dimensional (2-D) dynamic stall models were compared to recently obtained three-dimensional (3-D) dynamic stall

data in a workshop on modeling of 3-D dynamic stall of an unswept, rectangular wing, of aspect ratio 10. Dynamic stall test data both below and above the static stall angle-of-attack were supplied to the participants, along with a 'blind' case where only the test conditions were supplied in advance, with results being compared to experimental data at the workshop itself. Detailed graphical comparisons are presented in the report, which also includes discussion of the methods and the results. The primary conclusion of the workshop was that the 3-D effects of dynamic stall on the oscillating wing studied in the workshop can be reasonably reproduced by existing semi-empirical models once 2-D dynamic stall data have been obtained. The participants also emphasized the need for improved quantification of 2-D dynamic stall.
Author
Aerodynamic Stalling; Dynamic Response; Oscillating Flow; Rectangular Wings; Unswept Wings; Wing Oscillations; Helicopter Design

19960047499 National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA USA
User's Manual for FOMOCO Utilities-Force and Moment Computation Tools for Overset Grids
Chan, William M., MCAT Inst., USA; Buning, Pieter G., National Aeronautics and Space Administration. Ames Research Center, USA; Jul. 1996; 38p; In English
Contract(s)/Grant(s): RTOP 505-59-53
Report No.(s): NASA-TM-110408; NAS 1.15:110408; A-962064; No Copyright; Avail: CASI; A03, Hardcopy; A01, Microfiche

In the numerical computations of flows around complex configurations, accurate calculations of force and moment coefficients for aerodynamic surfaces are required. When overset grid methods are used, the surfaces on which force and moment coefficients are sought typically consist of a collection of overlapping surface grids. Direct integration of flow quantities on the overlapping grids would result in the overlapped regions being counted more than once. The FOMOCO Utilities is a software package for computing flow coefficients (force, moment, and mass flow rate) on a collection of overset surfaces with accurate accounting of the overlapped zones. FOMOCO Utilities can be used in stand-alone mode or in conjunction with the Chimera overset grid compressible Navier-Stokes flow solver OVERFLOW. The software package consists of two modules corresponding to a two-step procedure: (1) hybrid surface grid generation (MIXSUR module), and (2) flow quantities integration (OVERINT module). Instructions on how to use this software package are described in this user's manual. Equations used in the flow coefficients calculation are given in Appendix A.
Author
User Manuals (Computer Programs); Aerodynamic Coefficients; Mass Flow Rate; Computational Fluid Dynamics; Grid Generation (Mathematics); Computational Grids; Applications Programs (Computers)

19960047539 National Aeronautics and Space Administration. Langley Research Center, Hampton, VA USA
Artificial Boundary Conditions for Computation of Oscillating External Flows
Tsynkov, S. V., National Aeronautics and Space Administration. Langley Research Center, USA; Aug. 1996; 48p; In English
Contract(s)/Grant(s): RTOP 505-59-53-01
Report No.(s): NASA-TM-4714; NAS 1.15:4714; L-17513; No Copyright; Avail: CASI; A03, Hardcopy; A01, Microfiche

In this paper, we propose a new technique for the numerical treatment of external flow problems with oscillatory behavior of the solution in time. Specifically, we consider the case of unbounded compressible viscous plane flow past a finite body (airfoil). Oscillations of the flow in time may be caused by the time-periodic injection of fluid into the boundary layer, which in accordance with experimental data, may essentially increase the performance of the airfoil. to conduct the actual computations, we have to somehow restrict the original unbounded domain, that is, to introduce an artificial (external) boundary and to further consider only a finite computational domain. Consequently, we will need to formulate some artificial boundary conditions (ABC's) at the introduced external boundary. The ABC's we are aiming to obtain must meet a fundamental requirement. One should be able to uniquely complement the solution calculated inside the finite computational domain to its infinite exterior so that the original problem is solved within the desired accuracy. Our construction of such ABC's for oscillating flows is based on an essential assumption: the Navier-Stokes equations can be linearized in the far field against the free-stream back- ground. to actually compute the ABC's, we represent the far-field solution as a Fourier series in time and then apply the Difference Potentials Method (DPM) of V. S. Ryaben'kii. This paper contains a general theoretical description of the algorithm for setting the DPM-based ABC's for time-periodic external flows. Based on our experience in implementing analogous ABC's for steady-state problems (a simpler case), we expect that these boundary conditions will become an effective tool for constructing robust numerical methods to calculate oscillatory flows.
Author
Boundary Conditions; Compressible Flow; Airfoils; Finite Difference Theory; Free Flow; Navier-Stokes Equation; Viscous Flow; Oscillating Flow

19960047655 NASA Langley Research Center, Hampton, VA USA
Experimental Surface Pressure Data Obtained on 65 deg Delta Wing Across Reynolds Number and Mach Number Ranges, Volume 2, Small-Radius Leading Edge

Chu, Julio, NASA Langley Research Center, USA; Luckring, James M., NASA Langley Research Center, USA; Feb. 1996; 38p; In English
Contract(s)/Grant(s): RTOP 505-59-54-01
Report No.(s): NASA-TM-4645-Vol-2; L-174111B-Vol-2; NAS 1.15:4645-Vol-2; No Copyright; Avail: CASI; A03, Hardcopy; A01, Microfiche

An experimental wind tunnel test of a 65 deg. delta wing model with interchangeable leading edges was conducted in the Langley National Transonic Facility (NTF). The objective was to investigate the effects of Reynolds and Mach numbers on slender-wing leading-edge vortex flows with four values of wing leading-edge bluntness. Experimentally obtained pressure data are presented without analysis in tabulated and graphical formats across a Reynolds number range of 6 x 10(exp 6) to 84 x 10(exp 6) at a Mach number of 0.85 and across a Mach number range of 0.4 to 0.9 at Reynolds numbers of 6 x 10(exp 6) and 60 x 10(exp 6). Normal-force and pitching-moment coefficient plots for these Reynolds number and Mach number ranges are also presented.
Author
Aerodynamics; Delta Wings; Reynolds Number; Mach Number; Leading Edges; Slender Wings; Vortices

19960047767 Rensselaer Polytechnic Inst., Dept. of Applied Mathematics, Troy, NY USA
Theoretical Aerodynamics ***Final Report, 1 Nov. 1992 - 31 Oct. 1995***
Cole, Julian D., Rensselaer Polytechnic Inst., USA; Jan. 1996; 8p; In English
Contract(s)/Grant(s): F49620-93-1-0022
Report No.(s): AD-A304107; No Copyright; Avail: CASI; A02, Hardcopy; A01, Microfiche

Mathematical and computational studies have been carried out on problems of theoretical aerodynamics. Shock free bodies and optimum critical airfoils have been considered in transonic theory, optimum three-dimensional lifting wings in hypersonic theory. Stability and transition of boundary layers has been analyzed according to triple deck theory. The Benjamin-Davis-Acrivos equation has been derived and it has been shown how solitons can lead to chaotic motion.
DTIC
Boundary Layers; Airfoils; Aerodynamics; Hypersonics; Aerodynamic Characteristics

19960047883 Naval Air Warfare Center, Aircraft Div., Patuxent River, MD USA
Friction Damping of Hollow Airfoils, Experimental Verification., Part 2
El-Aini, Yehia M., Pratt and Whitney Aircraft, USA; Benedict, Barry K., Pratt and Whitney Aircraft, USA; Wu, Wen-Te, Carnegie-Mellon Univ., USA; McAdams, Stoney, Carnegie-Mellon Univ., USA; Dec. 22, 1995; 7p; In English
Report No.(s): AD-A305380; No Copyright; Avail: Issuing Activity (Defense Technical Information Center (DTIC)), Microfiche

The use of hollow airfoils in turbomachinery applications, in particular fans and turbines, is an essential element in reducing the overall engine weight. However, state-of-the-art airfoil geometries are of low aspect ratio and exhibit unique characteristics associated with plate-like modes. These modes are characterized by a chordwise form of bending and high modal density within the engine operating speed range. These features combined with the mistuning effects resulting from manufacturing tolerances make accurate frequency and forced response predictions difficult and increase the potential for High Cycle Fatigue (HCF) durability problems. The present paper summarizes the results of an experimental test program on internal damping of hollow blade-like specimens. Friction damping is provided via sheet metal devices configured to fit within a hollow cavity with various levels of preload. The results of the investigation indicate that such devices can provide significant levels of damping provided the damper location and preload is optimized for the modes of concern. The transition of this concept to actual engine hardware would require further optimization with regard to wear effects and loss of preload particularly in applications where the preload is independent of rotational speed. Excellent agreement was achieved between the experimental results and the analytical predictions using a micro-slip friction damping model.
DTIC
Rotor Blades (Turbomachinery); Evaluation; Velocity; Frequencies; Position (Location); Airfoils

19960048204 Lehigh Univ., Dept. of Mechanical Engineering and Mechanics, Bethlehem, PA USA
Interaction of Complex Vorticity Fields with Aerodynamic Surfaces: Sources of Buffeting-Induced Loading and Vibration ***Final Report, 1 Dec. 1992 - 30 Nov. 1995***
Rockwell, Donald, Lehigh Univ., USA; Jan. 22, 1996; 19p; In English
Contract(s)/Grant(s): F49620-93-1-0075; AF Proj. 2307
Report No.(s): AD-A306198; AFOSR-TR-96; No Copyright; Avail: CASI; A03, Hardcopy; A01, Microfiche

The central goal of this program is to determine the origin of unsteady loading on a fin or blade in terms of the instantaneous velocity and vorticity fields associated with an incident vortex. New techniques of high-image-density particle image velocimetry provide the first instantaneous, global representations of the crucial features of this class of flows. The basic mechanisms of distortion of quasi two dimensional and three dimensional vortices, including the case of a broken-down vortex, as the vortex encounters the leading edge of the fin or blade, provide fundamental insight into this class of flow-structure interaction. The instantaneous flow structure provides a basis for interpretation of time-averaged surface pressure and acceleration measurements obtained in both the

present and previous investigations. Knowledge of the flow patterns is expected to lead, in turn, to new techniques for control of the unsteady loading.
DTIC
Buffeting; Vortices; Control Surfaces; Aerodynamic Stability; Vorticity; Flow Distribution

19960048406 Cincinnati Univ., OH USA
Vortex Breakdown Over Unsteady Wings and Its Control ***Final Report, 30 Sep. 1992 - 30 Sep. 1995***
Gursul, Ismet, Cincinnati Univ., USA; Nov. 16, 1995; 87p; In English; Limited Reproducibility: More than 20% of this document may be affected by microfiche quality
Contract(s)/Grant(s): F49620-92-J-0532
Report No.(s): AD-A304465; No Copyright; Avail: Issuing Activity (Defense Technical Information Center (DTIC)), Microfiche

Control of vortex breakdown continues to be of vital importance because the breakdown may have a considerable effect on aircraft performance, such as the effect on the time-averaged lift force (Lee and Ho, 1990). Breakdown is also important because of the unsteady nature of flow downstream of vortex breakdown. The unsteadiness may affect the stability of the aircraft and also cause buffeting. The objectives of this work are to understand the physics of unsteady flow phenomena in vortex breakdown region, and to develop techniques for active (feedback) and passive (open loop) control of vortex breakdown over steady and unsteady delta wings.
DTIC
Aerodynamic Stability; Vortex Breakdown; Buffeting; Delta Wings

19960049728 NASA Ames Research Center, Moffett Field, CA USA
Aerodynamic Limitations of the UH-60A Rotor
Coleman, Colin P., NASA Ames Research Center, USA; Bousman, William G., Army Aviation Systems Command, USA; Aug. 1996; 22p; In English
Contract(s)/Grant(s): RTOP 505-59-36
Report No.(s): NASA-TM-110396; A-961611; NAS 1.15:110396; USAATCOM-TR-96-A-011; No Copyright; Avail: CASI; A03, Hardcopy; A01, Microfiche

High quality airloads data have been obtained on an instrumented UH-60A in flight and these data provide insight into the aerodynamic limiting behavior of the rotor. At moderate weight coefficients and high advance ratio limiting performance is largely caused by high drag near the blade tip on the advancing side of the rotor as supercritical flow develops on the rotor with moderate to strong, shocks on both surfaces of the blade. Drag divergence data from two-dimensional airfoil tests show good agreement with the development of the supercritical flow regions. Large aerodynamic pitching moments are observed at high advance ratio, as well, and these pitching moments are the source of high torsional moments on the blade and control system loads. These loads occur on the advancing side of the disk and are not related to blade stall which does not occur for these weight coefficients. At high weight coefficients aerodynamic and structural limits are related to dynamic stall cycles that begin on the retreating side of the blade and, for the most severe conditions, carry around to the advancing side of the blade at the presumed first frequency of the blade/control system.
Author
Aerodynamic Characteristics; Aerodynamic Loads; UH-60A Helicopter; Supercritical Flow; Rotors; Pitching Moments; Blade Tips

19960049782 Stanford Univ., CA USA
Simplified Aerodynamic and Structural Modeling for Oblique All-Wing Aircraft. Phase 2: Structures ***Final Report***
Kroo, Ilan, Principal Investigator, Stanford Univ., USA; Sep. 1994; 19p; In English
Contract(s)/Grant(s): NCC2-5025
Report No.(s): NASA-CR-202164; NAS 1.26:202164; No Copyright; Avail: CASI; A03, Hardcopy; A01, Microfiche

Any aircraft preliminary design study requires a structural model of the proposed configuration. The model must be capable of estimating the structural weight of a given configuration, and of predicting the deflections which will result from foreseen flight and ground loads. The present work develops such a model for the proposed Oblique All Wing airplane. The model is based on preliminary structural work done by Jack Williams and Peter Rudolph at Mdng, and is encoded in a FORTRAN program. As a stand-alone application, the program can calculate the weight CG location, and several types of structural deflections; used in conjunction with an aerodynamics model, the program can be used for mission analysis or sizing studies.
Derived from text
Oblique Wings; Tailless Aircraft; Predictions; Aircraft Design; Aircraft Models

19960049881 NASA Langley Research Center, Hampton, VA USA
Improving CAP-TSD steady pressure solutions through airfoil slope modification
Mitterer, Kent F., Pennsylvania State Univ., USA; Maughmer, Mark D., Pennsylvania State Univ., USA; Silva, Walter A., NASA Langley Research Center, USA; Batina, John T., NASA Langley Research Center, USA; Aug. 1996; 22p; In English
Contract(s)/Grant(s): RTOP 505-63-50-13
Report No.(s): NASA-TM-110214; NAS 1.15:110214; No Copyright; Avail: CASI; A03, Hardcopy; A01, Microfiche

A modification of airfoil section geometry is examined for improvement of the leading edge pressures predicted by

the Computational Aeroelasticity Program - Transonic Small Disturbance (CAP-TSD). Results are compared with Eppler solutions to assess improvement. Preliminary results indicate that a fading function modification of section slopes is capable of significant improvements in the pressures near the leading edge computed by CAP-TSD. Application of this modification to airfoil geometry before use in CAP-TSD is shown to reduce the nonphysical pressure peak predicted by the transonic small disturbance solver. A second advantage of the slope modification is the substantial reduction in sensitivity of CAP-TSD steady pressure solutions to the computational mesh.
Author
Computer Aided Design; Computerized Simulation; Airfoil Profiles; Aeroelasticity; Leading Edges

19960050516 Massachusetts Inst. of Tech., Dept. of Aeronautics and Astronautics., Cambridge, MA USA
Development and testing of airfoils for high-altitude aircraft ***Final Report, 1 Sep. 1994 - 31 May 1996***
Drela, Mark, Principal Investigator, Massachusetts Inst. of Tech., USA; Jun. 1996; 50p; In English
Contract(s)/Grant(s): NAG2-4008
Report No.(s): NASA-CR-201062; NAS 1.26:201062; No Copyright; Avail: CASI; A03, Hardcopy; A01, Microfiche

Specific tasks included airfoil design; study of airfoil constraints on pullout maneuver; selection of tail airfoils; examination of wing twist; test section instrumentation and layout; and integrated airfoil/heat-exchanger tests. In the course of designing the airfoil, specifically for the APEX test vehicle, extensive studies were made over the Mach and Reynolds number ranges of interest. It is intended to be representative of airfoils required for lightweight aircraft operating at extreme altitudes, which is the primary research objective of the APEX program. Also considered were thickness, pitching moment, and off-design behavior. The maximum ceiling parameter M(exp 2)C(sub L) value achievable by the Apex-16 airfoil was found to be a strong constraint on the pullout maneuver. The NACA 1410 and 2410 airfoils (inverted) were identified as good candidates for the tail, with predictable behavior at low Reynolds numbers and good tolerance to flap deflections. With regards to wing twist, it was decided that a simple flat wing was a reasonable compromise. The test section instrumentation consisted of surface pressure taps, wake rakes, surface-mounted microphones, and skin-friction gauges. Also, a modest wind tunnel test was performed for an integrated airfoil/heat-exchanger configuration, which is currently on Aurora's 'Theseus' aircraft. Although not directly related to the APEX tests, the aerodynamics or heat exchangers has been identified as a crucial aspect of designing high-altitude aircraft and hence is relevant to the ERAST program.
CASI
Airfoils; Aerodynamic Configurations; Airfoil Profiles; Tail Assemblies; Heat Exchangers

03
AIR TRANSPORTATION AND SAFETY

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

19960046983 NASA Ames Research Center, Moffett Field, CA USA
Reporter Concerns in 300 Mode-Related Incident Reports from NASA's Aviation Safety Reporting System
McGreevy, Michael W., National Aeronautics and Space Administration. Ames Research Center, USA; Jul. 1996; 176p; In English
Contract(s)/Grant(s): RTOP 505-64-53
Report No.(s): NASA-TM-110413; A-962350; NAS 1.15:110413; No Copyright; Avail: CASI; A09, Hardcopy; A02, Microfiche

A model has been developed which represents prominent reporter concerns expressed in the narratives of 300 mode-related incident reports from NASA's Aviation Safety Reporting System (ASRS). The model objectively quantifies the structure of concerns which persist across situations and reporters. These concerns are described and illustrated using verbatim sentences from the original narratives. Report accession numbers are included with each sentence so that concerns can be traced back to the original reports. The results also include an inventory of mode names mentioned in the narratives, and a comparison of individual and joint concerns. The method is based on a proximity-weighted co-occurrence metric and object-oriented complexity reduction.
Author
Aircraft Safety; Flight Safety; Airline Operations; Operational Problems; Natural Language Processing; Terminology; Computerized Simulation; Words (Language); Virtual Reality; Object-Oriented Programming

19960047367 Massachusetts Inst. of Tech., Lincoln Lab., Lexington, MA USA
Lincoln Laboratory Evaluation of TCAS-2 Logic Version 6.O4a, Volume 1
Drumm, Ann C., Massachusetts Inst. of Tech., USA; Feb. 21, 1996; 76p; In English
Contract(s)/Grant(s): F19628-95-C-0002
Report No.(s): AD-A305342; ATC-240-Vol-1; No Copyright; Avail: CASI; A05, Hardcopy; A01, Microfiche

This report documents the Lincoln Laboratory evaluation of the Traffic Alert and Collision Avoidance System 2 (TCAS-2) logic version 6.04a. TCAS-2 is an airborne collision avoidance System required since 30 December 1993 by the FAA on all air carrier aircraft with more than 30 passenger seats operating in U.S. airspace. Version 6.04a is a logic version mandated by the FAA by 30 December 1994 in order to correct a potential safety problem in earlier versions and to make the TCAS logic more compatible with the air traffic control system. Lincoln Laboratory evaluated the logic by ex-

amining approximately two million simulated pairwise TCAS-TCAS encounters, derived from actual aircraft tracks recorded in U.S. airspace. The main goals of the evaluation effort were: (1) to determine if version 6.04a successfully corrected the potential safety problem without introducing new problems; (2) to detect and explain any areas of poor performance; and (3) to understand the performance limits of the logic. Five analysis programs were written to aid in the evaluation, and these programs are described in the report. There were three phases of the evaluation corresponding to the above three goals. For each phase, the report gives an overview of the evaluation approach taken, a description of the results, and a summary. A description of follow-on activities plus overall conclusions and recommendations are given at the end of the report.
DTIC
Air Transportation; Collision Avoidance; Air Traffic Control; Aircraft Safety; Computerized Simulation

19960047494 Ohio State Univ., Columbus, OH USA
Developing the Personal Minimums Tool for Managing Risk During Preflight Go/No-Go Decisions ***Final Report***
Kirkbride, Larry A., Ohio State Univ., USA; Jensen, Richard S., Ohio State Univ., USA; Chubb, Gerald P., Ohio State Univ., USA; Hunter, David R., Federal Aviation Administration, USA; Jul. 1996; 56p; In English
Contract(s)/Grant(s): DTFA01-92-10204
Report No.(s): DOT/FAA/AM-96/19; No Copyright; Avail: CASI; A04, Hardcopy; A01, Microfiche

This report describes the preliminary design of a structured method for pilots to construct personal minimums related to safety for use during preflight decision making. The design uses a three-step process by which individual pilots prepare personal minimums that apply to the scope of their routine flight activities. The approach encourages voluntary compliance with the self-generated personal minimums guidelines prepared in checklist form.
Author
Risk; Decision Making; Aircraft Safety

19960047752 General Accounting Office, National Security and International Affairs Div., Washington, DC USA
Briefing Report to the Ranking Minority Member, Subcommittee on Military Procurement, Committee on National Security, House of Representatives. Military Aircraft Safety: Significant Improvements Since 1975
Feb. 1996; 30p; In English
Report No.(s): AD-A304699; GAO/NSIAD-96-69BR; B-270647; No Copyright; Avail: CASI; A03, Hardcopy; A01, Microfiche

It was noted that a number of military aircraft accidents had occurred over a period of a few weeks, resulting in the death of more than a dozen crew members and passengers. The request was made conduct a review of military aircraft accidents. The objectives were to identity (1) historical trends in aircraft accidents involving deaths or extensive aircraft damage (Class A flight mishaps), (2) investigations performed to determine the causes, and (3) examples of actions taken to reduce the number of aviation accidents. We also analyzed investigation summaries to identify the primary factors contributing to mishaps and reviewed studies which addressed the relationship of operating tempo to aviation safety. GAO did not address concerns about alleged mishandling of mishap investigations in the Air Force because the Department of Defense (DOD) Inspector General was already examining those allegations.
DTIC
Aircraft Accidents; Congressional Reports; Aircraft Safety; Flight Safety; Flight Hazards; Crash Injuries; Crashes; Pilot Performance; Death; Accident Investigation

19960047772 Army Aeromedical Research Lab., Fort Rucker, AL USA
Reduction and mitigation of thermal injuries; what can be done ***Final Report***
Voisine, Joel J., Army Aeromedical Research Lab., USA; Albano, John P., Army Aeromedical Research Lab., USA; Jan. 1996; 17p; In English
Contract(s)/Grant(s): 30162787A878
Report No.(s): AD-A304628; USAARL-96-03; No Copyright; Avail: CASI; A03, Hardcopy; A01, Microfiche

Soon after the introduction of the crashworthy fuel system and Nomex(Registered Mark) flight apparel, morbidity and mortality rates from thermal injuries in aviation were reduced to zero. Although the incidence of aircraft mishaps involving postcrash fires remained the same then and now, there has been a recent increase in thermal injury morbidity. The case reports describe three different aircraft accidents in which fire was caused by factors other than the crashworthy fuel system. They also describe sustained thermal injuries and compare them to personal protection equipment. We found that the condition of the personal protective equipment and unauthorized use of unapproved apparel were responsible for the sustained injuries. We maintain that personal protection equipment is effective if worn in a manner for which it was designed. We believe that the lessons learned apply to all military operations where the risk of fire is high, not solely aviation. A proactive program focused on education would reduce the thermal injury morbidity.
DTIC
Aircraft Accidents; Wound Healing; Thermal Stresses; Military Operations; Fuel Systems; Education; Risk; Accident Prevention; Crash Injuries

19960048391 Massachusetts Inst. of Tech., Lincoln Lab., Cambridge, MA USA
Lincoln Laboratory Evaluation of TCAS 2 Logic Version 6.O4a, Volume 2, Appendices A-M

Drumm, A. C., Massachusetts Inst. of Tech., USA; Feb. 15, 1996; 250p; In English
Contract(s)/Grant(s): F19628-95-C-0002
Report No.(s): AD-A305348; ATC-240-Vol-2-App-A-M; No Copyright; Avail: CASI; A11, Hardcopy; A03, Microfiche

This report documents the Lincoln Laboratory evaluation of the Traffic Alert and Collision Avoidance System II (TCAS II) logic version 6.04a. TCAS II is an airborne collision avoidance system required since 30 December 1993 by the FAA on all air carrier aircraft with more than 30 passenger seats operating in U.S. airspace. Version 6.04a is a logic version mandated by the FAA by 30 December 1994 in order to connect a potential safety problem in earlier versions and to make the TCAS logic more compatible with the air traffic control system. Lincoln Laboratory evaluated the logic by examining approximately two million simulated pairwise TCAS-TCAS encounters, derived from actual aircraft tracks recorded in U.S. airspace. The main goals of the evaluation effort were: (1) to determine if version 6.04a successfully corrected the potential safety problem without introducing new problems; (2) to detect and explain any areas of poor performance; and (3) to understand the performance limits of the logic. Five analysis programs were written to aid in the evaluation, and these programs are described in the report. There were three phases of the evaluation corresponding to the above three goals. For each phase, the report gives an overview of the evaluation approach taken, a description of the results, and a summary. A description of follow-on activities plus overall conclusions and recommendations are given at the end of the report.
DTIC
Air Traffic Control; Warning Systems; Safety Factors; Collision Avoidance; Regulations; Flight Paths; Airspace; Computer Programs; Aircraft Safety; Flight Rules

19960048652 Army Aviation Test Activity, Edwards AFB, CA USA
Airworthiness Qualification Test Directorate (AQTD). Bibliography: (Author/Report/Aircraft) 1961-1995
Benner, Shelia, Army Aviation Test Activity, USA; Jan. 1996; 298p; In English; Limited Reproducibility: More than 20% of this document may be affected by microfiche quality
Report No.(s): AD-A304334; No Copyright; Avail: Issuing Activity (Defense Technical Information Center (DTIC)), Microfiche

The mission of the Airworthiness Qualification Test Directorate (AQTD) (previously known as the U.S. Army Aviation Engineering Flight Activity (AEFA)) of the U.S. Army Aviation Technical Test Center, is to conduct airworthiness qualification flight tests of air vehicles developed and/or procured as integrated systems and airworthiness evaluations of those vehicles proposed or considered for Army application or which incorporate advanced concepts having potential military application; produce test data on basic air vehicle performance, handling qualities, system/subsystem interface, and integrated system performance; and conduct a test pilot orientation course to prepare Army aviators for attendance at U.S. Naval Test Pilot School.
DTIC
Aircraft Reliability; Test Pilots; Flight Tests; Controllability

04
AIRCRAFT COMMUNICATIONS AND NAVIGATION

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

19960047104 Massachusetts Inst. of Tech., Dept. of Mechanical Engineering., Cambridge, MA USA
Decision-Aiding and Optimization for Vertical Navigation of Long-Haul Aircraft *Final Report*
Patrick, Nicholas J. M., Massachusetts Inst. of Tech., USA; Sheridan, Thomas B., Massachusetts Inst. of Tech., USA; Aug. 1996; 122p; In English
Contract(s)/Grant(s): NAG2-729
Report No.(s): NASA-CR-202219; NAS 1.26:202219; No Copyright; Avail: CASI; A06, Hardcopy; A02, Microfiche

Most decisions made in the cockpit are related to safety, and have therefore been proceduralized in order to reduce risk. There are very few which are made on the basis of a value metric such as economic cost. One which can be shown to be value based, however, is the selection of a flight profile. Fuel consumption and flight time both have a substantial effect on aircraft operating cost, but they cannot be minimized simultaneously. In addition, winds, turbulence, and performance vary widely with altitude and time. These factors make it important and difficult for pilots to (a) evaluate the outcomes associated with a particular trajectory before it is flown and (b) decide among possible trajectories. The two elements of this problem considered here are: (1) determining what constitutes optimality, and (2) finding optimal trajectories. Pilots and dispatchers from major u.s. airlines were surveyed to determine which attributes of the outcome of a flight they considered the most important. Avoiding turbulence-for passenger comfort-topped the list of items which were not safety related. Pilots' decision making about the selection of flight profile on the basis of flight time, fuel burn, and exposure to turbulence was then observed. of the several behavioral and prescriptive decision models invoked to explain the pilots' choices, utility maximization is shown to best reproduce the pilots' decisions. After considering more traditional methods for optimizing trajectories, a novel method is developed using a genetic algorithm (GA) operating on a discrete representation of the trajectory search space. The representation is a sequence of command altitudes, and was chosen to be compatible with the constraints imposed by Air Traffic Control, and with the training given to pilots. Since trajectory evaluation for the GA is

performed holistically, a wide class of objective functions can be optimized easily. Also, using the GA it is possible to compare the costs associated with different airspace design and air traffic management policies. A decision aid is proposed which would combine the pilot's notion of optimality with the GA-based optimization, provide the pilot with a number of alternative pareto-optimal trajectories, and allow him to consider unmodelled attributes and constraints in choosing among them. A solution to the problem of displaying alternatives in a multi-attribute decision space is also presented.
Author
Air Navigation; Genetic Algorithms; Operating Costs; Decision Making; Aircraft Pilots; Aircraft Safety

19960051674
Fuzzy logic traffic control at a road junction with time-varying flow rates
Ho, T. K., Hong Kong Polytechnic Univ, Hong Kong; Electronics Letters; August 15 1996; ISSN 0013-5194; vol. 32, no. 17, pp. 1625-1626; In English; Copyright; Avail: Issuing Activity

Fuzzy logic has been applied to control traffic at road junctions. A simple controller with one fixed rule-set is inadequate to minimize delays when traffic flow rate is time-varying and likely to span a wide range. to achieve better control, fuzzy rules adapted to the current traffic conditions are used.
Author (EI)
Air Traffic Control; Control Theory; Delay Circuits; Fuzzy Sets; Numerical Control; Streets; Time Dependence; Traffic

05
AIRCRAFT DESIGN, TESTING AND PERFORMANCE

Includes aircraft simulation technology.

19960047027 Florida Atlantic Univ., Boca Raton, FL USA
Predictions of Control Inputs, Periodic Responses and Damping Levels of an Isolated Experimental Rotor in Trimmed Flight *Final Report*
Gaonkar, G. H., Florida Atlantic Univ., USA; Subramanian, S., Florida Atlantic Univ., USA; Jul. 31, 1996; 781p; In English
Contract(s)/Grant(s): NAG2-797
Report No.(s): NASA-CR-202121; NAS 1.26:202121; No Copyright; Avail: CASI; A99, Hardcopy; A10, Microfiche

Since the early 1990s the Aeroflightdynamics Directorate at the Ames Research Center has been conducting tests on isolated hingeless rotors in hover and forward flight. The primary objective is to generate a database on aeroelastic stability in trimmed flight for torsionally soft rotors at realistic tip speeds. The rotor test model has four soft inplane blades of NACA 0012 airfoil section with low torsional stiffness. The collective pitch and shaft tilt are set prior to each test run, and then the rotor is trimmed in the following sense: the longitudinal and lateral cyclic pitch controls are adjusted through a swashplate to minimize the 1/rev flapping moment at the 12 percent radial station. In hover, the database comprises lag regressive-mode damping with pitch variations. In forward flight the database comprises cyclic pitch controls, root flap moment and lag regressive-mode damping with advance ratio, shaft angle and pitch variations. This report presents the predictions and their correlation with the database. A modal analysis is used, in which nonrotating modes in flap bending, lag bending and torsion are computed from the measured blade mass and stiffness distributions. The airfoil aerodynamics is represented by the ONERA dynamic stall models of lift, drag and pitching moment, and the wake dynamics is represented by a state-space wake model. The trim analysis of finding, the cyclic controls and the corresponding, periodic responses is based on periodic shooting with damped Newton iteration; the Floquet transition matrix (FTM) comes out as a byproduct. The stabillty analysis of finding the frequencies and damping levels is based on the eigenvalue-eigenvector analysis of the FTM. All the structural and aerodynamic states are included from modeling to trim analysis. A major finding is that dynamic wake dramatically improves the correlation for the lateral cyclic pitch control. Overall, the correlation is fairly good.
Author
Aeroelasticity; Airfoils; Flight Tests; Rotor Aerodynamics; Lateral Control; Aerodynamic Stalling; Aerodynamic Balance

19960047059 Maryland Univ., Dept. of Aerospace Engineering., College Park, MD USA
Performance Analysis of Two Early NACA High Speed Propellers with Application to Civil Tiltrotor Configurations
Harris, Franklin D., Maryland Univ., USA; Aug. 1996; 154p; In English
Contract(s)/Grant(s): NCC2-829
Report No.(s): NASA-CR-196702; A-962481; NAS 1.26:196702; No Copyright; Avail: CASI; A08, Hardcopy; A02, Microfiche

The helicopter industry is vigorously pursuing development of civil tiltrotors. One key to efficient high speed performance of this rotorcraft is prop-rotor performance. of equal, if not greater, importance is assurance that the flight envelope is free of aeroelastic instabilities well beyond currently envisioned cuise speeds. This later condition requires study at helical tip Match numbers well in excess of 1.0. Two 1940's 'supersonic' propeller experiments conducted by NACA have provided an immensely valuable data bank with which to study prop-rotor behavior at transonic and supersonic helical tip Mach numbers. Very accurate 'blades alone' data were obtained by using nearly an infinite hub. Tabulated data were recreated from the many thrust and power figures and are in-

cluded in two Appendices to this report. This data set is exceptionally well suited to re-evaluating classical blade element theories as well as evolving computational fluid dynamic (CFD) analyses. A limited comparison of one propeller's experimental results to a modem rotorcraft CFD code is made. This code, referred to as TURNS, gives very encouraging results. Detailed analysis of the performance data from both propellers is provided in Appendix A. This appendix quantifies the minimum power required to produce usable prop-rotor thrust. The dependence of minimum profile power on Reynolds number is quantified. First order compressibility power losses are quantified as well and a first approximation to design air-foil thickness ratio to avoid compressibility losses is provided. Appendix A's results are applied to study high speed civil tiltrotor cruise performance. Predicted tiltrotor performance is compared to two turboprop commercial transports. The comparison shows that there is no fundamental aerodynamic reason why the rotorcraft industry could not develop civil tiltrotor aircraft which have competitive cruise performance with today's regional, turboprop airlines. Recommendations for future study that will insure efficient prop-rotor performance to well beyond 400 knots are given.
Author
Commercial Aircraft; Computational Fluid Dynamics; Rotary Wing Aircraft; Flight Envelopes; Aircraft Design; Propeller Efficiency; Reynolds Number; Tip Speed; Rotor Speed; Tilt Rotor Aircraft

19960047101 NASA Dryden Flight Research Center, Edwards, CA USA
Proceedings of the F-8 Digital Fly-By-Wire and Supercritical Wing First Flight's 20th Anniversary Celebration, Volume 1
Hodge, Kenneth E., Compiler, NASA Dryden Flight Research Center, USA; Feb. 1996; 188p; In English; 20th, 27 May 1992, Edwards, CA, USA
Contract(s)/Grant(s): RTOP 533-02
Report No.(s): NASA-CP-3256-Vol-1; H-1957-Vol-1; NAS 1.26:3256-Vol-1; No Copyright; Avail: CASI; A09, Hardcopy; A02, Microfiche

A technical symposium, aircraft display dedication, and pilots' panel discussion were held on May 27, 1992, to commemorate the 20th anniversary of the first flights of the F-8 Digital Fly-By-Wire (DFBW) and Supercrit- ical Wing (SCW) research aircraft. The symposium featured technical presentations by former key government and industry participants in the advocacy, design, aircraft modification, and flight research program activities. The DFBW and SCW technical contributions are cited. A dedication ceremony marked permanent display of both program aircraft. The panel discussion participants included eight of the eighteen research and test pilots who flew these experimental aircraft. Pilots' remarks include descriptions of their most memorable flight experiences The report also includes a survey of the Gulf Air War, and an after-dinner presentation by noted aerospace author and historian Dr. Richard Hallion.
Author
F-8 Aircraft; Fly by Wire Control; Supercritical Wings; Test Pilots; Flight Test Vehicles; Aircraft Control; Wing Profiles; Aerodynamic Configurations

19960047139 NASA Dryden Flight Research Center, Edwards, CA USA
Proceedings of the F-8 Digital Fly-By-Wire and Supercritical Wing First Flight's 20th Anniversary Celebration, Volume 2, Bibliography Appendices
Hodge, Kenneth E., Compiler, NASA Dryden Flight Research Center, USA; Kellogg, Yvonne, Editor, NASA Dryden Flight Research Center, USA; Feb. 1996; 98p; In English, 27 May 1992, Edwards, CA, USA
Contract(s)/Grant(s): RTOP 533-02-00
Report No.(s): NASA-CP-3256-Vol-2; H-1957-Vol-2; NAS 1.55:3256-Vol-2; No Copyright; Avail: CASI; A05, Hardcopy; A02, Microfiche

A technical symposium, aircraft display dedication, and pilots' panel discussion were held on May 27, 1992. to commemorate the 20th anniversary of the first flights of the F-8 Digital Fly-By-Wire (DFBW) and Supercritical Wing (SCW) research aircraft. The symposium featured technical presentations by former key government and industry participants in the advocacy, design, aircraft modification, and flight research program activities. The DFBW and SCW technical contributions are cited. A dedication ceremony marked permanent display of both program aircraft. The panel discussion participants included eight of the eighteen research and test pilots who flew these experimental aircraft. Pilots' remarks include descriptions of their most memorable flight experiences. The report also includes a survey of the Gulf Air War, an after-dinner presentation by noted aerospace author and historian Dr. Richard Hallion.
Author
F-8 Aircraft; Fly by Wire Control; Supercritical Wings; Aircraft Design; Digital Systems

19960047422 California Polytechnic State Univ., San Luis Obispo, CA USA
Development and Analysis of an Agility Assessment Module for Preliminary Fighter Design ***Final Report, Sep. 1993 - Mar. 1995***
Biezad, Daniel, California Polytechnic State Univ., USA; Ngan, Angelen, California Polytechnic State Univ., USA; Mar. 1995; 42p; In English
Contract(s)/Grant(s): NCC2-834
Report No.(s): NASA-CR-201915; NAS 1.26:201915; No Copyright; Avail: CASI; A03, Hardcopy; A01, Microfiche

A study has been conducted to develop and to analyze a FORTRAN computer code for performing agility analysis on fighter aircraft configurations. This program is one of the

modules of the NASA Ames ACSYNT (AirCraft SYNThesis) design code. The background of the agility research in the aircraft industry and a survey of a few agility metrics are discussed. The methodology, techniques, and models developed for the code are presented. The validity of the existing code was evaluated by comparing it with existing flight test data. A FORTRAN program was developed for a specific metric, PM (Pointing Margin), as part of the agility module. Example trade studies using the agility module along with ACSYNT were conducted using a McDonnell Douglas F/A- 1 8 Hornet aircraft model. The sensitivity of thrust loading, wing loading, and thrust vectoring on agility criteria were investigated. The module can compare the agility potential between different configurations and has the capability to optimize agility performance in the preliminary design process. This research provides a new and useful design tool for analyzing fighter performance during air combat engagements in the preliminary design.
Author
Aircraft Design; Aircraft Configurations; Fortran; Thrust Vector Control; Wing Loading; Fighter Aircraft; Maneuverability; Computerized Simulation

19960047887 Analytical Services and Materials, Inc., Hampton, VA USA
Structural Integrity Analysis and Verification for Aircraft Structures, Volume 1, Characterization of 7O75-T7351 Aluminum; MODGRO Verification; MODGRO GUI Development ***Final Report, 1 Oct. - 31 Dec. 1994***
Boyd, K. L., Analytical Services and Materials, Inc., USA; Jansen, D. A., Analytical Services and Materials, Inc., USA; Krishnan, S., Analytical Services and Materials, Inc., USA; Harter, J. A., Analytical Services and Materials, Inc., USA; Jan. 1996; 72p; In English
Contract(s)/Grant(s): F33615-94-D-3212; AF Proj. 2401
Report No.(s): AD-A305468; WL-TR-95-3090; No Copyright; Avail: CASI; A04, Hardcopy; A01, Microfiche

Crack growth rate tests were performed for 7O75-T7351 aluminum under standard laboratory environment. These data served to establish the baseline material properties of the alloy. The Air Force crack growth life prediction software (MoDGRO) was used to predict the life of 7O75-T7351 aluminum specimens tested with cracks emanating from open and pin loaded fastener holes. The ability to use cyclic material property data under any environment was added to MODGRO. The effect of cold-working and interference fit fasteners was also examined. In addition, a user-friendly graphical user interface (GUI) was added to NODGRO and is documented in this report.
DTIC
Aircraft Structures; Crack Propagation; Predictions; Holes (Mechanics); Applications Programs (Computers); Computer Aided Design; Diagnosis

19960048185 Naval Air Warfare Center, Aircraft Div., Patuxent River, MD USA
High Altitude Endurance UAVs
McDaniel, Michael L., Naval Air Warfare Center, USA; Dec. 22, 1995; 5p; In English
Report No.(s): AD-A305115; No Copyright; Avail: CASI; A01, Hardcopy; A01, Microfiche

Although not Navy programs, the Tier 2+ and Tier 3- Unmanned Air Vehicles (UAVs) of the Advanced Research Project Agency (ARPA) may be of great use in naval operations. These UAVs are the products of the High Altitude Endurance UAV program at ARPA. This program is intended to develop and demonstrate two rival reconnaissance UAVs, then let the users decide on the force balance and needed capabilities based on the performance of the candidates. The UAVs, designated Tier 2 + and Tier 3-, are intended to be theater level assets supplementing existing reconnaissance platforms.
DTIC
Aerial Reconnaissance; Military Operations; Pilotless Aircraft; Remotely Piloted Vehicles; High Altitude; Distance; Aircraft Performance; Deployment

19960048650 Naval Postgraduate School, Monterey, CA USA
Operation of an Untethered, Unmanned Air Vehicle
Hakun, Mark G., Naval Postgraduate School, USA; Sep. 1995; 73p; In English; Limited Reproducibility: More than 20% of this document may be affected by microfiche quality
Report No.(s): AD-A304280; No Copyright; Avail: Issuing Activity (Defense Technical Information Center (DTIC)), Microfiche

The goal of the Avionics lab at the Naval Postgraduate School is to develop an unmanned air vehicle that can be mass produced frugally with items readily available in the commercial marketplace. The Archytas vehicle under concurrent production and development at the Naval Postgraduate School accomplishes just that. This machine combines computer generated code personal computer and radio controlled equipment into a small but capable vehicle with applications in both the military and civilian sectors. In order to achieve flight free of tangible links to the earth's surface, computer models of the system evolved into a series of electrical signals mixed with commands of the ground-based pilot. These signals along with those of the on-board sensors blend inside the controlling software to produce stable flight. The initial phase of flight without the tether was successful in the test cage.
DTIC
Remotely Piloted Vehicles; Numerical Control; Radio Equipment; Avionics

19960049759 George Washington Univ., Joint Inst. for the Advancement of Flight Sciences., Hampton, VA USA
A method for landing gear modeling and simulation with experimental validation

Daniels, James N., George Washington Univ., USA; Jun. 1996; 100p; In English
Contract(s)/Grant(s): NCC1-208; RTOP 505-63-50-19
Report No.(s): NASA-CR-201601; NAS 1.26:201601; No Copyright; Avail: CASI; A05, Hardcopy; A02, Microfiche

This document presents an approach for modeling and simulating landing gear systems. Specifically, a nonlinear model of an A-6 Intruder Main Gear is developed, simulated, and validated against static and dynamic test data. This model includes nonlinear effects such as a polytropic gas model, velocity squared damping, a geometry governed model for the discharge coefficients, stick-slip friction effects and a nonlinear tire spring and damping model. An Adams-Moulton predictor corrector was used to integrate the equations of motion until a discontinuity caused by a stick-slip friction model was reached, at which point, a Runga-Kutta routine integrated past the discontinuity and returned the problem solution back to the predictor corrector. Run times of this software are around 2 mins. per 1 sec. of simulation under dynamic circumstances. to validate the model, engineers at the Aircraft Landing Dynamics facilities at NASA Langley Research Center installed one A-6 main gear on a drop carriage and used a hydraulic shaker table to provide simulated runway inputs to the gear. Model parameters were tuned to produce excellent agreement for many cases.
Author
Aircraft Landing; Aircraft Models; Landing Gear; Vibration; Landing Simulation; Nonlinearity; Equations of Motion; Computerized Simulation

19960050258 Department of the Navy, Washington, DC USA
Aircraft Control Lever Simulator
Thomas, G. T., Inventor, Department of the Navy, USA; Mar. 19, 1996; 9p; In English; Supersedes US-Patent-Appl-SN-130950
Patent Info.: US-Patent-Appl-SN-130950; US-Patent-5,499,919
Report No.(s): AD-D018013; No Copyright; Avail: US Patent and Trademark Office, Microfiche

An aircraft throttle simulator comprises throttle lever which extend upwardly from spheres fractionally clamped between plates. The levers are constrained for movement in a pattern allowing for forward movement from an idle position to a full throttle position, a lateral shift from the full throttle position, and forward movement to an afterburner position. A linkage is provided to connect each lever to a linear transducer to provide a position signal.
DTIC
Control Simulation; Aircraft Control; Levers

19960050465 Physics and Electronics Lab. TNO, The Hague, Netherlands
LCC Analysis Introduction ARMS for the Cougar Helicopter ***LCC analyse invoering ARMS voor de Cougar helikopter***
Smit, M. C., Physics and Electronics Lab. TNO, Netherlands; vanZijderveld, E. J. A., Physics and Electronics Lab. TNO, Netherlands; May 1995; 64p; In Dutch
Contract(s)/Grant(s): A95KLu766; TNO Proj. 25487
Report No.(s): TNO-FEL-95-A300; TD96-0064; Copyright; Avail: Issuing Activity (Physics and Electronics Lab. TNO, P. O. Box 96864, 2509 JG The Hague,, The Netherlands), Hardcopy, Microfiche

The Royal Netherlands Air Force (RNLAF) recently initiated a research program to control equipment life cycle costs (LCC). A pilot study is described which is based on the introduction of the Cougar light transport helicopter. This helicopter will be equipped with a new machine condition monitoring system called health and usage monitoring system (HUMS) which is scheduled to be replaced after several years by a monitoring system called aircraft recording and monitoring system (ARMS). This report identifies the main characteristics and impacts of both monitoring systems on helicopter maintenance procedures and costs. Two models are presented and used, as far as possible at the time of writing, to estimate the consequences of changes in maintenance intervals for the Cougar helicopter. This report presents a cost tree according to the FEL-SALDO method that can be used to find the life cycle cost of the Cougar helicopter with either HUMS or ARMS. Since most information required to calculate life cycle costs was not available from the producer (Eurocopter), a list of questions to be answered for further research on life cycle cost was constructed. The main conclusion of this study is the danger involved with the purchase of a monitoring system that is (partially) still is to be developed.
DFRC
Life Cycle Costs; Systems Health Monitoring; Scheduling; Aircraft Maintenance; Military Helicopters

07
AIRCRAFT PROPULSION AND POWER

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

19960048017 NASA Lewis Research Center, Cleveland, OH USA
Minimum weight design of a generic axisymmetric inlet
Nadell, Shari-Beth, NASA Lewis Research Center, USA; Aug. 1996; 18p; In English; 32nd; Joint Propulsion Conference, 1-3 Jul. 1996, Lake Buena Vista, FL, USA; Sponsored by American Inst. of Aeronautics and Astronautics, USA; Original contains color illustration
Contract(s)/Grant(s): RTOP 505-69-50
Report No.(s): NASA-TM-107288; E-10363; NAS 1.15:

107288; AIAA Paper 96-2550; No Copyright; Avail: CASI; A03, Hardcopy; A01, Microfiche

A new minimum weight design method for high-speed axisymmetric inlets was demonstrated on a generic inlet. The method uses Classical Beam Theory and shell buckling to determine the minimum required equivalent isotropic thickness for a stiffened shell based on prescribed structural design requirements and load conditions. The optimum spacing and equivalent isotropic thickness of ring frame supports are computed to prevent buckling. The method thus develops a preliminary structural design for the inlet and computes the structural weight. Finite element analyses were performed on the resulting inlet design to evaluate the analytical results. Comparisons between the analytical and finite element stresses and deflections identified areas needing improvement in the analytical method. The addition of the deflection due to shear and a torsional buckling failure mode to the new method brought its results in line with those from the finite element analyses. Final validation of the new method will be made using data from actual inlets.

Author

Symmetry; Air Intakes; Finite Element Method; Supersonic Inlets; Structural Design; Structural Weight; Engine Design

19960048150 Massachusetts Inst. of Tech., Gas Turbine Lab., Cambridge, MA USA

Air Force Research in Aero Propulsion Technology (AFRAPT) ***Final Report, 1 Sep. 1994 - 31 Aug. 1995***

Epstein, Alan H., Massachusetts Inst. of Tech., USA; Greizer, Edward M., Massachusetts Inst. of Tech., USA; Tan, Choon, S., Massachusetts Inst. of Tech., USA; Ingard, K. Uno, Massachusetts Inst. of Tech., USA; Waitz, Ian A., Massachusetts Inst. of Tech., USA; Jan. 16, 1996; 15p; In English

Contract(s)/Grant(s): F49620-94-1-0307; AFOSR-91-0052; AF Proj. 2307

Report No.(s): AD-A305483; AFOSR-TR-96-0116; No Copyright; Avail: CASI; A03, Hardcopy; A01, Microfiche

This report covers research performed under Grant AFOSR-91-0052. The work consisted of four separate projects: (1) Reduction of Fan Noise Thorough Boundary Layer and Wake Suction; (2) Effect of Rotor-Strator Interaction on Turbomachinery Stall Behavior; (3) Turbomachinery Tip Clearance Vortical Flows; (4) Effects of Compressibility on Streamwise Vorticity Enhanced Mixing.

DTIC

Aerodynamic Noise; Boundary Layers; Compressibility; Turbomachinery; Vorticity; Vortices; Wakes

19960048499 General Electric Co., Aircraft Engines, Cincinnati, OH USA

Improved NASA-ANOPP Noise Prediction Computer Code for Advanced Subsonic Propulsion Systems

Kontos, K. B., General Electric Co., USA; Janardan, B. A., General Electric Co., USA; Gliebe, P. R., General Electric Co., USA; Aug. 1996; 156p; In English

Contract(s)/Grant(s): NAS3-26617; RTOP 538-08-11

Report No.(s): NASA-CR-195480; NAS 1.26:195480; E-9710; No Copyright; Avail: CASI; A08, Hardcopy; A02, Microfiche

Recent experience using ANOPP to predict turbofan engine flyover noise suggests that it over-predicts overall EPNL by a significant amount. An improvement in this prediction method is desired for system optimization and assessment studies of advanced UHB engines. An assessment of the ANOPP fan inlet, fan exhaust, jet, combustor, and turbine noise prediction methods is made using static engine component noise data from the CF6-8OC2, E(3), and QCSEE turbofan engines. It is shown that the ANOPP prediction results are generally higher than the measured GE data, and that the inlet noise prediction method (Heidmann method) is the most significant source of this overprediction. Fan noise spectral comparisons show that improvements to the fan tone, broadband, and combination tone noise models are required to yield results that more closely simulate the GE data. Suggested changes that yield improved fan noise predictions but preserve the Heidmann model structure are identified and described. These changes are based on the sets of engine data mentioned, as well as some CFM56 engine data that was used to expand the combination tone noise database. It should be noted that the recommended changes are based on an analysis of engines that are limited to single stage fans with design tip relative Mach numbers greater than one.

Author

Noise Prediction; Turbofan Engines; Engine Noise; Subsonic Flow; Computer Programs; Noise Spectra; Aircraft Noise

19960048688 NASA Lewis Research Center, Cleveland, OH USA

Experimental investigation of unsteady flows at large incidence angles in a linear oscillating cascade

Buffum, Daniel H., NASA Lewis Research Center, USA; King, Aaron J., California Univ., USA; Capece, Vincent R., California Univ., USA; El-Aini, Yehia M., Pratt and Whitney Aircraft, USA; Jul. 1996; 18p; In English; 32nd; Joint Propulsion Conference, 1-3 Jul. 1996, Lake Buena Vista, FL, USA; Sponsored by American Inst. of Aeronautics and Astronautics, USA

Contract(s)/Grant(s): RTOP 505-62-10

Report No.(s): NASA-TM-107283; NAS 1.15:107283; AIAA Paper 96-2823; E-10358; No Copyright; Avail: CASI; A03, Hardcopy; A01, Microfiche

The aerodynamics of a cascade of airfoils oscillating in torsion about the midchord is investigated experimentally at a large mean incidence angle and, for reference, at a low mean incidence angle. The airfoil section is representative of a modern, low aspect ratio, fan blade tip section. Time-dependent airfoil surface pressure measurements were made for reduced frequencies up to 0.8 for out-of-phase oscillations at Mach

numbers up to 0.8 and chordal incidence angles of 0 deg and 10 deg. For the 10 deg chordal incidence angle, a separation bubble formed at the leading edge of the suction surface. The separated flow field was found to have a dramatic effect on the chordwise distribution of the unsteady pressure. In this region, substantial deviations from the attached flow data were found with the deviations becoming less apparent in the aft region of the airfoil for all reduced frequencies. In particular, near the leading edge the separated flow had a strong destabilizing influence while the attached flow had a strong stabilizing influence.
Author
Unsteady Flow; Oscillations; Unsteady Aerodynamics; Cascade Wind Tunnels; Airfoils; Pressure Distribution; Separated Flow; Cascade Flow

08
AIRCRAFT STABILITY AND CONTROL

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

19960045735 Stanford Univ., Dept. of Aeronautics and Astronautics., CA USA
Roll-Yaw control at high angle of attack by forebody tangential blowing
Pedreiro, N., Stanford Univ., USA; Rock, S. M., Stanford Univ., USA; Celik, Z. Z., Stanford Univ., USA; Roberts, L., Stanford Univ., USA; Oct. 1995; 54p; In English
Contract(s)/Grant(s): NCC2-55
Report No.(s): NASA-CR-201844; NAS 1.26:201844; JIAA-TR-113; No Copyright; Avail: CASI; A04, Hardcopy; A01, Microfiche

The feasibility of using forebody tangential blowing to control the roll-yaw motion of a wind tunnel model is experimentally demonstrated. An unsteady model of the aerodynamics is developed based on the fundamental physics of the flow. Data from dynamic experiments is used to validate the aerodynamic model. A unique apparatus is designed and built that allows the wind tunnel model two degrees of freedom, roll and yaw. Dynamic experiments conducted at 45 degrees angle of attack reveal the system to be unstable. The natural motion is divergent. The aerodynamic model is incorporated into the equations of motion of the system and used for the design of closed loop control laws that make the system stable. These laws are proven through dynamic experiments in the wind tunnel using blowing as the only actuator. It is shown that asymmetric blowing is a highly non-linear effector that can be linearized by superimposing symmetric blowing. The effects of forebody tangential blowing and roll and yaw angles on the flow structure are determined through flow visualization experiments. The transient response of roll and yaw moments to a step input blowing are determined. Differences on the roll and yaw moment dependence on blowing are explained based on the physics of the phenomena.
Author
Roll; Yawing Moments; Wind Tunnel Models; Wind Tunnel Tests; Blowing; Flow Visualization; Aircraft Control; Flight Control; Feedback Control

19960047275 NASA Langley Research Center, Hampton, VA USA
Sensitivity Analysis of Flutter Response of a Wing Incorporating Finite-Span Corrections
Issac, Jason Cherian, Virginia Polytechnic Inst. and State Univ., USA; Kapania, Rakesh K., Virginia Polytechnic Inst. and State Univ., USA; Barthelemy, Jean-Francois M., NASA Langley Research Center, USA; [Sep. 1996]; 19p; In English; 5th; Multidisciplinary Analysis and Optimization, 7-9 Sep. 1996, Panama City, FA, USA; Sponsored by NASA Langley Research Center, USA
Contract(s)/Grant(s): NAG1-1411
Report No.(s): NASA-CR-202089; NAS 1.26:202089; No Copyright; Avail: CASI; A03, Hardcopy; A01, Microfiche

Flutter analysis of a wing is performed in compressible flow using state-space representation of the unsteady aerodynamic behavior. Three different expressions are used to incorporate corrections due to the finite-span effects of the wing in estimating the lift-curve slope. The structural formulation is based on a Rayleigh-Pitz technique with Chebyshev polynomials used for the wing deflections. The aeroelastic equations are solved as an eigen-value problem to determine the flutter speed of the wing. The flutter speeds are found to be higher in these cases, when compared to that obtained without accounting for the finite-span effects. The derivatives of the flutter speed with respect to the shape parameters, namely: aspect ratio, area, taper ratio and sweep angle, are calculated analytically. The shape sensitivity derivatives give a linear approximation to the flutter speed curves over a range of values of the shape parameter which is perturbed. Flutter and sensitivity calculations are performed on a wing using a lifting-surface unsteady aerodynamic theory using modules from a system of programs called FAST.
Author
Flutter; Aerodynamic Characteristics; Aeroelasticity; Chebyshev Approximation; Aspect Ratio; Compressible Flow; Sweep Angle; Unsteady Aerodynamics; Wing Span

19960047362 Illinois Inst. of Tech., Fluid Dynamics Reseach Center., Chicago, IL USA
Closed-Loop Control Systems for Unsteady Forebodies and Three-Dimensional Pitching Airfoils at High Reynolds Number ***Final Report, Jan. 1993 - Aug. 1995***
Williams, David R., Illinois Inst. of Tech., USA; Archarua, Mukund, Illinois Inst. of Tech., USA; D'Souza, A. F., Illinois Inst. of Tech., USA; Archarua, Mukund, Illinois Inst. of Tech., USA; Dec. 1995; 116p; In English

Contract(s)/Grant(s): F49620-93-1-0106; AF Proj. 2307
Report No.(s): AD-A305405; ITT-5-54621; AFOSR-TR-96-0112; No Copyright; Avail: CASI; A06, Hardcopy; A02, Microfiche

Progress made on closed loop control systems with application to aircraft forebodies and pitching airfoils is described in this report. The three main areas of the investigation included: (1) development of suitable control law algorithms for control of pitching wings and forebodies; (2) vorticity control on three-dimensional swept wings at high angles of attack; and (3) vortex control on forebody models at high angles of attack with unsteady motions. The three areas were investigated in parallel by laboratory experiment and numerical simulations. The numerical simulations examined the ability of distributed suction to control the flow over an airfoil undergoing a pitch-up motio n and sinusoidal oscillation. Experiments on the feasibility of controlling dynamic stall using leading-edge suction were conducted. by studying the influence of different parameters such as pitch rate, Reynolds number, suction timing, suction slot size and location, a scaling law for the suction flow rate was developed. The third area of investigation involved closed-loop control of forebody flow vortex asymmetry. by incorporating a closed-loop system, the desired side force could be maintained under a variety of different pitching. The relative performance of linear, nonlinear and neural network control algorithms was explored.
DTIC

Flight Control; Aerodynamic Stability; Algorithms; Neural Nets; Size (Dimensions); Loads (Forces); Numerical Analysis; Swept Wings; Leading Edges; Feedback Control

19960047381 Naval Air Warfare Center, Aircraft Div., Patuxent River, MD USA
Flight Control Computer Development Through Application of Software Safety Technology
Gill, Janet A., Naval Air Warfare Center, USA; Oct. 1995; 36p; In English
Report No.(s): AD-A305293; No Copyright; Avail: CASI; A03, Hardcopy; A01, Microfiche

This presentation provides an overview of Software Safety Assurance, and includes a practical example as applied to the Vehicle Management System as a part of the V-22 Engineering Manufacturing Development Program. The following topics are addressed: What is Software Safety Assurance? Software Safety Assurance Mission Software Safety Assurance Program Analysis Techniques
DTIC

Software Engineering; Flight Control; Aircraft Safety; Computer Programs; Computer Design; Airborne/Spaceborne Computers

19960047575 Naval Air Warfare Center, Aircraft Div., Warminster, PA USA
Development of Lateral-Directional Transfer Functions for Class 4 Aircraft with Level 1 Flying Qualities ***Final Report, Oct. 1993 - Sep. 1994***
Booz, Julieta E., Naval Air Warfare Center, USA; Dec. 1995; 64p; In English
Report No.(s): AD-A307008; NAWCADWAR-95030-4.3; No Copyright; Avail: Issuing Activity (Defense Technical Information Center (DTIC)), Microfiche

This report describes the computer program that was developed to support the effort currently being conducted at C. S. Draper Laboratory, Inc. to develop a hybrid, learning augmented, lateral-directional flight control system. The output from the computer program is a set of transfer functions for trimmed flight conditions which can be used to describe representative F-18 time histories. The transfer functions meet the Level 1 Flying Qualities Requirements of MlL-F8785C for Flight Phase Categories A and B of the F-18's flight envelope. These include roll angle, roll rate, sideslip, yaw rate and lateral acceleration to lateral stick and pedal inputs. The computer program was written in visual Basic and the coefficients to the transfer functions are written to an output file.
DTIC

Flight Control; Aerodynamic Characteristics; Aircraft Performance; F-18 Aircraft; Flight Characteristics; Angles (Geometry); Transfer Functions; Yaw; Lateral Control; Aerodynamic Balance

19960048242 Wright Lab., Wright-Patterson AFB, OH USA
Interactive Flying Qualities Toolbox for MATLAB User's Guide, Volume 1, Short Term Pitch Response Criteria and Modified Optimal Control Pilot Model ***Final Report, 1 Aug. 1994 - 1 Aug. 1995***
Doman, David B., Wright Lab., USA; Aug. 1995; 113p; In English
Contract(s)/Grant(s): AF Proj. 2403
Report No.(s): AD-A305053; WL-TR-95-3070-Vol-1; No Copyright; Avail: CASI; A06, Hardcopy; A02, Microfiche

Aircraft flying qualities are of fundamental importance to aircraft designers and flight control engineers. An integrated efficient software tool has been developed for the purpose of predicting the short term pitch response flying qualities of an aircraft. All short term pitch response criteria of MIL-STD-1797-A are included as well as some additional criteria found in the literature. A general pilot modeling tool is also provided with this package. This report covers how to install and use the software and contains reference material for developers who wish to expand its' capabilities. The software was developed as a MATLAB(TM) Toolbox and is designed to be very easy to use. It can greatly reduce the amount of time and effort involved in a handling qualities analysis.
DTIC

Aircraft Performance; Flight Characteristics; Flight Control; Aircraft Design; User Manuals (Computer Programs); Pitching Moments

19960048458 NASA Langley Research Center, Hampton, VA USA

Modeling of Aircraft Unsteady Aerodynamic Characteristics/Part 3 - Parameters Estimated from Flight Data, Part 3, Parameters Estimated from Flight Data

Klein, Vladislav, Joint Inst. for Advancement of Flight Sciences, USA; Noderer, Keith D., Joint Inst. for Advancement of Flight Sciences, USA; May 1996; 48p; In English

Contract(s)/Grant(s): RTOP 505-64-52-01

Report No.(s): NASA-TM-110259; NAS 1.15:110259; No Copyright; Avail: CASI; A03, Hardcopy; A01, Microfiche

A nonlinear least squares algorithm for aircraft parameter estimation from flight data was developed. The postulated model for the analysis represented longitudinal, short period motion of an aircraft. The corresponding aerodynamic model equations included indicial functions (unsteady terms) and conventional stability and control derivatives. The indicial functions were modeled as simple exponential functions. The estimation procedure was applied in five examples. Four of the examples used simulated and flight data from small amplitude maneuvers to the F-18 HARV and X-31A aircraft. In the fifth example a rapid, large amplitude maneuver of the X-31 drop model was analyzed. From data analysis of small amplitude maneuvers ft was found that the model with conventional stability and control derivatives was adequate. Also, parameter estimation from a rapid, large amplitude maneuver did not reveal any noticeable presence of unsteady aerodynamics.

Author

X-31 Aircraft; F-18 Aircraft; Aerodynamic Characteristics; Unsteady Aerodynamics; Stability Derivatives; Applications Programs (Computers)

19960053303

Complementary flight control system for backside landing

Chubachi, Tatsuo, Iwate Univ, Japan; Kamimura, Makoto; Ohta, Hirobumi; Transactions of the Japan Society for Aeronautical and Space Sciences; August 1996; ISSN 0549-3811; vol. 39, no. 124, pp. 147-172; In English; Copyright; Avail: Issuing Activity

This paper is concerned with a complementary flight control system to assist the pilot's steering for the backside landing. A simple flight control system is designed using a PID perfect servo, which is effective to the control of non-minimum phase and time dependent plant. Many favourable simulation results are obtained which will substantiate the sufficient robust stability of present methods.

Author (EI)

Aircraft Landing; Computerized Simulation; Flight Paths; Proportional Control

10 ASTRONAUTICS

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

19960047140 NASA Langley Research Center, Hampton, VA USA

Subsonic Aerodynamic Characteristics of a Circular Body Earth-to-Orbit Vehicle

Lepsch, Roger A., Jr., NASA Langley Research Center, USA; Ware, George M., NASA Langley Research Center, USA; MacConochie, Ian O., Lockheed Engineering and Sciences Co., USA; Jul. 1996; 34p; In English

Contract(s)/Grant(s): RTOP 242-20-08-01

Report No.(s): NASA-TM-4726; L-17429; NAS 1.15:4726; No Copyright; Avail: CASI; A03, Hardcopy; A01, Microfiche

A test of a generic reusable earth-to-orbit transport was conducted in the 7- by 10-Foot high-speed tunnel at the Langley Research Center at Mach number 0.3. The model had a body with a circular cross section and a thick clipped delta wing as the major lifting surface. For directional control, three different vertical fin arrangements were investigated: a conventional aft-mounted center vertical fin, wingtip fins, and a nose-mounted vertical fin. The configuration was longitudinally stable about the estimated center-of-gravity position of 0.72 body length and had sufficient pitch-control authority for stable trim over a wide range of angle of attack, regardless of fin arrangement. The maximum trimmed lift/drag ratio for the aft center-fin configuration was less than 5, whereas the other configurations had values of above 6. The aft center-fin configuration was directionally stable for all angles of attack tested. The wingtip and nose fins were not intended to produce directional stability but to be active controllers for artificial stabilization. Small rolling-moment values resulted from yaw control of the nose fin. Large adverse rolling-moment increments resulted from tip-fin controller deflection above 13 deg angle of attack. Flow visualization indicated that the adverse rolling-moment increments were probably caused by the influence of the deflected tip-fin controller on wing flow separation.

Author

Wind Tunnel Tests; Delta Wings; Angle of Attack; Rolling Moments; Flow Visualization; Subsonic Flow; Wind Tunnel Models; Fins; Satellite Control; Directional Control; Lift Drag Ratio

19960050134 Moscow Inst. of Aviation Technology, USSR

Force Measurements in Magnetic Suspension and Balance System

Kuzin, Alexander, Moscow Inst. of Aviation Technology, USSR; Shapovalov, George, Tsentralni Aerogidrodinamicheskii Inst., USSR; Prohorov, Nikolay, MERA Ltd. Co., Russia; Third International Symposium on Magnetic Suspension Technology; Jul. 1996; vol. Part 2, pp. 493-503; In English; Also announced as 19960050126; No Copyright; Avail: CASI; A03, Hardcopy; A04, Microfiche

The description of an infrared telemetry system for measurement of drag forces in Magnetic Suspension and Balance Systems (MSBS) is presented. This system includes a drag force sensor, electronic pack and transmitter placed in the model which is of special construction, and receiver with a microprocessor-based measuring device, placed outside of the test section. Piezosensitive resonators as sensitive elements and non-magnetic steel as the material for the force sensor are used. The main features of the proposed system for load measurements are discussed and the main characteristics are presented.

Author

Magnetic Suspension; Infrared Instruments; Telemetry; Drag Measurement; Wind Tunnel Tests; Aerodynamic Drag

19960050546 Aerojet-General Corp., Sacramento, CA USA

Aerodynamic Performance of a Round-to-Square Nozzle

Nguyen, T. V., Aerojet-General Corp., USA; Spencer, R. G., Aerojet-General Corp., USA; Siebenhaar, A., Aerojet-General Corp., USA; 1995 JANNAF Propulsion Meeting; Dec. 1995; vol. 1, pp. 359-366; In English; Also announced as 19960050521

Contract(s)/Grant(s): F04611-92-C-0001; No Copyright; Avail: CPIA, 10630 Little Patuxent Pkwy., Suite 202, Columbia, MD 21044-3200 HC, Hardcopy, Microfiche

The concept of a modular engine using small thrust cells is a viable and promising propulsion system for future launch and space flight vehicles. In this concept, several thrust cells are mounted either around a plug nozzle or expansion-deflection nozzle, or simply as a cluster of separate rocket engines. The modular engine would be compact, light weight, and convenient for vehicle/engine integration. It is especially suited for single-stage-to-orbit spacecraft. Packaging of the thrust cells is greatly improved if the exit nozzles of the thrust cells can be made in square or rectangular shapes rather than the conventional round shape. The square or rectangular nozzle exists also provide better transition for flow from the thrust cells to an external nozzle shroud, resulting in less performance loss in the external nozzle. A procedure has been devised to calculate the aerodynamic performance of convergent-divergent nozzles with square or rectangular exit shapes. The procedure was applied to calculate the performance of a 30:1 area ratio nozzle with a round to square transition. The calculated results showed that the performance of this nozzle was very high. The vacuum thrust coefficient for such a nozzle was approximately 1.864 (99.45 percent of a conventional, optimally-contoured, round nozzle with the same length and expansion area ratio).

Author

Convergent-Divergent Nozzles; Plug Nozzles; Rocket Engine Design; Aerodynamic Characteristics; Nozzle Geometry; Mass Flow Factors; Shrouded Nozzles

11
CHEMISTRY AND MATERIALS

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

19960048214 Federal Aviation Administration, Airport and Aircraft Research and Development., Atlantic City, NJ USA

International Aircraft materials fire test working group: Material systems renovation and repair subgroup.

Marker, Timothy, Federal Aviation Administration, USA; Feb. 01, 1996; 37p; In English

Report No.(s): DOT/FAA/AR-TN9583; No Copyright; Avail: CASI; A03, Hardcopy; A01, Microfiche

In an effort to simplify the often complex task of certifying material fire testing methods throughout the aviation/aerospace industry, the International Aircraft Materials Fire Test Working Group was formed. The scope of the working group encompasses the standardization of FAA certification procedures of all material fire tests as well as the solving of new problems which exist with the current test methods. The working group investigates such tests as the Bunsen burner, the 2-gallon per hour seat fire blocking and cargo liner tests, the OSU rate of heat release apparatus, and the NBS smoke chamber. Due to the ever changing environment in which materials are developed, it is often necessary to make adjustments and refine elements of these certification tests to accommodate state-of-the-art materials used in the latest cabin interior systems. There is also a high level of complexity associated with these and other fire tests, and unforeseen problems often arise that need to be addressed to insure that certification tests conducted throughout the United States and foreign countries are performed equally and consistently, according to the intent of the FAR's.

Author

Heat Transfer; Aircraft Safety; Fires; Fire Prevention; Certification; Evaluation; Standardization; Regulations; Aircraft Industry; Aircraft Compartments

19960048186 Naval Air Warfare Center, Aircraft Div., Patuxent River, MD USA

Fatigue Initiation Study of Investment CAST Ti-6A1-4V Alloy

Hurd, D. S., Naval Air Warfare Center, USA; Lee, E. W., Naval Air Warfare Center, USA; Nov. 1995; 19p; In English

Report No.(s): AD-A305154; No Copyright; Avail: CASI; A03, Hardcopy; A01, Microfiche

This report describes how Investment cast titanium and aluminum alloys save material/labor/time/cost compared to wrought materials. The Navy goals include improved quality investment through the use of cast Ti-6A1-4V parts for the V-22 program; and fatigue-critical airframe parts. Since fatigue initiation dominates lifetime, problem areas in castings are: residual porosity, inclusions, and effective grain size; fatigue initiation; and microstructure. Defect data are required to optimize casting and HIPing parameters.

DTIC

V-22 Aircraft; Aluminum Alloys; Airframes; Investment Casting; Titanium Alloys; Cost Reduction; Cast Alloys

19960047469 McDonnell-Douglas Aerospace, Saint Louis, MO USA

Determination of the effectiveness of nonchromated conversion coatings for use with IVD aluminum coatings ***Final Report, Oct. 1993 - Jun. 1995***

Fournier, James A., McDonnell-Douglas Aerospace, USA; Reilly, Jim J., McDonnell-Douglas Aerospace, USA; Feb. 1996; 155p; In English

Contract(s)/Grant(s): F08635-94-C-0004

Report No.(s): AD-A306120; AL/EQ-TR-1995-0028; No Copyright; Avail: Issuing Activity (Defense Technical Information Center (DTIC)), Microfiche

The Air Force Air Logistics Centers (ALCs) have either recently eliminated or have plans to eliminate the usage of cadmium processing for the maintenance and overhaul of aircraft. The thrust of their effort is the elimination of the hazardous cadmium waste streams. The replacement process, ion vapor deposition (IVD) of aluminum, is free of the environmental problems associated with cadmium processing. However, as for cadmium processing, it still requires subsequent treatment with a chromate conversion coating which contains a known carcinogen. This program, then, addressed the effectiveness of nonchromated conversion coatings for use with IVD aluminum coatings. It concentrated on conversion coatings which were also being evaluated by the Aerospace Industry as replacements for chromated conversion coatings on bare aluminum alloys. IVD aluminum-coated steel and aluminum panels, and IVD aluminum-coated steel and titanium fasteners were treated with various candidate nonchromated conversion coatings and then subjected to various environmental exposures. The objective of this program was met in that a nonhazardous conversion coating, which could replace chromate conversion coating on IVD aluminum coatings, was identified and verified.

DTIC

Vapor Deposition; Aluminum Coatings; Ions; Aerospace Industry; Aircraft Maintenance; Aluminum Alloys; Titanium; Carcinogens; Cadmium; Steels; Logistics

19960047659 Texas Univ., Dept. of Mechanical and Aerospace Engineering., Arlington, TX USA

Use of Smart Structures for Control and Performance Improvement of Hypersonic Vehicles

August, James A., Texas Univ., USA; Joshi, Shiv, Texas Univ., USA; Proceedings of the 4th Annual Workshop: Advances in Smart Materials for Aerospace Applications; Mar. 1996, pp. 182-186; In English; Also announced as 19960047656; No Copyright; Avail: CASI; A01, Hardcopy; A03, Microfiche

The objective of this presentation was to point out the fact that there are many promising applications for smart structures technology on hypersonic vehicles. This is not inherently obvious due to the real and perceived operating environments of hypersonic vehicles. The idea behind this project was to talk to hypersonic vehicle designers and academics to find out what sort of problems could be solved with smart structures. Two main conclusions can be drawn: One is that the actual environment inside a hypersonic vehicle is not always as severe as it appears. The second is that the hypersonic community needs a different type of research done on a faster timetable in order to use smart structures technology. Vehicle design cycle times are such that a technology must be proven before the vehicle is designed.

Derived from text

Hypersonic Vehicles; Structural Engineering; Aircraft Construction Materials; Smart Structures; Missile Design; Aircraft Design

19960047661 NASA Langley Research Center, Hampton, VA USA

The Piezoelectric Aeroelastic Response Tailoring Investigation

McGowan, Anna-Maria Rivas, NASA Langley Research Center, USA; Proceedings of the 4th Annual Workshop: Advances in Smart Materials for Aerospace Applications; Mar. 1996, pp. 191-195; In English; Also announced as 19960047656; No Copyright; Avail: CASI; A02, Hardcopy; A03, Microfiche

The Piezoelectric Aeroelastic Response Tailoring Investigation (PARTI), a joint program between the NASA Langley Research Center and the Massachusetts Institute of Technology, was developed with the goal of advancing the state of the art in applying piezoelectric actuators to aeroelastic systems.The main objectives of this program are to develop detailed analytical and experimental techniques and demonstrate the ability of strain actuated adaptive wings to affect aeroelastic control. The PARTI wind-tunnel model is a five-foot long, transport style wing that was designed to flutter at low speeds to simplify aerodynamic analyses and wind-tunnel testing. The model consists of two primary structures: an exterior fiberglass shell used to obtain aerodynamic lift, and an interior composite plate that contains the piezoelectric actuators and acts as the main load carrying member. The PARTI

wind-tunnel test program consisted of two entries in the Transonic Dynamics Tunnel at NASA Langley. The first test was an open-loop test whose primary goal was to determine plant characteristics for control law design at subcritical speeds and to verify analytical models. The second test was a closed-loop test to investigate flutter suppression and reduced response at subcritical speeds.
Derived from text
Wind Tunnel Models; Wind Tunnel Tests; Dynamic Response; Aeroelasticity; Actuators; Piezoelectricity

19960047662 Old Dominion Univ., School of Aerospace and Mechanical Engineering., Norfolk, VA USA
Control of Thermal Deflection, Panel Flutter and Acoustic Fatigue at Elevated Temperatures Using Shape Memory Alloys
Mei, Chuh, Old Dominion Univ., USA; Huang, Jen-Kuang, Old Dominion Univ., USA; Proceedings of the 4th Annual Workshop: Advances in Smart Materials for Aerospace Applications; Mar. 1996, pp. 197-201; In English; Also announced as 19960047656; No Copyright; Avail: CASI; A02, Hardcopy; A03, Microfiche

The High Speed Civil Transport (HSCT) will have to be designed to withstand high aerodynamic load at supersonic speeds (panel flutter) and high acoustic load (acoustic or sonic fatigue) due to fluctuating boundary layer or jet engine acoustic pressure. The thermal deflection of the skin panels will also alter the vehicle's configuration, thus it may affect the aerodynamic characteristics of the vehicle and lead to poor performance. Shape memory alloys (SMA) have an unique ability to recover large strains completely when the alloy is heated above the characteristic transformation (austenite finish T(sub f)) temperature. The recovery stress and elastic modulus are both temperature dependent, and the recovery stress also depends on the initial strain. An innovative concept is to utilize the recovery stress by embedding the initially strained SMA wire in a graphite/epoxy composite laminated panel. The SMA wires are thus restrained and large inplane forces are induced in the panel at elevated temeperatures. by embedding SMA in composite panel, the panel becomes much stiffer at elevated temperatures. That is because the large tensile inplane forces induced in the panel from the SMA recovery stress. A stiffer panel would certainly yield smaller dynamic responses.
Derived from text
Shape Memory Alloys; Supersonic Transports; Acoustic Fatigue; Graphite-Epoxy Composites; Dynamic Response; Composite Structures; Temperature Dependence; Panel Flutter; Aircraft Structures; Embedding

12
ENGINEERING

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

19960047285 Civil Aeromedical Inst., Oklahoma City, OK USA
Aviation Topics Speech Acts Taxonomy (ATSAT) pc User's Guide Version 2.0 ***Final Report***
Prinzo, O. Veronika, Civil Aeromedical Inst., USA; Maclin, Otto, Civil Aeromedical Inst., USA; Aug. 1996; 28p; In English
Contract(s)/Grant(s): DTFA02-91-C-91089
Report No.(s): DOT/FAA/AM-96/20; No Copyright; Avail: CASI; A03, Hardcopy; A01, Microfiche

ATSATpc is a Windows (tm) based software program designed to facilitate posting of transcribed voice communications data into a pre-defined electronic spreadsheet. The steps involved in processing air traffic control communications using ATSATpc coincide with the steps that must be followed when manually encoding communications according to the procedures outlined in Development of a Coding Form for Approach Control/Pilot Voice Communications (Prinzo, Britton, & Hendrix, 1995).
Author
Air Traffic Control; Approach Control; Coding; Voice Communication; Applications Programs (Computers); Ground-Air-Ground Communication; User Manuals (Computer Programs)

19960050478 Physics and Electronics Lab. TNO, The Hague, Netherlands
System Architecture Study ROBIN2 ***Architectuuronderzoek ROBIN2***
Furth, B., Physics and Electronics Lab. TNO, Netherlands; Apr. 1996; 76p; In Dutch
Contract(s)/Grant(s): A92KLu743; TNO Proj. 23279
Report No.(s): TNO-FEL-95-A134; TD95-1049; Copyright; Avail: Issuing Activity (Physics and Electronics Lab. TNO, PO Box 96864, 2509 JG The Hague, The Netherlands), Hardcopy, Microfiche

This report describes an effort to define and select a computer system architecture for a radar data processing system to replace the existing Radar Observation of Bird INtensity (ROBIN) system used by the Royal Netherlands Air Force to monitor bird migration. The new system, to be called ROBIN2, will provide for advanced bird detection algorithms and will be implemented on a state-of-the-art computer/software configuration. This report describes the systems requirement study and a high level design for ROBIN2. Based on these, the

systems architecture iss defined, several systems are evaluated, and one is selected.
Derived from text
Architecture (Computers); Computer Programs; Radar Data; Bird-Aircraft Collisions; Flight Hazards; Ingestion (Engines); Aircraft Hazards; Radar Tracking

19960045755 Old Dominion Univ., Research Foundation., Norfolk, VA USA
Nonlinear stability of supersonic jets
Tiwari, S. N., Principal Investigator, Old Dominion Univ., USA; Bhat, T. R. S., Principal Investigator, Old Dominion Univ., USA; Sep. 1996; 31p; In English
Contract(s)/Grant(s): NAG1-1518
Report No.(s): NASA-CR-202199; NAS 1.26:202199; No Copyright; Avail: CASI; A03, Hardcopy; A01, Microfiche

The stability calculations made for a shock-free supersonic jet using the model based on parabolized stability equations are presented. In this analysis the large scale structures, which play a dominant role in the mixing as well as the noise radiated, are modeled as instability waves. This model takes into consideration non-parallel flow effects and also nonlinear interaction of the instability waves. The stability calculations have been performed for different frequencies and mode numbers over a range of jet operating temperatures. Comparisons are made, where appropriate, with the solutions to Rayleigh's equation (linear, inviscid analysis with the assumption of parallel flow). The comparison of the solutions obtained using the two approaches show very good agreement.
Author
Supersonic Jet Flow; Aerodynamic Stability; Nonlinearity; Parabolic Differential Equations; Parallel Flow; Rayleigh Equations; Operating Temperature; Aircraft Structures; Linearity; Aerodynamic Noise; Shock Waves; Jet Aircraft Noise; Navier-Stokes Equation

19960047099 Old Dominion Univ., Dept. of Mechanical Engineering., Norfolk, VA USA
Methodology for Sensitivity Analysis, Approximate Analysis, and Design Optimization in CFD for Multidisciplinary Applications ***Final Report, period ended 31 Dec. 1995***
Taylor, Arthur C., III, Old Dominion Univ., USA; Hou, Gene W., Old Dominion Univ., USA; Aug. 1996; 153p; In English
Contract(s)/Grant(s): NAG1-1265
Report No.(s): NASA-CR-201941; NAS 1.26:201941; No Copyright; Avail: CASI; A08, Hardcopy; A02, Microfiche

An incremental iterative formulation together with the well-known spatially split approximate-factorization algorithm, is presented for solving the large, sparse systems of linear equations that are associated with aerodynamic sensitivity analysis. This formulation is also known as the 'delta' or 'correction' form. For the smaller two dimensional problems, a direct method can be applied to solve these linear equations in either the standard or the incremental form, in which case the two are equivalent. However, iterative methods are needed for larger two-dimensional and three dimensional applications because direct methods require more computer memory than is currently available. Iterative methods for solving these equations in the standard form are generally unsatisfactory due to an ill-conditioned coefficient matrix; this problem is overcome when these equations are cast in the incremental form. The methodology is successfully implemented and tested using an upwind cell-centered finite-volume formulation applied in two dimensions to the thin-layer Navier-Stokes equations for external flow over an airfoil. In three dimensions this methodology is demonstrated with a marching-solution algorithm for the Euler equations to calculate supersonic flow over the High-Speed Civil Transport configuration (HSCT 24E). The sensitivity derivatives obtained with the incremental iterative method from a marching Euler code are used in a design-improvement study of the HSCT configuration that involves thickness. camber, and planform design variables.
Author
Aerodynamic Characteristics; Linear Equations; Matrices (Mathematics); Iterative Solution; Navier-Stokes Equation; Airfoils; Computational Fluid Dynamics; Supersonic Flow

19960047203 Old Dominion Univ., Norfolk, VA USA
A quiet tunnel investigation of hypersonic boundary-layer stability over a cooled, flared cone ***Final Report, Period Ended 15 Feb. 1996***
Blanchard, Alan E., Old Dominion Univ., USA; Selby, Gregory V., Old Dominion Univ., USA; Wilkinson, Stephen P., NASA Langley Research Center, USA; Sep. 1996; 30p; In English
Contract(s)/Grant(s): NCC1-180
Report No.(s): NASA-CR-202200; NAS 1.26:202200; No Copyright; Avail: CASI; A03, Hardcopy; A01, Microfiche

A flared-cone model under adiabatic and cooled-wall conditions was placed in a calibrated, low-disturbance Mach 6 flow and the stability of the boundary layer was investigated using a prototype constant-voltage anemometer. The results were compared with linear-stability theory predictions and good agreement was found in the prediction of second-mode frequencies and growth. In addition, the same 'N = 10' criterion used to predict boundary-layer transition in subsonic, transonic, and supersonic flows under low freestream noise conditions was found to be applicable for the hypersonic flow regime as well. Under cooled-wall conditions, a unique set of spectral data was acquired that documents the linear, nonlinear, and breakdown regions associated with the transition of hypersonic flow under low-noise conditions.
Author
Adiabatic Conditions; Boundary Layer Stability; Boundary Layer Transition; Hypersonic Flow; Low Noise; Linear Prediction; Wind Tunnel Tests; Wall Temperature; Aerodynamic Noise; Nose Cones; Nozzle Walls; Flow Distribution

19960047746 Cincinnati Univ., OH USA
A Study of Asymmetric Vortex Shedding Behind Missiles at High Angle of Attack Using Dynamic Solution Adaptive Meshes ***Final Report, Jun. 1992 - Aug. 1995***
Orkwis, Paul D., Cincinnati Univ., USA; Oct. 09, 1995; 9p; In English
Contract(s)/Grant(s): DAAL03-92-G-0240
Report No.(s): AD-A304583; No Copyright; Avail: CASI; A02, Hardcopy; A01, Microfiche

Vortices about the leeward side of cones at incidence become asymmetric past a critical incidence ratio. They consequently produce large side forces that lead to in flight control and maneuverability problems. The origins of this asymmetry have yet to be fully understood. Questions exist as to the nature of the asymmetry instability, the bifurcation process that occurs as the solution transitions from symmetric to asymmetric, and the numerical requirements for its computation. The reported research was initiated to seek answers to these questions.
DTIC
Vortices; Vortex Shedding; Angle of Attack; Flight Control; Maneuverability

19960048096 Institute for Computer Applications in Science and Engineering, Hampton, VA USA
Nonlinear axisymmetric and three-dimensional vorticity dynamics in a swirling jet model ***Final Report***
Martin, J. E., Christopher Newport Coll., USA; Meiburg, E., University of Southern California, USA; May 1996; 30p; In English
Contract(s)/Grant(s): NAS1-19480; NSF CTS-9196004; RTOP 505-90-52-01
Report No.(s): NASA-CR-198343; NAS 1.26:-198343; ICASE-96-41; No Copyright; Avail: CASI; A03, Hardcopy; A01, Microfiche

The mechanisms of vorticity concentration, reorientation, and stretching are investigated in a simplified swirling jet model, consisting of a line vortex along the jet axis surrounded by a jet shear layer with both azimuthal and streamwise vorticity. Inviscid three-dimensional vortex dynamics simulations demonstrate the nonlinear interaction and competition between a centrifugal instability and Kelvin-Helmholtz instabilities feeding on both components of the base flow vorticity. Under axisymmetric flow conditions, it is found that the swirl leads to the emergence of counterrotating vortex rings, whose circulation, in the absence of viscosity, can grow without bounds. Scaling laws are provided for the growth of these rings, which trigger a pinch-off mechanism resulting in a strong decrease of the local jet diameter. In the presence of an azimuthal disturbance, the nonlinear evolution of the flow depends strongly on the initial ratio of the azimuthal and axisymmetric perturbation amplitudes. The long term dynamics of the jet can be dominated by counterrotating vortex rings connected by braid vortices, by like-signed rings and streamwise braid vortices, or by wavy streamwise vortices alone.
Author
Vorticity; Aircraft Models; Three Dimensional Motion; Swirling; Computational Fluid Dynamics

19960050484 North Carolina State Univ., Raleigh, NC USA
Numerical solutions of the complete Navier-Strokes equations, no. 27 ***Interim Report, 1 Oct. 1995-30 Sep. 1996***
Hassan, H. A., North Carolina State Univ., USA; Sep. 30, 1996; 38p; In English
Contract(s)/Grant(s): NAG-1-244
Report No.(s): NASA-CR-202246; NAS 1.26:202246; No Copyright; Avail: CASI; A03, Hardcopy; A01, Microfiche

This report describes the development of an enstrophy model capable of predicting turbulence separation and its application to two airfoils at various angles of attack and Mach numbers. In addition, a two equation kappa-xi model with a tensor eddy viscosity was developed. Plans call for this model to be used in calculating three dimensional turbulent flows.
Derived from text
Three Dimensional Flow; Navier-Stokes Equation; Turbulent Flow; Airfoils; Aerodynamic Characteristics; Vortices; Boundary Layer Separation; Eddy Viscosity; Numerical Analysis; Pressure Gradients; Flow Velocity

19960051732 NASA Lewis Research Center, Cleveland, OH, USA
Numerical simulation of dynamic wave rotor performance
Paxson, Daniel E., NASA Lewis Research Cent, USA; Journal of Propulsion and Power; September 1996; ISSN 0748-4658; vol. 12, no. 5, pp. 949-957; In English; Copyright; Avail: Issuing Activity

A numerical model has been developed that can simulate the dynamic (and steady-state) performance of a wave rotor, given the geometry and time-dependent boundary conditions. The one-dimensional, perfect-gas, computational fluid dynamics-based code tracks the gasdynamics in each of the wave rotor passages as they rotate past the various ducts. The model can operate both on and off-design, allowing dynamic behavior to be studied throughout the operating range of the wave rotor. The model accounts for several major loss mechanisms including finite passage opening time, fluid friction, heat transfer to and from the passage walls, and leakage to and from the passage ends. In addition it can calculate the amount of work transferred to or from the fluid when the flow in the ducts is not aligned with the passages such as occurs in off-design operation. Since it is one-dimensional, the model runs reasonably fast on a typical workstation. This article will describe the model and present the results of some transient calculations for a conceptual four-port wave rotor designed as a topping cycle for a small gas-turbine engine.
Author (EI)

Boundary Conditions; Computerized Simulation; Ducts; Gas Dynamics; Geometry; Rotors

19960051721
High speed driving of a gain-switched laser diode with an exponential transmission line
Li, Zheng, Beijing Univ, China; Su, Yilcai; Tang, Yueping; IEEE Aerospace and Electronic Systems Magazine; September 1996; ISSN 0885-8985; vol. 11, no. 9, pp. 4-7; In English; Copyright; Avail: Issuing Activity

With the increase of information capacity of an airborne system, high speed driving of laser diodes have been of interest. In order to match the low resistive LD, proposed in this paper is an exponential transmission line, which is used as preshaping to compensate the pattern effect in gain switching of laser diodes. It also will be used to overcome the effect of parasitic elements in high speed driving to improve the rise and trail edges of the output waveform. An accurate circuit model of the exponential line for the PSPICE program has been developed and simulations are conveniently carried out by employing PSPICE.
Author (EI)
Aircraft Communication; Applications Programs (Computers); High Speed; Mathematical Models; Power Lines; Semiconductor Lasers; Switching; Transmission Lines; Waveforms

19960046982 NASA Lewis Research Center, Cleveland, OH USA
Cascade Optimization Strategy for Aircraft and Air-Breathing Propulsion System Concepts
Patnaik, Surya N., Ohio Aerospace Inst., USA; Lavelle, Thomas M., NASA Lewis Research Center, USA; Hopkins, Dale A., NASA Lewis Research Center, USA; Coroneos, Rula M., NASA Lewis Research Center, USA; Jul. 1996; 14p; In English; 6th; Symposium on Multidisciplinary Analysis and Optimization, 4-6 Sep. 1996, Bellevue, WA, USA; Sponsored by American Inst. of Aeronautics and Astronautics, USA
Contract(s)/Grant(s): RTOP 505-63-5B
Report No.(s): NASA-TM-107278; E-10346; NAS 1.15: 107278; AIAA Paper 96-4145; No Copyright; Avail: CASI; A03, Hardcopy; A01, Microfiche

Design optimization for subsonic and supersonic aircraft and for air-breathing propulsion engine concepts has been accomplished by soft-coupling the Flight Optimization System (FLOPS) and the NASA Engine Performance Program analyzer (NEPP), to the NASA Lewis multidisciplinary optimization tool COMETBOARDS. Aircraft and engine design problems, with their associated constraints and design variables, were cast as nonlinear optimization problems with aircraft weight and engine thrust as the respective merit functions. Because of the diversity of constraint types and the overall distortion of the design space, the most reliable single optimization algorithm available in COMETBOARDS could not produce a satisfactory feasible optimum solution. Some of COMETBOARDS' unique features, which include a cascade strategy, variable and constraint formulations, and scaling devised especially for difficult multidisciplinary applications, successfully optimized the performance of both aircraft and engines. The cascade method has two principal steps: In the first, the solution initiates from a user-specified design and optimizer, in the second, the optimum design obtained in the first step with some random perturbation is used to begin the next specified optimizer. The second step is repeated for a specified sequence of optimizers or until a successful solution of the problem is achieved. A successful solution should satisfy the specified convergence criteria and have several active constraints but no violated constraints. The cascade strategy available in the combined COMETBOARDS, FLOPS, and NEPP design tool converges to the same global optimum solution even when it starts from different design points. This reliable and robust design tool eliminates manual intervention in the design of aircraft and of air-breathing propulsion engines where it eases the cycle analysis procedures. The combined code is also much easier to use, which is an added benefit. This paper describes COMETBOARDS and its cascade strategy and illustrates the capability of the combined design tool through the optimization of a subsonic aircraft and a high-bypass-turbofan wave-rotor-topped engine.
Author
Air Breathing Engines; Aircraft Design; Aircraft Engines; Engine Design; Thrust-Weight Ratio; Turbofan Engines; Multidisciplinary Design Optimization; Computer Aided Design

19960047496 NASA Lewis Research Center, Cleveland, OH USA
ASTROP2 Users Manual: A Program for Aeroelastic Stability Analysis of Propfans
Reddy, T. S. R., Toledo Univ., USA; Lucero, John M., NASA Lewis Research Center, USA; Mar. 1996; 48p; In English
Contract(s)/Grant(s): NAG-1137; RTOP 538-06-13
Report No.(s): NASA-TM-107195; E-10174; NAS 1.15: 107195; No Copyright; Avail: CASI; A03, Hardcopy; A01, Microfiche

This manual describes the input data required for using the second version of the ASTROP2 (Aeroelastic STability and Response of Propulsion systems - 2 dimensional analysis) computer code. In ASTROP2, version 2.0, the program is divided into two modules: 2DSTRIP, which calculates the structural dynamic information; and 2DASTROP, which calculates the unsteady aerodynamic force coefficients from which the aeroelastic stability can be determined. In the original version of ASTROP2, these two aspects were performed in a single program. The improvements to version 2.0 include an option to account for counter rotation, improved numerical integration, accommodation for non-uniform inflow distribu-

tion, and an iterative scheme to flutter frequency convergence. ASTROP2 can be used for flutter analysis of multi-bladed structures such as those found in compressors, turbines, counter rotating propellers or propfans. The analysis combines a two-dimensional, unsteady cascade aerodynamics model and a three dimensional, normal mode structural model using strip theory. The flutter analysis is formulated in the frequency domain resulting in an eigenvalue determinant. The flutter frequency and damping can be inferred from the eigenvalues.
Author
Aeroelasticity; Aerodynamic Forces; Finite Element Method; Flutter; User Manuals (Computer Programs); Unsteady Aerodynamics; Contrarotating Propellers; Computer Programs

19960048016 NASA Lewis Research Center, Cleveland, OH USA
A General-Purpose Optimization Engine for Multi-Disciplinary Design Applications
Patnaik, Surya N., Ohio Aerospace Inst., USA; Hopkins, Dale A., NASA Lewis Research Center, USA; Berke, Laszlo, NASA Lewis Research Center, USA; Aug. 1996; 14p; In English; 6th; Multidisciplinary Analysis and Optimization Symposium, 4-6 Sep. 1996, Bellvue, WA, USA; Sponsored by American Inst. of Aeronautics and Astronautics, USA
Contract(s)/Grant(s): RTOP 505-63-5B
Report No.(s): NASA-TM-107314; NAS 1.15:107314; E-10409; AIAA Paper 96-4163; No Copyright; Avail: CASI; A03, Hardcopy; A01, Microfiche

A general purpose optimization tool for multidisciplinary applications, which in the literature is known as COMETBOARDS, is being developed at NASA Lewis Research Center. The modular organization of COMETBOARDS includes several analyzers and state-of-the-art optimization algorithms along with their cascading strategy. The code structure allows quick integration of new analyzers and optimizers. The COMETBOARDS code reads input information from a number of data files, formulates a design as a set of multidisciplinary nonlinear programming problems, and then solves the resulting problems. COMETBOARDS can be used to solve a large problem which can be defined through multiple disciplines, each of which can be further broken down into several subproblems. Alternatively, a small portion of a large problem can be optimized in an effort to improve an existing system. Some of the other unique features of COMETBOARDS include design variable formulation, constraint formulation, subproblem coupling strategy, global scaling technique, analysis approximation, use of either sequential or parallel computational modes, and so forth. The special features and unique strengths of COMETBOARDS assist convergence and reduce the amount of CPU time used to solve the difficult optimization problems of aerospace industries. COMETBOARDS has been successfully used to solve a number of problems, including structural design of space station components, design of nozzle components of an air-breathing engine, configuration design of subsonic and supersonic aircraft, mixed flow turbofan engines, wave rotor topped engines, and so forth. This paper introduces the COMETBOARDS design tool and its versatility, which is illustrated by citing examples from structures, aircraft design, and air-breathing propulsion engine design.
Author
Nonlinear Programming; Multidisciplinary Design Optimization; Parallel Processing (Computers); Applications Programs (Computers); Computer Aided Design; Structural Design; Aircraft Design; Engine Design; Aircraft Structures; Air Breathing Engines

19960048062 NASA Ames Research Center, Moffett Field, CA USA
A Thermostructural Analysis of a Diboride Composite Leading Edge
Kowalski, Tom, Eloret Corp., USA; Buesking, Kent, Mathematical Sciences Northwest, Inc., USA; Kolodziej, Paul, NASA Ames Research Center, USA; Bull, Jeff, NASA Ames Research Center, USA; Jul. 1996; 34p; In English; Original contains color illustrations
Contract(s)/Grant(s): RTOP 242-80-01
Report No.(s): NASA-TM-110407; A-962040; NAS 1.15:110407; No Copyright; Avail: CASI; A03, Hardcopy; A01, Microfiche

In an effort to support the design of zirconium diboride composite leading edges for hypersonic vehicles, a finite element model (FEM) of a prototype leading edge was created and finite element analysis (FEA) was employed to assess its thermal and structural response to aerothermal boundary conditions. Unidirectional material properties for the structural components of the leading edge, a continuous fiber reinforced diboride composite, were computed with COSTAR. These properties agree well with those experimentally measured. to verify the analytical approach taken with COSMOS/M, an independent FEA of one of the leading edge assembly components was also done with COSTAR. Good agreement was obtained between the two codes. Both showed that a unidirectional lay-up had the best margin of safety for a simple loading case. Both located the maximum stress in the same region and ply. The magnitudes agreed within 4 percent. Trajectory based aerothermal heating was then applied to the leading edge assembly FEM created with COSMOS/M to determine steady state temperature response, displacement, stresses, and contact forces due to thermal expansion and thermal strains. Results show that the leading edge stagnation line temperature reached 4700 F. The maximum computed failure index for the laminated composite components peaks at 4.2, and is located at the bolt flange in layer 2 of the side bracket. The temperature gradient in the tip causes a compressive stress of

279 ksi along its width and substantial tensile stresses within its depth.
Author
Leading Edges; Aerothermodynamics; Finite Element Method; Composite Materials; Tensile Stress; Aerodynamic Heating; Thermodynamic Properties; Compressive Strength; Structural Analysis

19960048076 NASA Langley Research Center, Hampton, VA USA
Correlation of Structural Analysis and Test Results for the McDonnell Douglas Stitched/RFI All-Composite Wing Stub Box
Wang, John T., NASA Langley Research Center, USA; Jegley, Dawn C., NASA Langley Research Center, USA; Bush, Harold G., NASA Langley Research Center, USA; Hinrichs, Stephen C., McDonnell-Douglas Aerospace, USA; Jul. 1996; 36p; In English
Contract(s)/Grant(s): RTOP 538-10-11-02
Report No.(s): NASA-TM-110267; NAS 1.15:110267; No Copyright; Avail: CASI; A03, Hardcopy; A01, Microfiche

The analytical and experimental results of an all-composite wing stub box are presented in this report. The wing stub box, which is representative of an inboard portion of a commercial transport high-aspect-ratio wing, was fabricated from stitched graphite-epoxy material with a Resin Film Infusion manufacturing process. The wing stub box was designed and constructed by the McDonnell Douglas Aerospace Company as part of the NASA Advanced Composites Technology program. The test article contained metallic load-introduction structures on the inboard and outboard ends of the graphite-epoxy wing stub box. The root end of the inboard load introduction structure was attached to a vertical reaction structure, and an upward load was applied to the outermost tip of the outboard load introduction structure to induce bending of the wing stub box. A finite element model was created in which the center portion of the wing-stub-box upper cover panel was modeled with a refined mesh. The refined mesh was required to represent properly the geometrically nonlinear structural behavior of the upper cover panel and to predict accurately the strains in the stringer webs of the stiffened upper cover panel. The analytical and experimental results for deflections and strains are in good agreement.
Author
Composite Structures; Finite Element Method; Graphite-Epoxy Composites; Wings; Strain Distribution; Bending; Commercial Aircraft; Aircraft Structures

19960048563 Air Force Inst. of Tech., Wright-Patterson AFB, OH USA
Fatigue Response of Cracked Aluminum Panel With Partially Bonded Composite Patch
Denney, Jason J., Air Force Inst. of Tech., USA; Dec. 1995; 179p; In English; Limited Reproducibility: More than 20% of this document may be affected by microfiche quality
Report No.(s): AD-A306361; AFIT/GAE/ENY/95D-7; No Copyright; Avail: Issuing Activity (Defense Technical Information Center (DTIC)), Microfiche

More and more aircraft, both commercial and military, are being called upon to fly well beyond their economic and structural service lives. Budget cuts and dwindling new aircraft development has forced the USA Air Force (USAF) to look toward more reliable structural repairs. One of these repair techniques, which was the subject of this study, is the repair of metallic aircraft structures using high strength composite materials. This study investigate d the fatigue response of a precracked, 508x1 52x1 mm, 2024-T3 aluminum panel repaired with a partially bonded, unidirectional, three-ply boron/epoxy composite reinforcement with ply lengths of 68, 56 and 50 mm and a width of 50 mm. Intentional disbonds were created in the bondline of the repair using teflon inserts to simulate defects seen in real applications due to service conditions or during manufacturing. The repaired panels were subjected to constant amplitude fatigue testing at a peak load of 120 MPa to study the damage and fatigue tolerance of partially bonded composite reinforcements to cracked aluminum panels. The effects of various disbond locations and sizes were investigated and compared to each other as well as to panels repaired with a completely bonded reinforcement and to cracked panels without any reinforcement. Five disbond locations were investigated. Also, the effect of disbond size varying from 5 to 20% of the total bond area for a few cases of disbond location was investigated. It was found that disbonds around the crack resulted in greater crack growth rates and reduced specimen life. The amount of patch efficiency reduction was a function of how much of the crack was covered by the disbond during growth within the patch as well as the size of the disbond perpendicular to the crack.
DTIC
Aircraft Structures; Tolerances (Mechanics); Teflon (Trademark); Panels; Maintenance; Bonded Joints; High Strength; Debonding (Materials); Damage; Crack Propagation; Boron-Epoxy Composites; Aluminum Alloys

19960049683 Lockheed Martin Corp., Hampton, VA USA
A study of facilities and fixtures for testing of a high speed civil transport wing component
Cerro, J. A., Lockheed Martin Corp., USA; Vause, R. F., Lockheed Martin Corp., USA; Bowman, L. M., Lockheed Martin Corp., USA; Jensen, J. K., Lockheed Martin Corp., USA; Martin, C. J., Jr., Lockheed Martin Corp., USA; Stockwell, A. E., Lockheed Martin Corp., USA; Waters, W. A., Jr., Lockheed Martin Corp., USA; Jul. 1996; 68p; In English
Contract(s)/Grant(s): NAS1-19000; RTOP 537-06-34
Report No.(s): NASA-CR-198352; NAS 1.26:198352; No Copyright; Avail: CASI; A04, Hardcopy; A01, Microfiche

A study was performed to determine the feasibility of testing a large-scale High Speed Civil Transport wing compo-

nent in the Structures and Materials Testing Laboratory in Building 1148 at NASA Langley Research Center. The report includes a survey of the electrical and hydraulic resources and identifies the backing structure and floor hard points which would be available for reacting the test loads. The backing structure analysis uses a new finite element model of the floor and backstop support system in the Structures Laboratory. Information on the data acquisition system and the thermal power requirements is also presented. The study identified the hardware that would be required to test a typical component, including the number and arrangement of hydraulic actuators required to simulate expected flight loads. Load introduction and reaction structure concepts were analyzed to investigate the effects of experimentally induced boundary conditions.
Author
X-30 Vehicle; Wings; Aerodynamic Loads; Test Chambers; Test Facilities; Finite Element Method; Loads (Forces); Supersonic Transports; Support Systems

19960050508 National Aerospace Lab., Tokyo, Japan
A Residual Strength Analysis of a Cracked Stiffened Panel with Stochastic Factors in Fastener Flexibility
Shoji, Hirokazu, National Aerospace Lab., Japan; Feb. 1996; ISSN 0389-4010; 16p; In English
Report No.(s): NAL-TR-1283T; No Copyright; Avail: CASI; A03, Hardcopy; A01, Microfiche

In this report, a residual strength analysis of a cracked stiffened panel was conducted on the basis of the displacement compatibility method, which is generally used as a handy tool. Stochastic factors in fastener flexibility are considered in the analysis by Monte Carlo simulation. The report outlines the displacement compatibility method, a method of taking in stochastic factors into account, some results ot'differences in stochastic distribution models in fastener flexibility, and some results of the analysis. The author shows that the stochastic flexibility coefficients in rivet fastening affect the residual strength estimation of a cracked stiffened panel considerably.
Author
Residual Strength; Panels; Cracks; Rigid Structures; Airframes; Stochastic Processes; Fasteners; Damage; Monte Carlo Method; Structural Analysis

19960050520 Organisatie voor Toegepast Natuurwetenschappelijk Onderzoek, Prins Maurits Lab., Rijswijk, Netherlands
Impact of High-Speed Fragments on Air Targets: An Exploratory Study ***Final Report Inslag van hoge-snelheidsfragmenten op luchtdoelen: een verkennende studie***
Van Ingen, R. P., Organisatie voor Toegepast Natuurwetenschappelijk Onderzoek, Netherlands; Jun. 1996; 30p; In Dutch
Contract(s)/Grant(s): A94KLu423; Proj. 231494329
Report No.(s): TD 96-0319; PML 1996-A14; Copyright; Avail: Issuing Activity (TNO, Prince Mautits Lab., P.O. Box 45, 2280 AA Rijswijk, The Netherlands), Hardcopy, Microfiche

The results of a literature study, a preliminary series of experiments and recommendations for research on the impact of high-velocity fragments on air targets are discussed. The literature study deals with such subjects as the Whipple shield, spall fragmentation models and experimental diagnostic techniques for the study of fragmentation effects. Since computerized simulation of fragmentation effects are shown to be unreliable, a proposal for further research is presented.
Derived from text
Penetration; Fragmentation; Impact Damage; High Speed; Targets; Shielding; Aircraft Survivability

13
GEOSCIENCES

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

19960048228 Army Construction Engineering Research Lab., Champaign, IL USA
Effects of Military Noise on Wildlife: A Literature Review ***Final Report***
Larkin, Ronald P., Army Construction Engineering Research Lab., USA; Pater, Larry L., Army Construction Engineering Research Lab., USA; Tazik, David J., Army Construction Engineering Research Lab., USA; Jan. 1996; 112p; In English
Report No.(s): AD-A305234; USACERL-TR-96/21; No Copyright; Avail: CASI; A06, Hardcopy; A02, Microfiche

Assessing and mitigating impacts of military training on threatened and endangered species (TES) is a high priority for the Army. Noise is one impact of concern that is not understood very well. This literature review looks at research on the effects on wildlife of noise associated with military training, especially vehicle noise, artillery, small arms and other blast noise, and helicopter noise. Physical (acoustic) and biological principles are briefly reviewed and traumatic, physiological, behavioral, and population-level effects are discussed. Direct physiological effects of noise on wildlife are difficult to measure and although the processes are technically successful, they do not indicate the individual's health or chances of survival. Behavioral effects that might decrease chances of surviving and reproducing include retreat from favorable habitat near noise sources and reduction of time spent feeding, with resulting energy depletion. The literature contains a preponderance of small, disconnected, anecdotal or correlational studies as opposed to coherent programs of controlled experiments. Future research should stress quantification of exposure of subjects to noise, experimental approaches such as

broadcasting accurate recordings of sounds, and observer effects.
DTIC
Noise Reduction; Endangered Species; Habitats; Bioacoustics; Physiological Effects; Physiology; Aircraft Noise

14
LIFE SCIENCES

Includes life sciences (general); aerospace medicine; behavioral sciences; man/system technology and life support; and space biology.

19960047364 Armstrong Lab., Brooks AFB, TX USA
Outline of Neuropsychiatry in Aviation Medicine 2 ***Interim Report, 1940-1995***
McGlohn, Suzanne E., Armstrong Lab., USA; King, Raymond E., Armstrong Lab., USA; Patterson, John C., Armstrong Lab., USA; Dec. 1995; 37p; In English
Contract(s)/Grant(s): AF Proj. 7755
Report No.(s): AD-A305300; AL/AO-TR-1995-0191; No Copyright; Avail: CASI; A03, Hardcopy; A01, Microfiche

This manual discusses issues in psychiatry and psychology unique to aerospace medicine including: psychiatric disease in the aviator, selection of aircrew and astronauts, fear of flying, and the personality of the successful aviator. This manual addresses issues not emphasized in the typical psychiatry or psychology text, specifically airsickness, combat stress, aircrew fatigue management, prisoner-of-war experiences, and sequelae of aviation mishaps (accidents). Other issues in psychiatry and psychology, which are not fundamentally different from those encountered in everyday civilian and military practice, are not addressed in detail here but are dealt with in many widely available textbooks.
DTIC
Aerospace Medicine; Aircraft Accidents; Neuropsychiatry; Flight Crews; Psychology

19960049790 Army Aeromedical Research Lab., Fort Rucker, AL USA
U.S. Army Aviation Epidemiology Data Register: Rates of Exceptions to Policy Granted to Medically Disqualified U.S. Army Aviator Students from Fiscal Year 1986 to Fiscal Year 1990 ***Final Report***
Mason, Kevin T., Army Aeromedical Research Lab., USA; Mar. 1996; 11p; In English
Contract(s)/Grant(s): Army Proj. 30162787A878
Report No.(s): AD-A306470; USAARL-96-15; No Copyright; Avail: CASI; A03, Hardcopy; A01, Microfiche

The U.S. Army Aviation Epidemiology Data Register and U.S. Army Aviation Center flight training school records were queried to determine the medical diagnosis, rank, and service component of those who entered aviator training with an exception to policy. The study period was fiscal years 1986 to 1990, five years. The exception to policy rates granted to medically disqualified U.S. Army aviator students before or upon entry into flight training is unknown. Sample case histories were discussed. The overall exception to policy rate was 1.45 exceptions to policy per 100 aviator student starts per fiscal year. Commissioned officer students h ad a significantly better chance of being granted an exception to policy (relative risk (Katz) = 2.24, CI(0.95) = 1.54, 3.26). No component of service had an advantage over the others for being granted an exception to policy. Exceptions to policy most often were granted for refractive error, hearing loss, anthropometry, and orthopedic conditions of the extremities.
DTIC
Flight Training; Aircraft Pilots; Epidemiology; Aerospace Medicine

19960047411 North Dakota State Univ., Fargo, ND USA
Proceedings of the ATB Model Users Group Conference
Feb. 09, 1996; 154p; In English; Articulated Total Body (ATB) Model Users' Group Conference, 8 - 9 Feb. 1996, Phoenix, AZ, USA; Sponsored by Armstrong Lab., USA
Contract(s)/Grant(s): AF Proj. 7184
Report No.(s): AD-A305617; 19960321-082; No Copyright; Avail: CASI; A08, Hardcopy; A02, Microfiche

The 1996 Articulated Total Body (ATB) Model Users' Group Conference was held at the Quality Inn South Mountain, Phoenix AZ on 8-9 February 1996. This Conference brought together over fifty users of the ATB model and its derivatives (CVS, Cal-3D, and DYNAMAN). The two day conference offered the opportunity to present and exchange the latest ATB modeling techniques and applications. Invited presentations, group discussions, and interactive exercises covered areas such as model features, harness belt modeling, vehicle and aircraft crashworthiness, design applications, and animation techniques. In addition, the newly-elected charter offices of the ATB Users' Group were introduced and committees formed to initiate group activities.
DTIC
Conferences; Human Factors Engineering; Flight Safety; Aircraft Safety

19960047766 Army Aeromedical Research Lab., Fort Rucker, AL USA
Communication earplug and active noise reduction: hearing protection technologies for air warrior ***Final Report***
Mason, Kevin T., Army Aeromedical Research Lab., USA; Mazo, Ben T., Army Aeromedical Research Lab., USA; Apr. 1995; 16p; In English
Contract(s)/Grant(s): 30162787A878
Report No.(s): AD-A304622; USAARL-95-26; No Copyright; Avail: CASI; A03, Hardcopy; A01, Microfiche

The U.S. Army Aeromedical Research Laboratory (USAARL) participated in the development and testing of two emerging hearing protection technologies for Army air-

crew members: Communications EarPlug (CEP), and Active Noise Reduction (ANR). Air Warrior is a program to develop the next generation, integrated, aircrew life support, and combat protection ensemble. The CEP or ANR may be part of the Air Warrior hearing protection strategy. This article compares the two technologies for compatibility with the Army aircrew member helmet and aircraft internal communication systems. In their current state of development, CEP provides better hearing protection, speech discrimination, and crash protection, lower weight and cost, and less need to modify existing aircraft systems compared to ANR.
DTIC
Flight Crews; Military Air Facilities; Noise Reduction; Cost Reduction; Aircraft Communication; Speech Recognition; Weight (Mass)

19960048693 Galaxy Scientific Corp., Atlanta, GA USA
Human Factors in Aviation Maintenance, Phase 5 ***Final Report - Progress, Apr. 1994 - Mar. 1995***
Shepherd, William T., Galaxy Scientific Corp., USA; Jan. 1996; 285p; In English; Limited Reproducibility: More than 20% of this document may be affected by microfiche quality
Contract(s)/Grant(s): DTFA01-94-C-01013
Report No.(s): AD-A304262; DOT/FAA/AM-96/2; No Copyright; Avail: Issuing Activity (Defense Technical Information Center (DTIC)), Microfiche

The fifth phase of research on human factors in aviation maintenance continued to look at the human's role in the aviation maintenance system via investigations, demonstrations, and evaluations of the research program outputs. This report describes the following areas: (Ch. 2) PENS mobile computing software for FAA inspectors; (Ch. 3) STAR computer-based training for aviation regulations; (Ch. 4) HIS digital documentation systems, a hypertext multimedia software system; (Ch. 5) software/hardware distribution on the Internet; (Ch. 6) human factors program reviewing human performance issues associated with inspection; (Ch. 7) human factors audit program providing a valid tool for evaluating human factors in maintenance tasks; (Ch. 8) a study of how the design of workcards affects their use and the subsequent potential for error; (Ch. 9) the process of visual inspection and evaluation measuring visual inspection performance; (Ch. 10) a battery of mechanical aptitude tests, a simulated NDI task, and the ability of the tests to predict performance; (Ch. 11) the results of a report on an evaluation of a teamwork training program in a FAR 147 school; and (Ch. 12) ARAC rule changes and impending rule changes.
DTIC
Aircraft Maintenance; Human Factors Engineering; Human Performance; Training Evaluation; Inspection; Computer Systems Programs

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.

19960047648 Army Construction Engineering Research Lab., Champaign, IL USA
Software Development Plan for the Assessment System for Aircraft Noise. Version 2.0 ***Final Report***
Hoff, Kendra Z., Army Construction Engineering Research Lab., USA; Ohler, Eric T., Army Construction Engineering Research Lab., USA; Feb. 1996; 47p; In English
Report No.(s): AD-A306586; CERL-TM-96/50; No Copyright; Avail: Issuing Activity (Defense Technical Information Center (DTIC)), Microfiche

The Assessment System for Aircraft Noise (ASAN) is a computer system being developed to model the effects of subsonic and supersonic aircraft noise from Military Training Routes and Military Operations Areas. The purpose is to assist U.S. Air Force environmental and route planners in planning minimal impact routes and in producing improved environmental impact analysis documents. This document provides a description of the activities to be performed by the U.S. Army Construction Engineering Research Laboratories during the design, development, and testing of the Computer Software Configuration Item for ASAN) Version 2.0. This information is necessary to guide project management of the ASAN Version 2.0 software development effort. The document also makes all management tasks and management information visible to the project sponsor and other interested parties.
DTIC
Aircraft Noise; Software Engineering; Information Management; Management Information Systems; Environmental Surveys; Project Management; Routes; Computer Programming; Computer Programs; Construction

19960053482
Adaptive control of induction motor systems despite rotor resistance uncertainty
Hu, J., Clemson Univ, USA; Dawson, D. M.; Automatica; August 1996; ISSN 0005-1098; vol. 32, no. 8, pp. 1127-1143; In English; Copyright; Avail: Issuing Activity

We present and adaptive, partial-state feedback, position tracking controller for the full-order, nonlinear dynamic model representing an induction motor actuating a mechanical subsystem. The proposed controller compensates for uncertainty in the form of the rotor resistance parameter and all of the mechanical subsystem parameters, while yielding asymptotic rotor position tracking. The proposed controller does not require measurement of rotor flux or rotor current; however,

it does exhibit a singularity when the magnitude of the estimated rotor flux is zero. Simulation results are provided to verify the effectiveness of the approach.
Author (EI)
Adaptive Control; Induction Motors; Rotors; Winding

19960048109 Institute for Computer Applications in Science and Engineering, Hampton, VA USA
A PDE sensitivity equation method for optimal aerodynamic design
Borggaard, Jeff, Virginia Polytechnic Inst. and State Univ., USA; Burns, John, Virginia Polytechnic Inst. and State Univ., USA; Jun 1996; 44p; In English
Contract(s)/Grant(s): NAS1-19480; RTOP 505-90-52-01
Report No.(s): NASA-CR-198349; NAS 1.26:198349; ICASE 96-44; No Copyright; Avail: CASI; A03, Hardcopy; A01, Microfiche

The use of gradient based optimization algorithms in inverse design is well established as a practical approach to aerodynamic design. A typical procedure uses a simulation scheme to evaluate the objective function (from the approximate states) and its gradient, then passes this information to an optimization algorithm. Once the simulation scheme (CFD flow solver) has been selected and used to provide approximate function evaluations, there are several possible approaches to the problem of computing gradients. One popular method is to differentiate the simulation scheme and compute design sensitivities that are then used to obtain gradients. Although this black-box approach has many advantages in shape optimization problems, one must compute mesh sensitivities in order to compute the design sensitivity. In this paper, we present an alternative approach using the PDE sensitivity equation to develop algorithms for computing gradients. This approach has the advantage that mesh sensitivities need not be computed. Moreover, when it is possible to use the CFD scheme for both the forward problem and the sensitivity equation, then there are computational advantages. An apparent disadvantage of this approach is that it does not always produce consistent derivatives. However, for a proper combination of discretization schemes, one can show asymptotic consistency under mesh refinement, which is often sufficient to guarantee convergence of the optimal design algorithm. In particular, we show that when asymptotically consistent schemes are combined with a trust- region optimization algorithm, the resulting optimal design method converges. We denote this approach as the sensitivity equation method. The sensitivity equation method is presented, convergence results are given and the approach is illustrated on two optimal design problems involving shocks.
Author
Algorithms; Design Analysis; Aerodynamics; Computation

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PHYSICS

Includes physics (general); acoustics; atomic and molecular physics; nuclear and high-energy; optics; plasma physics; solid-state physics; and thermodynamics and statistical physics.

19960047313 McDonnell-Douglas Aerospace, Long Beach, CA USA
Validation of Aircraft Noise Models at Lower Levels of Exposure
Page, Juliet A., Wyle Labs., Inc., USA; Plotkin, Kenneth J., Wyle Labs., Inc., USA; Carey, Jeffrey N., Wyle Labs., Inc., USA; Bradley, Kevin A., Wyle Labs., Inc., USA; Jun. 1996; 122p; In English
Contract(s)/Grant(s): NAS1-20103; RTOP 538-03-15-01
Report No.(s): NASA-CR-198315; NAS 1.26:198315; MDA-CRAD-9310-TR-1757; WR-96-11; No Copyright; Avail: CASI; A06, Hardcopy; A02, Microfiche

Noise levels around airports and airbases in the USA arc computed via the FAA's Integrated Noise Model (INM) or the Air Force's NOISEMAP (NMAP) program. These models were originally developed for use in the vicinity of airports, at distances which encompass a day night average sound level in decibels (Ldn) of 65 dB or higher. There is increasing interest in aircraft noise at larger distances from the airport. including en-route noise. To evaluate the applicability of INM and NMAP at larger distances, a measurement program was conducted at a major air carrier airport with monitoring sites located in areas exposed to an Ldn of 55 dB and higher. Automated Radar Terminal System (ARTS) radar tracking data were obtained to provide actual flight parameters and positive identification of aircraft. Flight operations were grouped according to aircraft type. stage length, straight versus curved flight tracks, and arrival versus departure. Sound exposure levels (SEL) were computed at monitoring locations, using the INM, and compared with measured values. While individual overflight SEL data was characterized by a high variance, analysis performed on an energy-averaging basis indicates that INM and similar models can be applied to regions exposed to an Ldn of 55 dB with no loss of reliability.
Author
Aircraft Noise; Noise Intensity; Noise Reduction; Flight Characteristics; Radar Tracking; Position (Location); Flight Operations; Sound Propagation; Noise Prediction (Aircraft); Aeroacoustics

19960047665 Delaware Univ., Dept. of Mechanical Engineering., Newark, DE USA
Aircraft Interior Noise Control Using Distributed Piezoelectric Actuators
Sun, Jian Q., Delaware Univ., USA; Proceedings of the 4th Annual Workshop: Advances in Smart Materials for Aerospace Applications; Mar. 1996, pp. 211-214; In English; Also announced as 19960047656; No Copyright; Avail: CASI;

A01, Hardcopy; A03, Microfiche

Developing a control system that can reduce the noise and structural vibration at the same time is an important task. This talk presents one possible technical approach for accomplishing this task. The target application of the research is for aircraft interior noise control. The emphasis of the present approach is not on control strategies, but rather on the design of actuators for the control system. In the talk, a theory of distributed piezoelectric actuators is introduced. A uniform cylindrical shell is taken as a simplified model of fuselage structures to illustrate the effectiveness of the design theory. The actuators developed are such that they can reduce the tonal structural vibration and interior noise in a wide range of frequencies. Extensive computer simulations have been done to study various aspects of the design theory. Experiments have also been conducted and the test results strongly support the theoretical development.

Author (revised)

Aircraft Compartments; Aircraft Noise; Noise Reduction; Piezoelectricity; Structural Vibration; Actuators

19960047666 NASA Langley Research Center, Hampton, VA USA

Noise Reduction in an Aircraft Fuselage Model Using Active Trim Panels

Silcox, Richard J., NASA Langley Research Center, USA; Lyle, Karen H., Army Vehicle Structures Lab., USA; Proceedings of the 4th Annual Workshop: Advances in Smart Materials for Aerospace Applications; Mar. 1996, pp. 215-218; In English; Also announced as 19960047656; No Copyright; Avail: CASI; A01, Hardcopy; A03, Microfiche

An experiment was conducted to evaluate the use of force actuators on a model aircraft interior trim panel as the control element for active control of interior noise. The trim panel, designed specifically for this study, was constructed in three large identical sections and hard mounted to the ring frames of the primary structure. Piezoceramic actuators were bonded to the outer surface of the trim panels. Studies of the interior pressure response due to both the primary source alone and control sources alone were conducted as well as the control cases. A single acoustic loudspeaker, centered at the axial midpoint, generated the acoustic field to be controlled.

Derived from text

Active Control; Actuators; Fuselages; Aircraft Noise; Noise Reduction; Piezoelectric Ceramics

19960047791 McDonnell-Douglas Aerospace, Long Beach, CA USA

Community Noise Impact of Advanced Aircraft Designs ***Final Report***

Elmer, Kevin R., McDonnell-Douglas Aerospace, USA; May 1996; 76p; In English

Contract(s)/Grant(s): NAS1-20103; RTOP 538-03-15-01

Report No.(s): NASA-CR-198309; NAS 1.26:198309; CRAD-9310-TR-1758; No Copyright; Avail: CASI; A05, Hardcopy; A01, Microfiche

The noise benefit of advanced designs on future aircraft was evaluated for short-to-medium and medium-to-long range aircraft operations at both small/medium size noise sensitive and large capacity airports. A study of advanced flight procedures made possible by incorporation of automated flight systems was also conducted. A modest noise benefit can be realized through 'noise sizing' with advanced high lift systems on future aircraft. The single event noise contour area was reduced by 25% for the short-to-medium aircraft. The noise contour of the medium-to-long range aircraft was reduced by 15%. Furthermore, the potential for growth in airport operations due to noise sized aircraft with advanced high lift systems was 10% for a small noise sensitive airport and 20% for a large capacity airport. The OTIS optimization program was used to show that the noise reduction benefit of new aircraft can be maximized by implementing automated flight management and thrust management systems in aircraft. Additional contour area reduction was obtained for the small-to-medium range aircraft with high bypass ratio engines.

Author

Noise Pollution; Noise Reduction; Airports; Commercial Aircraft; Aircraft Noise; Aircraft Design; Passenger Aircraft

19960047897 Texas Technological Univ., Dept. of Industrial Engineering., Lubbock, TX USA

Three-Dimensional Auditory Localization as a Cue for Spatial Orientation in Aircraft ***Final Report***

Endsley, Mica R., Texas Technological Univ., USA; Rosiles, S. Armida, Texas Technological Univ., USA; Zhang, Hua, Texas Technological Univ., USA; Macedo, Jose, Texas Technological Univ., USA; Mar. 1996; 59p; In English

Contract(s)/Grant(s): F49620-94-1-0114; AF Proj. 2313

Report No.(s): AD-A305569; TTU-IE-96-02; No Copyright; Avail: CASI; A04, Hardcopy; A01, Microfiche

The use of technology which provides spatially localizable auditory cues through headphones is proposed as a means of providing supplemental information to pilots on the spatial orientation of an aircraft. This technique shows promise for reducing accidents due to spatial disorientation associated with high visual load. An Auditory Head up Display (HUD) was developed that provides realtime aircraft pitch and roll indications in the form of spatially localized auditory tones. Three studies were conducted using U. S. Air Force pilots as subjects to determine its utility. The first study examined cue characteristics for optimizing vertical localization of auditory cues and successfully identified multidimensional cueing techniques that significantly improved localization performance. In the second study it was found that the addition of Auditory HUD information improved performance in a flight management task but not in a secondary visual search task. In the third study, the cues were employed in a recovery from unusual attitude task in a T-38 training simulator, however, no

improvement in time to recover was found. Subjective data indicates that mentally processing the auditory cues is fairly demanding for subjects but was deemed useful. Implications for the use of three dimensional auditory cues in aircraft tasks and further research needs are discussed.
DTIC
Auditory Tasks; Aircraft Pilots; Disorientation; Real Time Operation; Training Simulators; Flight Instruments; Head-Up Displays; Auditory Perception; Earphones

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GENERAL

19960050110 National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX USA
National Aeronautics and Space Administration (NASA)/American Society for Engineering Education (ASEE) Summer Faculty Fellowship Program: 1995., Volume 2
Hyman, William A., Editor, Texas A&M Univ., USA; Sickorez, Donn G., Editor, NASA Johnson Space Center, USA; National Aeronautics and Space Administration (NASA)/American Society for Engineering Education (ASEE) Summer Faculty Fellowship Program - 1995.; Aug. 1996; 218p; In English, 1995, Houston, TX, USA; Sponsored by National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, USA; Also announced as 19960050111 through 19960050125
Contract(s)/Grant(s): NGT44-001-800
Report No.(s): NASA-CR-201377-Vol-2; NAS 1.26: 201377-Vol-2; No Copyright; Avail: CASI; A10, Hardcopy; A03, Microfiche

The JSC NASA/ASEE Summer Faculty Fellowship Program was conducted at JSC, including the White Sands Test Facility, by Texas A&M University and JSC. The objectives of the program, which began nationally in 1964 and at JSC in 1965, are (1) to further the professional knowledge of qualified engineering and science faculty members; (2) to stimulate an exchange of ideas between participants and NASA; (3) to enrich and refresh the research and teaching activities of the participants' institutions; and (4) to contribute to the research objectives of the NASA centers. Each faculty fellow spent at least 10 weeks at JSC engaged in a research project in collaboration with a NASA/JSC colleague. In addition to the faculty participants, the 1995 program included five students. This document is a compilation of the final reports on the research projects completed by the faculty fellows and visiting students during the summer of 1995. The reports of two of the students are integral with that of the respective fellow. Three students wrote separate reports.
Author (ESA)
Information Transfer; University Program; Research and Development; Conferences; Mechanical Engineering; Aeronautical Engineering; Systems Engineering

Subject Term Index

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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 ESDU International topic categories can be obtained from ESDU International.

Avail: Fachinformationszentrum Karlsruhe. Gesellschaft für wissenschaftlich-technische Information mbH 76344 Eggenstein-Leopoldshafen, Germany.

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1H23), Washington, DC 20546-0001, or public document rooms located at NASA installations, and the NASA Pasadena Office at the Jet Propulsion Laboratory.

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