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A Continuing Bibliography with Indexes

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AERONAUTICAL ENGINEERING

A CONTINUING BIBLIOGRAPHY WITH INDEXES

(Supplement 251)

A selection of annotated references to unclassified reports and journal articles that were introduced into the NASA scientific and technical information system and announced in March 1990 in

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

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INTRODUCTION

This issue of *Aeronautical Engineering -- A Continuing Bibliography* (NASA SP-7037) lists 526 reports, journal articles and other documents originally announced in March 1990 in *Scientific and Technical Aerospace Reports (STAR)* or in *International Aerospace Abstracts (IAA).*

The coverage includes documents on the engineering and theoretical aspects of design, construction, evaluation, testing, operation, and performance of aircraft (including aircraft engines) and associated components, equipment, and systems. It also includes research and development in aerodynamics, aeronautics, and ground support equipment for aeronautical vehicles.

Each entry in the bibliography consists of a standard bibliographic citation accompanied in most cases by an abstract. The listing of the entries is arranged by the first nine *STAR* specific categories and the remaining *STAR* major categories. This arrangement offers the user the most advantageous breakdown for individual objectives. The citations include the original accession numbers from the respective announcement journals. The *IAA* items will precede the *STAR* items within each category.

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

An annual cumulative index will be published.

Information on the availability of cited publications including addresses of organizations and NTIS price schedules is located at the back of this bibliography.

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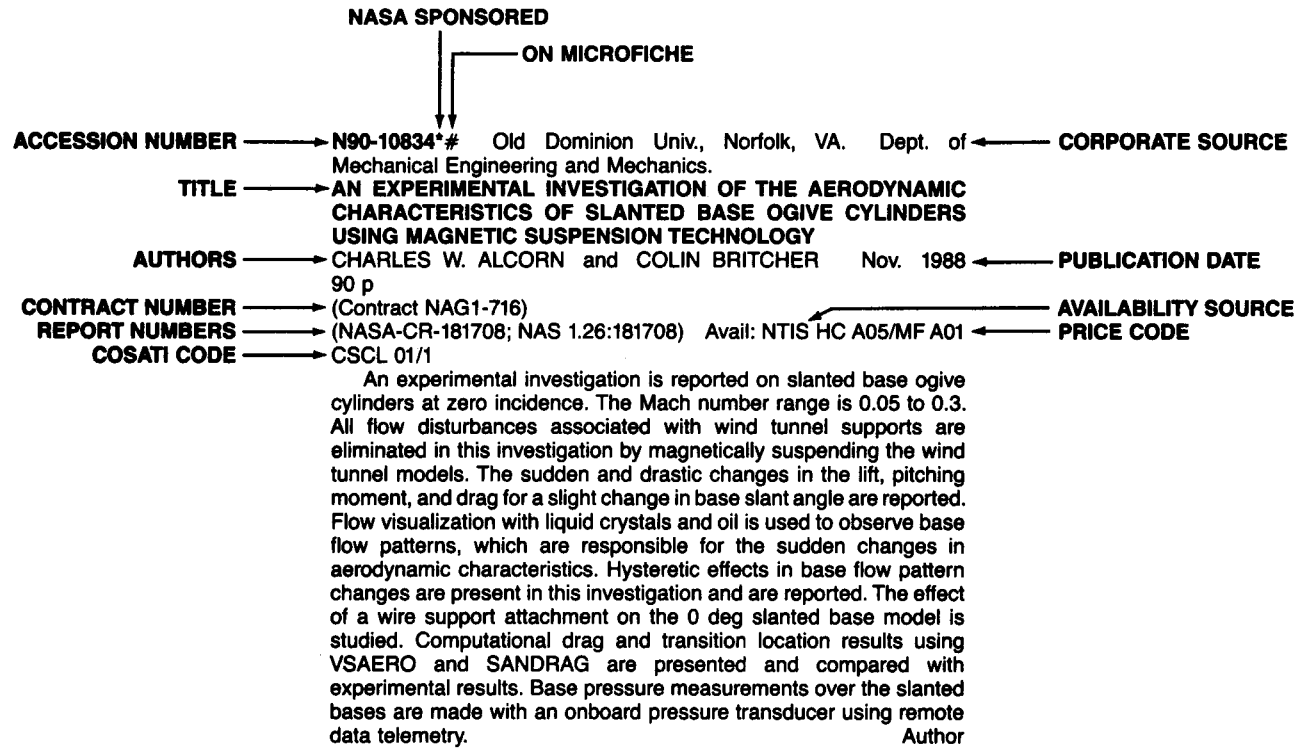
TYPICAL REPORT CITATION AND ABSTRACT



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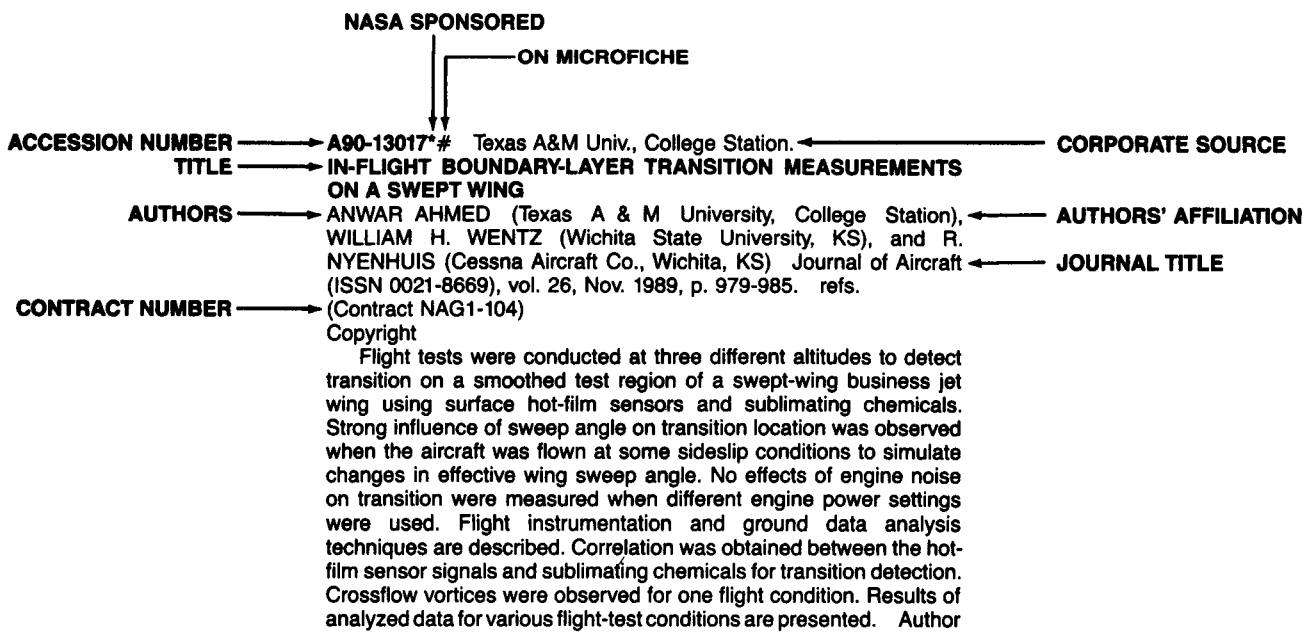

AERONAUTICAL ENGINEERING

A Continuing Bibliography (Suppl. 251)

APRIL 1990

01

AERONAUTICS (GENERAL)

A90-16824
AEROSPATIALE'S MILITARY HELICOPTER PROGRAMS
J. L. ESPES (Aerospatiale, Division Helicopteres, La Courneuve, France) Vertiflite (ISSN 0042-4455), vol. 35, Nov.-Dec. 1989, p. 42-48.
Copyright

The current development status of military helicopters at Aerospatiale is reviewed. Consideration is given to the Gazelle antitank helicopter; the Ecureuil family of composite-rotor-hub helicopters; the Panther multirole ground-combat platform; the twin-engine medium-tonnage AS 332 M1, F1, and MK2 Super Pumas; the Orchidee battlefield surveillance system; the French-FRG cooperative development of the HAP/HAC-PAH specialized helicopters; and the French-Italian-FRG-Netherlands NH 90 program. Photographs are included. T.K.

A90-17780
HSCT RESEARCH FOCUSES ON ENVIRONMENTAL ISSUES
JAMES OTT Aviation Week and Space Technology (ISSN 0005-2175), vol. 131, Dec. 4, 1989, p. 54-57.
Copyright

Airlines want a highly productive supersonic transport that is compatible with the environment and can operate at maximum speed over land. Environmental issues addressed in the three-year NASA High-Speed Civil Transport (HSCT) study on a supersonic transport aircraft are discussed. The types of technology being considered for the aircraft are examined with regard to their effect on speed, fuel economy, noise, and cost. C.D.

A90-17919
STRONGER STARLIFTER
FRANK COLUCCI Aerospace Composites and Materials (ISSN 0954-5832), vol. 1, Fall 1989, p. 11, 12.
Copyright

A series of boron/epoxy and graphite/epoxy repairs has been developed to strengthen the metal structures of the Lockheed C-141B Starlifter. The Starlifter repairs consist of patches intended to stop cracks and doublers intended to redistribute stresses in aluminum structures. The current status of the composite repair program is briefly reviewed, and the cost effectiveness of the repairs is evaluated. V.L.

N90-13323*# Sverdrup Technology, Inc., Cleveland, OH.
MULTIGRID CALCULATIONS OF 3-D TURBULENT VISCOUS FLOWS Final Report
JEFFREY W. YOKOTA Oct. 1989 18 p Presented at the 1st Canadian Symposium on Aerodynamics, Ottawa, Ontario, 4-5 Dec. 1989; sponsored by Canadian Aeronautics and Space Inst.
(Contract NAS3-25266)
(NASA-CR-185154; E-5116; NAS 1.26:185154) Avail: NTIS HC A03/MF A01 CSCL 01B

Convergence properties of a multigrid algorithm, developed to calculate compressible viscous flows, are analyzed by a vector sequence eigenvalue estimate. The full 3-D Reynolds-averaged Navier-Stokes equations are integrated by an implicit multigrid scheme while a k-epsilon turbulence model is solved, uncoupled from the flow equations. Estimates of the eigenvalue structure for both single and multigrid calculations are compared in an attempt to analyze the process as well as the results of the multigrid technique. The flow through an annular turbine is used to illustrate the scheme's ability to calculate complex 3-D flows. Author

N90-13324*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
APPLICATION OF A SELF-ADAPTIVE GRID METHOD TO COMPLEX FLOWS
G. S. DEIWERT, E. VENKATAPATHY, C. DAVIES, J. DJOMEHRI, and K. ABRAHAMSON (Boeing Military Airplane Development, Wichita, KS.) Jul. 1989 20 p
(NASA-TM-102223; A-89172; NAS 1.15:102223) Avail: NTIS HC A03/MF A01 CSCL 01B

A directional-split, modular, user-friendly grid point distribution code is applied to several test problems. The code is self-adaptive in the sense that grid point spacing is determined by user-specified constants denoting maximum and minimum grid spacings and constants relating the relative influence of smoothness and orthogonality. Estimates of truncation error, in terms of flow-field gradients and/or geometric features, are used to determine the point distribution. Points are redistributed along grid lines in a specified direction in an elliptic manner over a user-specified subdomain, while orthogonality and smoothness are controlled in a parabolic (marching) manner in the remaining directions. Multidirectional adaption is achieved by sequential application of the method in each coordinate direction. The flow-field solution is redistributed onto the newly distributed grid points after each unidirectional adaption by a simple one-dimensional interpolation scheme. For time-accurate schemes such interpolation is not necessary and time-dependent metrics are carried in the fluid dynamic equations to account for grid movement. Author

02

AERODYNAMICS

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

A90-16735#
ON A LIFTING LINE THEORY FOR SUPERSONIC FLOW. I - THE VELOCITY FIELD DUE TO A VORTEX LINE IN SUPERSONIC FLOW
V. N. CONSTANTINESCU (Institutul Politehnic, Bucharest, Rumania) and I. JADIC (Institutul National pentru Creatie Stiintifica si Tehnica, Bucharest, Rumania) Revue Roumaine des Sciences Techniques, Serie de Mecanique Appliquee (ISSN 0035-4074), vol. 34, Sept.-Oct. 1989, p. 439-452. refs

A study of the velocity field due to a straight vortex line is presented under the usual assumptions of small perturbation theory. Starting from an equivalent Biot-Savart formula for supersonic flow,

the velocity field is determined under various circumstances which may be encountered, particularly when the vortex line intersects the upstream Mach cone with apex at the point where the induced velocity is calculated. The paper demonstrates the usefulness of lifting line theory in the prediction of global characteristics and spanwise load distributions on wings of arbitrary planforms in supersonic flow using simpler and time-saving computer programs. If the required accuracy of the results is not too severe, a rather simple unitary theory can be produced irrespective of numerous local details concerning the nature of leading and trailing edges of the wing and of other intricate details like Mach cone reflections on the lateral edges of wings with small aspect ratios. C.D.

A90-16736#
ON STEADY SUBSONIC FLOW PAST SLENDER BODIES OF REVOLUTION
L. DRAGOS and A. CARABINEANU (Bucuresti, Universitatea, Bucharest, Rumania) Revue Roumaine des Sciences Techniques, Serie de Mecanique Appliquee (ISSN 0035-4074), vol. 34, Sept.-Oct. 1989, p. 453-459. refs

The fundamental solution method is applied to investigate the steady subsonic flow past axisymmetric slender bodies. This method consists of assimilating wings or bodies by distributing pertubation forces whose intensity is determined from the boundary conditions. A natural solution to the problem is obtained, including the case of nonvanishing incidence. C.D.

A90-16751*
SYMPOSIUM ON NUMERICAL AND PHYSICAL ASPECTS OF AERODYNAMIC FLOWS, 4TH, CALIFORNIA STATE UNIVERSITY, LONG BEACH, JAN. 16-19, 1989, PROCEEDINGS
Symposium supported by the California State University, U.S. Navy, NASA, and U.S. Army. Long Beach, CA, California State University, 1989, 513 p. For individual items see A90-16752 to A90-16792.

Papers are presented on the calculation of flows of relevance to aircraft, ships, and missiles, with emphasis on the solution of two-dimensional unsteady and three-dimensional steady equations. Papers are also presented describing experimental work and the representation of the onset of transition from laminar to turbulent flow. S.A.V.

A90-16752#
EXPERIMENTS ARE TELLING YOU SOMETHING (STEWARTSON MEMORIAL LECTURE)
J. H. WHITELAW (Imperial College of Science, Technology, and Medicine, London, England) IN: Symposium on Numerical and Physical Aspects of Aerodynamic Flows, 4th, Long Beach, CA, Jan. 16-19, 1989, Proceedings. Long Beach, CA, California State University, 1989, 8 p. Research supported by SERC and Ministry of Defence Procurement Executive. refs

The findings of a research program addressing the problem of flows at the trailing-edge region of airfoils at high angle of attack are discussed. The mean flow properties, turbulence properties, and numerical accuracy of the solution methods are examined. The computer programs used were based on the TEACH code for the solution of the time-averaged two-dimensional form of the Navier-Stokes equations in rectangular Cartesian coordinates. Several programs for the solution of boundary-layer equations were also used. The findings make it clear that the pressure gradients and normal stress diffusion are important where the upper-surface flow is separated. This implies the need for consideration of equations for the conservation of cross flow momentum and the components of the stress tensor in any calculation method which is required to represent the details of these flows. The need for careful evaluation of numerical uncertainty in Navier-Stokes solvers is emphasized. S.A.V.

A90-16753*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
PREDICTIONS OF AIRFOIL AERODYNAMIC PERFORMANCE DEGRADATION DUE TO ICING
ROBERT J. SHAW, MARK G. POTAPCZUK, and COLIN S. BIDWELL (NASA, Lewis Research Center, Cleveland, OH) IN: Symposium on Numerical and Physical Aspects of Aerodynamic Flows, 4th, Long Beach, CA, Jan. 16-19, 1989, Proceedings. Long Beach, CA, California State University, 1989, 9 p. Previously announced in STAR as N89-13412. refs

An overview of NASA's ongoing efforts to develop an airfoil icing analysis capability is developed. An indication is given to the approaches being followed to calculate the water droplet trajectories past the airfoil, the buildup of ice on the airfoil, and the resultant changes in aerodynamic performance due to the leading edge ice accretion. Examples are given of current code capabilities/limitations through comparisons of predictions with experimental data gathered in various calibration/validation experiments. A brief discussion of future efforts to extend the analysis to handle three-dimensional components is included. Author

A90-16754#
AN INTERACTIVE BOUNDARY LAYER METHOD FOR SUBSONIC AIRFOIL FLOWS
M. M. GIBSON and P.-Y. HO (Imperial College of Science, Technology, and Medicine, London, England) IN: Symposium on Numerical and Physical Aspects of Aerodynamic Flows, 4th, Long Beach, CA, Jan. 16-19, 1989, Proceedings. Long Beach, CA, California State University, 1989, 10 p. Research supported by British Aerospace, PLC. refs

The main features of an interactive boundary layer method for aerofoils is described and results of calculations for an NACA 4412 aerofoil at varying incidence are compared with published benchmark data. Special attention is paid to the treatment of the off-body Kutta condition and to the effects of curvature in the near wake. Use of a modified FLARE approximation permits stable calculations for separated regions of up to 20 percent of the boundary layer thickness. The performance of different turbulence models is assessed. Author

A90-16755#
COMPUTATION OF MULTI-ELEMENT AIRFOIL FLOWS INCLUDING CONFLUENCE EFFECTS
F. ARNOLD, P. THIEDE (MBB GmbH, Bremen, Federal Republic of Germany), and F. THIELE (Berlin, Technische Universitaet, Federal Republic of Germany) IN: Symposium on Numerical and Physical Aspects of Aerodynamic Flows, 4th, Long Beach, CA, Jan. 16-19, 1989, Proceedings. Long Beach, CA, California State University, 1989, 10 p. refs

An interactive method for calculating the incompressible viscous flow about multi-element airfoils is presented. Based on the outflow concept a panel method for the inviscid flow is coupled with a finite-difference method of Hermitian type for the viscous flow. By applying a finite-difference method, even complex regions having confluent shear layers can be treated in the same way as regular boundary layers. Thus, the merging of viscous shear layers is simultaneously described. In addition, the turbulent shear stress is approximated by an algebraic eddy-viscosity model. Using a semi-inverse iteration technique the strong interaction between viscous and inviscid flow at high angles of attack is accounted for. Author

A90-16756#
VISTRAFS - A SIMULATION METHOD FOR STRONGLY-INTERACTING VISCOUS TRANSONIC FLOW
A. E. P. VELDMAN, J. P. F. LINDHOUT, E. DE BOER, and M. A. M. SOMERS (Nationaal Lucht- en Ruimtevaartlaboratorium, Amsterdam, Netherlands) IN: Symposium on Numerical and Physical Aspects of Aerodynamic Flows, 4th, Long Beach, CA, Jan. 16-19, 1989, Proceedings. Long Beach, CA, California State University, 1989, 11 p. Research supported by the Nederlands Instituut voor Vliegtuigontwikkeling en Ruimtevaart. refs

A description is given of the program system VISTRAFS, which simulates two-dimensional transonic viscous flow with strong viscous-inviscid interaction. VISTRAFS consists of two parts: the viscous-flow solver VISIAN and the inviscid-flow solver TRAFS. These solvers are coupled in a quasi-simultaneous way. A number of examples are presented which show that the VISTRAFS results

are comparable to those of present-day Navier-Stokes solvers; however, they are obtained with much less computational effort. Author

A90-16757#
PREDICTION OF POST-STALL FLOWS ON AIRFOILS
TUNCER CEBECI, JULAN JAU, DOMENICO VITIELLO, and K. C. CHANG (Douglas Aircraft Co., Long Beach, CA) IN: Symposium on Numerical and Physical Aspects of Aerodynamic Flows, 4th, Long Beach, CA, Jan. 16-19, 1989, Proceedings. Long Beach, CA, California State University, 1989, 8 p. refs

An interactive boundary-layer method previously developed for calculating the performance of airfoils up to and including stall is extended to include post-stall flows. The method is based on the solution of inviscid flow equations with a panel method and the solution of boundary-layer equations with an inverse finite-difference scheme which employs a special technique to couple the inviscid flow solutions. Calculated lift and drag coefficients of four airfoils show good agreement with experiment. Author

A90-16758#
FURTHER WORK ON AEROFOILS AT REYNOLDS NUMBERS BETWEEN 3 X 10 TO THE 5TH AND 1 X 10 TO THE 6TH
J. L. STOLLERY, C. J. DAVIDSON, A. ITO (Cranfield Institute of Technology, England), and B. R. WILLIAMS (Royal Aerospace Establishment, Farnborough, England) IN: Symposium on Numerical and Physical Aspects of Aerodynamic Flows, 4th, Long Beach, CA, Jan. 16-19, 1989, Proceedings. Long Beach, CA, California State University, 1989, 9 p. Research supported by the Ministry of Defence. refs

The effects of roughness and trailing edge extensions on the performance of airfoils at low Reynolds numbers are studied in two separate sets of experiments. Roughness strips added to the NACA 64(3)-418, Goettingen 797, and Wortmann FX63-137 wing sections already tested result in significant reductions in the maximum lift/drag ratio. To improve the performance of the smooth Goettingen and Wortmann airfoils simple flat-plate extensions of 10 and 20 percent chords are fitted tangentially to the upper surface at the trailing edge. This resulted in far greater performance benefits for the Goettingen 797 section than for the FX63-137. The semi-inverse viscous-inviscid interaction method of Williams (1984) gives useful predictions down to Reynolds numbers of 5 x 10 to the 5th. A number of comparisons are presented between the computer program calculations and the experimental data. S.A.V.

A90-16759#
THEORETICAL PREDICTION OF HIGH REYNOLDS NUMBER VISCID/INVISCID INTERACTION PHENOMENA IN CASCADES
MARK BARNETT and JOSEPH M. VERDON (United Technologies Research Center, East Hartford, CT) IN: Symposium on Numerical and Physical Aspects of Aerodynamic Flows, 4th, Long Beach, CA, Jan. 16-19, 1989, Proceedings. Long Beach, CA, California State University, 1989, 11 p. refs
(Contract N62271-87-M-0187)

A method is presented for predicting two-dimensional high Reynolds number flow through a turbomachine cascade with strong viscid/inviscid interaction. The analysis uses an interacting boundary-layer approach in which the flow in the outer inviscid region is assumed to be potential, and that in the inner viscous region is governed by Prandtl's boundary layer equations. The viscous effect on the base inviscid flow through the cascade is assumed to be small. Thus, the base inviscid flow is determined using a full-potential analysis, and the perturbation to this flow caused by viscous effects is predicted using a linearized potential analysis. The viscous equations are solved directly in the leading-edge region, where the viscid/inviscid interaction is weak, and inversely over the remainder of the blade surface and in the wake. The viscous and inviscid solutions are coupled using a semi-inverse iteration procedure. Calculations are carried out, and results are presented for a flat-plate cascade and a compressor cascade. S.A.V.

A90-16764*# Imperial Coll. of Science and Technology, London (England).
INTERACTION BETWEEN STRONG LONGITUDINAL VORTICES AND TURBULENT BOUNDARY LAYERS
A. D. CUTLER, M. NAASERI, and P. BRADSHAW (Imperial College of Science, Technology, and Medicine, London, England) IN: Symposium on Numerical and Physical Aspects of Aerodynamic Flows, 4th, Long Beach, CA, Jan. 16-19, 1989, Proceedings. Long Beach, CA, California State University, 1989, 10 p. refs
(Contract NAGW-581)

The latest stages of work on the interaction between longitudinal vortices and turbulent boundary layers show that very large changes in turbulence structure occur when the vortices are strong (crossflow angles of order 20 deg). The changes are poorly correlated by current turbulence models and go well beyond the rotation of the stress tensor in the vortex region that is explicitly represented by the exact 'generation' (exchange) terms in the Reynolds-stress transport equations. Measurements in the interaction between a burst vortex and a boundary layer show qualitatively similar results to the unburst case, but shed useful light on the bursting process itself. Author

A90-16765#
THE FLOW AROUND WING-BODY JUNCTIONS
H. C. CHEN and V. C. PATEL (Iowa, University, Iowa City) IN: Symposium on Numerical and Physical Aspects of Aerodynamic Flows, 4th, Long Beach, CA, Jan. 16-19, 1989, Proceedings. Long Beach, CA, California State University, 1989, 15 p. refs
(Contract N00014-88-K-0001)

The turbulent shear flow at the junction of an airfoil with a flat plate is considered. A numerical method for the solution of the Reynolds-averaged Navier-Stokes equations has been developed and employed to calculate the flow around this relatively simple model geometry with the objective of evaluating the performance of the method in a three-dimensional flow involving horseshoe vortex formation, corner boundary layers, and interaction among the vortex system, the airfoil wake and the plate boundary layer. Comparisons are made with available experimental data to show that most of the important features of the mean flow can be predicted with some accuracy. Author

A90-16767#
SUPERSONIC/HYPERSONIC EULER FLOWFIELD PREDICTION METHOD FOR AIRCRAFT CONFIGURATIONS
A. VERHOFF, D. C. STOOKESBERRY, B. M. HOPPING, and T. R. MICHAL (McDonnell Aircraft Co., Saint Louis, MO) IN: Symposium on Numerical and Physical Aspects of Aerodynamic Flows, 4th, Long Beach, CA, Jan. 16-19, 1989, Proceedings. Long Beach, CA, California State University, 1989, 10 p. refs

Numerical solutions of the Euler equations for supersonic flowfields about various aircraft configurations have been obtained using the SCRAM code. The code has been coupled with a versatile grid generation procedure for constructing high-quality computational grids about these complex configurations. Pressure distributions, forces, and moments compare well with test data for configurations having aft-swept wing trailing edges, vertical tails, and engine inlets and nozzles. A fully iterative procedure is used to obtain starting solutions for blunt-nosed geometries. Efficient real gas capability has been validated against analytic cone solutions. C.D.

A90-16768#
CALCULATION OF TRANSONIC FLOWS FOR NOVEL ENGINE-AIRFRAME INSTALLATIONS
ARVIN SHMILOVICH and N. DOUGLAS HALSEY (Douglas Aircraft Co., Long Beach, CA) IN: Symposium on Numerical and Physical Aspects of Aerodynamic Flows, 4th, Long Beach, CA, Jan. 16-19, 1989, Proceedings. Long Beach, CA, California State University, 1989, 15 p. refs

A method for calculating transonic flows past aft-fuselage mounted nacelle/pylon combinations has been developed. A viscous/inviscid interactive procedure is used to compute flowfields with viscous effects. The inviscid flowfield is described by the

potential equation which is approximated and solved numerically using a multigrid finite-volume method. The inviscid flow technique is coupled with a boundary-layer method that uses an inverse formulation in order to calculate shock-induced separated flows. Experimental results obtained for several configurations are used to evaluate the accuracy of the method in predicting flowfields for a range of operating conditions. Author

A90-16769#
RESULTS FROM A NUMERICAL SIMULATION OF AN F-16A CONFIGURATION AT A SUPERSONIC MACH NUMBER
G. W. HUBAND, D. P. RIZZETTA, and J. J. S. SHANG (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) IN: Symposium on Numerical and Physical Aspects of Aerodynamic Flows, 4th, Long Beach, CA, Jan. 16-19, 1989, Proceedings. Long Beach, CA, California State University, 1989, 10 p. refs

A numerical simulation is presented for the steady flow over an F-16A aircraft configuration at a freestream Mach number of 1.2, a Reynolds number of 12.75 million and an angle of attack of six degrees. The three-dimensional Navier-Stokes equations in mass-averaged variables were numerically integrated using the MacCormack explicit algorithm with an algebraic turbulence model to provide closure of the system of equations. The grid structure, boundary conditions, and solution procedure are discussed in detail for this complex aircraft geometry. The solution is then compared to experimental results in terms of surface pressure coefficients, lift coefficient, and drag coefficient with reasonable agreement. Finally, details of the flow are discussed, such as the strake vortex and the wing vortex structures. Author

A90-16771
A VISCOUS PACKAGE FOR ATTACHED AND SEPARATED FLOWS ON SWEPT AND TAPERED WINGS
P. D. SMITH (Royal Aerospace Establishment, Farnborough, England) IN: Symposium on Numerical and Physical Aspects of Aerodynamic Flows, 4th, Long Beach, CA, Jan. 16-19, 1989, Proceedings. Long Beach, CA, California State University, 1989, 4 p. refs
Copyright

A method is described for the calculation of viscous effects on a streamwise section of a swept tapered wing and its wake. A feature of the method is the choice of a geometry which facilitates both the combination of the method with two-dimensional inviscid codes with the aid of simple sweep theory and the coupling of the method in a strip fashion to fully three-dimensional inviscid codes for wings. A second new feature is the use of a generalized boundary condition in the solution procedure which permits the use of direct, semi-inverse and quasi-simultaneous modes. Author

A90-16772*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
NUMERICAL SIMULATION OF SEPARATED AND VORTICAL FLOWS ON BODIES AT LARGE ANGLES OF ATTACK
LEWIS B. SCHIFF, DAVID DEGANI, and RUSSELL M. CUMMINGS (NASA, Ames Research Center, Moffett Field, CA) IN: Symposium on Numerical and Physical Aspects of Aerodynamic Flows, 4th, Long Beach, CA, Jan. 16-19, 1989, Proceedings. Long Beach, CA, California State University, 1989, 13 p. Research supported by the U.S. Army. refs

Navier-Stokes computations were carried out for high-angle-of-attack flow about bodies of revolution in supersonic and subsonic flow. Numerical and physical factors affecting flow predictions are discussed. Accurate prediction of the complex three-dimensional separated flow is found to depend on using grids sufficiently fine to resolve the details of both the viscous boundary layer and the off-surface separated flow structures, and, for turbulent flow cases, use of an eddy-viscosity turbulence model which accounts for the leeward vortical flow structures. An example of high-incidence flow computed about a more complex geometry, the F-18 fighter fuselage forebody and leading edge extension, is also presented. Author

A90-16773#
CALCULATION OF THREE-DIMENSIONAL BOUNDARY LAYERS INCLUDING HYPERSONIC FLOWS
B. AUPOIX, S. BONNET, C. GLEYZES, and J. COUSTEIX (ONERA, Centre d'Etudes et de Recherches de Toulouse, France) IN: Symposium on Numerical and Physical Aspects of Aerodynamic Flows, 4th, Long Beach, CA, Jan. 16-19, 1989, Proceedings. Long Beach, CA, California State University, 1989, 11 p. refs

Three-dimensional boundary layer computation methods are required for practical use. Two methods are presented. The integral method provides a good prediction for adiabatic flows at subsonic and moderate supersonic speeds, either for wing or fuselage applications, for laminar and turbulent flows. For hypersonic flows, when nonequilibrium effects are to be accounted for, resolution of local boundary layer equations is preferred. Application to the laminar regime, bringing into evidence the importance of the wall catalytic efficiency and the pressure distribution data, as well as stagnation point and attachment line solutions are presented. Author

A90-16774#
VERIFICATION OF A NAVIER-STOKES CODE FOR SOLVING THE HYPERSONIC BLUNT BODY PROBLEM
FREDERICK G. BLOTTNER (Sandia National Laboratories, Albuquerque, NM) IN: Symposium on Numerical and Physical Aspects of Aerodynamic Flows, 4th, Long Beach, CA, Jan. 16-19, 1989, Proceedings. Long Beach, CA, California State University, 1989, 12 p. refs
(Contract DE-AC04-76DP-00789)

Computational results obtained from a Navier-Stokes code for the subsonic noise region flow on blunt bodies in supersonic flow have been evaluated for accuracy. The unsteady thin-layer form of the governing equations for a perfect gas are solved with a linearized block alternating-direction implicit finite-difference procedure. A modification to the usual numerical scheme is required near the stagnation point to obtain satisfactory heat transfer results in this region. Sensitivity of the solutions to code input parameters is investigated. Predictions obtained from the code are presented and compared to numerical and experimental results. This study indicates that very accurate surface pressures and reasonably accurate heat transfer predictions are obtained from the code. Author

A90-16775#
THE RELEVANCE OF UNSTEADY AERODYNAMICS FOR HIGHLY MANEUVERABLE AND AGILE AIRCRAFT
HANK E. HELIN (USAF, Washington, DC) IN: Symposium on Numerical and Physical Aspects of Aerodynamic Flows, 4th, Long Beach, CA, Jan. 16-19, 1989, Proceedings. Long Beach, CA, California State University, 1989, 7 p. refs

This paper emphasizes the relevance of unsteady aerodynamics for highly maneuverable and agile aircraft and highlights several selected problems in unsteady aerodynamics. These ties, coupled with our desire for enhanced aircraft maneuverability and agility, emphasize the urgency to increase our understanding of unsteady aerodynamics. The underlying time scales of unsteady flows which are driven by rapidly maneuvering aircraft, along with the influence of three dimensionality and localized compressibility, provide important insights into this complex problem. The present paper is not intended to critically evaluate the state-of-the-art, but rather to emphasize the importance of understanding unsteady aerodynamics, and to highlight a few recent advances. Author

A90-16776#
COMPUTATIONAL AND EXPERIMENTAL STUDIES OF COMPRESSIBLE DYNAMIC STALL
MICHAEL T. PATTERSON and PETER F. LORBER (United Technologies Research Center, East Hartford, CT) IN: Symposium on Numerical and Physical Aspects of Aerodynamic Flows, 4th, Long Beach, CA, Jan. 16-19, 1989, Proceedings. Long Beach, CA, California State University, 1989, 15 p. refs
(Contract F49620-84-C-0082)

Two numerical methods for the solution of the Navier-Stokes

equations are applied to the thin airfoil dynamic stall problem at high Reynolds number, moderate pitch rate, and low subsonic Mach number. One code solves the compressible flow equations in primitive variables. The other solves for incompressible flow using the vorticity transport equation. The results of both codes are compared to experimental surface pressures and airload data obtained for a constant pitch rate of 0.01 at Mach numbers of 0.2 and 0.4. The codes are found to predict the lift curve quite well prior to stall, including the unsteady stall angle, the variations in the lift curve slopes, and the effect of the formation of the stall vortex near the leading edge. C.D.

A90-16777#
ON THE EFFECTS OF WIND TUNNEL TURBULENCE ON STEADY AND UNSTEADY AIRFOIL CHARACTERISTICS
ANDREW M. WO and EUGENE E. COVERT (MIT, Cambridge, MA) IN: Symposium on Numerical and Physical Aspects of Aerodynamic Flows, 4th, Long Beach, CA, Jan. 16-19, 1989, Proceedings. Long Beach, CA, California State University, 1989, 9 p. refs
(Contract N00014-85-K-0513)

Aerodynamic data are discussed for two airfoils, a Wortmann FX63-137 and NACA 0012. These data were taken over reduced frequencies of 0 to 6.4, Re = 125,000, alpha = 0 and 10 deg, and in two wind tunnels. Steady state data show that higher free stream turbulence or larger Reynolds number leads to earlier transition of the bubble separation. Unsteady pressure data, for both airfoils at alpha = 0 deg, show larger fluctuation at higher values of reduced frequencies in the region where the boundary layer is undergoing reattachment. Author

A90-16779
A CRITIQUE OF THE EXPERIMENTAL AERODYNAMIC DATA BASE FOR AN OSCILLATING STRAKED WING AT HIGH ANGLES
ATLEE M. CUNNINGHAM, JR. (General Dynamics Corp., Fort Worth, TX) IN: Symposium on Numerical and Physical Aspects of Aerodynamic Flows, 4th, Long Beach, CA, Jan. 16-19, 1989, Proceedings. Long Beach, CA, California State University, 1989, 13 p. refs
(Contract F33615-85-C-3013)
Copyright

A critique of an extensive aerodynamic data base is presented for the low speed wind tunnel test of a straked wing model oscillating in pitch up to high angles of attack. Force data from a six-component balance, pressure data from 42 in situ pressure transducers and flow-visualization data with laser light sheet illuminated smoke flow were all recorded for a wide variety of conditions for both steady and unsteady model states. The purpose of this paper is to provide information on the development of the data base and how the various data forms interplay to provide a more complete understanding of the production of aerodynamic forces in a highly unsteady environment. Author

A90-16780*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
EXPERIMENTAL AND COMPUTATIONAL STUDIES OF DYNAMIC STALL
L. W. CARR (NASA, Ames Research Center; U.S. Army, Aeroflightdynamics Directorate, Moffett Field, CA), M. F. PLATZER, M. S. CHANDRASEKHARA (U.S. Navy-NASA Joint Institute of Aeronautics, Monterey, CA), and J. EKATERINARIS (Sterling Federal Systems, Mountain View, CA) IN: Symposium on Numerical and Physical Aspects of Aerodynamic Flows, 4th, Long Beach, CA, Jan. 16-19, 1989, Proceedings. Long Beach, CA, California State University, 1989, 15 p. refs

A review of dynamic stall research in progress under the Navy-NASA Joint Institute of Aeronautics is presented. This effort, which includes both experimental and computational studies of the dynamic stall process, is directed toward better understanding and modeling of the fluid flow that occurs on helicopters and aircraft flying in conditions that induce dynamic stall. The results of research now in progress are presented, with discussion of the experimental program on compressibility effects on dynamic stall, related CFD studies of the stall process based on Navier-Stokes modeling, and viscous-inviscid flow modeling of the incipient stall process. Author

A90-16781*# Cincinnati Univ., OH.
ANALYSIS OF HIGH-INCIDENCE SEPARATED FLOW PAST AIRFOILS
K. N. CHIA, G. A. OSSWALD, and U. CHIA (Cincinnati, University, OH) IN: Symposium on Numerical and Physical Aspects of Aerodynamic Flows, 4th, Long Beach, CA, Jan. 16-19, 1989, Proceedings. Long Beach, CA, California State University, 1989, 4 p. refs
(Contract AF-AFOSR-87-0074; NAG1-753)

An unsteady Navier-Stokes (NS) analysis is developed and used to carefully examine high-incidence aerodynamic separated flows past airfoils. Clustered conformal C-grids are employed for the 12 percent thick symmetric Joukowski airfoil as well as for the NACA 0012 airfoil with a sharp trailing edge. The clustering is controlled by appropriate one-dimensional stretching transformations. An attempt is made to resolve many of the dominant scales of an unsteady flow with massive separation, while maintaining the transformation metrics to be smooth and continuous in the entire flow field. A fully implicit time-marching alternating-direction implicit-block Gaussian elimination (ADI-BGE) method is employed, in which no use is made of any explicit artificial dissipation. Detailed results are obtained for massively separated, unsteady flow past symmetric Joukowski and NACA 0012 airfoils. Author

A90-16782#
THE CALCULATION OF UNDER-EXPANDED IMPINGING JETS
JAMES J. MCGUIRK and GARY J. PAGE (Imperial College of Science, Technology, and Medicine, London, England) IN: Symposium on Numerical and Physical Aspects of Aerodynamic Flows, 4th, Long Beach, CA, Jan. 16-19, 1989, Proceedings. Long Beach, CA, California State University, 1989, 9 p. Research supported by the Ministry of Defence Procurement Executive. refs

This paper reports the application of a new pressure-correction scheme for transonic flows to the case of a single under-expanded impinging jet. The basic novelties of the pressure-correction algorithm are the use of dependent variables per unit volume rather than per unit mass, and the introduction of a retarded pressure approach. Results are presented for the unsteady start-up phase of a jet at a pressure ratio of 2.7 and an impingement distance of 1.96 nozzle diameters. Also, the steady state solution is compared to the experimental impingement plane pressure distribution. Finally, the transient behavior induced by the nozzle exit descending toward the ground plane at a velocity of 10 m/s is studied. Author

A90-16783#
MULTIGRID ACCELERATION OF TRANSSONIC FLOW COMPUTATIONS
G. CAPDEVILLE, Y. MARX, and J. PIQUET (Ecole Nationale Superieure de Mecanique, Nantes, France) IN: Symposium on Numerical and Physical Aspects of Aerodynamic Flows, 4th, Long Beach, CA, Jan. 16-19, 1989, Proceedings. Long Beach, CA, California State University, 1989, 10 p. refs
(Contract DRET-86-107)

The resolution of the compressible Navier-Stokes equation still requires a large computing time even on supercomputers, unless acceleration techniques are used. In this work several implicit methods are tested on several two-dimensional configurations. For the GAMM double nozzle the combination of implicit methods with multigrid techniques is demonstrated to lead to efficient steady state computations. Several characteristics of the separated turbulent flow resulting from a shock-boundary layer interaction on the bump are then studied. Endly, the capabilities of the implicit method to describe a blade-to-blade flow are discussed. Author

A90-16786#
TRANSITION PHENOMENA ON AIRFOILS OPERATING AT LOW CHORD REYNOLDS NUMBERS IN STEADY AND UNSTEADY FLOW
M. BRENDEL (Florida Institute of Technology, Melbourne) and T. J. MUELLER (Notre Dame, University, IN) IN: Symposium on Numerical and Physical Aspects of Aerodynamic Flows, 4th, Long Beach, CA, Jan. 16-19, 1989, Proceedings. Long Beach, CA, California State University, 1989, 8 p. refs
(Contract N00014-83-K-0239)

The boundary layer on an airfoil operating at low chord Reynolds numbers is often characterized by the appearance of a transitional separation bubble. Here, the transition process is discussed in the context of conventional time-averaged separation bubble models and experimental evidence. The results indicate that saturation of the fundamental instability mode of the separated shear layer coincides with the maximum vertical displacement of the shear layer. The saturation appears to signify the beginning of the abrupt pressures rise in the aft portion of the transitional bubble. It is shown that the problem of transition in the separation bubble involves the proximity of the separated shear layer to the surface. C.D.

A90-16787#
DISTURBANCE GROWTH IN AN UNSTABLE THREE-DIMENSIONAL BOUNDARY LAYER
H. BIPPES and B. MUELLER (DLR, Institut fuer experimentelle Stroemungsmechanik, Goettingen, Federal Republic of Germany) IN: Symposium on Numerical and Physical Aspects of Aerodynamic Flows, 4th, Long Beach, CA, Jan. 16-19, 1989, Proceedings. Long Beach, CA, California State University, 1989, 7 p. refs

The natural transition process in the three-dimensional boundary layer is investigated experimentally on a swept-back flat plate. The evolution of stationary and nonstationary disturbances is traced by means of extensive field measurements using hot-wire anemometry. Emphasis is placed upon the growth of the apparent instability modes. Evidence is presented that the growth depends on the relative size of manufactured tolerances and free-stream turbulence whether the stationary or nonstationary instability mode dominates the transition process. The occurrence of both types of disturbance in the linear range of amplification causes the early appearance of nonlinear effects acting over more than half of the transition process in the case of low free-stream turbulence. C.D.

A90-16788*# High Technology Corp., Hampton, VA.
CURVATURE EFFECTS ON THE STABILITY OF LAMINAR BOUNDARY LAYERS ON SWEPT WINGS
F. S. COLLIER, JR. (High Technology Corp., Hampton, VA), D. W. BARTLETT, and R. D. WAGNER (NASA, Langley Research Center, Hampton, VA) IN: Symposium on Numerical and Physical Aspects of Aerodynamic Flows, 4th, Long Beach, CA, Jan. 16-19, 1989, Proceedings. Long Beach, CA, California State University, 1989, 13 p. refs

The stability of the laminar boundary layer on a swept wing is examined. An improved linear stability theory which includes the effects of body and streamline curvature and compressibility is utilized for the calculations. The computed N-factor is correlated with the onset of transition. For this study, only test conditions where transition is due to the growth of highly amplified crossflow instabilities on convex surfaces are examined. The calculations show that the effect of the curvature terms is to dramatically reduce local amplification rates in regions where body and streamline curvature are large. For the cases where transition occurred ahead of the pressure minimum on the upper surface of the wing, the N-factor at transition onset is near 9 when the effects of body and streamline curvature are included in the computations. When the curvature terms are neglected, the average N-factor is about 17. The calculations show that traveling crossflow waves are most amplified. Author

A90-16789#
LEADING EDGE CONTAMINATION AND RELAMINARISATION ON A SWEPT WING AT INCIDENCE
D. ARNAL and J. C. JUILLEN (ONERA, Centre d'Etudes et de Recherches de Toulouse, France) IN: Symposium on Numerical and Physical Aspects of Aerodynamic Flows, 4th, Long Beach, CA, Jan. 16-19, 1989, Proceedings. Long Beach, CA, California State University, 1989, 11 p. refs

This study is concerned with an experimental investigation of the leading edge contamination on a swept wing. The contamination is induced by the turbulent boundary layer developing along the wind tunnel floor; it is detected by using hot films glued along the span direction, close to the leading edge. The possibilities of relaminarization are also examined. Author

A90-16790#
PREDICTION OF TRANSITION ON AIRFOILS WITH SEPARATION BUBBLES, SWEPT WINGS AND BODIES OF REVOLUTION AT INCIDENCE
TUNCER CEBECI and H. H. CHEN (California State University, Long Beach) IN: Symposium on Numerical and Physical Aspects of Aerodynamic Flows, 4th, Long Beach, CA, Jan. 16-19, 1989, Proceedings. Long Beach, CA, California State University, 1989, 15 p. refs
(Contract N00406-87-C-0790)

Calculations were performed to predict transition from laminar to turbulent flow on two airfoils with regions of separation, a swept wing, and a prolate spheroid at 10 deg angle of attack. The airfoil results were obtained by solving boundary-layer equations in interactive form, together with linear stability theory as presented by the e exp n method. The results confirm the importance of the location of the onset of transition in low Reynolds-number flows and demonstrate the practical usefulness of the computational method utilized. The accuracy of the e exp n method is even better for separation-induced transition due to the rapid growth of the amplification rates which reduces uncertainties associated with the value of n. The swept-wing calculations show that spatial amplification theory leads to accurate results and that the location and magnitude of the critical frequency can be obtained correctly and efficiently. C.D.

A90-16792*# McDonnell Aircraft Co., Saint Louis, MO.
SUPERSONIC BOUNDARY LAYER STABILITY ANALYSIS WITH AND WITHOUT SUCTION ON AIRCRAFT WINGS
SHREEKANT AGRAWAL, TOM A. KINARD (McDonnell Aircraft Co., Saint Louis, MO), and ARTHUR G. POWEL (Douglas Aircraft Co., Long Beach, CA) IN: Symposium on Numerical and Physical Aspects of Aerodynamic Flows, 4th, Long Beach, CA, Jan. 16-19, 1989, Proceedings. Long Beach, CA, California State University, 1989, 11 p. refs
(Contract NAS1-18037)

An analysis of the boundary layer and its stability with and without suction on a supersonic cruise fighter wing having biconvex 5 percent thick airfoils is conducted for a free-stream Mach number of 2.0 and an angle of attack of 4.0 deg. It is found that the largest amplification is due to the highly oblique traveling cross flow type waves, oriented approximately 80 deg without suction, and 87.5 deg with suction, from the local external velocity vector. It is concluded that with the biconvex airfoil section on the thin swept wing, this type of instability would be the likely cause of transition. The approximate values of the frequency, wave orientation angle, and wavelength/chord ratio for the most amplified disturbance are given for the cases of suction and no suction. The largest amplifications are found for highly oblique traveling crossflow type waves oriented at approximately 80 deg without suction and 87.5 deg with suction, measured from the local external velocity vector. C.D.

A90-16793*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
EXPERIMENTAL TRANSITION AND BOUNDARY-LAYER STABILITY ANALYSIS FOR A SLOTTED SWEPT LAMINAR FLOW CONTROL AIRFOIL

WILLIAM D. HARVEY, CHARLES D. HARRIS, and CUYLER W. BROOKS, JR. (NASA, Langley Research Center, Hampton, VA) California State University, U.S. Navy, NASA, and U.S. Army, Symposium on Numerical and Physical Aspects of Aerodynamic Flows, 4th, California State University, Long Beach, Jan. 16-19, 1989, Paper. 17 p. refs

A swept, supercritical laminar flow control (LFC) airfoil designated NASA SCLFC(1)-0513F was tested at subsonic and transonic speeds in the NASA Langley eight-foot Transonic Pressure Tunnel. This paper examines Tollmien-Schlichting and crossflow disturbance amplification for this airfoil using the linear stability method. The design methodology using linear stability analysis is evaluated and the results of the incompressible and compressible methods are compared. Experimental data on the swept, supercritical LFC airfoil and reference wind tunnel and flight results are used to correlate and evaluate the N-factor method for transition prediction over a speed range M(infinity) from zero to one. C.D.

A90-16794*# Arizona State Univ., Tempe.
EXPERIMENTS IN SWEPT-WING TRANSITION
WILLIAM S. SARIC, J. RAY DAGENHART, and MARC C. MOUSSEUX (Arizona State University, Tempe) California State University, U.S. Navy, NASA, and U.S. Army, Symposium on Numerical and Physical Aspects of Aerodynamic Flows, 4th, California State University, Long Beach, Jan. 16-19, 1989, Paper. 14 p. refs
(Contract NAG1-805)

Stability and transition experiments are conducted on a 45 degree sweep airfoil in the ASU Unsteady Wind Tunnel. Combined flow-visualization techniques and hot-wire measurements are used in conjuction with stability-code calculations to map out transition behavior for this flow geometry. Both steady and unsteady crossflow vortices are observed and at this time there is no contradiction with the theoretical predictions. Author

A90-16797#
CALCULATION OF FLOW OVER AIRFOIL WITH SLAT AND FLAP
WEI JIA, YOSIAKI NAKAMURA, MICHIRU YASUHARA, and KOSEI KUWABARA Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 37, no. 428, 1989, p. 430-440. In Japanese, with abstract in English. refs

A numerical procedure for computing the incompressible viscous flow about an airfoil with a slat and a flap is presented. The full Navier-Stokes equations are discretized in curvilinear coordinates, using the cell method. The generalized Quick method is incorporated to suppress the instability from the convective terms at higher Reynolds numbers. A multidomain technique is used to calculate a flow problem with a complicated geometry. This procedure has been applied to calculate the flow about a NACA4412 airfoil at high Reynolds number for various attack angles; good agreement with experiment is obtained. Author

A90-16799#
TRANSONIC FLOW IN THROAT REGION OF SUPERSONIC NOZZLES
SHIGERU YAMANAKA Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 37, no. 428, 1989, p. 451-455. In Japanese, with abstract in English. refs

The transonic potential flows in the throat region of two-dimensional and axisymmetric nozzles were calculated using a biquadratic expression for the velocity potential in case of R/h = 3, 4 and 5, where R is the radius of throat wall and h is half-width of throat. In addition, the effects of the radius of curvature of the wall were calculated; the flow was also visualized using a schlieren technique. Author

A90-16826#
AN EXPERIMENT STUDY OF ROTOR AERODYNAMIC IN GROUND EFFECT AT LOW SPEED
MAO SUN (Beijing University of Aeronautics and Astronautics , People's Republic of China) and H. C. CURTISS (Princeton University, NJ) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 10, Sept. 1989, p. A413-A419. In Chinese, with abstract in English.

Results of an experimental study of the aerodynamics of a helicopter rotor in ground effect at low speeds are presented in this paper. Experiments of rotor wake flow visualization and induced velocity measurement near the rotor disk were conducted. The results obtained explain the irregular variations of rotor forces and moments with advance ratio reported in previous studies. Author

A90-16835#
CALCULATION OF TWO-DIMENSIONAL TRANSONIC FLOW OF EULER EQUATIONS WITH MULTIGRID METHOD
SHENG LIU, YUN BAO, and SHONGLING LIU (Northwestern Polytechnical University, Xian, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 10, Sept. 1989, p. A493-A496. In Chinese, with abstract in English. refs

The Euler equations of the two-dimensional transonic flow around airfoils are solved by the finite-volume method with Mac-Cormack explicit scheme. The boundary conditions on the airfoil surface are derived directly using the momentum equations on the mesh cell. The new conditions are of the same two-order accuracy with the difference formulas in the flow field, and make it possible to avoid numerical computations of the coordinate derivatives, which generally have the large errors. The no-reflected far-field conditions are used as well. The convergence rates are effectively improved when the enthalpy damping is included. According to the multigrid principle, an explicit multigrid scheme is devised to accelerate the convergence of the calculations of Euler equations. The four-level multigrid algorithm is used, and the convergence processes are dramatically changed. The satisfied results of the typical transonic flows on NACA0012 airfoil are obtained. Author

A90-16841#
MULTIGRID SOLUTION METHOD FOR THE EULER EQUATIONS
TIMO SIIKONEN and JAAKKO HOFFREN Otaniemi, Finland, Helsinki University of Technology, 1989, 40 p. refs

A multigrid numerical procedure is developed analytically to solve the Euler equations for two-dimensional flow. A finite-volume formulation and the upwind-differenced flux-vector splitting scheme of Van Leer (1982) are combined with an approximately factored implicit time scheme and a multigrid algorithm which improves the convergence by a factor of three. Results for typical airfoil-flow problems are presented in extensive graphs and briefly characterized. Good qualitative agreement with published data is obtained for transonic and supersonic flows, but spurious drag is predicted at subsonic velocities, especially at high angles of attack. T.K.

A90-16844
AIRFOILS IN SUPERSONIC SOURCE AND SINK FLOWS
G. H. SCHNERR and J. ZIEREP (Karlsruhe, Universitaet, Federal Republic of Germany) Zeitschrift fuer Flugwissenschaften und Weltraumforschung (ISSN 0342-068X), vol. 13, Sept.-Oct. 1989, p. 281-290. refs
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On the basis of the known relationships for the bow wave distance in uniform transonic flow, the paper discusses the case of two-dimensional accelerated and decelerated free stream and new transonic similarity parameters are derived. Compared with homogeneous free flow at constant Mach number, the bow wave distance, for example, decreases considerably in the case of accelerated incident flow and for M = 1 ahead of the shock, a finite bow wave distance exists which depends on the incident flow velocity gradients. In the case of constant acceleration dM/dx, the theoretical results are confirmed for three flow fields of different but constant acceleration along the nozzle axis. This applies particularly to the limiting case of vanishing shock intensity when M = 1 ahead of a bow wave having a finite shock distance. The discussion on flows around objects in the field of a supersonic

source or sink provides the curvature behavior of the bow wave. These results are important for technical applications of flows over airfoils in a nonhomogeneous free stream. Author

A90-16845* Technische Univ., Aachen (Germany, F.R.).
NUMERICAL STUDIES OF INCOMPRESSIBLE FLOW AROUND DELTA AND DOUBLE-DELTA WINGS
E. KRAUSE (Aachen, Rheinisch-Westfaelische Technische Hochschule, Federal Republic of Germany) and C. H. LIU (NASA, Langley Research Center, Hampton, VA) Zeitschrift fuer Flugwissenschaften und Weltraumforschung (ISSN 0342-068X), vol. 13, Sept.-Oct. 1989, p. 291-301. refs
(Contract NAS1-17919; NAS1-18585; DFG-SFB-25)
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The subject has been jointly investigated at NASA Langley Research Center and the Aerodynamisches Institut of the RWTH Aachen over a substantial period. The aim of this investigation has been to develop numerical integration procedures for the Navier-Stokes equations - particularly for incompressible three-dimensional viscous flows about simple and double delta wings - and to study the low speed flow behavior, with its complex vortex structures on the leeward side of the wing. The low speed flight regime poses unusual problems because high incidence flight conditions may, for example, encounter symmetric and asymmetric vortex breakdown. Because of the many difficulties to be expected in solving the problem, it was divided into two - analysis of the flow without vortex breakdown and analysis of the breakdown of isolated vortices. The major results obtained so far on the two topics are briefly described. Author

A90-16846
TWO-DIMENSIONAL TRANSONIC FLOW FIELD ANALYSIS WITH DIFFERENT TURBULENCE MODELS
I. TEIPEL and A. WIEDERMANN (Hannover, Universitaet, Hanover, Federal Republic of Germany) Zeitschrift fuer Flugwissenschaften und Weltraumforschung (ISSN 0342-068X), vol. 13, Sept.-Oct. 1989, p. 302-307. refs
Copyright

A time-dependent Navier-Stokes code for calculating transonic viscous internal flows is presented. The emphasis is on the determination of the important quantities of the wall shear layer. The system of Reynolds-averaged governing equations for the turbulent flow is closed by different turbulence models of the eddy-viscosity type. Algebraic closure formulas and a modified k-epsilon model are compared. Numerical experiments have been carried out using two-dimensional unseparated flowfields in nozzles. The results and the numerical efficiencies of the vectorized codes on a CRAY-XMP are discussed. Author

A90-16852#
A NUMERICAL METHOD FOR COMPUTING THE AERODYNAMIC LOADS ON WINGS WITH SHARP-EDGE SEPARATIONS AT LARGE ANGLES OF ATTACK IN SUBCRITICAL TRANSONIC FLOWS
ZHENGYIN YE, YONGNIAN YANG, and LINGCHENG ZHAO (Northwestern Polytechnical University, Xian, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 10, Oct. 1989, p. B468-B473. In Chinese, with abstract in English. refs

A numerical method is presented based on the nonlinear potential equation containing all the quadratic terms for computing the nonlinear aerodynamic loads on wings with sharp edge separations at large angles of attack in subcritical near-sonic flows. A local linearization assumption is imposed in this method. The problem with a boundary-oriented and an equation-oriented nonlinearity is treated successfully. Numerical results are compared with experimental data and are found to be in good agreement. Author

A90-17107
PERTURBATIONS OF A THREE-DIMENSIONAL BOUNDARY LAYER PRODUCED BY BODY IRREGULARITIES [O VOZMUSHCHENIIAKH PROSTRANSTVENNOGO POGRANICHNOGO SLOIA, VYZVANNYKH NEROVNOSTIAMI OBTEKAEMOGO TELA]
S. V. MANUILOVICH Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza (ISSN 0568-5281), Sept.-Oct. 1989, p. 129-134. In Russian. refs
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Uniform flow of a viscous incompressible fluid past a swept wing is investigated analytically in orthogonal coordinates. The main flow is characterized by stationary perturbations excited by the periodic surface roughness of the wing in the transverse direction. The analysis employs a formulation based on linearized Navier-Stokes equations; the boundary value problem is solved numerically. The applicability limits of the formulation proposed here are defined. V.L.

A90-17108
CHANGES IN SUPERSONIC FLOW PAST AN OBSTACLE DUE TO THE FORMATION OF A THIN RAREFACTION CHANNEL AHEAD OF THE OBSTACLE [IZMENENIE REZHIMA SVERKHZVUKOVOGO OBTEKANIIA PREPIATSTVIIA PRI VOZNIKNOVENII PERED NIM TONKOGO RAZREZHENNOGO KANALA]
V. I. ARTEM'EV, V. I. BERGEL'SON, I. V. NEMCHINOV, T. I. ORLOVA, V. A. SMIRNOV et al. Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza (ISSN 0568-5281), Sept.-Oct. 1989, p. 146-151. In Russian. refs
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The effect of a rarefaction channel on supersonic flow past an obstacle is investigated numerically and experimentally. Results of the numerical analysis are examined for the case of flow of an ideal gas (Mach 3.07, adiabatic exponent gamma 1.08) past a cylinder end. The results obtained indicate a restructuring of supersonic flow ahead of the body with the formation of a thin rarefaction channel. The numerical results are found to be in good agreement with experimental data. V.L.

A90-17109
EQUILIBRIUM OF AN ELASTIC POROUS SHELL IN SUPERSONIC GAS FLOW [O RAVNOVESII GIBKOI PRONITSAEMOI OBOLOCHKI V SVERKHZVUKOVOM POTOKE GAZA]
S. V. GUVERNIUK and K. G. SAVINOV Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza (ISSN 0568-5281), Sept.-Oct. 1989, p. 152-158. In Russian.
Copyright

Stationary plane flow past a uniaxial perfectly elastic open porous shell supported in a fixed position in uniform supersonic flow of an ideal gas is investigated numerically. The effect of angle of attack and of the degree of porosity distribution nonuniformity on the aerodynamic characteristics and equilibrium mode of the shell are determined for different shell support conditions. Approximate relations are formulated which describe the distributed load on a concave porous screen as a function of the screen porosity and incoming flow parameters. The application of these relations to three-dimensional problems of porous shell equilibrium in supersonic flow is illustrated by an example. V.L.

A90-17112
EFFECT OF THE INERTIAL NATURE OF INJECTION AND TEMPERATURE ON THE DAMPING OF BODY VIBRATIONS [VLIIANIE INERTSIONNOSTI VDUVA I TEMPERATURY NA DEMPFIROVANIE KOLEBANII TEL]
E. S. KORNIENKO and V. A. PLATONOV Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza (ISSN 0568-5281), Sept.-Oct. 1989, p. 171-174. In Russian. refs
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The problem of determining the nonstationary aerodynamic characteristics of bodies vibrating, with a small amplitude, about a certain nonzero angle of attack is analyzed for the case where

the rate of change of the angle of attack is small in comparison with the rate of the gasdynamic processes. The analysis indicates the presence of a substantial dependence of the nonstationary characteristics of conical bodies on the characteristics of inertial thermal processes occurring at the material surface at high flow velocities. In particular, the presence of a positive phase shift between the injection and heat flow oscillations improves the dynamic stability of a body, whereas the presence of a negative shift reduces the stability. V.L.

A90-17311
EFFECT OF TIP SPEED ON ROTOR INFLOW
SUSAN L. ALTHOFF (U.S. Army, Aviation Systems Command, Hampton, VA) American Helicopter Society, Journal (ISSN 0002-8711), vol. 34, Oct. 1989, p. 18-27. refs
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Recent investigations have demonstrated the use of a laser velocimeter system to measure inflow velocity into a model rotor system at advance ratios of 0.15, 0.23, and 0.30. To obtain higher advance ratio data, the rotor tip speed can be reduced or the freestream velocity can be increased. Theoretically, these two methods are equivalent, provided that other scaling parameters such as Mach number do not affect the phenomena which are being studied. Experimental and analytical studies have been conducted to determine the effect of reducing rotor tip speed while maintaining constant advance ratio on the measured inflow velocity ratio. The results of the experiment for two different tip speeds at an advance ratio = 0.30 show that changing rotor tip speed does change both the mean and the azimuthally dependent inflow velocity ratio significantly. The results of the analyses have shown that further studies are needed to understand the way two analysis methods predict rotor induced velocities. Author

A90-17464
COMPUTATION OF THE TRAILING EDGE FLOW DOWNSTREAM A FLAT PLATE WITH FINITE THICKNESS
E I. ELBIALY, A. M. MOBARAK, and M. A. SERAG-ELDIN (Cairo University, Egypt) International Journal of Turbo and Jet-Engines (ISSN 0334-0082), vol. 6, no. 1, 1989, p. 89-102. refs
Copyright

A computational model is presented for the numerical prediction of the near-wake flow downstream a blade trailing edge. The model incorporates a two-equation model of turbulence and an adapted solution procedure, to which special modifications have been introduced in order to represent the curved and inclined trailing edge boundary shapes accurately while still retaining an orthogonal grid. The model is validated against experimental measurements provided for three different trailing edge geometries downstrean a flat plate blade, and the individual trailing edge flows are analyzed and discussed with the aid of the predicted flow patterns. Author

A90-17580
THE INTERACTION BETWEEN A COUNTER-ROTATING VORTEX PAIR IN VERTICAL ASCENT AND A FREE SURFACE
DANIEL L. MARCUS and STANLEY A. BERGER (California, University, Berkeley) Physics of Fluids A (ISSN 0899-8213), vol. 1, Dec. 1989, p. 1988-2000. refs
(Contract N00014-85-K-0509)
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The inviscid, two-dimensional interaction between a pair of counter-rotating line vortices and a free surface has been studied. A solution to the linearized, small-disturbance problem has been thoroughly explored. For the nonlinear problem numerical calculations were carried out for Froude numbers representing a range of very weak to very strong vortices. Strong vortices are little affected by the presence of the surface, rising to form a bubblelike disturbance; weaker vortices follow paths like vortices approaching a plane boundary. The experimentally observed scarring phenomena - surface depressions whose axes are perpendicular to the flow plane - are seen in the numerical results. Author

A90-17585
AN EXPERIMENTAL INVESTIGATION OF THE DOWNWASH BENEATH A LIFTING ROTOR AND LOW ADVANCE RATIOS
I. C. CHEESEMAN and C. HADDOW (Southampton, University, England) Vertica (ISSN 0360-5450), vol. 13, no. 4, 1989, p. 421-445. refs
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An investigation of the downwash just beneath a lifting rotor has been made using triaxial hot wire probes. The rotor was operated at two low advance ratios using both near full scale tip speed and reduced tip speed. Comparison of the two cases showed that in particular areas the flow was sensitive to tip speed. Careful checks were made to ensure that only results within the calibrated hot wire reigons were accepted. Rev by rev data were taken. Author

A90-17586
THEORETICAL AND EXPERIMENTAL ANALYSIS OF A MODEL ROTOR BLADE INCORPORATING A SWEPT TIP
R. MARKIEWICZ (Royal Aerospace Establishment, Farnborough, England) Vertica (ISSN 0360-5450), vol. 13, no. 4, 1989, p. 447-461. refs
Copyright

The design of a swept tip model rotor blade for testing in the RAE 24ft Wind Tunnel is described. The swept tip is chosen to provide a pitch-flap coupling and an azimuthal variation of blade twist. The design is the first step in an investigation of aeroelastic tailoring as a means of reducing helicopter vibration and increasing rotor performance. Comparisons are made between the stresses measured on the swept-tip blade and those on a dynamically similar rectangular blade. Comparisons are also made between the experimental results and those predicted by the RAE/WHL coupled modes analysis and an assessment is made of the suitability of the method for the design of a further set of blades. The aim of the second design is to achieve a performance improvement such as reduced vibration while allowing the blade to vary its twist with azimuth. Author

A90-17692#
LOW REYNOLDS NUMBER AIRFOILS EVALUATION PROGRAM
D. KOSS, D. ABOUDI, M. SHEPSHELOVICH (Israel Aircraft Industries, Ltd., Lod), A. SEIFERT, and I. WYGNANSKI (Tel-Aviv University, Israel) IN: Israel Annual Conference on Aviation and Astronautics, 30th, Tel Aviv and Haifa, Israel, Feb. 15, 16, 1989, Collection of Papers. Haifa, Technion - Israel Institute of Technology, 1989, p. 150-161. refs

The major milestones of an evaluation program of high-lift airfoils, designed to operate at low Reynolds numbers, are described. The program was characterized by two main trends: front-loaded and aft-loaded configurations. After a short study phase, during which a Wortman- and a Liebeck-type airfoil were tested, two airfoils, one front-loaded and one aft-loaded, were designed and tested. The experimental results were compared with corresponding data for well-known advanced high-lift airfoils. Active methods for boundary layer control were applied on the front-loaded configuration airfoil, showing that further drag reductions can be achieved. Finally, design targets were set for further development. Author

A90-17693#
WING-BODY MUTUAL INFLUENCE COEFFICIENTS AT ANGLES-OF-ATTACK TO 24 DEG
ASHER SIGAL (Technion - Israel Institute of Technology, Haifa) and DAVID SIM IN: Israel Annual Conference on Aviation and Astronautics, 30th, Tel Aviv and Haifa, Israel, Feb. 15, 16, 1989, Collection of Papers. Haifa, Technion - Israel Institute of Technology, 1989, p. 168-172. Research supported by Israel Aircraft Industries, Ltd. refs

The sum of wing-body mutual influence coefficients was extracted from the experimental data of Gudmandson and Torengren (1972) for two configurations at Mach numbers from 0.7 to 3.07 and angles-of-attack to 24 deg. The analysis takes

into account the influence of forebody vortices on the wing assembly and that of wing vortices on the afterbody. The wings have aspect ratios of 0.857 and 0.514 and span to body diameter ratios of 4.0 and 2.8, respectively. The configuration with the wider wing shows an almost constant sum of wing-body mutual influence coefficients at transonic Mach numbers. In the supersonic range, there is a reduction of 16 percent in the sum as the angle-of-attack increases to 24 deg. The configuration having the narrower wing shows a reduction of 15 percent in the sum of the influence coefficients at transonic Mach numbers, and of 22 percent to 30 percent at supersonic ones, at the same range of angles-of-attack. Author

A90-17781#
A METHOD FOR AERODYNAMIC DESIGN CALCULATION OF AXIAL GAS TURBINE STAGES WITH COOLING AIR MIXING
ZHONGHU HUANG, YUEQI WANG (Shenyang Aeroengine Research Institute, People's Republic of China), and JINFU YANG (Gas Turbine Establishment, People's Republic of China) Journal of Aerospace Power (ISSN 1000-8055), vol. 4, Oct. 1989, p. 301-304, 388. In Chinese, with abstract in English.

This paper presents a method for the aerodynamic design calculation of axial gas turbine stages with the mixing of cooling air. The mass flow mixing and the energy mixing of the cooling air with the main gas flow are considered directly in the continuity and energy equations, while the momentum loss resulting from the mixing is considered indirectly. The losses of blade rows and their distributions in the radial direction are determined by means of loss models. The influences of different cooling types of blades and the nonuniformity of the inlet total temperature and total pressure in the radial direction are considered in the calculation. The method could be applied to multi-stage air-cooled gas turbines. Author

A90-17784#
AN APPROACH FOR CALCULATING STEADY SUBSONIC AND TRANSONIC BLADE TO BLADE FLOWS
PINGQIA WANG (Chinese Academy of Sciences, Computing Center, People's Republic of China) Journal of Aerospace Power (ISSN 1000-8055), vol. 4, Oct. 1989, p. 313-318, 388. In Chinese, with abstract in English. refs

A software is designed to calculate steady subsonic and transonic blade flows. It can analyze the features of the flow field according to the boundary conditions and automatically choose the numerical method which is suitable to obtain the accurate results and save calculation time. When the coordinates on blade surface at inlet and outlet are given, the user can determine the Mach number or pressure distribution on blade surface, Mach number or pressure contours in all of the flow field. Two kinds of numerical methods are used: the streamline curvature method and the time-matching method. Three numerical examples are given. Both calculation methods give comparable results, and the results agree well with the measurements. Author

A90-17785#
COMPUTATION OF TRANSONIC FLOW IN A PLANE CASCADE WITH AN UNFACTORED FLUX SPLITTING IMPLICIT METHOD
DONGTAO HUANG, MENGYU SHEN (Tsinghua University, Beijing, People's Republic of China), and YAOKE ZHANG (Chinese Academy of Sciences, Computing Centre, People's Republic of China) Journal of Aerospace Power (ISSN 1000-8055), vol. 4, Oct. 1989, p. 319-324, 389. In Chinese, with abstract in English.

MacCormack's flux splitting method has proven itself quite fast converging in numerical simulation of flows in converging-diverging nozzle. In this paper, a development on the basis of this method is presented for Euler equations in order to obtain numerical solutions of inviscid transonic flow through a two-dimensional turbine cascade. In the present finite-area flux splitting implicit method, the Gauss-Seidel line relaxation is applied to solving the implicit discretization equations. But the predictor-corrector two-step method is abandoned to cut down the computational time in every time step, because it cannot enhance the accuracy of the steady solution in flux-splitting methods. In order to improve the accuracy of the solution, the right side of the difference equation is discretized to be of second-order accuracy. The blade wall boundary conditions and the numerical results show that the present method retains the effective convergence rate (only about 30 time steps to attain a steady solution) and yields numerical solutions consistent with the experimental results. Author

A90-17786#
A RELAXATION METHOD FOR TRANSONIC POTENTIAL FLOWS THROUGH 2-D CASCADE WITH LARGE CAMBER ANGLE
GUOHUA WU and ZEYAN PENG (Beijing University of Aeronautics and Astronautics, People's Republic of China) Journal of Aerospace Power (ISSN 1000-8055), vol. 4, Oct. 1989, p. 325-328, 389. In Chinese, with abstract in English. refs

A new transonic relaxation method is presented which can be used for the computation of transonic potential flows through a two-dimensional cascade with a large camber angle. A nonorthogonal mesh system composed of streamlines and straight lines parallel to the y-axis is employed. The governing equation expressed by the streamline coordinate system is solved in physical plane. In the case of the cascade with large camber angle (especially for turbines), direct formulation of a difference scheme from the full-potential equation (instead of the perturbation-potential equation) is suggested. Numerical results show that both the convergence and the stability of the finite difference scheme proposed here are satisfactory. Author

A90-17787#
EXPERIMENTAL INVESTIGATION ON THE PERFORMANCE OF AN ANNULAR NOZZLE CASCADE OF A HIGHLY-LOADED TRANSONIC TURBINE STAGE
SHIYING ZHOU, JINNIAN LI, ZHONGHU HUANG (Shenyang Aeroengine Research Institute, People's Republic of China), XUEZHEN YANG, and TIANSONG ZHANG (Gas Turbine Establishment, People's Republic of China) Journal of Aerospace Power (ISSN 1000-8055), vol. 4, Oct. 1989, p. 329-332, 389. In Chinese, with abstract in English.

An annular nozzle cascade of a highly-loaded transonic turbine stage has been tested in an annular cascade wind tunnel, and its two-plane cascades at the hub and mid-sections in a plane cascade wind tunnel. Their loss performance, exit flow angle, exit flow velocity as well as the flow velocity distribution on the blade-profile surfaces obtained in both cases are analyzed comparatively. It is proven that the experimental results of the annular nozzle cascade are comparable with those of the plane cascades, with particularly good agreement at the mid-section. But at the hub section, an obvious difference in both the experimental results is seen because of the local flow complexity in the annular nozzle cascade.
Author

A90-17862#
TRANSITION EFFECTS ON AIRFOIL DYNAMICS AND THE IMPLICATIONS FOR SUBSCALE TESTS
L. E. ERICSSON (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA) Journal of Aircraft (ISSN 0021-8669), vol. 26, Dec. 1989, p. 1051-1058. Previously cited in issue 21, p. 3337, Accession no. A87-49072. refs

A90-17863*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
DESIGN AND EXPERIMENTAL VERIFICATION OF AN EQUIVALENT FOREBODY REPRESENTATION OF FLOWING INLETS
DAVY A. HAYNES, DAVID S. MILLER (NASA, Langley Research Center, Hampton, VA), JOHN R. KLEIN, and CHECK M. LOUIE (McDonnell Aircraft Co., Saint Louis, MO) Journal of Aircraft (ISSN 0021-8669), vol. 26, Dec. 1989, p. 1059-1066. Previously cited in issue 07, p. 929, Accession no. A88-22143. refs

A90-17864*# Colorado Univ., Boulder.
COMPUTATION OF VISCOUS TRANSONIC FLOW OVER POROUS AIRFOILS
CHUNG-LUNG CHEN, CHUEN-YEN CHOW (Colorado, University, Boulder), WILLIAM R. VAN DALSEM, and TERRY L. HOLST (NASA, Ames Research Center, Moffett Field, CA) Journal of Aircraft (ISSN 0021-8669), vol. 26, Dec. 1989, p. 1067-1075. Previously cited in issue 08, p. 1037, Accession no. A87-22582. refs
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A90-17866#
NUMERICAL SIMULATION OF WINGS IN STEADY AND UNSTEADY GROUND EFFECTS
D. T. MOOK (Virginia Polytechnic Institute and State University, Blacksburg) and A. O. NUHAIT Journal of Aircraft (ISSN 0021-8669), vol. 26, Dec. 1989, p. 1081-1089. Previously cited in issue 16, p. 2593, Accession no. A88-40728. refs
(Contract AF-AFOSR-85-0158)
Copyright

A90-17868#
FURTHER ANALYSIS OF WING ROCK GENERATED BY FOREBODY VORTICES
L. E. ERICSSON (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA) Journal of Aircraft (ISSN 0021-8669), vol. 26, Dec. 1989, p. 1098-1104. Previously cited in issue 16, p. 2597, Accession no. A88-40768. refs
(Contract F33615-87-C-3607)
Copyright

A90-17869*# Flow Analysis, Inc., Mountain View, CA.
ROTOR HOVER PERFORMANCE PREDICTION USING A FREE-WAKE, COMPUTATIONAL FLUID DYNAMICS METHOD
K. RAMACHANDRAN (Flow Analysis, Inc., Mountain View, CA), C. TUNG, and F. X. CARADONNA (NASA, Ames Research Center, Moffett Field, CA) Journal of Aircraft (ISSN 0021-8669), vol. 26, Dec. 1989, p. 1105-1110. Previously cited in issue 10, p. 1432, Accession no. A89-28443. refs
Copyright

A90-17871#
SUPERSONIC LOW-DENSITY FLOW OVER AIRFOILS
TSZE C. TAI and MARK S. MORAN (U.S. Navy, David W. Taylor Naval Ship Research and Development Center, Bethesda, MD) Journal of Aircraft (ISSN 0021-8669), vol. 26, Dec. 1989, p. 1118-1122. Research supported by the U.S. Navy. Previously cited in issue 09, p. 1282, Accession no. A89-25424. refs

A90-17872*# Tokyo Univ., Sagamihara (Japan).
HIGH-RESOLUTION UPWIND SCHEME FOR VORTICAL-FLOW SIMULATIONS
KOZO FUJII (Institute of Space and Astronautical Science, Sagamihara, Japan) and SHIGERU OBAYASHI (NASA, Ames Research Center, Moffett Field, CA) Journal of Aircraft (ISSN 0021-8669), vol. 26, Dec. 1989, p. 1123-1129. Previously cited in issue 18, p. 2749, Accession no. A89-41802. refs
Copyright

A90-17976#
POTENTIAL FLOW CALCULATION FOR THREE-DIMENSIONAL WINGS AND WING-BODY COMBINATION IN OSCILLATORY MOTION
N. SINGH, S. AIKAT, and B. C. BASU (Indian Institute of Technology, Kharagpur, India) AIAA Journal (ISSN 0001-1452), vol. 27, Dec. 1989, p. 1665, 1666. Research supported by the Ministry of Defence of India.
Copyright
A method based on camber surface source-vortex distribution has been developed to calculate steady and unsteady pressure distribution on wings and wing-body combinations undergoing small-amplitude simple-harmonic pitching motion in incompressible potential flow. The method is linearized with respect to amplitude of oscillation, but is numerically exact in representing the sectional profile shape. Problems considered in this paper include wings, control surfaces, and wing-body combinations oscillating in pitching mode. To demonstrate the accuracy of the present method, results are compared with other available theoretical as well as experimental data. Author

A90-17978*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
NAVIER-STOKES COMPUTATIONS OF LEE-SIDE FLOWS OVER DELTA WINGS
JAMES L. THOMAS (NASA, Langley Research Center, Hampton, VA) and RICHARD W. NEWSOME (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) AIAA Journal (ISSN 0001-1452), vol. 27, Dec. 1989, p. 1673-1679. Previously cited in issue 17, p. 2466, Accession no. A86-38420. refs
Copyright

A90-17979#
ESSENTIAL INGREDIENTS OF A METHOD FOR LOW REYNOLDS-NUMBER AIRFOILS
TUNCER CEBECI (California State University, Long Beach) AIAA Journal (ISSN 0001-1452), vol. 27, Dec. 1989, p. 1680-1688. refs
(Contract N00014-85-K-0346)
Copyright
A calculation method for low-Reynolds-number flows is described and appraised in terms of comparisons between calculations and measurements. It comprises interaction between solutions of inviscid- and boundary-layer equations and involves the exp n method to determine the location of the onset of transition with further interaction to insure that upstream effects of the turbulent-flow region are correctly represented. The importance of the length of the transition region, which usually occurs within a separation bubble, is demonstrated, and an extended version of the intermittency expression used in the Cebeci-Smith algebraic, eddy-viscosity formulation is proposed and shown to represent the separation-induced transitional flows. The comparison of calculated and measured results encompasses five airfoils, chord Reynolds numbers from 300,000 to 8 million, and angles of attack from 0-11 deg, and shows that the essential features of these flows are correctly represented. Author

A90-17981# Texas Univ., Austin.
SEPARATION SHOCK DYNAMICS IN MACH 5 TURBULENT INTERACTIONS INDUCED BY CYLINDERS
D. S. DOLLING and D. R. SMITH (Texas, University, Austin) AIAA Journal (ISSN 0001-1452), vol. 27, Dec. 1989, p. 1698-1706. Research supported by NASA and U.S. Navy. Previously cited in issue 07, p. 931, Accession no. A88-22220. refs
(Contract AF-AFOSR-86-0112)
Copyright

A90-17985*# California Univ., Los Angeles.
MODELING OF LIQUID JETS INJECTED TRANSVERSELY INTO A SUPERSONIC CROSSFLOW
S. D. HEISTER, T. T. NGUYEN, and A. R. KARAGOZIAN (California, University, Los Angeles) AIAA Journal (ISSN 0001-1452), vol. 27, Dec. 1989, p. 1727-1734. Previously cited in issue 07, p. 927, Accession no. A88-22071. refs
(Contract DE-FG03-88ER-13910; NCC2-374)
Copyright

A90-17989*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
NUMERICAL STUDY OF CHEMICALLY REACTING FLOWS USING A LOWER-UPPER SYMMETRIC SUCCESSIVE OVERRELAXATION SCHEME
JIAN SHUN SHUEN (NASA, Lewis Research Center, Cleveland, OH) and SEOKKWAN YOON (NASA, Ames Research Center, Moffett Field, CA) AIAA Journal (ISSN 0001-1452), vol. 27, Dec. 1989, p. 1752-1760. Previously cited in issue 08, p. 1143,

Accession no. A88-24825. refs
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A90-17990#
APPROXIMATIONS FOR NONEQUILIBRIUM HYPERVELOCITY AERODYNAMICS
R. J. STALKER (Queensland, University, Brisbane, Australia) AIAA Journal (ISSN 0001-1452), vol. 27, Dec. 1989, p. 1761-1769. Research supported by the Australian Research Grants Scheme. Previously cited in issue 07, p. 935, Accession no. A88-22337. refs
Copyright

A90-17997#
DESIGN OF AXISYMMETRIC BODIES WITH MINIMUM TRANSONIC DRAG
HELGE NORSTRUD (Norges Tekniske Hogskole, Trondheim, Norway) and CUONG P. NGHIEM AIAA Journal (ISSN 0001-1452), vol. 27, Dec. 1989, p. 1818-1820. refs
Copyright
Typical bodies-of-revolution with pointed noses are presently decomposed into a forebody and an afterbody. It is shown that, in the case of a general parabolic shape with midsection as maximum body cross-section, nose bluntness yields low body drag, but afterbody bluntness does not. Nose bluntness leads to foredrag reduction. Among the characteristic axisymmetric shapes treated, the blunt ogive generates minimum wave drag at transonic speeds. O.C.

A90-18001#
HIGH REYNOLDS NUMBER WEDGE-INDUCED SEPARATION LENGTHS AT MACH 6
PETER J. DISIMILE (Cincinnati, University, OH) and NORMAN E. SCAGGS (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) AIAA Journal (ISSN 0001-1452), vol. 27, Dec. 1989, p. 1827, 1828. refs
Copyright
Experimental data are presented which clearly demonstrate the behavior of the separation region in high Re turbulent boundary layers at hypersonic speeds. Attention is given to the reaction of the separation zone to changes in Re from 33 to 98 million at Mach 6. The separation point was defined as the approximate location of the first inflection-point in the surface pressure distribution. O.C.

A90-18002#
MECHANISM OF SIDEWALL EFFECT STUDIED WITH OIL FLOW VISUALIZATION
YAOXI SU (Northwestern Polytechnical University, Xian, People's Republic of China) AIAA Journal (ISSN 0001-1452), vol. 27, Dec. 1989, p. 1828-1830. refs
Copyright
A series of oil flow visualization and pressure distribution measurements was conducted in the DFVLR Transonic Wind Tunnel for an NPU2 airfoil of 3.4 aspect ratio, using a wind tunnel test section with slotted upper and lower walls and solid sidewalls. Test Mach numbers were 0.4-0.78, at Re of about 3 million. The oil flow patterns observed fall into five categories. The sidewall effect of supercritical flow is found to be more complex, and its influence is more pronounced, than in subcritical flow cases. O.C.

A90-18136*# California Univ., Los Angeles.
PRESSURE FLUCTUATIONS IN THE TIP REGION OF A BLUNT-TIPPED AIRFOIL
S. A. MCINERNY, W. C. MEECHAM (California, University, Los Angeles), and P. T. SODERMAN (NASA, Ames Research Center, Moffett Field, CA) AIAA Journal (ISSN 0001-1452), vol. 28, Jan. 1990, p. 6-13. refs
Copyright
The characteristics of turbulence generated in the tip region of a blunt-tipped airfoil were studied using surface pressure measurements. The model was a NACA 0012; tests were performed at flow speeds of 75, 55, and 35 m/s and angles of attack of 6, 12, and 16 deg. Reynolds numbers based on the wing chord were 1.9, 3.0, and 4.1 million. Pressure fluctuations measured near the primary tip-vortex on the upper, low pressure side of the wing tip were uncorrelated with those on the blunt tip. Fluctuations on the high pressure side of the wing were strongly correlated with those on the flat tip, but 10-20 dB less intense. Spectra measured on the flat tip displayed pronounced peaks at dimensionless frequencies of 0.8 to 1.3. Cross correlations between some of the flat-tip pressures displayed two echolike groupings. A model is proposed that explains these correlations. Author

A90-18137*# Douglas Aircraft Co., Inc., Long Beach, CA.
EXPERIMENTAL INVESTIGATION OF FLOWFIELD ABOUT A MULTIELEMENT AIRFOIL
A. NAKAYAMA (Douglas Aircraft Co., Long Beach, CA), H.-P. KREPLIN (DLR, Goettingen, Federal Republic of Germany), and H. L. MORGAN (NASA, Langley Research Center, Hampton, VA) AIAA Journal (ISSN 0001-1452), vol. 28, Jan. 1990, p. 14-21. Previously cited in issue 15, p. 2393, Accession no. A88-37937. refs
Copyright

A90-18138#
HOT-WIRE MEASUREMENTS OF NEAR WAKES BEHIND AN OSCILLATING AIRFOIL
SEUNG O. PARK, JONG SEONG KIM, and BOO IL LEE (Korea Advanced Institute of Science and Technology, Seoul, Republic of Korea) AIAA Journal (ISSN 0001-1452), vol. 28, Jan. 1990, p. 22-28. Previously cited in issue 20, p. 3346, Accession no. A88-48923. refs
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A90-18141#
UNDEREXPANDED JET-FREESTREAM INTERACTIONS ON AN AXISYMMETRIC AFTERBODY CONFIGURATION
N. B. MATHUR and K. S. YAJNIK (National Aeronautical Laboratory, Bangalore, India) (International Symposium on Air Breathing Engines, 8th, Cincinnati, OH, June 14-19, 1987, Proceedings, p. 507-512) AIAA Journal (ISSN 0001-1452), vol. 28, Jan. 1990, p. 47-50. Previously cited in issue 20, p. 3148, Accession no. A87-46232. refs
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A90-18144#
HYBRID FINITE VOLUME APPROACH TO EULER SOLUTIONS FOR SUPERSONIC FLOWS
M. J. SICLARI and P. DEL GUIDICE (Grumman Corporate Research Center, Bethpage, NY) AIAA Journal (ISSN 0001-1452), vol. 28, Jan. 1990, p. 66-74. Previously cited in issue 07, p. 930, Accession no. A88-22167. refs
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A90-18147*# Pennsylvania State Univ., University Park.
MACH NUMBER EFFECTS ON CONICAL SURFACE FEATURES OF SWEPT SHOCK-WAVE/BOUNDARY-LAYER INTERACTIONS
F. K. LU, G. S. SETTLES (Pennsylvania State University, University Park), and C. C. HORSTMAN (NASA, Ames Research Center, Moffett Field, CA) AIAA Journal (ISSN 0001-1452), vol. 28, Jan. 1990, p. 91-97. Previously cited in issue 18, p. 2808, Accession no. A87-42415. refs
(Contract NCA2-IR-589-502; AF-AFOSR-86-0092)
Copyright

A90-18153*# Pennsylvania State Univ., University Park.
SKIN FRICTION MEASUREMENTS BY LASER INTERFEROMETRY IN SWEPT SHOCK/BOUNDARY-LAYER INTERACTIONS
KWANG-SOO KIM and GARY S. SETTLES (Pennsylvania State University, University Park) AIAA Journal (ISSN 0001-1452), vol. 28, Jan. 1990, p. 133-139. Previously cited in issue 07, p. 937, Accession no. A88-22364. refs

(Contract AF-AFOSR-86-0082; NAG3-527)
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A90-18158#
UNSTEADY STREAMLINES NEAR THE TRAILING EDGE OF NACA 0012 AIRFOIL AT A REYNOLDS NUMBER OF 125,000
XIAO L. LIU, ANDREW WO, and EUGENE E. COVERT (Karlsruhe, Universitaet, Federal Republic of Germany) AIAA Journal (ISSN 0001-1452), vol. 28, Jan. 1990, p. 169, 170. Research supported by the Grumman Aircraft and Engineering Co. refs
(Contract N0014-86-K-0513)
Copyright

Novel results are presented on the unsteady streamlines near the trailing edge of a NACA 0012 airfoil in unsteady flow developed by a rotating ellipse located downstream of, and below, the airfoil. For a constant phase excitation, the streamline comes off the trailing edge smoothly when the airfoil is in motion in a fixed stream, or when the stream is in motion and the airfoil is fixed, for either a laminar or a transitional boundary layer. O.C.

A90-18243
SOLVING COMPRESSIBLE FLOW PROBLEMS USING ADAPTIVE FINITE QUADTREE AND OCTREE GRIDS
PEGGY L. BAEHMANN, JOSEPH E. FLAHERTY, FABIO GUERINONI, RAYMOND LUDWIG, and MARK S. SHEPHARD (Rensselaer Polytechnic Institute, Troy, NY) IN: Finite element analysis in fluids; Proceedings of the Seventh International Conference on Finite Element Methods in Flow Problems, Huntsville, AL, Apr. 3-7, 1989. Huntsville, AL, University of Alabama in Huntsville Press, 1989, p. 87-92. Research supported by General Dynamics Corp. refs
(Contract NSF DMC-86-03025)
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Numerical techniques for solving the two-dimensional Euler equations are described and demonstrated. A first-order finite-volume method with van Leer flux-vector splitting is combined with finite quadtree and octree mesh-generation schemes and h-adaptive mesh refinement. The solution technique is briefly outlined, and results are presented in graphs for: (1) a staggered biplane configuration of NACA 0012 airfoils at freestream Mach number 0.7; and (2) three-dimensional flow over a 1 x 0.5 x 1 box at Mach 2. T.K.

A90-18249* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
THE CRITICAL ROLE OF AERODYNAMIC HEATING EFFECTS IN THE DESIGN OF HYPERSONIC VEHICLES
ALLAN R. WIETING (NASA, Langley Research Center, Hampton, VA) IN: Finite element analysis in fluids; Proceedings of the Seventh International Conference on Finite Element Methods in Flow Problems, Huntsville, AL, Apr. 3-7, 1989. Huntsville, AL, University of Alabama in Huntsville Press, 1989, p. 143-150. refs
Copyright

Hypersonic vehicles operate in a hostile aerothermal environment, which has a significant impact on their aerothermostructural performance. Significant coupling occurs between the aerodynamic flow field, structural heat transfer, and structural response, creating a multidisciplinary interaction. The critical role of aerodynamic heating effects in the design of hypersonic vehicles is identified with an example of high localized heating on an engine-cowl leading edge. Recent advances is integrated fluid-thermal-structural finite-element analyses are presented. Author

A90-18254* Planning Research Corp., Hampton, VA.
EULER AND NAVIER-STOKES SOLUTIONS FOR HYPERSONIC FLOWS
RAJIV R. THAREJA, RAMADAS K. PRABHU, JAMES R. STEWART (Planning Research Corp., Hampton, VA), KEN MORGAN, JAIME PERAIRE (University of Wales, Swansea) et al. IN: Finite element analysis in fluids; Proceedings of the Seventh International Conference on Finite Element Methods in Flow Problems, Huntsville, AL, Apr. 3-7, 1989. Huntsville, AL, University of Alabama in Huntsville Press, 1989, p. 180-186. refs
(Contract NAGW-478)
Copyright

An upwind finite-element technique that uses cell-centered quantities and implicit and/or explicit time marching has been developed for computing hypersonic laminar viscous flows using adaptive unstructured grids in two and three dimensions. A perfect gas model as well as an equilibrium air model is implemented for solving high-speed flows. A first-order basic scheme and a higher-order flux-corrected transport (FCT) scheme have been implemented. This technique has been used to predict 'Type III and IV' shock interactions on a cylinder in two dimensions and a swept cylinder in three dimensions, with a view to determine the pressure and heating rate augmentation caused by an impinging shock on the leading edge of a cowl lip of an engine inlet. The predictions of wall pressure and heating rates compare very well with experimental data. The flow features are very distinctly captured with a sequence of adaptively-generated grids. Three-dimensional corner flow, typically encountered in engine inlets due to compression of the flow by ramps in the walls, is also modeled. This procedure is the first step in developing an integrated fluid, thermal, structural analysis capability for hypersonic flight vehicles like the National Aero-Space Plane. Author

A90-18296
COMPUTATION OF HYPERSONIC FLOWS BY A FINITE ELEMENT LEAST-SQUARES METHOD
CHARLES-HENRI BRUNEAU (Paris XI, Universite, Orsay, France) IN: Finite element analysis in fluids; Proceedings of the Seventh International Conference on Finite Element Methods in Flow Problems, Huntsville, AL, Apr. 3-7, 1989. Huntsville, AL, University of Alabama in Huntsville Press, 1989, p. 757-762. Research supported by DRET and Centre de Calcul Vectoriel pour la Recherche.
Copyright

The steady Euler equations written in conservative form are linearized by Newton's method and embedded in a least-squares formulation to compute compressible flows in an external domain. This method is able to treat subsonic as well as supersonic flows without any addition of artificial viscosity. To enforce the conservative properties the groups of conservative variables are approximated by linear finite elements. The results presented concern flows around circular cylinder in two dimensions and past a flat plate at incidence in three dimensions. They show the occurrence of a strong bow shock in the first case and of vortical flows due to the sharp edges in the second case. Author

A90-18297
ON THE COUPLING OF FINITE ELEMENTS AND BOUNDARY ELEMENTS FOR TRANSONIC POTENTIAL FLOWS
H. BERGER, G. WARNECKE, and W. WENDLAND (Stuttgart, Universitaet, Federal Republic of Germany) IN: Finite element analysis in fluids; Proceedings of the Seventh International Conference on Finite Element Methods in Flow Problems, Huntsville, AL, Apr. 3-7, 1989. Huntsville, AL, University of Alabama in Huntsville Press, 1989, p. 763-768. Research supported by the Stiftung Volkswagenwerk. refs
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An improved treatment method for the far-field boundary conditions in compressible transonic flow around airfoil profiles is proposed. Assuming the far field to be subsonic, the full potential equations may be linearized to the Prandtl-Glauert equation on the outside of a bounded region containing the supersonic flow regions. This linear equation can easily be transformed to an integral equation on a specified boundary. This leads to a coupled FEM/BEM for the flow problem. The numerical results show a considerable improvement in comparison with the commonly used method of taking the normal projection of the far-field flow on the boundary. Author

A90-18298
A FINITE ELEMENT SOLUTION FOR TRANSONIC FLOW AROUND LIFTING FUSELAGE WITH ARBITRARY CROSS SECTIONS FROM THE MINIMUM PRESSURE INTEGRAL
GUO-FU ZHANG and XIAN-PIN LI (Nanjing Aeronautical Institute, People's Republic of China) IN: Finite element analysis in fluids; Proceedings of the Seventh International Conference on Finite Element Methods in Flow Problems, Huntsville, AL, Apr. 3-7, 1989. Huntsville, AL, University of Alabama in Huntsville Press, 1989, p. 769-774. Research sponsored by National Natural Science Foundation of China.
Copyright

The lifting fuselage in transonic flow is calculated by the finite element method. The minimum pressure integral is obtained by applying the variational principle to the full potential equation. The artificial density method is applied to capture the shock. On the fuselage surface, Neumann conditions are automatically satisfied; Dirichlet boundary conditions on the far field are prescribed from an approximate formula. The set of equations is solved by the SLOR scheme, and the density is updated after each SLOR sweep. Examples of numerical computations are presented and compared with the available experimental data. V.L.

A90-18301
SIMULATION OF HIGH INCIDENCE UNSTEADY FLOW PAST JOUKOWSKI AIRFOILS
K. N. GHIA, G. A. OSSWALD, and U. GHIA (Cincinnati, University, OH) IN: Finite element analysis in fluids; Proceedings of the Seventh International Conference on Finite Element Methods in Flow Problems, Huntsville, AL, Apr. 3-7, 1989. Huntsville, AL, University of Alabama in Huntsville Press, 1989, p. 813-817.
Copyright

An effort is made to quantify the self-excited large-scale vortex-dominated unsteady separation connected with symmetric and cambered Joukowski airfoils at high incidence. An attempt is made to resolve many of the dominant scales of an unsteady flow with massive separation while maintaining the transformation metrics smooth and continuous in the entire flow field. The fully implicit time-marching alternating-direction implicit-block Gaussian elimination method is used in which all spatial derivatives are approximated using central differences. Unsteady flow results are obtained for various flow configurations with an Re number of 1000 and incidence angles ranging from 15 to 53 deg. B.J.

A90-18305
APPLICATION OF THE FINITE ELEMENT METHOD TO THE PROBLEM OF ROTATIONAL FLOW AROUND WINGS
A. L. KUDRIAVTSEV and N. B. PLISSOV (Leningradskii Korablestroitel'nyi Institut, Leningrad, USSR) IN: Finite element analysis in fluids; Proceedings of the Seventh International Conference on Finite Element Methods in Flow Problems, Huntsville, AL, Apr. 3-7, 1989. Huntsville, AL, University of Alabama in Huntsville Press, 1989, p. 851-856.
Copyright

A numerical method based on the solution of a boundary value problem for a nonlinear differential equation is used to determine the characteristics of an airfoil in a nonuniform flow. In addition, the characteristics of a finite-span wing are obtained through a numerical treatment of lifting-line theory suggested by Karman and Tsien (1945). The finite element method is used to solve these two problems. Numerical examples are presented which show the significant effect of vorticity on the aerodynamic characteristics of wings. B.J.

A90-18308
OPTIMIZATION METHODS APPLIED TO AERODYNAMIC DESIGN PROBLEMS IN COMPUTATIONAL FLUID DYNAMICS
D. H. HUDDLESTON (Sverdrup Technology, Inc., Arnold AFB, TN) and C. W. MASTIN (Mississippi State University, Mississippi State) IN: Finite element analysis in fluids; Proceedings of the Seventh International Conference on Finite Element Methods in Flow Problems, Huntsville, AL, Apr. 3-7, 1989. Huntsville, AL, University of Alabama in Huntsville Press, 1989, p. 899-907. refs
Copyright

A design optimization technique which couples direct optimization algorithms with the aerodynamic analysis capability provided by a versatile CFD program is presented. This technique is shown to be an aid in designing aerodynamic shapes concurrently with certain aerodynamic test parameters. The approach minimizes a nonlinear least-squares objective function which may be defined in a region remote to the geometric surface being optimized. A particular finite-difference CFD analysis code was applied to obtain the objective function evaluations, although the optimization method applied could be coupled to any CFD analysis technique. Sample computations are presented for a supersonic planar nozzle, and a planar, supersonic forebody simulator design. Author

A90-18310
GRID GENERATION WITH THE 1988 EAGLE CODE
JOE F. THOMPSON (Mississippi State University, Mississippi State) IN: Finite element analysis in fluids; Proceedings of the Seventh International Conference on Finite Element Methods in Flow Problems, Huntsville, AL, Apr. 3-7, 1989. Huntsville, AL, University of Alabama in Huntsville Press, 1989, p. 1005-1010. refs
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New features incorporated in the 1988 version of the EAGLE algebraic/elliptic grid generation code are discussed, and examples of application to complex aircraft configurations are given. These new features allow changes in parameters to be localized, removing the need for corresponding changes throughout the input runstream. Author

A90-18443
INCOMPRESSIBLE POTENTIAL FLOW ABOUT COMPLETE AIRCRAFT CONFIGURATIONS
N. SINGH, S. AIKAT, and B. C. BASU (Indian Institute of Technology, Kharagpur, India) Aeronautical Journal (ISSN 0001-9240), vol. 93, Nov. 1989, p. 335-343. Research supported by the Ministry of Defence of India. refs
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An economic numerical method has been developed to calculate the incompressible potential flow about complete aircraft configurations by taking advantage of the computational efficiency of the internal distribution of singularities. For wing and wing-like components, source and vorticity singularities are distributed on the respective mean camber surfaces, while the fuselage carries a source distribution on its wetted surface. The singularity strengths are obtained by satisfying the flow tangency condition at selected points on all the wetted surfaces of the configuration. No attempt has been made to consider wing or body vortex shedding or separation. The results of the present method were compared with other theoretical and experimental data. Author

A90-18479#
AERODYNAMIC DESIGN OF AN HP COMPRESSOR STAGE USING ADVANCED COMPUTATION CODES
F. FALCHETTI and M. GOUTINES (SNECMA, Moissy-Cramayel, France) Aeronautical Society of India, Journal (ISSN 0001-9267), vol. 41, Aug. 1989, p. 253-262. refs

This paper presents the SNECMA aerodynamic design methodology for the first stages of advanced high pressure axial flow compressors. Special emphasis is focused on the use of three-dimensional Euler computations, secondary flow prediction methods and the improvements obtained for the design of a selected application. Rotor blades of this one-stage compressor are supersonic from hub to tip, and fine measurements are available, which provide good information on viscous flow properties close to the walls. Some comparison between theoretical computations and experimental data are presented. Author

A90-18481#
WAKE BEHAVIOUR OF A LARGE DEFLECTION TURBINE ROTOR LINEAR CASCADE
N. SITARAM, M. GOVARDHAN, and N. VENKATARAYULU (Indian Institute of Technology, Madras, India) Aeronautical Society of India, Journal (ISSN 0001-9267), vol. 41, Aug. 1989, p. 269-275. refs

The wake behavior of a large deflection turbine rotor linear cascade at three incidence angles (one at zero incidence and one each at above and below zero incidence) is presented. Flow properties across the wake at various axial distances downstream of the blade trailing edge were measured with a small five hole probe. The wakes are asymmetrical about the wake center near the trailing edge, due to differential growth of the boundary layers on the pressure and suction surfaces of the blade. The total, axial, and pitchwise velocity defects are maximum at negative incidence and minimum at zero incidence. The maximum velocity defect decreases rapidly at negative incidence. Author

A90-18483#
EFFECT OF DOWNSTREAM ELEMENTS ON THE FLOW AT THE EXIT OF CENTRIFUGAL COMPRESSOR ROTOR
B. SALIM (Regional Engineering College, Srinagar, India), D. P. AGRAWAL, R. C. MALHOTRA, and S. N. SINGH (Indian Institute of Technology, New Delhi, India) Aeronautical Society of India, Journal (ISSN 0001-9267), vol. 41, Aug. 1989, p. 281-288. refs

The study deals with the effect of downstream diffusing elements on the flow at the exit of compressor rotor and its development up to a radius ratio of 1/1. The flow parameters are studied for both vaneless and vaned diffusers. The study shows that diffuser configuration affects the uniform distribution of the flow parameters at the different locations. The diffuser configuration also influences the stalling behavior and the overall performance characteristics of the centrifugal compressor. Author

A90-18501#
SECONDARY FLOWS IN A TRANSONIC CASCADE - COMPARISON BETWEEN EXPERIMENTAL AND NUMERICAL RESULTS
F. BASSI (Catania, Universita, Italy), C. OSNAGHI (Milano, Politecnico, MIlan, Italy), A. PERDICHIZZI (Brescia, Universita, Italy), and M. SAVINI (CNRS, CNPM, Peschiera Borromeo, Italy) ASME, Transactions, Journal of Fluids Engineering (ISSN 0098-2202), vol. 111, Dec. 1989, p. 369-377. refs
(Contract CNR-86,00758,59)
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A comparison of numerical results and experimental data is presented for the secondary flow development in a linear transonic turbine cascade. A three-dimensional inviscid Euler code is used which is based on a Runge-Kutta explicit finite volume method. The experimental inlet total pressure distribution is imposed as inlet boundary condition to simulate the incoming endwall boundary layer. The comparison is made in four planes downstream of the cascade. For each of these planes secondary velocities and streamwise vorticity contour plots are presented and discussed. Pitchwise mass-averaged flow angle distributions showing overturning and underturning regions are shown. The comparison shows that an Euler code can predict the essential features of secondary flow phenomena like passage vortex location and intensity, but some disagreement is found in the evaluation of overturning and underturning. The investigation is carried out for Mach numbers 0.5, 1.02, and 1.38 to show the compressibility influence on the flow vortex structure. S.A.V.

A90-18532#
ANALYSES OF FULL 3D S1-S2 ITERATIVE SOLUTION IN CAS TRANSONIC COMPRESSOR ROTOR AND COMPARISON WITH QUASI-3D S1-S2M ITERATIVE SOLUTION AND L2F MEASUREMENT
LISEN QIN, XIAOLU ZHAO, and CHUNG-HUA WU (Chinese Academy of Sciences, Institute of Engineering Thermophysics, Beijing, People's Republic of China) Journal of Engineering Thermophysics (ISSN 0253-231X), vol. 10, Aug. 1989, p. 255-261. In Chinese, with abstract in English. refs

The full three-dimensional S1-S2 iterative solution for the CAS transonic compressor rotor has been analyzed in detail by describing the variations of flow parameters on S1 and S2 surfaces and on the quasi-normal plane and the structure of the spatial shock. Comparison of the full solution with the quasi-three-dimensional solution and the L2F measurement shows that the results of the two iterative calculations are close to each other, although the former has a stronger three-dimensional effect than the latter, and in good agreement with the measurement. Author

A90-18534#
THROUGHFLOW NUMERICAL CALCULATIONS INCLUDING INFLUENCE OF SPANWISE MIXING IN A MULTISTAGE AXIAL FLOW COMPRESSOR
FANGYUAN ZHU (Northwestern Polytechnical University, Xian, People's Republic of China) Journal of Engineering Thermophysics (ISSN 0253-231X), vol. 10, Aug. 1989, p. 265-268. In Chinese, with abstract in English. refs

Modeling mixing as a turbulent diffusion process, computing formulas and a method to calculate throughflow are developed, including the influence of spanwise mixing for subsonic and transonic multistage axial-flow compressors with higher-aerodynamic-loading stages. Initial analysis of flow through a realistic core compressor with transonic stages has been carried out. Author

A90-18537#
STUDY OF CALCULATING AN APPROXIMATELY CONSTANT REACTION TURBINE STAGE WITH A TENSION SPLINE STREAMLINE CURVATURE METHOD
CHIHYA TSUI, PINGJI LIN, and YUCHUN LI (Beijing University of Aeronautics and Astronautics, People's Republic of China) Journal of Engineering Thermophysics (ISSN 0253-231X), vol. 10, Aug. 1989, p. 280-283. In Chinese, with abstract in English. refs

Tension splines for the streamline curvature method are used to calculate an approximately constant reaction turbine stage. The proper arrangement of hub and shroud profiles, nozzle-vane exit swirl distribution, and lean angles can be obtained by cut and trial. Significant features of constant reaction are shown for reference in design and research; these need experimental verification. Author

A90-18578#
NUMERICAL METHOD FOR SOLVING THE EULER EQUATION FOR UNSTEADY TRANSONIC FLOWS OVER OSCILLATING AIRFOILS
FENGWEI LI (Northwestern Polytechnical University, Xian, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 10, May 1989, p. A205-A213. In Chinese, with abstract in English. refs

Through transformations, the time-dependent boundary conditions on the airfoil contour and the boundary conditions at infinity are fixed to the boundaries of a finite domain. The boundary conditions can thus be satisfied exactly without increasing the computational time. This scheme is useful for computing transonic, strong disturbance, unsteady flows with high reduced frequencies. The scheme makes use of curve-fitted orthogonal meshes and the lattice-control technique to obtain the optimal grid distribution. Author

A90-18587#
AN INVESTIGATION OF UNSTEADY LEADING EDGE SEPARATION OF RAPIDLY PITCHED AIRFOILS
DENGBIN TANG (Nanjing Aeronautical Institute, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 10, May 1989, p. A279-A283. In Chinese, with abstract in English. refs

The unsteady laminar flow separation phenomenon near the leading edge of a rapidly pitched airfoil at a constant rate is investigated computationally. The differential-integral method, used

to compute zonally unsteady flowfield, can handle any flow region surrounding the airfoil involving reversed separation lines. The emphasis is on studying flow behavior and features in the vicinity of the separation point according to computer results. Three airfoil shapes, NACA 0012, NACA 0015, and unsymmetric SIKORSKY SC-1095 are studied. Finally, a relationship between shape factors and the leading edge separation is established, and a practical criterion is proposed. Author

A90-18590#
A STUDY OF GROUND VORTEX
SHENYI MA (Nanjing Aeronautical Institute, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 10, May 1989, p. A293-A296. In Chinese, with abstract in English.

The formation mechanism and the flow characteristics of the ground vortices as well as the method of eliminating ground vortices are studied. It is noted that, when air is sucked into an aircraft engine while on the ground, a momentum is exerted on a point sink flow by a lateral wind or a reversed jet from the tail pipe, resulting in the formation of eddy stream known as ground vortices. Through an analysis of numerous experimental data, it is found that the ground vortices are composed of two vortices instead of a single and concentrated free vortex. The tangential velocity distribution curves of the ground vortex can be expressed as two independent functions: one is directly proportional function located at the core, and the other is an inversely proportional function around the outer surrounding. The pressure distribution is also composed of two parabolic functions. In addition, a method of significant engineering importance for eliminating the ground vortices is presented. Author

A90-18591#
ANALYSIS OF BLADE LOADINGS IN CENTRIFUGAL COMPRESSORS
YINGKANG ZHU, QI CAO, and CHENGFAN YAO (Xian Jiaotong University, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 10, May 1989, p. A297-A299. In Chinese, with abstract in English.

Some types of blade loadings often used for the design of centrifugal compressor impellers were analyzed. The blade loading with the minimum diffusivity in the blade passages is recognized as a kind of idealer and more pratical blade loading. The maximum loading in the center and the minimum one at the edges of a blade passage characterized this kind of blade loading for different flow conditions, resulting thus in a higher flow efficiency. In fact, it is found that the high-efficiency and saving-energy impellers can be fullfilled by using this kind of blade loading. Author

A90-18604#
WALL INTERFERENCE CORRECTION OF HIGH-LIFT MULTI-COMPONENT AIRFOILS
WENHUA ZHANG (Nanjing Aeronautical Institute, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 10, June 1989, p. B324-B329. In Chinese, with abstract in English. refs

Due to the fact that the influence function possesses a character of focusing itself (i.e., there are some regions on the wall where the influence function and the tunnel-width/model-span ratio are independent), the number of the necessary circumferential pressure measurement stations can be dropped to only a few, when the wall pressure correction method is employed for computng the three-dimensional wall interference. By adopting two-section or three-section method, the influence of the longitudinal displacement can also be eliminated. The present paper extends the aforementioned measure to wind tunnel interference correction for two-dimensional, high-lift, multicomponent airfoil testings. The advantages of the present method are rendered from the reduction of measurement stations, simplifying data processing. Author

A90-18608#
A NEW IMPLICIT HYBRID SCHEMES FOR THE EULER EQUATION OF TRANSONIC FLOW
BAOGUO WANG (Chinese Academy of Sciences, Institute of Engineering Thermophysics, Beijing, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 10, July 1989, p. A309-A315. In Chinese, with abstract in English. refs

A new implicit hybrid scheme, created by coupling the Jameson and Turkel's LU decompositions with modified viscous terms in Harten's TVD (total variation diminishing) formulation, is presented. The LU decomposition is applied to discretize the implicit part of the Euler equations and the Harten's viscous terms to handle the usually called residual of steady-state solutions. Numerical experiments show that the scheme is quite robust and can generate good shock resolution for steady-state computations. Author

A90-18609#
COMPUTATIONS OF UNSTEADY TRANSONIC FLOWS ABOUT THIN AIRFOILS BY INTEGRAL EQUATION METHOD
JICHAO SU and LIYI WU (Beijing University of Aeronautics and Astronautics, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 10, July 1989, p. A316-A323. In Chinese, with abstract in English. refs

An integral equation for two-dimensional unsteady transonic small disturbance (TSD) flows around oscillating airfoils is derived from the unsteady TSD equation. An artificial viscosity is introduced to make the integral equation solvable for flows with shocks. Numerical results for airfoils are presented and compared with experimental data and other numerical results. The comparisons show that the integral equation method is satisfactory so far as the accuracy is concerned, and consumes less computer time and yields a fast convergence. Author

A90-18623#
THE AERODYNAMIC BEHAVIOURS OF VORTICES FOR SLENDER-WING
XUEYING DENG (Beijing University of Aeronautics and Astronautics, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 10, Aug. 1989, p. B351-B359. In Chinese, with abstract in English. refs

This paper reviews the aerodynamic behaviors of leading-edge vortices on slender wings. The following problems concerning the dynamics of vortices are discussed in detail: the formation of leading-edge vortex and its main flow structure, the phenomenon of the leading-edge-vortex breakdown and its effects on the aerodynamic characteristics of the wings, the theoretical models to depict the vortex breakdown, and methods for predicting the leading-edge-vortex breakdown. Finally, a brief review on the interactions of vortices in the flow field of slender wings is presented. Author

A90-18886* Exeter Univ. (England).
ON THE GOERTLER VORTEX INSTABILITY MECHANISM AT HYPERSONIC SPEEDS
PHILIP HALL and YIBIN FU (Exeter University, England) Theoretical and Computational Fluid Dynamics (ISSN 0935-4964), vol. 1, no. 3, 1989, p. 125-134. refs
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The linear instability of the hypersonic boundary layer on a curved wall is considered. As a starting point, the viscosity of the fluid is taken to be a linear function of temperature and real-gas effects are ignored. It is shown that the flow is susceptible to Goertler vortices and that they are trapped in the logarithmically thin adjustment layer in which the temperature of the basic flow changes rapidly to its free stream value. The vortices decay exponentially in both directions away from this layer and are most unstable when their wavelength is comparable with the depth of the adjustment layer. The nonuniqueness of the neutral stability curve associated with incompressible Goertler vortices is shown to disappear at high Mach numbers if the appropriate 'fast' streamwise dependence of the instability is built into the disturbance flow structure. It is shown that in the hypersonic limit, wall-cooling affects the leading-order term in the expansion of the Goertler number which is independent of the wavenumber, and which is

due to the curvature of the basic state but it has a negligible effect on the other terms which are dependent on the wavenumber. Author

A90-19236
NUMERICAL MODELING OF A VISCOUS SEPARATED FLOW IN THE NEAR WAKE [CHISLENNOE MODELIROVANIE VIAZKOGO OTRYVNOGO TECHENIIA V BLIZHNEM SLEDE]
V. M. KOVENIA and A. S. LEBEDEV PMTF - Zhurnal Prikladnoi Mekhaniki i Tekhnicheskoi Fiziki (ISSN 0044-4626), Sept.-Oct. 1989, p. 53-59. In Russian. refs
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Laminar flow in the near wake of a blunt body of small aspect ratio is analyzed. The geometrical characteristics of the wake, relative base pressure, and its contribution to the integral body drag are determined as a function of the Mach and Reynolds numbers of the incoming flow. Examples are presented which illustrate the effect of the body shape and its surface heat characteristics on the base pressure. For certain parameters of the incoming flow, the formation of small-scale vortices near the separation point is shown to be possible; a local supersonic zone may be formed at the axis of symmetry in the reverse flow. V.L.

A90-19237
SUPERSONIC NONUNIFORM FLOW OF A GAS PAST OBLONG AXISYMMETRIC BODIES [OBTEKANIE UDLINENNYKH OSESIMMETRICHNYKH TEL SVERKHZVUKOVYM NERAVNOMERNYM POTOKOM GAZA]
S. V. PEIGIN and S. V. TIMCHENKO PMTF - Zhurnal Prikladnoi Mekhaniki i Tekhnicheskoi Fiziki (ISSN 0044-4626), Sept.-Oct. 1989, p. 60-65. In Russian. refs
Copyright

Equations of a thin viscous shock layer near oblong hyperboloids of revolution are solved numerically for the case of nonuniform gas flow at zero angle of attack. Attention is given to two particular cases of such flows: far-wake flow and flow from a supersonic spherical source. The effect of the nonuniformity type and intensity, Reynolds number, body shape, and body surface temperature on the flow structure in a viscous shock layer and surface friction and heat transfer coefficients is analyzed. V.L.

A90-19387#
LOW-SPEED UNSTEADY AERODYNAMICS OF A PITCHING STRAKED WING AT HIGH INCIDENCE. I - TEST PROGRAM. II - HARMONIC ANALYSIS
R. G. DEN BOER (Nationaal Lucht- en Ruimtevaartlaboratorium, Amsterdam, Netherlands) and A. M. CUNNINGHAM, JR. (General Dynamics Corp., Fort Worth, TX) Journal of Aircraft (ISSN 0021-8669), vol. 27, Jan. 1990, p. 23-41. refs
(Contract F33615-85-C-3013)
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A straked delta wing oscillating in pitch has been wind tunnel tested to measure unsteady overall airloads and pressure distributions over a wide, -8 to + 50 deg range of incidences and 1-16 deg range of amplitudes, at 80 m/sec. The first part of this work presents the experimental setup and procedures employed; the second part undertakes a preliminary harmonic analysis of the data obtained within the + or - 4-6 deg amplitude range irrespective of mean angle of frequency. Force, pressure, and flow visualization data are used to describe the flow phenomena, as well as the fashion in which they interact with the model to produce the aerodynamic forces. O.C.

A90-19388#
EFFECT OF MOVING SURFACES ON THE AIRFOIL BOUNDARY-LAYER CONTROL
V. J. MODI, F. MOKHTARIAN (British Columbia, University, Vancouver, Canada), and T. YOKOMIZO (Kanto Gakuin University, Yokohama, Japan) Journal of Aircraft (ISSN 0021-8669), vol. 27, Jan. 1990, p. 42-50. Previously cited in issue 21, p. 3482, Accession no. A88-50583. refs
(Contract NSERC-A-2181)
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A90-19389#
NUMERICAL SIMULATION OF UNSTEADY FLOW ABOUT CAMBERED PLATES
TURGUT SARPKAYA, SAMIR M. MOSTAFA, and PAUL D. MUNZ (U.S. Naval Postgraduate School, Monterey, CA) Journal of Aircraft (ISSN 0021-8669), vol. 27, Jan. 1990, p. 51-59. Research supported by Sandia National Laboratories. Previously cited in issue 09, p. 1277, Accession no. A89-25247. refs

A90-19390#
FURTHER INVESTIGATIONS OF TRANSONIC SHOCK-WAVE BOUNDARY-LAYER INTERACTION WITH PASSIVE CONTROL
S. RAGHUNATHAN and S. T. MCILWAIN (Belfast, Queen's University, Northern Ireland) (ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 2, p. 1826-1834) Journal of Aircraft (ISSN 0021-8669), vol. 27, Jan. 1990, p. 60-65. Previously cited in issue 03, p. 260, Accession no. A89-13685. refs
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A90-19391*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
ESTIMATE OF LOADS DURING WING-VORTEX INTERACTIONS BY MUNK'S TRANSVERSE-FLOW METHOD
VERNON J. ROSSOW (NASA, Ames Research Center, Moffett Field, CA) Journal of Aircraft (ISSN 0021-8669), vol. 27, Jan. 1990, p. 66-74. refs
Copyright

The inviscid, incompressible interaction of a wing with a vortex is studied by use of Munk's transverse-flow method. The method assumes that the loading on the wing is such that the local circulatory flow of the vortex is turned so that the wing and its vortex wake act as a barrier to the flow. This permits the analysis to be carried out by mapping the transverse flowfield into the flow about a circle to find the vorticity distribution in the wake. Closed-form expressions are then derived for the bound circulation in the wind and for the lift and rolling moment induced by the vortex on the encountering wing. Comparisons of the loads predicted by these relationships with those of vortex-lattice theory for a flat wing of a rectangular planform indicate that they accurately represent the various parameters when the aspect ratio of the encountering wing is less than about two. When flat rectangular wings of higher aspect ratios are considered, some sort of correction is needed. Examples are then presented to illustrate some applications of the results. Author

A90-19392*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
UNSTEADY PRESSURE AND STRUCTURAL RESPONSE MEASUREMENTS ON AN ELASTIC SUPERCRITICAL WING
CLINTON V. ECKSTROM, DAVID A. SEIDEL, and MAYNARD C. SANDFORD (NASA, Langley Research Center, Hampton, VA) (Structures, Structural Dynamics and Materials Conference, 29th, Williamsburg, VA, Apr. 18-20, 1988, Technical Papers. Part 1, p. 509-519) Journal of Aircraft (ISSN 0021-8669), vol. 27, Jan. 1990, p. 75-80. Previously cited in issue 12, p. 1818, Accession no. A88-32231. refs
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A90-19396#
COMMENT ON 'DRAG REDUCTION FACTOR DUE TO GROUND EFFECT'
E. V. LAITONE Journal of Aircraft (ISSN 0021-8669), vol. 27, Jan. 1990, p. 96.
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A90-19426#
UNSTEADY AERODYNAMIC FORCES ON ROLLING DELTA WINGS AT HIGH ANGLE OF ATTACK
YUICHI SHINBO and JUNZO SATO Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 37, no. 429, 1989, p. 476-484. In Japanese, with abstract in English. refs

Normal force and rolling moment acting on a delta wing in forced sinsoidal rolling oscillation are measured in low-speed wind tunnels. Flow visualization revealed details of the separated vortices. With increasing rolling frequency, the normal force and the rolling moment show, within a cycle of motion, large hysteresis which are due to the time lag of leading-edge separated vortices following the moving wing surface. The amplitude of hysteresis increases with angle of attack, up to the angle at which the vortex breakdown reaches the trailing edge of the wing. Beyond this angle, nonlinearities are introduced by the vortex breakdown.
Author

A90-19431#
FULL 3D ITERATIVE SOLUTION OF TRANSONIC FLOW FOR A SWEPT WING TEST CHANNEL
XIAOLU ZHAO (Chinese Academy of Sciences, Institute of Engineering Thermophysics, Beijing, People's Republic of China) Journal of Engineering Thermophysics (ISSN 0253-231X), vol. 10, Feb. 1989, p. 29-31. In Chinese, with abstract in English. refs

Based on Wu's (1952) general theory of three-dimensional turbomachine flow, a full three-dimensional iterative procedure for analyzing internal transonic inviscous flow is developed and used to compute the flow through a transonic swept-wing channel with strong three-dimensional flow effects. A comparison of computed results with experimental data shows fairly good agreement.
Author

A90-19434#
VARIATIONAL PRINCIPLE WITH VARIABLE DOMAIN DISCONTINUOUS FINITE ELEMENT METHOD FOR *TRANSONIC FLOW AND DETERMINING AUTOMATICALLY* THE POSITION AND SHAPE OF THE SHOCK WAVES
ZHIGUO ZHU, KANGMIN CHEN, YANSHENG LI, and YUELIN CHEN (Shanghai Institute of Mechanical Engineering, People's Republic of China) Journal of Engineering Thermophysics (ISSN 0253-231X), vol. 10, Feb. 1989, p. 40-42. In Chinese, with abstract in English. refs

The theory of variational principles with variable domain suggested by Liu (1981) is applied. A discontinuous finite-element model with moving nodes is made, and it can determine automatically and exactly the position and shape of the shock wave in two-dimensional transonic flow; the velocity and density are jumping on both sides of the shock wave. Accurate results are obtained and compare satisfactorily with the exact solution for a wedge at inlet Mach number 1.2. Author

A90-19436#
EFFECT OF GROUND ON WAKE ROLL-UP BEHIND A LIFTING SURFACE
KEQIN ZHU (University of Science and Technology of China, Hefei, People's Republic of China) and HIDEO TAKAMI (Tokyo, University, Japan) Acta Aerodynamica Sinica (ISSN 0258-1825), vol. 7, Dec. 1989, p. 383-393. refs

The superconvergence of an improved vortex lattice method for a two-dimensional flat plate has been verified theoretically. The improved vortex lattice method is used to predict the gound effect on wake roll-up behind a lifting surface. The wake geometry is obtained through iteration by satisfying the condition that free vortex lines are consistent with the local streamlines. The ground effect is simulated by use of an image vortex system. Numerical results show rapid convergence of the iterative procedure.
Author

A90-19438#
THE COMPUTATIONAL METHOD FOR THE TRANSONIC WING DESIGN
CHANGYOU HUANG and ZUOBIN CHEN (China Aerodynamic Research and Development Center, Sichuan, People's Republic of China) Acta Aerodynamica Sinica (ISSN 0258-1825), vol. 7, Dec. 1989, p. 400-406. In Chinese, with abstract in English. refs

A computational method for three-dimensional transonic wing design is presented based on the small disturbance theory of transonic flow. The differences between the specified and the calculated pressure distributions are considered as the objective function. The linear algebraic equations about the objective function and the modified wing section shape quantities are established using Green's theorem. From this, the modified quantities of the wing section shapes can be solved. The quantities are added to the original wing sections, and so a new wing is formed. The pressure distribution for the new wing is calculated using the computational method again. The procedure is repeated until the design objective is achieved. A feature of this method is that the analysis and the design programs can be relatively independent of one another, and only a few changes are made if they are used together. When compared to other design methods, the computational time is greatly reduced. Two cases are presented as examples. S.A.V.

A90-19441#
THE EXPERIMENTS FOR GAS TURBINE PLANE CASCADE IN A SHOCK TUNNEL
JINGMEI LI, RENMIN ZHAO, JINMING HU (Chinese Academy of Sciences, Institute of Mechanics, Beijing, People's Republic of China), and SUGING DENG (Chinese Academy of Sciences, Institute of Engineering Thermophysics, Beijing, People's Republic of China) Acta Aerodynamica Sinica (ISSN 0258-1825), vol. 7, Dec. 1989, p. 428-434. In Chinese, with abstract in English. refs

Experiments involving heat transfer, pressure and laser interferometry visualization for a gasturbine plane cascade were preformed in a shock tunnel under free stream conditions. The measurement distributions of heat flux and pressure on the blades are consistent with the results. Author

A90-19446#
COMPUTATION AND ANALYSIS OF THE SHAPES OF S1 AND S2 STREAMSURFACES IN A TRANSONIC COMPRESSOR ROTOR
JIALIN ZHANG (Chinese Academy of Sciences, Institute of Engineering Thermophysics, Beijing, People's Republic of China) Acta Aerodynamica Sinica (ISSN 0258-1825), vol. 7, Dec. 1989, p. 463-468. In Chinese, with abstract in English.

Based on Wu's stream surface theory and a solved three-dimensional transonic flowfield of an axial-flow compressor rotor, a method to compute three-dimensional streamlines and stream surfaces in the flowfield has been proposed. The shapes of S1 and S2 stream surfaces have been computed; three-dimensional effects of transonic flow in turbomachinery have been analyzed. The computation and analysis show that there are strong interactions within the flows in the subsonic and the supersonic stream tubes in the flowfield of turbomachinery.
Author

A90-19449#
EXPERIMENTAL INVESTIGATION OF TRAILING-EDGE AND NEAR WAKE FLOW OF A SYMMETRIC AIRFOIL
KEMIN HE and XING TU (Northwestern Polytechnical University, Xian, People's Republic of China) Acta Aerodynamica Sinica (ISSN 0258-1825), vol. 7, Dec. 1989, p. 479-484. In Chinese, with abstract in English. refs

This paper describes the trailing edge and near-wake flow of an NACA 63-012 symmetric airfoil measured by a hot wire anemometer. The distribution of mean flow velocity and Reynolds stress is measured and discussed. A semiempirical relation for the nondimensional velocity distribution is obtained. Some correlation parameters and analytical correlation functions are also obtained. At last, some important conclusions are given. Author

A90-19636*# Princeton Univ., NJ.
LARGE-SCALE MOTIONS IN A SUPERSONIC TURBULENT BOUNDARY LAYER ON A CURVED SURFACE
J. F. DONOVAN and A. J. SMITS (Princeton University, NJ) AIAA, Aerospace Sciences Meeting, 28th, Reno, NV, Jan. 8-11, 1990. 11 p. refs
(Contract NAG1-545; AF-AFOSR-88-0120)
(AIAA PAPER 90-0019) Copyright

This paper presents measurements in a Mach 3 turbulent

boundary layer which was subjected to a short region of concave surface curvature. Mean velocity and time-averaged turbulence measurements are presented to indicate the severity of the distortion, although the focus of this study is on how the large-scale organized motions are affected by the distortion. A 12 deg increase in the inclination angle of organized motions is observed, and correlation measurements indicate an increase in the streamwise length scale. VITA conditional sampling is used to identify strong positive streamwise mass-flux gradients as the large-scale structure responsible for the measured structure angle and to determine the ensemble-averaged flowfield associated with the mass-flux gradient structures. Author

A90-19641#
THRUST AUGMENTATION CHARACTERISTICS OF JET REACTIONS
YUJIRO SAKAMOTO, TOSHIO KUROSAKA, MASAHIKO MITSUDA, TOSHIYA MIYAKE (Kobe Steel, Ltd., Japan), and KUNIO KUWAHARA (Institute of Space and Astronautical Science, Tokyo, Japan) AIAA, Aerospace Sciences Meeting, 28th, Reno, NV, Jan. 8-11, 1990. 12 p. refs
(AIAA PAPER 90-0033) Copyright

By conceiving the fan of a high-bypass turbofan engine as a shrouded helicopter rotor of exceptionally high rotational speed, it is presently speculated that the augmentation of the jet momentum of a turbofan per unit engine power could justify its use to replace helicopter rotors. Attention is given to the thrust-augmentation characteristics of jet reactions; it is demonstrated that a system composed of two specially designed circular wings and a gas turbine-driven turbofan shows promise, in view of computational fluid-dynamics analyses and small scale model tests. O.C.

A90-19648#
ALLEVIATION OF SHOCK OSCILLATIONS IN TRANSONIC FLOW BY PASSIVE CONTROLS
S. RAGHUNATHAN, D. E. HALL (Belfast, Queen's University, Northern Ireland), and D. G. MABEY (Royal Aerospace Establishment, Bedford, England) AIAA, Aerospace Sciences Meeting, 28th, Reno, NV, Jan. 8-11, 1990. 8 p. Research supported by the Department of Education of Northern Ireland. refs
(AIAA PAPER 90-0046) Copyright

Passive control experiments were made on an 18 percent thick biconvex aerofoil model in the Mach number range giving shock oscillations and at a Reynolds number of 700,000 with fixed boundary layer transition. The control methods studied included a passive control of shock wave boundary layer interaction by a porous surface and a cavity, and buffet breather made of holes connecting upper and lower surfaces of the aerofoil. The experiments show that the shock oscillations can be virtually eliminated by these methods. Author

A90-19652#
NONEQUILIBRIUM RECOMBINATION-DISSOCIATION BOUNDARY LAYER FLOWS ALONG ARBITRARILY-CATALYTIC HYPERSONIC VEHICLES
G. R. INGER (Iowa State University of Science and Technology, Ames) AIAA, Aerospace Sciences Meeting, 28th, Reno, NV, Jan. 8-11, 1990. 10 p. refs
(AIAA PAPER 90-0055) Copyright

A unified theory is proposed for two-dimensional laminar boundary layers along a highly cooled body. The entire range of possible gas/surface catalysis nonequilibrium effects is considered over a wide range of aerothermodynamic flight conditions between the extremes of chemically frozen and dissociate-equilibrium gas phase behavior. Closed-form analytical solutions for the nonequilibrium properties are given for both the recombination-dominated nose region and dissociation-dominated behavior far downstream. The efficiency and applications of the model are illustrated by results of parametric studies. V.L.

A90-19663#
THE FICKLE EFFECT OF NOSE MICROASYMMETRY ON THE HIGH-ALPHA AERODYNAMICS
LARS E. ERICSSON (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA) AIAA, Aerospace Sciences Meeting, 28th, Reno, NV, Jan. 8-11, 1990. 8 p. refs
(AIAA PAPER 90-0067) Copyright

Nose microasymmetry has been shown to determine the direction and magnitude of the large sideforce generated by a slender forebody at high angles of attack. It has also been shown that this force can cause the yawing moment characteristics of an advanced aircraft to vary between several highly nonlinear types, requiring extensive testing to define. The present paper shows that such extensive tests would be of little help, and that the coupling between vehicle motion and forebody flow separation, the so-called moving-wall effect, will determine the characteristics in free flight. Author

A90-19664#
ROTATIONAL AERODYNAMICS OF ELLIPTIC BODIES AT HIGH ANGLES OF ATTACK
WILLIAM B. BLAKE (USAF, Wright Research and Development Center, Wright-Patterson AFB, OH) and BILLY P. BARNHART (Bihrle Applied Research, Inc., Jericho, NY) AIAA, Aerospace Sciences Meeting, 28th, Reno, NV, Jan. 8-11, 1990. 10 p. refs
(AIAA PAPER 90-0068)

Rotary balance yawing moment data obtained on a series of body alone configurations are studied. The effects of body ellipticity, nose fineness ratio, nose bluntness, nose droop, and nose chines are discussed. Bodies which are autorotative at moderate angles of attack become damped as the angle of attack is increased. The angles of attack for neutral damping for these bodies are found. A two-dimensional cross-flow parameter successfully collapses these data onto a single neutral damping boundary. Author

A90-19665*# Virginia Polytechnic Inst. and State Univ., Blacksburg.
EXPERIMENTAL INVESTIGATION OF A NEW DEVICE TO CONTROL THE ASYMMETRIC FLOWFIELD ON FOREBODIES AT LARGE ANGLES OF ATTACK
CARY A. MOSKOVITZ (Virginia Polytechnic Institute and State University, Blacksburg), ROBERT M. HALL (NASA, Langley Research Center, Hampton, VA), and F. R. DEJARNETTE (North Carolina State University, Raleigh) AIAA, Aerospace Sciences Meeting, 28th, Reno, NV, Jan. 8-11, 1990. 11 p. refs
(AIAA PAPER 90-0069) Copyright

An exploratory experimental investigation of a new device to control the asymmetric flowfield on forebodies at large angles of attack has been conducted. The device is a rotatable forebody tip, which varies in cross section from circular at its base to elliptic at its tip. The device itself extends over a small portion of the aircraft or missile forebody. The device provides two important improvements. First, it replaced the normally random behavior of the nose side force as a function of nose tip orientation with a predictable and generally sinusoidal distribution and, second, the device showed promise for use as part of a vehicle control system, to be deflected in a prescribed manner to provide additional directional control for the vehicle. The device was tested on a cone/cylinder model having a 10 deg semiapex angle and on a 3.0 caliber tangent ogive model, each with a base diameter of 3.5 in, for angles of attack from 30 to 60 deg. Data were taken from 3 circumferential rows of pressure taps on each model at a Reynolds number of 84,000 based on cylinder diameter and by a helium-bubble flow visualization technique at a Reynolds number of 24,000. Author

A90-19666#
AERODYNAMIC LOADS COMPUTATION ON COAXIAL HINGELESS HELICOPTER ROTORS
THEODORE V. VALKOV AIAA, Aerospace Sciences Meeting, 28th, Reno, NV, Jan. 8-11, 1990. 13 p.
(AIAA PAPER 90-0070) Copyright

This paper presents computational methods for coaxial hingeless rotors in steady axial and forward flight. The aerodynamics loads are found by solving combined blade

element-momentum equation on both rotors. Two models were developed to represent the mutually induced inflow - the linear interaction model and the wake superposition model. Tip losses, ground effect and blade aeroelasticity can also be accounted for. Application of the wake superposition model to Canadair CL-227 remotely piloted vehicle show good agreement with experiment for hover and fair agreement with wind tunnel measured forward flight performances. Encouraging preliminary results have been obtained from the elastic lifting line model, developed in order to improve unsteady loads calculation and interaction representation. Author

A90-19670#
VIDEO VISUALIZATION OF SEPARATION SHOCK MOTION FROM MEASURED WALL PRESSURE SIGNALS IN A MACH 5 COMPRESSION RAMP INTERACTION
TAUNYA BOITNOTT AIAA, Aerospace Sciences Meeting, 28th, Reno, NV, Jan. 8-11, 1990. 9 p. refs
(Contract AF-AFOSR-86-0112)
(AIAA PAPER 90-0074) Copyright

This paper describes a technique which was developed to create a video visualization of the unsteady motion of the separation shock wave in an unswept compression ramp-induced interaction at Mach 5. Flow visualization is essential for gaining insight into the separation shock dynamics, and can also provide helpful information for developing appropriate methods of numerically modeling the flowfield's unsteadiness. A new method of flow visualization was needed because such traditional methods as high speed shadowgraphs or schlieren images are ineffective. In this new method, the shock foot position with respect to time was obtained by measuring the fluctuating wall pressures using a streamwise row of high frequency response pressure transducers. Then a series of computer codes was written to transform the data into a video representation. A variable 'moving-window' analysis code was written to convert the multichannel pressure/time histories into a form which could then be used with a graphics program to generate a video of the shock wave motion. No repetitive shock motion patterns were identified in the video. However, the characteristics observed agree well with quantitative results from other types of analyses, thereby confirming the video's accuracy and the utility of the technique. Author

A90-19682#
INVESTIGATION OF HIGH ANGLE OF ATTACK VORTICAL FLOWS OVER DELTA WINGS
J. D. HAWK, R. M. BARNETT, P. J. O'NEIL (McDonnell Aircraft Co., Saint Louis, MO), and N. M. WALTERS (U.S. Navy, Naval Air Development Center, Warminster, PA) AIAA, Aerospace Sciences Meeting, 28th, Reno, NV, Jan. 8-11, 1990. 9 p. refs
(AIAA PAPER 90-0101) Copyright

An experimental investigation addressing the fundamental issues of leading edge vortical flow and burst phenomena was conducted. A comprehensive database was obtained for both 60 and 70 degree delta wings at angles of attack where burst occurs. This database was used to evaluate the validity of the underlying assumptions in conventional vortex theories which attempt to predict burst phenomena. Where trends in the data are not explained by conventional theory, analysis identified key parameters governing those effects. Author

A90-19684#
BLOCK MULTIGRID IMPLICIT SOLUTION OF THE EULER EQUATIONS OF COMPRESSIBLE FLUID FLOW
YORAM YADLIN and DAVID A. CAUGHEY (Cornell University, Ithaca, NY) AIAA, Aerospace Sciences Meeting, 28th, Reno, NV, Jan. 8-11, 1990. 12 p. Research supported by the McDonnell Douglas Corp. and U.S. Army. refs
(AIAA PAPER 90-0106) Copyright

A multigrid diagonal implicit algorithm has been developed to solve the Euler equations of inviscid compressible flow on Block Structured grids. Two modes of advancing the multigrid cycle have been examined with respect to convergence rates, accuracy and efficiency. The algorithm has been designed to run on parallel computers. Results are computed for transonic flows past airfoils and include pressure distributions to verify the accuracy of the scheme, and convergence histories to demonstrate the efficiency of the method. Efficiencies which were obtained using a modest number of processors in parallel are presented and discussed. Author

A90-19686*# Vigyan Research Associates, Inc., Hampton, VA.
FRESH LOOK AT FLOATING SHOCK FITTING
PETER-M. HARTWICH (Vigyan, Inc., Hampton, VA) AIAA, Aerospace Sciences Meeting, 28th, Reno, NV, Jan. 8-11, 1990. 12 p. refs
(Contract NAS1-18585)
(AIAA PAPER 90-0108)

A fast implicit upwind procedure for the two-dimensional Euler equations is described that allows accurate computations of shocked flows on nonadapted meshes. Away from shocks, the second-order accurate upwinding is based on the split-coefficient-matrix (SCM) method. In the presence of shocks, the difference stencils are modified using a floating shock fitting technique. Rapid convergence to steady-state solutions is attained with a diagonalized approximate factorization (AF) algorithm. Results are presented for Riemann's problem, for a regular shock reflection at an inviscid wall, for supersonic flow past a cylinder, and for a transonic airfoil. All computed shocks are ideally sharp and in excellent agreement with other numerical results or 'exact' solutions. Most importantly, this has been accomplished on unusually crude meshes without any attempt to align grid lines with shock fronts or to cluster grid lines around shocks. Author

A90-19694#
COMPLEX VARIABLE BOUNDARY ELEMENT METHOD FOR EXTERNAL POTENTIAL FLOWS
M. MOKRY (National Research Council of Canada, High Speed Aerodynamics Laboratory, Ottawa) AIAA, Aerospace Sciences Meeting, 28th, Reno, NV, Jan. 8-11, 1990. 12 p. refs
(AIAA PAPER 90-0127) Copyright

A simple and efficient complex-variable boundary-element algorithm is described for calculating potential flow past single and multicomponent airfoils in free air, in ground effect, in an infinite cascade, and in solid open perforated-wall wind tunnels. The theoretical development is based on the representation of the complex disturbance velocity by the Cauchy-type integral, thereby formulating the airfoil problem as an exterior Hilbert problem. The outer constraints are therefore accounted for using the concept of Green's function in the complex plane. S.A.V.

A90-19695#
AN EFFICIENT UPWIND RELAXATION-SWEEPING ALGORITHM FOR THREE-DIMENSIONAL EULER EQUATIONS
GE-CHENG ZHA and DAO-ZHI LIU (Beijing University of Aeronautics and Astronautics, People's Republic of China) AIAA, Aerospace Sciences Meeting, 28th, Reno, NV, Jan. 8-11, 1990. 10 p. Research supported by the Aeronautics Science Foundation. refs
(AIAA PAPER 90-0129) Copyright

An efficient finite-volume algorithm for three-dimensional Euler equations is presented. The spatial discretization is based on Van Leer's flux vector splitting. The flow field is analyzed by alternating sweeping in the spanwise direction and local Gauss-Seidel iteration on each vertical streamwise plane. Two internal transonic flows are calculated to show efficiency and accuracy. Author

A90-19704*# Vigyan Research Associates, Inc., Hampton, VA.
DIRECT SIMULATION OF HYPERSONIC RAREFIED FLOW ABOUT A DELTA WING
M. CEVDET CELENLIGIL (Vigyan Research Associates, Inc., Hampton, VA) and JAMES N. MOSS (NASA, Langley Research Center, Hampton, VA) AIAA, Aerospace Sciences Meeting, 28th, Reno, NV, Jan. 8-11, 1990. 9 p. refs
(AIAA PAPER 90-0143)

Three-dimensional hypersonic rarefied flow about a delta wing at angle of incidence has been studied using the direct simulation

Monte Carlo technique. Results are obtained for a transitional flow case which has been investigated in a nitrogen wind-tunnel experiment. The simulations are performed using a nonreacting, single-species gas model that accounts for rotational and vibrational internal energies. The computations yield an attached leeside flow associated with supersonic expansion over the leeside of the wing. Results are presented for the computed flowfield and surface quantities and overall aerodynamic coefficients. Author

A90-19710#
A NUMERICAL STUDY OF MIXING AND CHEMICAL HEAT RELEASE IN SUPERSONIC MIXING LAYERS
S. MENON and E. M. FERNANDO (Flow Research, Inc., Kent, WA) AIAA, Aerospace Sciences Meeting, 28th, Reno, NV, Jan. 8-11, 1990. 15 p. refs
(Contract F33615-88-C-2904)
(AIAA PAPER 90-0152) Copyright

Direct numerical simulations are used to study the effects of Mach number and chemical heat release on the evolution of a low Reynolds number temporal mixing layer confined between a pair of parallel slip walls. The chemical reaction considered is exothermic, binary, single-step and irreversible. Results are reported for three convective Mach numbers: 0.15, 0.75 and 1.42 using two-dimensional simulations. The results demonstrate the effects of compressibility and show that the mixing layer growth rate decrease with increasing convective Mach number. The effect of heat release at convective Mach numbers of 0.15 and 0.75 is similar to that previously observed in essentially zero Mach number flows; heat release reduces the growth rate and the amount of product formed. Unlike its behavior at the two lower convective Mach numbers, the mixing layer is characterized by an absence of vortex rollup and pairing at the convective Mach number of 1.42. Furthermore, heat release increases the growth rate of the mixing layer at this Mach number. However, recent work using a three-dimensional numerical solver indicates the growing importance of spanwise perturbations with increasing Mach number and suggests that the two-dimensional results at high Mach numbers be treated with some caution. Author

A90-19722#
MEAN FLOW MEASUREMENTS OF HEATED SUPERSONIC SLOT INJECTION INTO A HIGH REYNOLDS NUMBER SUPERSONIC STREAM
BENJAMIN ROBERT SMITH (Virginia Polytechnic Institute and State University, Blacksburg) AIAA, Aerospace Sciences Meeting, 28th, Reno, NV, Jan. 8-11, 1990. 12 p. refs
(AIAA PAPER 90-0180) Copyright

Shear layer mixing is presently studied by means of mean flow measurements and short duration Schlieren and shadowgraph photography of both heated and unheated supersonic slot injection of air into a supersonic airstream. The heated and unheated cases are similar except in the slot, where the temperature difference leads to changes in density, in streamwise velocity, and in the product of these two parameters. The heated slot flow did not create a marked difference in the location of the merging of the freestream boundary layer with the slot flow when compared to the unheated slot flow. O.C.

A90-19742#
LARGE-AMPLITUDE HIGH-RATE ROLL EXPERIMENTS ON A DELTA AND DOUBLE DELTA WING
E. S. HANFF and S. B. JENKINS (National Aeronautical Establishment, Ottawa, Canada) AIAA, Aerospace Sciences Meeting, 28th, Reno, NV, Jan. 8-11, 1990. 10 p. refs
(AIAA PAPER 90-0224) Copyright

A comprehensive wind-tunnel test program on both a 65-deg delta and an 80/65-deg double-delta-wing model has been recently completed. The program included static and dynamic force tests, high-speed flow visualization, and free-to-roll tests. A brief description of the various experiments is presented, as well as results that demonstrate the value of the previously proposed 'hypersurface' representation of aerodynamic loads in the nonlinear and unsteady regimes. Author

A90-19745*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.
IN-FLIGHT FLOW FIELD ANALYSIS ON THE NASA F-18 HIGH ALPHA RESEARCH VEHICLE WITH COMPARISONS TO GROUND FACILITY DATA
JOHN H. DEL FRATE and FANNY A. ZUNIGA (NASA, Flight Research Center, Edwards, CA) AIAA, Aerospace Sciences Meeting, 28th, Reno, NV, Jan. 8-11, 1990. 27 p. refs
(AIAA PAPER 90-0231) Copyright

In-flight flow visualization results of the vortical flow on the forebody and leading-edge extensions (LEX) of an F-18 research aircraft have been presented for angles of attack from 15.8 to 42.5 deg and for sideslip angles up to 7.5 deg. Water tunnel results using a 3-percent scale F-18 model and a variety of wind tunnel results are used for comparison and interpretation of the flight results. The LEX vortex core breakdown point moved forward with increasing angle of attack. For a constant angle of attack, the windward LEX vortex core breakdown moves forward and inboard with sideslip and the leeward vortex core breakdown moves aft and outboard. For a constant angle of attack, the windward location of interaction moved aft with increasing sideslip and the leeward interaction moved forward. Author

A90-19782#
RAPID PREDICTION OF SLENDER-WING-AIRCRAFT STABILITY CHARACTERISTICS
L. E. ERICSSON and H. H. C. KING (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA) AIAA, Aerospace Sciences Meeting, 28th, Reno, NV, Jan. 8-11, 1990. 11 p. Research supported by Lockheed Missiles and Space Co., Inc. refs
(AIAA PAPER 90-0301) Copyright

Most aerospace vehicles, both civil and military, although designed for hypersonic cruise at low angles of attack often have to perform maneuvers at high angles of attack from low supersonic down to low subsonic Mach numbers. There is, therefore, a need for rapid prediction of the nonlinear high-alpha aerodynamics of slender-wing-aircraft configurations in the speed range. The present paper describes how such a prediction method has been developed, which can account for the nonlinear effects of leading edge vortices at combined angles of attack and yaw. Author

A90-19786*# High Technology Corp., Hampton, VA.
NUMERICAL SOLUTION OF THE BOUNDARY-LAYER EQUATIONS FOR A GENERAL AVIATION FUSELAGE
YONG-SUN WIE (High Technology Corp., Hampton, VA) and JULIUS E. HARRIS (NASA, Langley Research Center, Hampton, VA) AIAA, Aerospace Sciences Meeting, 28th, Reno, NV, Jan. 8-11, 1990. 15 p. refs
(Contract NAS1-18240)
(AIAA PAPER 90-0305)

Numerical solutions of the three-dimensional, compressible laminar boundary-layer equations for a general aviation fuselage are presented. The numerical procedure is second-order accurate and independent of the cross-flow velocity direction. Numerical results are presented for a Mach number and unit Reynolds number of 0.3 and 7 x 10 to the 6th/m, respectively, for angles of attack of 0 and 3 deg. Comparisons are made between results obtained using a general nonorthogonal curvilinear body oriented coordinate system and a streamline coordinate system. Axisymmetric analogue results are also compared with the three-dimensional solutions. Author

A90-19787*# Lehigh Univ., Bethlehem, PA.
EMBEDDED FUNCTION METHODS FOR SUPERSONIC TURBULENT BOUNDARY LAYERS
J. HE, J. Y. KAZAKIA, and J. D. A. WALKER (Lehigh University, Bethlehem, PA) AIAA, Aerospace Sciences Meeting, 28th, Reno, NV, Jan. 8-11, 1990. 17 p. refs
(Contract NAG1-832)
(AIAA PAPER 90-0306) Copyright

The development of embedded functions to represent the mean velocity and total enthalpy distributions in the wall layer of a supersonic turbulent boundary layer is considered. The asymptotic

scaling laws (in the limit of large Reynolds number) for high speed compressible flows are obtained to facilitate eventual implementation of the embedded functions in a general prediction method. A self-consistent asymptotic structure is derived, as well as a compressible law of the wall in which the velocity and total enthalpy are logarithmic within the overlap zone, but in the Howarth-Dorodnitsyn variable. Simple outer region turbulence models are proposed (some of which are modifications of existing incompressible models) to reflect the effects of compressibility. As a test of the methodology and the new turbulence models, a set of self-similar outer region profiles is obtained for constant pressure flow; these are then coupled with embedded functions in the wall layer. The composite profiles thus obtained are compared directly with experimental data and good agreement is obtained for flows with Mach numbers up to 10. Author

A90-19789#
LIFT DEVELOPMENT OF DELTA WINGS UNDERGOING CONSTANT ACCELERATION FROM REST
R. STEVEN SAWYER and JOHN P. SULLIVAN (Purdue University, West Lafayette, IN) AIAA, Aerospace Sciences Meeting, 28th, Reno, NV, Jan. 8-11, 1990. 12 p. refs
(AIAA PAPER 90-0310) Copyright

An experimental study of two delta-wing planforms undergoing constant acceleration from rest has been performed. Flat plate planforms with aspect ratios of 2.29 and 4.01 have been tested at nominal angles of attack of 10, 20, and 30 deg for accelerations equal to approximately 0.4, 0.6, and 0.8 Gs. Lift as a function of time was measured during these maneuvers. A modified Von Karman and Sears analysis suggested a nondimensionalization by which the results at different angles of attack and accelerations could be directly compared. When analyzed in this manner, the data for the aspect ratio 2.29 data were noticeably less than predicted. This was attributed to movement of the leading edge vortex burst position with acceleration, which was confirmed by flow visualization. At 10 deg, the aspect ration 4.01 wing showed response that was well predicted by the analysis. The upper-surface flow field was found to remain similar to the steady state case. For post-stall cases, response was noticeably higher than predicted, which was surprisingly nonmonotonic with increasing acceleration. Flow visualization revealed that ordered vortical structures were formed under acceleration, in contrast to the disordered wake seen at steady state. Author

A90-19790*# Notre Dame Univ., IN.
UNSTEADY SURFACE PRESSURE DISTRIBUTIONS ON A DELTA WING UNDERGOING LARGE AMPLITUDE PITCHING MOTIONS
S. A. THOMPSON, S. M. BATILL, and R. C. NELSON (Notre Dame, University, IN) AIAA, Aerospace Sciences Meeting, 28th, Reno, NV, Jan. 8-11, 1990. 9 p. Research sponsored by the University of Notre Dame. refs
(Contract NAG1-727)
(AIAA PAPER 90-0311) Copyright

Wind tunnel experiments were performed on a 70-deg-sweep delta wing to determine the effect of a sinusoidal pitching motion on the pressure field on the suction side of the wing. Pressure taps were placed from 35-90 percent of the chord, at 60 percent of the local semi-span. Pressure coefficients were measured as functions of Reynolds number and pitch rate. The surface pressure distribution was seen to vary at the same frequency as the pitching frequency, though distortion due to the vortex breakdown was observed. Comparing the upstroke (angle of attack increasing) and downstroke (angle of attack decreasing) pressures for a specific angle of attack, a time lag in the pressure distribution was observed. The downstroke pressures were slightly larger at the forward chord locations. Vortex breakdown was seen to have the most significant effect at the 40-45-percent chord location, where an increase in local pressure was apparent, as well as a distortion of the periodic pressure fluctuation. Author

A90-19799#
THREE-DIMENSIONAL SOLUTION-ADAPTIVE GRID GENERATION ON COMPOSITE CONFIGURATIONS
YEN TU (USAF, Armament Laboratory, Eglin AFB, FL) and JOE F. THOMPSON (Mississippi State University, Mississippi State) AIAA, Aerospace Sciences Meeting, 28th, Reno, NV, Jan. 8-11, 1990. 11 p. refs
(AIAA PAPER 90-0329)

The EAGLE three-dimensional composite-block grid code has been coupled with an implicit Euler flow solver to generate solution-adaptive grids for composite-block configurations with an improved control function formulation. This was implemented on a Cray 2 supercomputer system. The code was tested with two complex composite configurations, namely, an eight-block finned body of revolution and a thirty-block multiple-store ogive-cylinder-ogive configuration at transonic speeds. The solution-adaptive grids obtained show continuous slopes across block boundaries and improved quality of aerodynamics simulation about complex geometries. Author

A90-19802#
APPLICATION OF A ROTARY-WING VISCOUS FLOW SOLVER ON A MASSIVELY PARALLEL COMPUTER
BRIAN E. WAKE and T. ALAN EGOLF (United Technologies Research Center, East Hartford, CT) AIAA, Aerospace Sciences Meeting, 28th, Reno, NV, Jan. 8-11, 1990. 12 p. refs
(AIAA PAPER 90-0334) Copyright

An unsteady, compressible, three-dimensional, implicit Navier-Stokes solver (NSR3D) for helicopter and propeller application has been implemented using FORTRAN with 8X array extensions on the massively parallel Connection Machine (CM-2). The changes to the original algorithm necessary to achieve CRAY-2 speeds on a 16,384-processor CM-2 have been described previously. The emphasis of the present paper is on a recent improvement to the parallel algorithm resulting in better than twice the performance of a single-processor CRAY-2 on a 16k CM-2, and the application of this flow solver to rotary-wing problems on the CM-2. The predictions presented include flow solutions for an advanced helicopter rotor blade tip and comparisons with test data for propeller geometries. Author

A90-19816*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
A STUDY OF SONIC BOOM OVERPRESSURE TRENDS WITH RESPECT TO WEIGHT, ALTITUDE, MACH NUMBER, AND VEHICLE SHAPING
KATHY E. NEEDLEMAN (Lockheed Engineering and Sciences Co., Hampton, VA) and ROBERT J. MACK (NASA, Langley Research Center, Hampton, VA) AIAA, Aerospace Sciences Meeting, 28th, Reno, NV, Jan. 8-11, 1990. 9 p. refs
(AIAA PAPER 90-0367)

This paper presents and discusses trends in nose shock overpressure generated by two conceptual Mach 2.0 configurations. One configuration was designed for high aerodynamic efficiency, while the other was designed to produce a low boom, shaped-overpressure signature. Aerodynamic lift, sonic boom minimization, and Mach-sliced/area-rule codes were used to analyze and compute the sonic boom characteristics of both configurations with respect to cruise Mach number, weight, and altitude. The influence of these parameters on the overpressure and the overpressure trends are discussed and conclusions are given. Author

A90-19822*# Texas Univ., Arlington.
UPSTREAM-INFLUENCE SCALING OF FIN-GENERATED SHOCK WAVE BOUNDARY-LAYER INTERACTIONS
FRANK K. LU (Texas, University, Arlington) and GARY S. SETTLES (Pennsylvania State University, University Park) AIAA, Aerospace Sciences Meeting, 28th, Reno, NV, Jan. 8-11, 1990. 9 p. refs
(Contract AF-AFOSR-86-0082; NCA2-192; NAG1-891)
(AIAA PAPER 90-0376) Copyright

An upstream-influence scaling law, previously formulated through analysis of Mach 3 data, has been extended to Mach

numbers from 2.5 through 4. For adiabatic, equilibrium, turbulent boundary layers, there is no Mach number effect on the constants in the Reynolds number parameters of this law. In addition, based on local similarity, a new Mach number parameter, namely, the Mach number component of the incoming stream normal to the farfield upstream influence, is proposed. Scaling by either the incoming Mach number normal to the inviscid shock or by the incoming Mach number normal to the farfield upstream influence is equivalent to scaling by the hypersonic similarity parameter. Author

A90-19825#
AN INVESTIGATION ON THE COILED-UP OF VORTICES ON A DOUBLE DELTA WING
F. M. YU, K. G. YOUNG, and R. C. CHANG (National Cheng Kung University, Tainan, Republic of China) AIAA, Aerospace Sciences Meeting, 28th, Reno, NV, Jan. 8-11, 1990. 11 p. refs
(AIAA PAPER 90-0382) Copyright

An investigation is carried out on the vortex flow properties of the interaction of edge vortices above a double delta wing surface. A mathematical model of the flow field with two vortices is presented. The trajectories of the two vortices are then solved from the modeling equations. A water tunnel flow visualization study is carried out for two single delta wings with sweep angles of 50 and 75 degrees, respectively, and a double delta wing with sweep angles of 80 and 50 degrees. The vortex trajectories and the behavior of the corotating vortices above the wings are studied using still photography and video recording and analysis techniques. S.A.V.

A90-19826#
EXPERIMENTAL AND NUMERICAL INVESTIGATION OF THE FLOW IN THE CORE OF A LEADING EDGE VORTEX
NICK G. VERHAAGEN (Delft, Technische Universiteit, Netherlands) and PETER R. O. VAN RANSBEECK AIAA, Aerospace Sciences Meeting, 28th, Reno, NV, Jan. 8-11, 1990. 12 p. refs
(AIAA PAPER 90-0384) Copyright

An investigation of the characteristics of a leading edge vortex is described. The objective of the investigation is to support the development and validation of core-flow models by measuring the detailed flowfield in the core of a leading edge vortex. The vortex flow measurements were carried out using a large half model delta wing in combination with a thin 5-hole probe. The results are compared with the solution of Stewartson and Hall for the flow in an isolated rotational core. A qualitative good agreement is found between the solution and the experimental results. Author

A90-19828*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
IMPACT OF NOSE-PROBE CHINES ON THE VORTEX FLOWS ABOUT THE F-16C
R. M. HALL, G. E. ERICKSON (NASA, Langley Research Center, Hampton, VA), W. A. STRAKA (George Washington University, Hampton, VA), S. E. PETERS, B. H. MAINES (General Dynamics Corp., Fort Worth, TX) et al. AIAA, Aerospace Sciences Meeting, 28th, Reno, NV, Jan. 8-11, 1990. 18 p. refs
(AIAA PAPER 90-0386) Copyright

A 1/15-scale model of the F-16C aircraft was tested at subsonic and transonic speeds to determine the effects of small nose-probe chines on the high angle-of-attack aerodynamic and stability characteristics. Off-body flow visualization using a laser vapor screen technique and six-component forces and moments were obtained at freestream Mach numbers of 0.30, 0.60, and 0.80. The nose-probe chines generated strong vortices interacting with the vortices generated over the smooth forebody or over the strakes. These vortices in turn led to global flow unsteadiness and model dynamics at the high angles of attack. The test results underscore the sensitivity of the high angle-of-attack flow field to small geometry changes in the nose region. C.E.

A90-19829#
GENERALIZED FLUXVECTORS FOR HYPERSONIC SHOCK-CAPTURING
ALBRECHT EBERLE, MANFRED A. SCHMATZ, and NORBERT C. BISSINGER (MBB GmbH, Munich, Federal Republic of Germany) AIAA, Aerospace Sciences Meeting, 28th, Reno, NV, Jan. 8-11, 1990. 12 p. Research supported by BMVg and BMFT. refs
(AIAA PAPER 90-0390) Copyright

An approach is described whereby characteristic-based methods can be updated to enable them to capture shocks of any strength, to represent leeside flows, and to represent base flows past vehicles cruising at any (particularly, hypersonic) speed. The approach is based on the observation that flux differences from plus/minus split flux vectors generate a much larger positive contribution to the matrix diagonal than flux differences obtained from a Riemann-averaged flow variable vector at cells where one of the extreme eigenvalues changes sign, thus indicating the presence of a shock wave. New split flux vectors for shock capturing are developed which guarantee the perfect conservation of the total temperature, particularly at hypersonic speeds. V.L.

A90-19830#
SOLUTION OF THE PARABOLIZED NAVIER-STOKES EQUATIONS USING OSHER'S UPWIND SCHEME
R. A. GERBSCH and R. K. AGARWAL (McDonnell Douglas Research Laboratories, Saint Louis, MO) AIAA, Aerospace Sciences Meeting, 28th, Reno, NV, Jan. 8-11, 1990. 17 p. refs
(AIAA PAPER 90-0392) Copyright

A new, explicit, finite-volume algorithm based on Osher's upwind method is applied to the two-dimensional parabolized Navier-Stokes equations. The algorithm is second-order accurate in the marching direction and employs flux limiters to make the scheme total variation diminishing. The streamwise pressure gradient is limited in the subsonic regions to maintain a hyperbolic inviscid equation set. Second-order central differencing is applied to the viscous terms and upwind differencing is applied to the inviscid terms throughout the flowfield. The new algorithm is demonstrated by computing four laminar-flow cases; supersonic flow over a flat plate, supersonic flow in a diffuser, hypersonic flow over a 15-degree ramp, and hypersonic flow in a 15-degree converging inlet. Author

A90-19831*# Engineering Analysis, Inc., Ames, IA.
A THREE-DIMENSIONAL UPWIND PARABOLIZED NAVIER-STOKES CODE FOR CHEMICALLY REACTING FLOWS
PHILIP E. BUELOW, JOHN C. TANNEHILL, JOHN O. IEVALTS (Engineering Analysis, Inc., Ames, IA), and SCOTT L. LAWRENCE (NASA, Ames Research Center, Moffett Field, CA) AIAA, Aerospace Sciences Meeting, 28th, Reno, NV, Jan. 8-11, 1990. 21 p. refs
(Contract NAS2-12861)
(AIAA PAPER 90-0394) Copyright

A new upwind, parabolized Navier-Stokes (PNS) code has been developed to compute the three-dimensional flow of chemically reacting air around hypersonic vehicles. The code is a modification of the perfect gas, three-dimensional UPS code of Lawrence et al. (1986) which has been extended in the present study to permit the calculation of hypersonic, viscous flows in chemical nonequilibrium. The algorithm solves the PNS equations using a finite-volume, upwind TVD method based on Roe's approximate Riemann solver that has been modified to account for real gas effects. The present code solves the fluid dynamic and species continuity equations in a loosely-coupled manner. The fluid medium is assumed to be a chemically reacting mixture of thermally perfect (but calorically imperfect) gases in thermal equilibrium. Results are presented for the hypersonic laminar flow over a cone at 0- and 10-deg angles of attack and for a generic hypersonic vehicle. Calculations are performed assuming either perfect gas, equilibrium air, or finite-rate chemistry. Author

A90-19833#
DEVELOPMENT OF FINITE ELEMENT METHODS FOR COMPRESSIBLE NAVIER-STOKES FLOW SIMULATIONS IN AEROSPACE DESIGN
M. O. BRISTEAU (INRIA, Le Chesnay, France), M. MALLET, J. PERIAUX, and G. ROGE (AMDBA, Saint-Cloud, France) AIAA, Aerospace Sciences Meeting, 28th, Reno, NV, Jan. 8-11, 1990. 14 p. Research supported by CNES and ESA. refs
(Contract DRET-88-103)
(AIAA PAPER 90-0403) Copyright

Two FEMs coupled with mesh adaptation are being developed to solve the compressible Navier-Stokes equations while accurately capturing features such as the boundary layer yielding pressure, skin friction and heat transfer coefficients, and recirculation, vortex, wave, and shock interaction structures. One of the FEMs is based on a Galerkin least-square formulation and is designed for high Mach number calculations. The other is focused on accurate centered space discretization using a compatible finite element approximation and is intended for use in aerodynamic shape design at subsonic and transonic regimes. Numerical flow simulations around reference simplified two- and three-dimensional industrial computations originating from aircraft-aerospace applications are presented to demonstrate the two methodologies. R.B.

A90-19837#
AERODYNAMIC SPIKE FLOWFIELDS COMPUTED TO SELECT OPTIMUM CONFIGURATION AT MACH 2.5 WITH EXPERIMENTAL VALIDATION
J. MICHAEL SHOEMAKER (Martin Marietta Corp., Orlando, FL) AIAA, Aerospace Sciences Meeting, 28th, Reno, NV, Jan. 8-11, 1990. 11 p. refs
(AIAA PAPER 90-0414) Copyright

An implicit, Beam-Warming Navier-Stokes code is validated for computing gross flowfield features and axial forces for zero angle of attack for a blunted cone with a complex aerodynamic spike. The code is applied to a hemisphere cylinder with a family of aerodynamic spikes created by increasing the length of the spike from 2 inches to 9 inches to determine the optimum length for the spike for a design Mach number of 2.5. Axial force reductions of 35 percent are achieved. The effectiveness of the selected spike in reducing drag is determined for a Mach number range from 1.5 to 3.0. The spike is effective in reducing drag for all Mach numbers greater than 1.5. However, axial force reduction efficiency decreases with Mach number. Since the performance of optical seekers is best when used with hemispherical noses, the aerodynamic spike offers a method of increasing the range of these missile systems. Author

A90-19841#
VISCOUS SUPERSONIC FLOW COMPUTATIONS OVER A DELTA-RECTANGULAR WING WITH SLANTING SURFACES
JOHN S. CHAN (Boeing Aerospace and Electronics, Seattle, WA) AIAA, Aerospace Sciences Meeting, 28th, Reno, NV, Jan. 8-11, 1990. 10 p. Research supported by Boeing Independent Research and Development Program. refs
(AIAA PAPER 90-0419) Copyright

A three-dimensional Navier-Stokes code has been applied to calculate flowfields over a sharp-edged delta-rectangular wing with slanting surfaces at supersonic conditions. The steady-state solutions were obtained by solving the full compressible Reynolds-averaged Navier-Stokes equations on a three-dimensional multizone grid using the MacCormack finite-volume explicit algorithm and the Baldwin-Lomax turbulence model. The computations were carried out at a fixed freestream Mach number and at various angles of attack. Grid resolution effects were also investigated. The numerical computations were found to agree well with the experimental data. Author

A90-19842#
HYPERSONIC RAREFIED FLOW AND ITS SOLUTION OVER THE STAGNATION REGION
SIN-I CHENG and SHENG LIU (Princeton University, NJ) AIAA, Aerospace Sciences Meeting, 28th, Reno, NV, Jan. 8-11, 1990. 12 p. refs
(AIAA PAPER 90-0420) Copyright

A two-beam model in multispace dimensions was developed for the analysis of the external hypersonic rarefied over a convex body. A scattering collision correlation is derived for analyzing transitional flow fields. The solution of the local flow field over the axisymmetric stagnation region is presented. R.B.

A90-19844*# Vigyan Research Associates, Inc., Hampton, VA.
TRANSONIC NAVIER-STOKES SOLUTIONS ABOUT A COMPLEX HIGH-SPEED ACCELERATOR CONFIGURATION
FARHAD GHAFFARI, BRENT L. BATES (Vigyan Research Associates, Inc., Hampton, VA), JAMES M. LUCKRING, and JAMES L. THOMAS (NASA, Langley Research Center, Hampton, VA) AIAA, Aerospace Sciences Meeting, 28th, Reno, NV, Jan. 8-11, 1990. 17 p. refs
(Contract NAS1-18585)
(AIAA PAPER 90-0430)

Three-dimensional transonic viscous flow computations are presented for a generic high-speed accelerator model which includes wing, body, fillets, and a no-flow through engine nacelle. Solutions are obtained from an algorithm for the compressible Navier-Stokes equations which incorporates an upwind-biased, flux-vector-splitting approach along with longitudinally-patched grids. Results are presented for fully turbulent flow assumptions and include correlations with wind tunnel data. A good quantitative agreement for the forebody surface pressure distribution is achieved between computations and the available wind-tunnel measurements at freestream Mach number equal to 0.9. Furthermore, it is demonstrated that the flow is stagnating around the boattail region due to separation from the aft-engine cowl lip. Author

A90-19845#
STATIC AEROELASTIC ANALYSIS OF FIGHTER AIRCRAFT USING A THREE-DIMENSIONAL NAVIER-STOKES ALGORITHM
DAVID M. SCHUSTER (Georgia Institute of Technology, Atlanta), JOSEPH VADYAK (Lockheed Aeronautical Systems Co., Marietta, GA), and ESSAM ATTA (Lockheed Aeronautical Systems Co., Valencia, CA) AIAA, Aerospace Sciences Meeting, 28th, Reno, NV, Jan. 8-11, 1990. 7 p. refs
(Contract F33615-87-C-3209)
(AIAA PAPER 90-0435) Copyright

An aeroelastic analysis method for fighter aircraft operating at extreme flight conditions has been developed and tested. The method involves the use of state-of-the-art zonal grid generation methods, three-dimensional Navier-Stokes analysis and linear structures to analyze the flow over complex, flexible aircraft. The main objective of this effort is to analyze aircraft operating at flight conditions where vortices, strong shock waves, separated flow and even highly unsteady flow may be present. The present application focuses on the static aeroelastic analysis of fighter aircraft operating at high angle-of-attack and high transonic Mach number. The developed method has been compared against static aeroelastic wind tunnel data on an aeroelastically tailored wing/fuselage configuration, and the results are very encouraging. Author

A90-19846*# Purdue Univ., West Lafayette, IN.
PROPELLER TIP VORTEX INTERACTIONS
ROBERT T. JOHNSTON and JOHN P. SULLIVAN (Purdue University, West Lafayette, IN) AIAA, Aerospace Sciences Meeting, 28th, Reno, NV, Jan. 8-11, 1990. 11 p. Research supported by NASA. refs
(AIAA PAPER 90-0437) Copyright

Propeller wakes interacting with aircraft aerodynamic surfaces are a source of noise and vibration. For this reason, flow visualization work on the motion of the helical tip vortex over a wing and through the second stage of a counterrotation propeller (CRP) has been pursued. Initially, work was done on the motion of a propeller helix as it passes over the center of a 9.0 aspect ratio wing. The propeller tip vortex experiences significant spanwise

displacements when passing across a lifting wing. A stationary propeller blade or stator was installed behind the rotating propeller to model the blade vortex interaction in a CRP. The resulting vortex interaction was found to depend on the relative vortex strengths and vortex sign. Author

A90-19874*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
RESULTS OF AERODYNAMIC TESTING OF LARGE-SCALE WING SECTIONS IN A SIMULATED NATURAL RAIN ENVIRONMENT
GAUDY M. BEZOS, R. EARL DUNHAM, JR., BRYAN A. CAMPBELL (NASA, Langley Research Center, Hampton, VA), and W. EDWARD MELSON, JR. (NASA, Wallops Flight Center, Wallops Island, VA) AIAA, Aerospace Sciences Meeting, 28th, Reno, NV, Jan. 8-11, 1990. 9 p. refs
(AIAA PAPER 90-0486)

The NASA Langley Research Center has developed a large-scale ground testing capability for evaluating the effect of heavy rain on airfoil lift. The paper presents the results obtained at the Langley Aircraft Landing Dynamics Facility on a 10-foot cord NACA 64-210 wing section equipped with a leading-edge slat and double-slotted trailing-edge flap deflected to simulate landing conditions. Aerodynamic lift data were obtained with and without the rain simulation system turned on for an angle-of-attack range of 7.5 to 19.5 deg and for two rainfall conditions: 9 in/hr and 40 in/hr. The results are compared to and correlated with previous small-scale wind tunnel results for the same airfoil section. It appears that to first order, scale effects are not large and the wind tunnel research technique can be used to predict rain effects on airplane performance. Author

A90-19876#
THE SONIC EDDY - A MODEL FOR COMPRESSIBLE TURBULENCE
ROBERT E. BREIDENTHAL (Washington, University, Seattle) AIAA, Aerospace Sciences Meeting, 28th, Reno, NV, Jan. 8-11, 1990. 7 p. refs
(Contract AF-AFOSR-87-0366)
(AIAA PAPER 90-0495) Copyright

A new model is proposed for entrainment in supersonic turbulence. The central assumption is that only those eddies whose rotational Mach number is unity directly engulf fluid. With the additional assumption that a Kolmogorov spectrum of eddy scales exist for all subsonic eddies, the theoretical effect of the sonic eddy on entrainment and structure is compared to observation in shear layers and wakes. Author

A90-19896*# Vigyan Research Associates, Inc., Hampton, VA.
A NUMERICAL PARAMETRIC STUDY OF A SCRAMJET INLET IN A MACH 6 ARC HEATED TEST FACILITY
B. SEKAR (Vigyan Research Associates, Inc., Hampton, VA), S. THOMAS (NASA, Langley Research Center, Hampton, VA), and S. SRINIVASAN (A.S.&M., Inc., Hampton, VA) AIAA, Aerospace Sciences Meeting, 28th, Reno, NV, Jan. 8-11, 1990. 17 p. refs
(Contract NAS1-18585)
(AIAA PAPER 90-0531)

A numerical study of the NASA Langley Arc Heated Scramjet Test Facility (AHSTF) is reported. The facility test flow through the Mach 6 quasi-two-dimensional nozzle was computed, and the flow through the Langley parametric inlet was calculated using different regions of the computed facility nozzle exit flow as inflow, exploring in more detail the effect of boundary layer ingestion on inlet performance. The potential advantage of using a quasi-two-dimensional nozzle in the Langley AHSTF versus the square cross-sectioned nozzle currently used for Scramujet engine tests is explored in terms of resulting inlet performance. C.D.

A90-19921#
CALCULATION OF LOW REYNOLDS NUMBER FLOWS AT HIGH ANGLES OF ATTACK
T. CEBECI, H. H. CHEN (California State University, Long Beach), R. H. LIEBECK (Douglas Aircraft Co., Long Beach, CA), and M. MCILVAINE AIAA, Aerospace Sciences Meeting, 28th, Reno, NV, Jan. 8-11, 1990. 10 p. refs
(AIAA PAPER 90-0569) Copyright

Calculated results are reported for Eppler and Liebeck airfoils with chord Reynolds numbers ranging from 100,000 to 500,000 and for angles of attack up to stall. They were obtained with an interactive finite-difference boundary-layer method in which the turbulence model employs an extended intermittency expression in the Cebeci and Smith (1974) eddy-viscosity model and the location of the onset of transition is determined from linear-stability theory. Comparisons with experiments indicate agreement within measurement uncertainty, except at stall conditions, and close correspondence with the ISES code which is based on the solution of integral equations. Author

A90-19922*# Georgia Inst. of Tech., Atlanta.
A NUMERICAL STUDY OF GENERAL VISCOUS FLOWS AROUND MULTI-ELEMENT AIRFOILS
C. M. WANG, J. C. WU (Georgia Institute of Technology, Atlanta), and C. TUNG (NASA, Ames Research Center; U.S. Army, Aeroflightdynamics Directorate, Moffett Field, CA) AIAA, Aerospace Sciences Meeting, 28th, Reno, NV, Jan. 8-11, 1990. 15 p. Research supported by the U.S. Army. refs
(AIAA PAPER 90-0572) Copyright

An efficient numerical procedure based on a velocity integral representation and Fourier series expansion is developed to compute the unsteady viscous flows around multielement airfoils. Flow developments initiated from an impulsively started motion of a Boeing VR7 airfoil with or without a leading-edge slat are studied in both laminar and turbulent flow conditions. The effect of the presence of the slat to the surface pressure distribution of the airfoil is assessed. Author

A90-19923#
DYNAMIC STALL OF CIRCULATION CONTROL AIRFOILS
GEORGE D. SHREWSBURY and L. N. SANKAR (Georgia Institute of Technology, Atlanta) AIAA, Aerospace Sciences Meeting, 28th, Reno, NV, Jan. 8-11, 1990. 10 p. Research supported by the U.S. Army. refs
(AIAA PAPER 90-0573) Copyright

A two-dimensional, time accurate Navier-Stokes analysis' method has been used to evaluate the dynamic airloads of a circulation control airfoil. When the pitching amplitude is sufficient to produce dynamic stall, the loss in lift is severe, although the airfoil recovers quickly at moderate values of reduced frequency. For higher values of reduced frequency, dynamic stall produces a complex bimodal characteristic for the airloads. Author

A90-19924#
NAVIER-STOKES METHODS TO PREDICT CIRCULATION CONTROL AIRFOIL PERFORMANCE
S. L. WILLIAMS (USAF, Aeronautical Systems Div., Wright-Patterson AFB, OH) and M. E. FRANKE (USAF, Institute of Technology, Wright-Patterson AFB, OH) AIAA, Aerospace Sciences Meeting, 28th, Reno, NV, Jan. 8-11, 1990. 9 p. refs
(AIAA PAPER 90-0574)

The predictive capability of the two-dimensional, compressible, mass-averaged, Navier-Stokes equations is investigated for a typical circulation control airfoil. The governing equations are solved using the implicit approximate-factorization algorithm of Beam-Warming with the turbulence model of Baldwin-Lomax. To account for the unique characteristics of circulation control airfoils, an empirical turbulence model correction due to Bradshaw is employed. The predictive capability of the computational method is explored by examining the importance of the Bradshaw curvature correction constant on the computed results. Author

A90-19925*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
AMPLITUDE EFFECTS ON DYNAMIC STALL OF AN OSCILLATING AIRFOIL
M. S. CHANDRASEKHARA (U.S.Navy-NASA Joint Institute of Aeronautics, Monterey, CA) and B. E. BRYDGES (NASA, Ames

Research Center, Moffett Field, CA) AIAA, Aerospace Sciences Meeting, 28th, Reno, NV, Jan. 8-11, 1990. 12 p. Research supported by the U.S. Army, USAF, U.S. Navy, and NASA. refs
(AIAA PAPER 90-0575)

Amplitude effects on dynamic stall of an oscillating airfoil in locally transonic flow were studied using stroboscopic schlieren flow visualization. The dynamic stall vortex was photographed for various conditions and its properties were documented. Results show a pronounced effect of the amplitude of oscillation. The airfoil flow can sustain the larger amplitudes with the vortex retained on the surface and thus, produce dynamic lift to higher angles of attack at higher amplitudes. A possible explanation for this is offered in terms of the vorticity generation due to surface acceleration and local streamwise pressure gradient. Also, for the first time a shock has been photographed on the airfoil upper surface and some of its characteristics are discussed. Author

A90-19926#
INVISCID DRAG PREDICTION FOR TRANSONIC TRANSPORT WINGS USING A FULL-POTENTIAL METHOD
J. VAN DER VOOREN and A. J. VAN DER WEES (Nationaal Lucht- en Ruimtevaartlaboratorium, Amsterdam, Netherlands) AIAA, Aerospace Sciences Meeting, 28th, Reno, NV, Jan. 8-11, 1990. 19 p. refs
(AIAA PAPER 90-0576) Copyright

A theory of drag analysis in full-potential flow is summarized, based on the generalization and extension of the idea of Garabedian and McFadden (1982) of determining wave drag by volume integration of the artificial viscosity. A series of mesh refinement experiments on nested grids is carried out for a DFVLR-F4-wing in transonic flow using CH- as well as CO-topology grids in order to provide insight into the accuracy of inviscid drag prediction for transonic transport wings. The MATRICS code used in the experiments is first-order accurate in the mesh size used throughout the supersonic flow regions. It is concluded that CO-topology grids are better suited for drag analysis than are CH-topology grids. It is also concluded that the accuracy of each individual drag component can be improved by extrapolating to the limit of vanishing mesh size. In order to avoid excessively fine grids in an engineering environment, the need is stressed for artificial viscosity terms that are second-order small in the mesh size in supersonic flow regions, except for the immediate vicinity of the shock waves. S.A.V.

A90-19929#
VISCOUS OSCILLATING CASCADE AERODYNAMICS AND FLUTTER BY A LOCALLY ANALYTICAL METHOD
JAMES M. WOLFF and SANFORD FLEETER (Purdue University, West Lafayette, IN) AIAA, Aerospace Sciences Meeting, 28th, Reno, NV, Jan. 8-11, 1990. 11 p. refs
(Contract F49620-88-C-0022)
(AIAA PAPER 90-0579) Copyright

A mathematical model is developed to analyze the viscous aerodynamics of an harmonically oscillating flat plate airfoil cascade in an incompressible laminar flow. The steady flow field is described by the Navier-Stokes equations, with the unsteady viscous flow modeled as a small perturbation to this steady flow. Solutions for both the steady and the unsteady viscous flow fields are then obtained by developing locally analytical solutions. The significant effects of Reynolds number, elastic axis, interblade phase angle and incidence angle on the oscillating cascade unsteady aerodynamics and torsional flutter characteristics are then demonstrated. Author

A90-19932#
THE INFLUENCE OF A ROTATING LEADING EDGE ON ACCELERATING STARTING FLOW OVER AN AIRFOIL
F. FINAISH (Missouri-Rolla, University, Rolla) and R. W. JEFFERIES (USAF, Flight Dynamics Laboratory, Wright-Patterson AFB, OH) AIAA, Aerospace Sciences Meeting, 28th, Reno, NV, Jan. 8-11, 1990. 7 p. refs
(AIAA PAPER 90-0583) Copyright

This study reports an experimental investigation on the influences of a rotating leading edge on vortex developments over an airfoil uniformly accelerated from rest. To evaluate such flow, a NACA 0015 airfoil that incorporates a rotating leading edge was subjected to a nearly constant acceleration of 2.4 m/sq sec after start from rest. The flow visualization technique of direct injection of liquid titanium tetrachloride was employed to visualize the flow developments over the airfoil. The results suggest that the concept of the rotating leading edge may be utilized to control the characteristics of unsteady separated flows over lifting surfaces. Author

A90-19936#
SEMI-IMPLICIT NAVIER-STOKES SOLVER (SINSS) CALCULATIONS OF SEPARATED FLOWS AROUND BLUNT DELTA WINGS
BERNARD LOYD, KUOK-MING LEE, and EARLL M. MURMAN (MIT, Cambridge, MA) AIAA, Aerospace Sciences Meeting, 28th, Reno, NV, Jan. 8-11, 1990. 14 p. Research supported by Grumman Aerospace Corp. and Flygtekniska Forsoksanstalten. refs
(Contract N00014-86-K-0288)
(AIAA PAPER 90-0590) Copyright

The present semiimplicit Navier-Stokes solver (SINSS), combining implicit temporal integration in the body-normal direction with explicit temporal integrations in the streamwise and cross-stream directions, eliminates the numerical stiffness due to disparate physical scales in the normal direction. Illustrative problems are treated which demonstrate that this scheme is significantly more efficient than corresponding explicit and fully-implicit schemes. Attention is given to SINSS calculations for several semiinfinite elliptical wings at various supersonic flow conditions; the physics of leading-edge flow separation is examined. O.C.

A90-19939#
NUMERICAL INVESTIGATION OF AIRFOIL/JET/FUSELAGE-UNDERSURFACE FLOWFIELDS IN GROUND EFFECT
C. J. HWANG (National Cheng Kung University, Tainan, Republic of China), S. Y. YANG, and J. L. LIU AIAA, Aerospace Sciences Meeting, 28th, Reno, NV, Jan. 8-11, 1990. 10 p. refs
(AIAA PAPER 90-0597) Copyright

The problems of airfoil/jet/ground-interaction flowfields and a planar jet issuing from a fuselage undersurface in ground effect are presently treated by solving the Euler-Reynolds-averaged compressible Navier-Stokes continuity and energy equations in conjunction with a two-equation k-epsilon model for turbulent flows related to V/STOL aircraft. The grid points are generated by the algebraic method and differential equation technique. Explicit fourth-order and implicit second-order dissipation terms are employed in order to suppress numerical oscillations. The accuracy and reliability of the present work are evaluated by comparing the computed flow field properties with related numerical and experimental results. O.C.

A90-19940*# Old Dominion Univ., Norfolk, VA.
PREDICTION OF STEADY AND UNSTEADY ASYMMETRIC VORTICAL FLOWS AROUND CONES
OSAMA A. KANDIL, TIN-CHEE WONG (Old Dominion University, Norfolk, VA), and C. H. LIU (NASA, Langley Research Center, Hampton, VA) AIAA, Aerospace Sciences Meeting, 28th, Reno, NV, Jan. 8-11, 1990. 16 p. refs
(Contract NAS1-18584-08)
(AIAA PAPER 90-0598) Copyright

Steady and unsteady, supersonic asymmetric vortical flows and their passive control around circular and noncircular cones are considered in this paper. These problems are formulated by using the unsteady, compressible, single and double, thin-layer. Navier-Stokes equations. The equations are solved by using an implicit, upwind, flux-difference splitting, finite-volume scheme, either in a pseudotime stepping or in an accurate-time stepping. An implicit, approximately-factored, central-difference finite-volume scheme has also been used to validate some applications of the upwind scheme. Steady asymmetric vortical flows have been

predicted by using random and controlled disturbances for circular and noncircular cones. Unsteady asymmetric vortex-shedding flows have also been predicted, for the first time, using time-accurate solutions, for circular and noncircular cones. Control of flow asymmetry have been demonstrated computationally, for the first time, by inserting a vertical fin the leeward plane of geometric symmetry. Author

A90-19978*# Mississippi State Univ., Mississippi State.
COUNTERROTATING PROP-FAN SIMULATIONS WHICH FEATURE A RELATIVE-MOTION MULTIBLOCK GRID DECOMPOSITION ENABLING ARBITRARY TIME-STEPS
J. MARK JANUS and DAVID L. WHITFIELD (Mississippi State University, Mississippi State) AIAA, Aerospace Sciences Meeting, 28th, Reno, NV, Jan. 8-11, 1990. 26 p. refs
(Contract NAG3-767; NAG3-869)
(AIAA PAPER 90-0687) Copyright

Improvements are presented of a computer algorithm developed for the time-accurate flow analysis of rotating machines. The flow model is a finite volume method utilizing a high-resolution approximate Riemann solver for interface flux definitions. The numerical scheme is a block LU implicit iterative-refinement method which possesses apparent unconditional stability. Multiblock composite gridding is used to orderly partition the field into a specified arrangement of blocks exhibiting varying degrees of similarity. Block-block relative motion is achieved using local grid distortion to reduce grid skewness and accommodate arbitrary time step selection. A general high-order numerical scheme is applied to satisfy the geometric conservation law. An even-blade-count counterrotating unducted fan configuration is chosen for a computational study comparing solutions resulting from altering parameters such as time step size and iteration count. The solutions are compared with measured data. S.A.V.

A90-19981#
INVESTIGATION OF OSCILLATING AIRFOIL SHOCK PHENOMENA
DANIEL D. GIORDANO and SANFORD FLEETER (Purdue University, West Lafayette, IN) AIAA, Aerospace Sciences Meeting, 28th, Reno, NV, Jan. 8-11, 1990. 16 p. refs
(AIAA PAPER 90-0695) Copyright

Fundamental experiments are performed on an unsteady flow water table to investigate and quantify the shock motion generated by a biconvex airfoil in supersonic and transonic flow fields and an airfoil cascade in a supersonic inlet flow which are executing torsion mode oscillations at realistic reduced frequencies. A computer-based image enhancement and analysis system is used to measure the oscillating supersonic and transonic shock flow phenomena. Utilizing the hydraulic analogy, appropriate data are analyzed and correlated with predictions from a linear oscillating airfoil and airfoil cascade model. For the isolated airfoil bow shock the magnitude and phase relationships are determined to be relatively independent of Mach x number. However, both the magnitude and phase are a strong function of the reduced frequency with the bow shock in phase with the airfoil motion at low reduced frequencies and lagging the airfoil motion as the reduced frequency is increased. Author

A90-19983#
APPLICATION OF AN ADAPTIVE ALGORITHM TO SINGLE AND TWO-ELEMENT AIRFOILS IN TURBULENT FLOW
YANNIS KALLINDERIS and JUDSON R. BARON (MIT, Cambridge, MA) AIAA, Aerospace Sciences Meeting, 28th, Reno, NV, Jan. 8-11, 1990. 23 p. refs
(Contract AF-AFOSR-82-0136; AF-AFOSR-87-0218)
(AIAA PAPER 90-0698) Copyright

An adaptive algorithm for turbulent flows, which has been developed recently, is applied to airfoil flow fields for relatively high Reynolds numbers. The adaptive algorithm employs both grid embedding and redistribution, as well as equation adaptation, in order to compute viscous flows. Two kinds of geometries are considered. The first involves a single element NACA 0012 airfoil; the second is a two-element NLR airfoil, consisting of a main airfoil and a flap. Specifically, the NACA 0012 airfoil is considered for both subsonic and transonic flow. The flow past the two-element airfoil configuration is low subsonic and considers two flap deflection angles. The numerical results are compared with corresponding NLR experimental measurements. Important flow physics, such as shock-boundary layer interactions and small separation bubbles, are 'captured' by the adaptive algorithm with considerable detail. Author

A90-20010*# Georgia Inst. of Tech., Atlanta.
NUMERICAL STUDY OF THE EFFECTS OF ICING ON FINITE WING AERODYNAMICS
OH J. KWON and LAKSHMI N. SANKAR (Georgia Institute of Technology, Atlanta) AIAA, Aerospace Sciences Meeting, 28th, Reno, NV, Jan. 8-11, 1990. 10 p. refs
(Contract NAG3-768)
(AIAA PAPER 90-0757) Copyright

The sectional and total aerodynamics load characteristics of moderate aspect ratio wings with and without simulated glaze leading-edge ice are studied using a three-dimensional, compressible Navier-Stokes solver. The wing has an untwisted, untapered planform shape with NACA 0012 airfoil section. The aspect ratio of the wing is chosen to be 5. Comparisons of computed surface pressures and sectional loads with experimental data for identical configurations are given. The abrupt decrease in the wing stall angle as a result of the leading edge ice formation is numerically demonstrated. Author

A90-20011*# Nielsen Engineering and Research, Inc., Mountain View, CA.
DEVELOPMENT OF AN UNSTRUCTURED MESH/NAVIER-STOKES METHOD FOR AERODYNAMICS OF AIRCRAFT WITH ICE ACCRETIONS
STEVEN C. CARUSO (Nielsen Engineering and Research, Inc., Mountain View, CA) AIAA, Aerospace Sciences Meeting, 28th, Reno, NV, Jan. 8-11, 1990. 15 p. refs
(Contract NAS3-25601)
(AIAA PAPER 90-0758) Copyright

An advanced flowfield prediction method for airfoils with leading edge ice accretions was developed and applied. The method is intended to be eventually used in an aircraft icing analysis. The flowfield is obtained by solving the Euler or Navier-Stokes equations on an unstructured triangular mesh. A new method has been developed to permit efficient mesh generation while providing high grid resolution near complicated airfoil ice accumulations. Unstructured-mesh Euler calculations are presented for clean and iced airfoils; the results are compared to similar structured-mesh calculations to demonstrate the new method's accuracy and efficiency. Author

N90-13325 Arizona Univ., Tucson.
INFLUENCE OF VANE SWEEP ON ROTOR-STATOR INTERACTION NOISE Ph.D. Thesis
EDMANE ENVIA 1988 169 p
Avail: Univ. Microfilms Order No. DA8907954

The influence of vane sweep on rotor-stator interaction noise is investigated. In an analytical approach, the interaction of a convected gust, representing the rotor viscous wake, with a cascade of finite span swept airfoils, representing the stator, is analyzed. The analysis is based on the solution of the exact linearized equations of motion. High-frequency convected gusts for which noise generation is concentrated near the leading edge of the airfoils are considered. In a preliminary study, the problem of an isolated finite span swept airfoil interacting with a convected gust is analyzed. Using Fourier transform methods and the Wiener-Hopf technique, an approximate solution for this problem is developed. Closed form expressions for the acoustic farfield are obtained and used in a parametric study to assess the effect of airfoil sweep on noise generation. Utilizing the single airfoil model, an approximate solution to the problem of noise radiation from a cascade of finite span swept airfoils interacting with a convected gust is derived. A parametric study of noise generated

by gust-cascade interaction is then performed to assess the effectiveness of vane sweep in reducing rotor-stator interaction noise. Dissert. Abstr.

N90-13326# National Aeronautical Establishment, Ottawa (Ontario).
ANALYSIS OF EXPERIMENTAL DATA FOR CAST 10-2/DOA 2 SUPERCRITICAL AIRFOIL AT LOW REYNOLDS NUMBERS AND APPLICATION TO HIGH REYNOLDS NUMBER FLOW
Y. Y. CHAN Jan. 1989 42 p
(AD-A211654; NAE-AN-60; NRC-30268) Avail: NTIS HC A03/MF A01 CSCL 01/3

The experimental investigation of CAST 10-2/DOA 2 supercritical airfoil previously conducted in the NAE Two-Dimensional Test Facility has been extended to low Reynolds number range at the design Mach number 0.765. The results indicate that with forward transition fixing, the data trend at low Reynolds number is different from that at high Reynolds number with the former more sensitive to the Reynolds number variation. The dividing Reynolds number for these two regions is about 10 million. With aft fixing, the low Reynolds number data approach those at higher Reynolds numbers for cruise conditions. However, at high list conditions the thin boundary layer delays separation and higher maximum lift is obtained. The characteristics of the Reynolds number dependency obtained from the analysis *substantiate the principle of the simulation/extrapolation* methodology for data obtained from low Reynolds number to flight Reynolds number as proposed by the AGARD/Fluid Dynamics Panel. GRA

N90-13327*# Army Aviation Systems Command, Moffett Field, CA.
CORRELATION OF PUMA AIRLOADS: LIFTING-LINE AND WAKE CALCULATION
WILLIAM G. BOUSMAN, COLIN YOUNG, NEIL GILBERT, FRANCOIS TOULMAY, WAYNE JOHNSON, and M. J. RILEY (Royal Aerospace Establishment, Bedford, England) Nov. 1989 31 p Presented at the 15th European Rotorcraft Forum, Amsterdam, The Netherlands, 12-15 Sep. 1989
(NASA-TM-102212; USAAVSCOM-TR-89-A-006; A-89209; NAS 1.15:102212) Avail: NTIS HC A03/MF A01 CSCL 01/1

A cooperative program undertaken by organizations in the United States, England, France, and Australia has assessed the strengths and weaknesses of four lifting-line/wake methods and three CFD methods by comparing their predictions with the data obtained in flight trials of a research Puma. The Puma was tested in two configurations: a mixed bladed rotor with instrumented rectangular tip blades, and a configuration with four identical swept tip blades. The results are examined of the lifting-line predictions. The better lifting-line methods show good agreement with lift at the blade tip for the configuration with four swept tips; the moment is well predicted at 0.92 R, but deteriorates outboard. The predictions for the mixed bladed rotor configuration range from fair to good. The lift prediction is better for the swept tip blade than for the rectangular tip blade, but the reasons for this cannot be determined because of the unmodeled effects of the mixed bladed rotor. Author

N90-13330# Indiana Univ.-Purdue Univ., Indianapolis. School of Engineering and Technology.
BLOCK-STRUCTURED SOLUTION OF THREE-DIMENSIONAL TRANSONIC FLOWS USING PARALLEL PROCESSING Final Report, 1 Jun. 1987 - 31 May 1989
AKIN ECER Aug. 1989 20 p
(Contract AF-AFOSR-0184-87; AF PROJ. 2307)
(AD-A212851; AFOSR-89-1256TR) Avail: NTIS HC A03/MF A01 CSCL 20/4

The main objective of the program has been to implement and test the three-dimensional, block-structured Euler solver on computers with multiple processors. The developed scheme involves the partitioning of a large aerodynamics problem into several smaller problems where each represents a particular flow region. Each of these problems are solved on an Intel-IPSC computer with sixteen processors and an IBM 3090 computer with four processors. In the case of IPSC, the memory is distributed between sixteen processors (4.5 megabytes each). In the case of IBM 3090, all four processors share the same large memory. Several test cases have been run on these computers and basic considerations for analyzing large problems on parallel computers have been investigated. GRA

N90-13331# Air Force Avionics Lab., Wright-Patterson AFB, OH.
TRANSONIC EULER SOLUTIONS ON MUTUALLY INTERFERING FINNED BODIES Final Report, Oct. 1983 - Sep. 1989
LAWRENCE E. LIJEWSKI Sep. 1989 7 p Previously announced in IAA as A89-25222
(AD-A213395; AFATL-TP-89-18) Avail: NTIS HC A02/MF A01 CSCL 01/1

The ability of an Euler code to predict mutual aerodynamic interference in the transonic regime was investigated. One, two, and three body combinations of a cruciform finned configuration were examined at Mach numbers from 0.80 to 1.20 and angles of attack up to ten degrees. Predicted surface pressure distributions were compared with wind tunnel data or the first time on three finned bodies with success. The Euler code was found to predict body pressures well in many interference regions, although shock location often was less accurate due to viscous effects in the strongest interference flow field near Mach 1. Rigid body physics of the three body combination was investigated from integrated pressure distributions. Force and moment behavior was found to be strongly dependent upon Mach number. GRA

N90-13332*# National Aeronautics and Space Administration. *Ames Research Center, Moffett Field, CA.*
STUDY OF THE INTEGRATION OF WIND TUNNEL AND COMPUTATIONAL METHODS FOR AERODYNAMIC CONFIGURATIONS
LINDSEY E. BROWNE and DALE L. ASHBY Oct. 1989 69 p
(NASA-TM-102196; A-89148; NAS 1.15:102196) Avail: NTIS HC A04/MF A01 CSCL 01/1

A study was conducted to determine the effectiveness of using a low-order panel code to estimate wind tunnel wall corrections. The corrections were found by two computations. The first computation included the test model and the surrounding wind tunnel walls, while in the second computation the wind tunnel walls were removed. The difference between the force and moment coefficients obtained by comparing these two cases allowed the determination of the wall corrections. The technique was verified by matching the test-section, wall-pressure signature from a wind tunnel test with the signature predicted by the panel code. To prove the viability of the technique, two cases were considered. The first was a two-dimensional high-lift wing with a flap that was tested in the 7- by 10-foot wind tunnel at NASA Ames Research Center. The second was a 1/32-scale model of the F/A-18 aircraft which was tested in the low-speed wind tunnel at San Diego State University. The panel code used was PMARC (Panel Method Ames Research Center). Results of this study indicate that the proposed wind tunnel wall correction method is comparable to other methods and that it also inherently includes the corrections due to model blockage and wing lift. Author

N90-13333# Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, Brunswick (Germany, F.R.). Abteilung Unterschall-Entwurfsaerodynamik.
COMPUTATION OF FLOW FIELDS AROUND PROPELLERS AND HOVERING ROTORS BASED ON THE SOLUTION OF THE EULER EQUATIONS Ph.D. Thesis - Tech. Univ. Brunswick
NORBERT KROLL Jun. 1989 134 p In GERMAN; ENGLISH summary
(DLR-FB-89-37; ISSN-0171-1342; ETN-90-95051) Avail: NTIS HC A07/MF A01; DLR, VB-PL-DO, Postfach 90 60 58, 5000 Cologne, Fed. Republic of Germany, 43.50 DM

A numerical method for the calculation of inviscid flow fields

around propellers in axial uniform onflow and around hovering rotors is described. The method is based on the solution of the Euler equations in a blade-attached Cartesian reference frame. The solution method presented here is an extension of the finite volume method for nonrotating coordinate systems outlined by Jameson et al. Due to a suitable choice of the dependent variables for the system of the Euler equations, it is guaranteed that important properties of the discrete system known in the nonrotating coordinate system are preserved in the blade-attached rotating reference frame. In order to verify the solution method computations for a two-blade propeller and rotor in hover are carried out. The numerical results show good agreement with the experiment. Since the Euler equations are solved in the whole computational domain, a modeling of the wake geometry is not necessary. ESA

N90-13335# Maryland Univ., College Park. Dept. of Aerospace Engineering.
HYPERSONIC AERODYNAMICS
JOHN D. ANDERSON, JR. *In* VKI, An Introduction to Hypersonic Aerodynamics 171 p 1989
Avail: NTIS HC A18/MF A03

The basic concepts of the hypersonic flow phenomena are reviewed. The inviscid, viscous, high temperature and low density flows are analyzed. Concerning the inviscid flow, the following topics are considered: the basic hypersonic shock relations, the Newtonian flow, the tangent wedge/tangent cone methods, the shock expansion theory, the Euler equation, the Mach number independence, the concept of hypersonic similarity, the thin shock layer theory, and the influence of the vehicles blunt nose shape. In the analysis of the viscous effects prevailing in hypersonic flight conditions, the Navier-Stokes and the boundary layer equations, and the weak and strong viscous interaction theories, are examined. ESA

N90-13336# State Univ. of New York, Buffalo. Cornell Aeronautical Lab.
BLUNT-NOSE INVISCID AIRFLOWS WITH COUPLED NONEQUILIBRIUM PROCESSES
J. GORDON HALL, ALAN Q. ESCHENROEDER, and PAUL V. MARRONE *In* VKI, An Introduction to Hypersonic Aerodynamics 20 p 1989 Revised Sponsored in part by the DOE and CAL Internal Research
(Contract AF 49(638)-792)
Avail: NTIS HC A18/MF A03

The effect of coupled chemical rate processes in external inviscid hypersonic airflows, at high enthalpy levels, is discussed. Exact numerical solutions are obtained, for nose radii about 1 ft, at an altitude of 250,000 ft, and velocities of 15,000 and 23,000 ft/s. The importance of the coupling among the reactions considered is demonstrated. The dissociation-recombination, the bimolecular-exchange and ionization reactions, are included. The gasdynamic expansion in the curved shock layer in the blunt nose flow is observed. The inviscid nose flow is shown to be amenable to binary scaling for a given velocity. ESA

N90-13340# Oxford Univ. (England). Dept. of Engineering Sciences.
DATA ACQUISITION IN AERODYNAMIC RESEARCH
R. W. AINSWORTH *In* VKI, Measurement Techniques in Aerodynamics 78 p 1989
Avail: NTIS HC A23/MF A03

The data acquisition technology in aerodynamic research, from transducer performance through signal conditioning to digitization and processing, is discussed. The construction, the excitation, and the signal response of typical transducers used in aerodynamic research, is reviewed. The waveform of a continuous time or analog signal is presented. Emphasis is given to the digital manipulation of output signals involving frequency time transformations, Fourier analysis and correlation functions. Examples of applications in the field of turbomachinery are given. ESA

N90-13341# Essen Univ. (Germany, F.R.).
PRACTICAL SYSTEMS FOR SPECKLE VELOCIMETRY
W. MERZKIRCH *In* VKI, Measurement Techniques in Aerodynamics 14 p 1989 Previously announced as N89-17185
Avail: NTIS HC A23/MF A03

Three dimensional flow visualization, applying a thin light sheet method of illumination, is presented. The speckle velocimetry technique is described. The combination of the cylindrical lens with two telescope lenses is used. Concerning the specklegram, the length and the number of exposures is discussed. The illumination of the system, applying white light speckle patterns, is included. The importance and influences of the photographic film on the speckle velocimetry is emphasized. The direct visualization of the velocity field, by analyzing the spatial filtering of the developed specklegram, is emphasized. ESA

N90-13349*# Stanford Univ., CA. Dept. of Aeronautics and Astronautics.
A CFD STUDY OF TILT ROTOR FLOWFIELDS
IAN FEJTEK and LEONARD ROBERTS Oct. 1989 101 p
(NASA-CR-186116; JIAA-TR-96; NAS 1.26:186116) Avail: NTIS HC A06/MF A01 CSCL 01/1

The download on the wing produced by the rotor wake of a tilt rotor vehicle in hover is of major concern because of its severe impact on payload-carrying capability. In a concerted effort to understand the fundamental fluid dynamics that cause this download, and to help find ways to reduce it, computational fluid dynamics (CFD) is employed to study this problem. The thin-layer Navier-Stokes equations are used to describe the flow, and an implicit, finite difference numerical algorithm is the method of solution. The methodology is developed to analyze the tilt rotor flowfield. Included are discussions of computations of an airfoil and wing in freestream flows at -90 degrees, a rotor alone, and wing/rotor interaction in two and three dimensions. Preliminary results demonstrate the feasibility and great potential of the present approach. Recommendations are made for both near-term and far-term improvements to the method. Author

N90-13350 Manchester Univ. (England).
STUDY OF FORCES AND MOMENTS ON WING-BODIES AT HIGH INCIDENCE, VOLUMES 1 AND 2 Ph.D. Thesis
G. A. JOHNSON 1987 555 p
Avail: Univ. Microfilms Order No. BRD-85587

A systematic experimental study of the forces and moments on a wing-body combination at high incidence is reported. The effect of several parameters, such as wing planform, wing axial location, and wing roll angle were investigated. Throughout the tests the basic body used was a three diameter tangent-ogive forebody with a nine diameter cylindrical afterbody. Flow visualization tests were also done using the smoke-wire and oil-surface flow techniques, this enabled the leeward flow structure of the wing-body to be studied, particularly in the vital region near the wings. The results of these tests showed that the overall out-of-plane forces and moments were more dependent on incidence and the structure of the body asymmetric flow than on the parameters of wing planform, wing axial location, and wing roll angle. The flow visualization results showed several important changes to the flow structure compared to a body-alone case.
Dissert. Abstr.

N90-13351*# Institute for Computer Applications in Science and Engineering, Hampton, VA.
OPTIMUM SHAPE OF A BLUNT FOREBODY IN HYPERSONIC FLOW Final Report
L. MAESTRELLO and L. TING (New York Univ., New York.) Dec. 1989 22 p
(Contract NAS1-18605)
(NASA-CR-181955; NAS 1.26:181955; ICASE-89-51) Avail: NTIS HC A03/MF A01 CSCL 01/1

The optimum shape of a blunt forebody attached to a symmetric wedge or cone is determined. The length of the forebody, its semi-thickness or base radius, the nose radius and the radius of the fillet joining the forebody to the wedge or cone are specified. The optimum shape is composed of simple curves. Thus

experimental models can be built readily to investigate the utilization of aerodynamic heating for boundary layer control. The optimum shape based on the modified Newtonian theory can also serve as the preliminary shape for the numerical solution of the optimum shape using the governing equations for a compressible inviscid or viscous flow. Author

N90-13352*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
EFFECT OF REDUCED AFT DIAMETER AND INCREASED BLADE NUMBER ON HIGH-SPEED COUNTERROTATION PROPELLER PERFORMANCE
GAYLE E. ROSE (Sverdrup Technology, Inc., Cleveland, OH.) and ROBERT J. JERACKI 1989 31 p Presented at the 27th Aerospace Sciences Meeting, Reno, NV, 9-12 Jan. 1989; sponsored by AIAA
(NASA-TM-102077; E-4837; NAS 1.15:102077; AIAA-89-0438) Avail: NTIS HC A03/MF A01 CSCL 01/1

Performance data of 0.17-scale model counterrotation pusher propeller configurations were taken in the NASA Lewis 8- by 6-Foot Supersonic Wind Tunnel at Mach numbers of 0.66, 0.71, 0.75, and 0.79. These tests investigated the aerodynamic performance of the unducted fan (UDF) demonstrator propeller engine developed in a joint program by General Electric and NASA. Data were recorded to show the effect on counterrotation propeller cruise efficiency of two takeoff noise-reduction concepts. These two concepts are reduced aft blade diameter and increased forward blade number. The four configurations tested were a baseline (F1/A1 8/8) configuration, a reduced aft diameter (F1/A3 8/8) configuration, an increase forward blade number (F1/A1 9/8) configuration, and a combination of the latter two (F1/A3 9/8) configurations. Data were collected with a complex counterrotation propeller test rig via rotating thrust and torque balances and pressure instrumentation. Data comparisons documented the power differences between the baseline and the reduced aft diameter concepts. Performance comparisons to the baseline configuration showed that reducing the aft blade diameter reduced the net efficiency, and adding a blade to the front rotor increased the net efficiency. The combination of the two concepts showed only slightly lower net efficiency than the baseline configuration. It was also found that the counterrotation demonstrator propeller model (F7/A7 8/8) configuration outperformed the baseline (F1/A1 8/8) configuration. Author

N90-13353*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
COMPUTATION OF NAVIER-STOKES EQUATIONS FOR THREE-DIMENSIONAL FLOW SEPARATION
CHING-MAO HUNG Dec. 1989 22 p
(NASA-TM-102266; A-90036; NAS 1.15:102266) Avail: NTIS HC A03/MF A01 CSCL 01/1

Supersonic flows over a sharp and a flat-faced blunt fin mounted on a flat plate are simulated numerically. Several basic issues involved in the resultant three-dimensional steady flow separation are studied. Using the same number of grid points, different grid spacings are employed to investigate the effects of a grid resolution on the origin of the line of separation. Various shock strengths are used to study the so-called separated and unseparated boundary layer and to establish the existence or absence of secondary separation. The length of separation ahead of the flat-faced blunt fin, bifurcation of a horseshoe vortex, and the accessibility of a closed-type separation are investigated. The usual interpretation of the flow field from previous studies and new interpretations arising from the present simulation are discussed. Author

N90-13354*# Kansas Univ. Center for Research, Inc., Lawrence. Flight Research Lab.
AERODYNAMICS OF THRUST VECTORING Semiannual Status Report, 11 Jun. - 10 Dec. 1989
J. B. TSENG and C. EDWARD LAN Dec. 1989 50 p
(Contract NAG1-837)
(NASA-CR-185074; NAS 1.26:185074) Avail: NTIS HC A03/MF A01 CSCL 01/1

Thrust vectoring as a means to enhance maneuverability and aerodynamic performane of a tactical aircraft is discussed. This concept usually involves the installation of a multifunction nozzle. With the nozzle, the engine thrust can be changed in direction without changing the attitude of the aircraft. Change in the direction of thrust induces a significant change in the aerodynamic forces on the aircraft. Therefore, this device can be used for lift-augmenting as well as stability and control purposes. When the thrust is deflected in the longitudinal direction, the lift force and the pitching stability can be manipulated, while the yawing stability can be controlled by directing the thrust in the lateral direction. Author

N90-13355*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
APPLICATION OF AN EFFICIENT HYBRID SCHEME FOR AEROELASTIC ANALYSIS OF ADVANCED PROPELLERS
R. SRIVASTAVA, N. L. SANKAR, T. S. R. REDDY (Toledo Univ., OH.), and D. L. HUFF 1989 30 p Presented at the 28th Aerospace Sciences Meeting, Reno, NV, 8-11 Jan. 1990; sponsored by AIAA
(NASA-TM-102428; E-5196; NAS 1.15:102428; AIAA-90-0028) Avail: NTIS HC A03/MF A01 CSCL 01/1

An efficient 3-D hybrid scheme is applied for solving Euler equations to analyze advanced propellers. The scheme treats the spanwise direction semi-explicitly and the other two directions implicitly, without affecting the accuracy, as compared to a fully implicit scheme. This leads to a reduction in computer time and memory requirement. The calculated power coefficients for two advanced propellers, SR3 and SR7L, and various advanced ratios showed good correlation with experiment. Spanwise distribution of elemental power coefficient and steady pressure coefficient differences also showed good agreement with experiment. A study of the effect of structural flexibility on the performance of the advanced propellers showed that structural deformation due to centrifugal and aero loading should be included for better correlation. Author

N90-13356# Institut de Mecanique des Fluides de Lille (France). Groupe Mecanique des Fluides Fondamentales.
REDUCTION OF PROFILE DRAG BY MODIFYING THE STRUCTURE NEXT TO THE WAKE AREA [REDUCTION DE LA TRAINEE DE CULOT D'UN PROFIL PAR MODIFICATION DE LA STRUCTURE DU SILLAGE PROCHE]
O. RODRIGUEZ and J. PRUVOST 13 Dec. 1988 48 p In FRENCH
(Contract DRET-87-003)
(IMFL-88/35; ETN-90-95269) Avail: NTIS HC A03/MF A01

Drag reduction of two dimensional profiles with thick trailing edges in subsonic flow is experimentally studied by carrying out performance tests in subsonic wind tunnel with the help of a variable shape three dimensional auxiliary device to determine optimum drag reduction. The study leads to the design of a dented trailing edge characterized by the inclusion of a solid angle. The device allows a reduction of 49 percent of the drag in a profile with 0.036 relative thickness. ESA

N90-13357# Technische Univ., Delft (Netherlands). Dept. of Aerospace Engineering.
INDUCED DRAG FOR NON-PLANAR WINGS
H. J. BOS Aug. 1987 69 p
(LR-521; ETN-90-95980) Avail: NTIS HC A04/MF A01

Induced drag for nonplanar wings is studied with the rolling-up process of the wake and its influence on lift and drag particularly analyzed. Important conclusions are given with examples, including that in general it is favorable to extend a lift generating geometry in vertical or horizontal direction since the induced mass is increased in this way. The most favorable way to enlarge the induced mass is by increasing the span. ESA

N90-14186*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
EFFECT OF BLADE PLANFORM VARIATION ON A SMALL-SCALE HOVERING ROTOR
SUSAN L. ALTHOFF and KEVIN W. NOONAN Washington Jan. 1990 26 p Prepared in cooperation with Army Aerostructures Directorate, Hampton, VA
(Contract DA PROJ. 1L1-61102-AH-45-A)
(NASA-TM-4146; L-16608; NAS 1.15:4146; AVSCOM-TM-89-B-009) Avail: NTIS HC A03/MF A01 CSCL 01/1

A hover test was conducted on a small-scale rotor model for three sets of tapered rotor blades and a baseline rectangular planform rotor blade. All configurations had the same airfoils, twist, and thrust-weighted solidity. The tapered blade planforms had taper initiating at 50, 75, and 94 percent of the blade radius with a taper ratio of 3 to 1 for each blade set. The experiment was conducted for a range of thrust coefficients, and the data were compared to the predictions of three hover analysis methods. The data show the 94 percent tapered blade was slightly more efficient at the higher rotor thrust levels. The other tapered planform rotors did not show the expected improvement over the baseline rotor, and all configurations had similar performance for low thrust coefficients. None of the analysis methods correlated well with the experimental data. Author

N90-14187*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
VALIDATION OF A COMPUTER CODE FOR ANALYSIS OF SUBSONIC AERODYNAMIC PERFORMANCE OF WINGS WITH FLAPS IN COMBINATION WITH A CANARD OR HORIZONTAL TAIL AND AN APPLICATION TO OPTIMIZATION
HARRY W. CARLSON (PRC Systems Services Co., Hampton, VA.), CHRISTINE M. DARDEN, and MICHAEL J. MANN Jan. 1990 125 p
(NASA-TP-2961; L-16611; NAS 1.60:2961) Avail: NTIS HC A06/MF A01 CSCL 01/1

Extensive correlations of computer code results with experimental data are employed to illustrate the use of a linearized theory, attached flow method for the estimation and optimization of the longitudinal aerodynamic performance of wing-canard and wing-horizontal tail configurations which may employ simple hinged flap systems. Use of an attached flow method is based on the premise that high levels of aerodynamic efficiency require a flow that is as nearly attached as circumstances permit. The results indicate that linearized theory, attached flow, computer code methods (modified to include estimated attainable leading-edge thrust and an approximate representation of vortex forces) provide a rational basis for the estimation and optimization of aerodynamic performance at subsonic speeds below the drag rise Mach number. Generally, good prediction of aerodynamic performance, as measured by the suction parameter, can be expected for near optimum combinations of canard or horizontal tail incidence and leading- and trailing-edge flap deflections at a given lift coefficient (conditions which tend to produce a predominantly attached flow). Author

N90-14190*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
EFFECT OF PYLON WAKE WITH AND WITHOUT PYLON BLOWING ON PROPELLER THRUST
GARL L. GENTRY, JR., EARL R. BOOTH, JR., and M. A. TAKALLU (PRC Kentron, Inc., Hampton, VA.) Washington Feb. 1990 26 p
(NASA-TM-4162; L-16645; NAS 1.15:4162) Avail: NTIS HC A03/MF A01 CSCL 01/1

Pylon trailing edge blowing was investigated as a means of alleviating the effects of the pylon wake on a pusher arrangement of an advanced single-rotation turboprop. Measurements were made of steady-state propeller thrust and pylon wake pressures and turbulence levels with and without blowing. Results show that the pylon trailing edge blowing practically eliminated the pylon wake, significantly reduced the pylon wake turbulence, and had a relatively small effect on the steady-state propeller thrust. The data are presented with a minimum of analysis. Author

N90-14192 ESDU International Ltd., London (England).
NORMAL FORCE, PITCHING MOMENT, AND SIDE FORCE OF FOREBODY-CYLINDER COMBINATIONS FOR ANGLES OF ATTACK UP TO 90 DEGREES AND MACH NUMBERS UP TO 5
Aug. 1989 20 p Supersedes ESDU-83039; ESDU-85025; and ESDU-86009
(ESDU-89014; ESDU-83039; ESDU-85025; ESDU-86009; ISBN-0-85679-686-7; ISSN-0141-397X) Avail: ESDU

This Data Item 89014, an addition to the Aerodynamic Subseries, provides a simple empirical method for estimating normal forces and pitching moment. Although developed using wind-tunnel data for blunted and pointed tangent-ogive and cone cylinders, and secant-ogive and ellipsoid-nosed cylinders, the method is applicable to any axisymmetric smooth forebody-cylinder combination. It requires as inputs the normal-force-curve and pitching-moment-curve slopes at zero angle of attack, which may be obtained from ESDU 89008, and simple geometric parameters which may be obtained from ESDU 77028. The method predicts normal force within 15 percent at subsonic speeds but within 5 percent at supersonic speeds, and predicts the center of pressure to within 5 percent of body length. The range of data used in the correlation covered forebody fineness ratio of 0.75 to 6.28, overall body fineness ratio of 6 to 22.3 and Mach numbers from 0.27 to 4.5. The use of the method is illustrated by a worked example. The effect of boat-tailing on normal force and pitching moment may be found from ESDU 87033. At high angles of attack, at subsonic and transonic Mach numbers, asymmetric vortex flow may occur on the leeward side of the body, creating an out-of-plane force distribution that may result in large side force and yawing moments and can also affect the normal force. The flow phenomena are considered and the local force distribution is illustrated. The influence of Reynolds number and nose blunting is considered and a discussion of Mach number effects is also given together with an envelope of maximum side force. The existence of various types of flow instability, depending on the Reynolds number/angle of attack combination, can affect the normal force and pitching moment predictions, and the region of applicability is illustrated and found to apply to the majority of the flight cases. ESDU

N90-14194 Oklahoma Univ., Norman.
A COMPUTATIONAL ANALYSIS OF THE TRANSONIC FLOW FIELD OF TWO-DIMENSIONAL MINIMUM LENGTH NOZZLES Ph.D. Thesis
BRIAN MAURICE ARGROW 1989 142 p
Avail: Univ. Microfilms Order No. DA8921078

The method of characteristics is used to generate supersonic contours for two-dimensional straight sonic line (SSL) and curved sonic line (CSL) minimum length nozzles (MLNs) for exit Mach numbers of two, four and six. These contours are combined with subsonic inlets to determine the influence of the inlet geometry on the sonic-line shape and location, and on the supersonic flow field. This is accomplished by computing the inviscid and viscous laminar flow fields for Reynolds number of 1,170, 11,700, and 23,400. The flow fields are computed using a modified version of the code VNAP2 which solves the Euler and full Navier-Stokes equations. The results indicate that the inlet geometry directly determines the sonic-line shape and location. Both are almost totally independent of the MLN type, Reynolds number and exit Mach number. Supersonic flow field phenomena including boundary-layer separation and oblique shock waves are also observed to be a direct result of the inlet geometry. The sonic line assumptions made for the SSL prove to be superior to the CSL assumptions for the cases examined. Dissert. Abstr.

N90-14195 Iowa State Univ. of Science and Technology, Ames.
NAVIER-STOKES SOLUTIONS OF 2-D TRANSONIC FLOW OVER UNCONVENTIONAL AIRFOILS Ph.D. Thesis

R. A. COX 1989 112 p
Avail: Univ. Microfilms Order No. DA8920119

A finite-volume code was written to solve the complete, Reynolds-averaged Navier-Stokes equations around unconventional airfoils. The numerical algorithm is based on a flux-difference splitting form of a total variation diminishing (TVD) scheme. Various modifications to the scheme were incorporated to provide a spatially second-order-accurate scheme in physical space. The scheme is conservative at steady state but employs nonconservative differencing during the integration to steady state to allow incorporation of implicit boundary conditions in the farfield. A zero-equation eddy viscosity model was employed to represent the effects of turbulence. The code was validated by comparisons with flat plate and NACA 0012 data. Excellent results were obtained for both attached flow and shock induced separation cases. Numerical results are also presented for transonic flow over an unconventional airfoil and show good agreement. Dissert. Abstr.

N90-14196 Akron Univ., OH.
NAVIER-STOKES ANALYSIS OF AIRFOILS WITH LEADING EDGE ICE ACCRETIONS Ph.D. Thesis
MARK GREGORY POTAPCZUK 1989 215 p
Avail: Univ. Microfilms Order No. DA8922320

A numerical analysis of the flow field characteristics and the performance degradation of an airfoil with leading edge ice accretions was performed. The important fluid dynamic processes were identified and calculated. Among these were the leading edge separation bubble at low angles of attack, complete separation on the low pressure surface resulting in premature stall, drag rise due to the ice shape, and the effects of angle of attack on the separated flow field. Comparisons to experimental results were conducted to confirm these calculations. A computer code which solves the Navier-Stokes equations in two dimensions, ARC2D, was used to perform the calculations. A Modified Mixing Length turbulence model was developed to improve capabilities in calculating the separated flow phenomena. A grid generation code, GRAPE, was used to produce grids for several ice shape and airfoil combinations. Results indicate that the ability to predict overall performance characteristics, such as lift and drag, at low angles of attack is excellent. Transition location is important for accurately determining separation bubble shape. Details of the flow field in and downstream of the separated regions requires some modifications. Calculations for the stalled airfoil indicate periodic shedding of vorticity that was generated aft of the ice accretion. Time averaged pressure values produce results which compare favorably with experimental information. A turbulence model which accounts for the history effects in the flow may be justified. Dissert. Abstr.

N90-14197 North Carolina State Univ., Raleigh.
NUMERICAL MODELING OF SUPERSONIC TURBULENT REACTING FREE SHEAR LAYERS Ph.D. Thesis
DEAN ROBERT EKLUND 1989 112 p
Avail: Univ. Microfilms Order No. DA8918087

To increase the fundamental understanding of the physical processes present within scramjet combustors, an experimental effort is underway at the NASA Langley Research Center to examine the turbulent combustion within supersonic H2 - air coaxial streams. The objective of this study is to numerically model the turbulent mixing and combustion process within these free shear layers and to examine the effects of different turbulence models, of different chemistry models, and of grid refinement upon the numerical solutions. To conduct this study, a computer program was written to solve the axisymmetric Reynolds-averaged Navier-Stokes equations. The numerical method integrates the governing equations using a central-difference finite volume approach while advancing the solution in time using a Runge-Kutta scheme. Turbulence is modeled using three algebraic eddy viscosity models while two finite-rate chemistry models are employed for modeling the H2 - air chemical kinetics. Three turbulent coaxial jet flowfields are calculated. Adjustments to the algebraic turbulence models are found necessary between bases, and hence, these turbulence models do not provide a true predictive capability. The effect of turbulent mixing upon the extent of combustion is demonstrated and the effect of grid refinement is found to be especially important for reacting flows. Dissert. Abstr.

N90-14198# Kansas Univ., Lawrence.
COMPUTATION OF UNSTEADY TRANSONIC FLOW ABOUT AIRFOILS IN FREQUENCY DOMAIN USING THE FULL-POTENTIAL EQUATION Ph.D. Thesis
HORNG-REN HWANG 1988 141 p
Avail: Univ. Microfilms Order No. DA8918375

A new method based on considerations in frequency domain is developed for calculating the nonlinear unsteady aerodynamic flow field about oscillating airfoils using the 2-D, full potential equation. The method employs an averaging technique to separate the governing nonlinear steady equation into its Fourier components for the in-phase and the out-of-phase solutions without time linearization. These two equations are then solved simultaneously with a finite difference scheme which is adopted directly from the one for solving the steady full potential equation. Computed results are compared with results from wind tunnel data and existing computational methods with time-domain integration for NACA 64A010A, NACA 64A006, and MBB-A3 airfoils in pitching, flapping, and plunging oscillations, respectively. It is shown that the present method predicts the unsteady aerodynamic characteristics in good agreement in most cases with experimental data and/or results from other theoretical methods. Effects of Mach number, the motion amplitude, the reduced frequency, and the steady angle of attack on unsteady characteristics are discussed. It is concluded that the method of harmonic averaging is applicable to directly solving unsteady nonlinear transonic aerodynamic problems in frquency domain. Dissert. Abstr.

N90-14199 North Carolina State Univ., Raleigh.
A ONE EQUATION TURBULENCE MODEL FOR TRANSONIC AIRFOILS Ph.D. Thesis
ROBERT ALAN MITCHELTREE 1989 108 p
Avail: Univ. Microfilms Order No. DA8918118

A one equation turbulence model based on the turbulent kinetic energy equation is presented. The model is motivated by the success of the Johnson-King model and is developed from the available experimental observations on both attached and separated turbulent flows. The model consists of three elements: an attached flow formulation, a separated flow formulation and an automatic blending function which smoothly switches between the two formulations. A central difference finite volume Navier Stokes code based on a Runge-Kutta time marching scheme is modified to facilitate numerical solution of the resulting set of equations. Results for both attached and separated flow about the NACA 0012 and RAE 2822 airfoils are compared with the Baldwin-Lomax algebraic turbulence model, the q - omega two equation model, the Johnson-King model and available experimental pressure and skin friction data. Based on the results obtained, the model duplicates the success of algebraic models in attached flow cases. For separated flow cases, it predicts shock location and strength closer to the experimentally observed values than both the algebraic and two equation models. However, the model suffers some limitation in predicting shock location for transonic cases with large shock induced separation. Dissert. Abstr.

N90-14201# Naval Postgraduate School, Monterey, CA.
COMPUTATIONAL INVESTIGATION OF INCOMPRESSIBLE AIRFOIL FLOWS AT HIGH ANGLES OF ATTACK M.S. Thesis
JOHN MARK MATHRE Dec. 1988 157 p
(AD-A205885) Avail: NTIS HC A08/MF A01 CSCL 01/1

Cebeci's viscous/inviscid interaction program was applied to the analysis of steady, two dimensional, incompressible flow past the NACA 663-018 0010 (Modified), 4412 and the Wortmann FX 63-137 airfoils. Detailed comparisons with the available experimental results show that the essential features are correctly modelled, but that significant discrepancies are found in regions of flow separations. Author

N90-14202*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.
AN IN-FLIGHT INVESTIGATION OF GROUND EFFECT ON A FORWARD-SWEPT WING AIRPLANE
ROBERT E. CURRY, BRYAN J. MOULTON, and JOHN KRESSE Sep. 1989 14 p Presented at the AGARD Symposium on Aerodynamics of Combat Aircraft, Controls, and of Ground Effect, Madrid, Spain, 2-5 Oct. 1989
(NASA-TM-101708; H-1573; NAS 1.15:101708) Avail: NTIS HC A03/MF A01 CSCL 01/1

A limited flight experiment was conducted to document the ground-effect characteristics of the X-29A research airplane. This vehicle has an aerodynamic platform which includes a forward-swept wing and close-coupled, variable incidence canard. The flight-test program obtained results for errors in the airdata measurement and for incremental normal force and pitching moment caused by ground effect. Correlations with wind-tunnel and computational analyses were made. The results are discussed with respect to the dynamic nature of the flight measurements, similar data from other configurations, and pilot comments. The ground-effect results are necessary to obtain an accurate interpretation of the vehicle's landing characteristics. The flight data can also be used in the development of many modern aircraft systems such as autoland and piloted simulations. Author

N90-14205*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
EXPERIMENTAL TRANSONIC FLUTTER CHARACTERISTICS OF TWO 72 DEG-SWEEP DELTA-WING MODELS
ROBERT V. DOGGETT, JR., DAVID L. SOISTMANN, CHARLES V. SPAIN, ELLEN C. PARKER, and WALTER A. SILVA (Planning Research Corp., Hampton, VA.) Nov. 1989 20 p
(NASA-TM-101659; NAS 1.15:101659) Avail: NTIS HC A03/MF A01 CSCL 01/1

Transonic flutter boundaries are presented for two simple, 72 deg. sweep, low-aspect-ratio wing models. One model was an aspect-ratio 0.65 delta wing; the other model was an aspect-ratio 0.54 clipped-delta wing. Flutter boundaries for the delta wing are presented for the Mach number range of 0.56 to 1.22. Flutter boundaries for the clipped-delta wing are presented for the Mach number range of 0.72 to 0.95. Selected vibration characteristics of the models are also presented. Author

03

AIR TRANSPORTATION AND SAFETY

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

A90-17416
AFT FACING TRANSPORT AIRCRAFT PASSENGER SEATS UNDER 16G DYNAMIC CRASH SIMULATION
VAHE BILEZIKJIAN (Weber Aircraft, Inc., Fullerton, CA) IN: Annual SAFE Symposium, 26th, Las Vegas, NV, Dec. 5-8, 1988, Proceedings. Newhall, CA, SAFE Association, 1989, p. 138-142. Copyright

Forward-facing transport aircraft passenger seat design practices are presently applied to the case of aft-facing seating for a military transport aircraft, in the interest of improving passenger survivability in dynamic impacts. Seats designed and tested to static loads as high as 16 G do not necessarily perform adequately under dynamic impact; only dynamic impact tests can expose design flaws associated with stress-concentrating joints and abrupt load-path changes. Brittle materials will show realistic crash impact behavior only in dynamic impact tests. O.C.

A90-17973
EFFECT OF WIND SHEAR ON FLIGHT SAFETY
K.-U. HAHN (Braunschweig, Technische Universitaet, Brunswick, Federal Republic of Germany) Progress in Aerospace Sciences (ISSN 0376-0421), vol. 26, no. 3, 1989, p. 225-259. refs Copyright

Wind shears impact the energy availability as well as the stability of aircraft motion in takeoff and landing operations. At these low altitudes, downdrafts and/or tail-wind shear can lead to a fatal ground impact. Flight safety can be enhanced through the use of up-to-date flight control systems and an adequate wind shear warning-and-indication display from which the pilot can deduce the required manual-mode control inputs. Attention is given to ground impact coordinates for various parameters and thrust limits for wind compensation. O.C.

A90-19734#
ATMOSPHERIC CONDITIONS PRODUCING AIRCRAFT ICING ON 24-25 JANUARY 1989 - A CASE STUDY UTILIZING COMBINATIONS OF SURFACE AND REMOTE SENSORS
B. B. STANKOV and A. J. BEDARD, JR. (NOAA, Wave Propagation Laboratory, Boulder, CO) AIAA, Aerospace Sciences Meeting, 28th, Reno, NV, Jan. 8-11, 1990. 11 p. refs
(AIAA PAPER 90-0197)

An array of remote sensing instruments and in situ instruments were used to study aircraft icing conditions during the winter storm on January 24-25, 1989, in Colorado. For adequate meteorological characterization of the observed aircraft icing event, it was found to be necessary to have continuous measurements of cloud liquid water, continuous measurements with high vertical resolution of temperature, and measurements of the height of cloud base and cloud top. Present and future remote sensing capabilities for the detection of aircraft icing events are described. Author

A90-19735*# Akron Univ., OH.
IMPACT ICE STRESSES IN ROTATING AIRFOILS
R. J. SCAVUZZO, M. L. CHU, and C. J. KELLACKEY (Akron, University, OH) AIAA, Aerospace Sciences Meeting, 28th, Reno, NV, Jan. 8-11, 1990. 9 p. refs
(Contract NAG3-479)
(AIAA PAPER 90-0198)

Finite element analysis is used to study the tensile and shear stresses at the interface between impact ice adhering to a rotating airfoil and the metal airfoil surface. A simple rotating beam-ice structure is used to obtain basic understanding of stress distribution in the ice. Calculations show that shear stresses increase linearly with ice thickness and tensile stresses tend to zero for a fully bonded surface. When shear stresses exceed the ultimate strength, adhesive failure occurs and tensile stresses are developed in the unbonded ice, resulting in tensile failure of the impact ice. A second model is used to study the OH-58 tail rotor with a measured ice profile. Ice shedding predictions are compared to the resulting data using a statistical structural analysis. C.D.

A90-19818#
COLORADO MOUNTAIN FLYING - CRASHES AND WEATHER
MARGARET W. LAMB (J. D. & CFII, Questa, NM) and SUSAN P. BAKER (Johns Hopkins University, Baltimore, MD) AIAA, Aerospace Sciences Meeting, 28th, Reno, NV, Jan. 8-11, 1990. 9 p. refs
(AIAA PAPER 90-0369) Copyright

Data supplied by the National Transportation Safety Board for aircraft crashes that have occurred in a study area of a mountainous terrain near Aspen, Colorado, were used to investigate major factors related to these crashes. It was found that almost half of all crashes involved one or more weather-related factors, with the most frequently mentioned cause (48 out of 113 weather-related cases) being the high density altitude. A rarely recognized phenomenon that appeared to be a factor in five of 113 weather-related crashes was the downslope or gravity winds flowing downhill against prevailing winds aloft when pilots were flying in an easterly direction, anticipating updrafts on the western slopes of the Continental Divide. I.S.

A90-19820#
AVIATION LITIGATION - AN ATC PERSPECTIVE

JOSEPH A. BEAUDOIN AIAA, Aerospace Sciences Meeting, 28th, Reno, NV, Jan. 8-11, 1990. 5 p. refs
(AIAA PAPER 90-0372) Copyright

Since the Federal Aviation Administration (FAA), in conjunction with the National Weather Service, has implemented an improved weather analysis and reporting service for the air traffic service, under the title of the Center Weather Service Unit (CWSU), the 'flying public' demanded that additional weather information be provided to airborne pilots, and law suits were filed against the federal government for failing to provide this additional service. In the future, the FAA is planning to install more advanced equipment in order to provide air traffic controllers with the 'real time' weather in the form of colored weather radar. It is noted however, that, until this new generation radar is implemented, the FAA will continue to be subjected to law suits which cite the failure to disseminate weather information. I.S.

A90-20009*# California State Univ., Long Beach.
FORTIFIED LEWICE WITH VISCOUS EFFECTS
TUNCER CEBECI, H. H. CHEN, and N. ALEMDAROGLU (California State University, Long Beach) AIAA, Aerospace Sciences Meeting, 28th, Reno, NV, Jan. 8-11, 1990. 13 p. refs
(Contract NAG3-935)
(AIAA PAPER 90-0754) Copyright

A method for computing the prediction of ice shapes on airfoils and their effects on the airfoil lift and drag coefficients are described. The previously developed LEWICE code has been modified to avoid problems due to multiple stagnation points. The interactive boundary-layer method developed by Cebeci has been incorporated into LEWICE to improve the accuracy of predicting ice shapes as well as to compute the performance characteristics of iced airfoils. The paper also presents ice shapes calculated without and with viscous effects, the consequences for aerodynamic properties, particulary lift and drag, and evaluation of the time steps used in the ice accretion process. Author

N90-13358# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
THE HUMAN FACTORS RELATING TO ESCAPE AND SURVIVAL FROM HELICOPTERS DITCHING IN WATER
C. J. BROOKS (Defence and Civil Inst. of Environmental Medicine, Downsview, Ontario) Aug. 1989 71 p
(AGARD-AG-305(E); ISBN-92-835-0522-0) Copyright Avail: NTIS HC A04/MF A01

The worldwide incidence of military and civilian over-water helicopter accidents and the problems related to survival are described. Typical accident scenarios are reviewed from the moment the occupant steps on board a helicopter to the pre-flight briefing through to the accident itself, to the difficulties with escape (commonly from underwater and in darkness), to the rescue and return safely to dry land. Improvements to crashworthiness and life support equipment in current in-service and future helicopters are proposed. A syllabus for underwater escape training is also discussed. Author

N90-13359# Southwest Research Inst., San Antonio, TX.
NDI (NONDESTRUCTIVE INSPECTION) ORIENTED CORROSION CONTROL FOR ARMY AIRCRAFT. PHASE 1: INSPECTION METHODS Final Report
F. A. IDDINGS Jul. 1989 253 p
(Contract DLA900-84-C-0910; SWRI PROJ. 17-7958-843)
(AD-A213368) Avail: NTIS HC A12/MF A02 CSCL 11/6

The purpose of the work in this project was to assess the extent of corrosion in Army aircraft and its cost, to investigate nondestructive inspection (NDI) methods of corrosion control, and to formulate specific recommendations for detecting corrosion in new and fielded Army aircraft. The work focused on corrosion detection based on techniques in place and on the latest NDI techniques taking into account the type and stage of corrosion. Included was investigation of the application of NDI methods at critical points in the Corpus Christi Army Depot (CCAD) operation in order to better detect, prevent, and control corrosion in aircraft components as a result of depot maintenance. A key task involved determining how to proceed in developing an NDI oriented manufacturing model for CCAD into which can be incorporated candidate NDI methods that would improve the prevention of corrosion during CCAD's depot maintenance/NDI operations. Effort was concentrated on structuring a flexible manufacturing system (FMS) model for CCAD, including the defining of an FMS cell for support of corrosion control. The report contains a summary of the NTIAC State-of-the-Art (SOAR) on Nondestructive Evaluation methods for Characterization of Corrosion. GRA

N90-13360# Dayton Univ., OH. Structural Integrity Div.
STUDY OF THE ENGINE BIRD INGESTION EXPERIENCE OF THE BOEING 737 AIRCRAFT Interim Report, Oct. 1986 - Sep. 1987
PETER W. HOVEY and DONALD A. SKINN Oct. 1989 106 p Prepared in cooperation with Federal Aviation Administration, Atlantic City, NJ
(Contract DTFA03-88-C-00024)
(DOT/FAA/CT-89/16; UDR-TR-88-137) Avail: NTIS HC A06/MF A01

The Federal Aviation Administration (FAA) Technical Center initiated a study in October 1986 to determine the numbers, stress, and types of birds which are being ingested into medium and large inlet area turbofan engines and to determine what damage, if any, results. Bird ingestion data are being collected for the Boeing 737 model aircraft which uses either the Pratt and Whitney JT8D medium inlet area turbofan engine or the CFM International CFM56 large inlet area turbofan engine. The first of 3 years of data collection are analyzed. The first year extends from October 1986 through September 1987. Author

N90-14211# Royal Aircraft Establishment, Farnborough (England).
EVALUATION OF THE INDIRECT EFFECTS OF LIGHTNING ON A SYSTEM: DOUBLE TRANSFER FUNCTION METHOD
G. CHAMBERT and Y. GUILLEMOT (Aerospatiale, Les Mureaux, France) Jan. 1989 16 p Transl. into ENGLISH of Evaluation des Effets Indirects de la Foudre sur un Systeme Methode la Double Fonction de Transfert (Les Mureaux, France, Aerospatiale)
(RAE-TRANS-2172; BR111413) Avail: NTIS HC A03/MF A01

A program of evaluation and research into methods of testing on aircraft for the indirect effects of lightning is presented. After a statement of the principles, the validation of the method is undertaken by means of impulsive tests performed on a wing of an A300 and its application to a type AEHP lightning pulse is finally considered. Author

N90-14212*# California Polytechnic State Univ., San Luis Obispo. Dept. of Aeronautical Engineering.
CALIFORNIA AIR TRANSPORTATION STUDY: A TRANSPORTATION SYSTEM FOR THE CALIFORNIA CORRIDOR OF THE YEAR 2010
22 May 1989 195 p
(Contract NASW-4435)
(NASA-CR-186219; NAS 1.26:186219) Avail: NTIS HC A09/MF A02 CSCL 01/3

To define and solve the problems of transportation in the California Corrider in the year 2010, the 1989 California Polytechnic State University Aeronautical Engineering Senior Design class determined future corridor transportation needs and developed a system to meet the requirements. A market study, which included interpreting travel demand and gauging the future of regional and national air travel in and out of the corridor, allowed the goals of the project to be accurately refined. Comprehensive trade-off studies of several proposed transporation systems were conducted to determine which components would form the final proposed system. Preliminary design and further analysis were performed for each resulting component. The proposed system consists of three vehicles and a special hub or mode mixer, the Corridor Access Port (CAP). The vehicles are: (1) an electric powered aircraft to serve secondary airports and the CAP; (2) a high speed magnetic levitation train running through the CAP and the high population

density areas of the corridor; and (3) a vertical takeoff and landing tilt rotor aircraft to serve both intercity and intrametropolitan travelers from the CAP and city vertiports. The CAP is a combination and an extension of the hub, mode mixer, and Wayport concepts. The CAP is an integrated part of the system which meets the travel demands in the corridor, and interfaces with interstate and international travel. Author

N90-14213# Committee on Science, Space and Technology (U.S. House).
REVIEW OF THE AEROSPACE SAFETY ADVISORY PANEL REPORT FOR NASA FISCAL YEAR 1990 AUTHORIZATION
1989 113 p Hearing before the Subcommittee on Space Science and Applications of the Committee on Science, Space, and Technology, 101st Congress, 1st Session, no. 69, 28 Sep. 1989
(GPO-24-234) Avail: Subcommittee on Space Science and Applications, Washington, D.C. 20510 HC free; SOD HC $3.50 as 552-070-07499-6

The Panel identified five main categories of findings under the National Space Transportation System (NSTS), including management structure, safety enhancements, advanced solid rocket motor, logistics and support, and space shuttle elements. The Panel found that the NSTS management structure has been clarified and strengthened, and that the safety, reliability, maintainability, and quality assurance function is now stronger, more visible, better staffed, and better funded. It was recommended that these funds be protected to maintain safety. It was also recommended that lists of safety enhancements that are maintained be kept current and prioritized. NASA's decision to develop an advanced solid rocket motor was questioned. Implementation should be deferred until other alternatives have been evaluated. The NSTS logistics and support systems showed a satisfactory trend, but an improvement in overhaul and repair turnaround time was recommended. A program to improve solid rocket motors and boosters was also recommended, as well as tests to determine design corrections to meet original requirements for the booster aft skirt. The Panel recommended continued emphasis on developing and using strong risk assessment and management procedures. The Space Station Freedom Program is ongoing a complete review to accommodate anticipated reduced funding levels. Flight safety procedures for all NASA Centers are to be reviewed to determine their adequacy. J.P.S.

04

AIRCRAFT COMMUNICATIONS AND NAVIGATION

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

N90-13361# Mitre Corp., McLean, VA.
NATIONAL AIRSPACE SYSTEM AIRSPACE MANAGEMENT OPERATIONAL CONCEPT
STEPHANIE B. FRASER Sep. 1989 81 p
(Contract DTFA01-89-C-00001)
(DOT/FAA/DS-89/29; NAS-SR-1321) Avail: NTIS HC A05/MF A01

This concept of operations describes the operation of the National Airspace System (NAS), as it will be in the projected upgrade, i.e., end state. The requirements specified in NAS System Requirements Specification (NASSRS) is linked with the NAS design. The NASSRS addresses airspace management requirements. Airspace management serves to organize air traffic in the aggregate so that it can be managed with maximum safety and throughput, while minimizing delays, controller stress, and interference with pilot intent. Operational concepts are provided for airspace management, as it is described in the NASSRS. Author

N90-13362# Mitre Corp., McLean, VA.
NATIONAL AIRSPACE SYSTEM FLIGHT PLANNING OPERATIONAL CONCEPT
ALEXANDRA ARGYROPOULOS Oct. 1989 57 p
(Contract DTFA01-89-C-00001)
(DOT/FAA/DS-89/30; NAS-SR-1310) Avail: NTIS HC A04/MF A01

An operational concept of the flight planning processing system which will be in place upon implementation of the Federal Aviation Administration (FAA) National Airspace System (NAS) Plan is presented. Flight planning includes all activities involved in the preparation of a flight, that is the information retrieved by the pilot prior to the flight and used to make go/no go decisions; the information conveyed by the pilot to the NAS in the form of a flight plan; and all NAS related services which support these activities. The objective is to describe the relationship between subsystems, facilities, information, and operators/users involved in the flight planning process. In addition, the elements and operations of the NAS Plan are mapped into the flight planning requirements stated in the National Airspace System Requirement Specification. Several types of block diagrams are used to illustrate systems connectivity and operational flow. Scenarios are also derived to describe the flight planning process from a user's perspective. Author

N90-13363# Mitre Corp., McLean, VA. Civil Systems Div.
AN UPDATE TO THE SYSTEM SAFETY STUDY OF TCAS 2 Final Report
NED A. SPENCER Jun. 1989 87 p
(Contract DTFA01-89-C-00001)
(DOT/FAA/SA-89/3; MTR-88W115) Avail: NTIS HC A05/MF A01

An update to the System Safety Study of the Traffic Alert and Collision Avoidance System TCAS 2 is given. Since the time of the original study, and its companion study for instrument weather conditions, new data and new concepts have become available. Recent measurements of the Mode C reported altitude in general aviation aircraft strongly indicate that the errors assumed in the previous studies were overly conservative. On the other hand, new data on the vertical separation of aircraft at their closest point of approach indicates that this factor may have been too optimistic. The Advisory Invalid feature of the collision avoidance logic, which would provide a warning against an intruder's sudden levelling-off maneuver, was replaced with an explicit reversal or increase rate, as the case may require. These and other new concepts in the collision avoidance logic greatly reduce the computed susceptibility to a sudden intruder maneuver, given reasonable pilot reaction. Several features were also introduced into the modified logic to improve interaction with the ATC system. The effects of all of these changes are taken into account in this update. Author

N90-13364# Federal Aviation Administration, Atlantic City, NJ. Technical Center.
LORAN C STABILITY INTEGRITY ASSURANCE
THOMAS WISSER Jun. 1989 40 p
(AD-A212663; DOT/FAA/CT-TN88/13) Avail: NTIS HC A03/MF A01 CSCL 17/7

A program is described which determines if an operational integrity check is necessary before beginning a Loran C nonprecision approach. Simulation testing and a questionnaire distributed to Loran C receiver manufacturers were used to determine if present state-of-the-art receivers could reliably acquire the Loran C signal. The questionnaire was designed to solicit from manufacturers the probability of reliable acquisition for state-of-the-art receivers and if improvements are possible. Flight tests were also conducted to gather preliminary information related to employing Loran C operational integrity checks prior to initiating a nonprecision approach. GRA

N90-13365# Technische Univ., Delft (Netherlands). Faculty of Geodesy.

TEST NETWORK DELFT Thesis
W. H. VANOOIJEN Aug. 1988 109 p
(ETN-90-96009) Avail: NTIS HC A06/MF A01

The accuracy of relative positioning with the Global Positioning System (GPS), using Trimble 4000SX receivers and the Trimble supplied baseline calculation software is tested. The test consists of the comparison of the network measured with the GPS system and the same network terrestrially surveyed with conventional surveying methods. The observations were made at five stations simultaneously. It is shown that it is not allowed to perform a network adjustment using the baselines that close a traverse one. Treatment of the eventually existing misclosure vectors in the closed traverses is studied. A procedure handling the correlated nature of the independently calculated baselines is suggested. The coordinate sets obtained from the GPS measurements and from conventional surveying are compared. It is concluded that there are no biases in the GPS derived coordinates in this network. ESA

N90-13366# Royal Signals and Radar Establishment, Malvern (England).
COMPUTER-BASED TOOLS FOR ASSISTING AIR TRAFFIC CONTROLLERS WITH ARRIVALS FLOW MANAGEMENT
S. A. N. MAGILL, A. C. F. TYLER, E. T. WILKINSON, and W. FINCH Sep. 1988 110 p Sponsored by Civil Aviation Authority
(RSRE-88001; BR108480; ETN-90-94833) Copyright Avail: NTIS HC A06/MF A01

The use of computer based tools for arrivals flow management at major airports is reported. Two experimental prototype tools are described in detail. They were constructed and exercised in a real time simulation environment. The tools were a landing order calculator and a speed control adviser. Both give advice to air traffic controllers for aircraft which are in the vicinity of their top-of-descent points. The underlying concepts and the methods used in the tools are described. The real time simulation environment is discussed. ESA

N90-13367# Stuttgart Univ. (Germany, F.R.). Inst. of Geodesy.
GEODETIC NETWORK ADJUSTMENT USING GPS TRIPLE DIFFERENCE OBSERVATIONS AND A PRIORI STOCHASTIC INFORMATION
K. EREN Oct. 1987 56 p Sponsored by the Alexander von Humboldt Foundation
(TR-1-1987; ISSN-0933-2839; ETN-90-95861) Avail: NTIS HC A04/MF A01

A triple difference network adjustment software is presented which provides the option of introducing a priori information for the associated parameters for processing of GPS (global positioning system) observations. Triple differences are selected because they contain no bias parameters except receiver clock errors and the magnitude of clock terms is so small that a linear function can be easily substituted for the adjustment purpose. The receiver clock parameters and all the receiver and satellite positions are considered as parameters with their a priori stochastic information. Since the triple difference observations are correlated in terms of time, satellites, and receivers, the derivation and coding of these correlations is described. GPS satellites and positioning are reviewed, and GPS observations, and partials for triple difference observations and their correlations are explained. The adjustment models, mathematical derivations, and final expressions as used in the software are presented. Some case studies are provided. The approach is proposed as improving precision of adjusted quantities and yielding realistic values of uncertainties. ESA

N90-13368# Stuttgart Univ. (Germany, F.R.). Inst. of Geodesy.
PROCESSING OF UNDIFFERENCES GPS CARRIER BEAT PHASE MEASUREMENTS AND ADJUSTMENT COMPUTATIONS
W. LINDLOHR 1988 66 p
(TR-5-1988; ISSN-0933-2839; ETN-90-95863) Avail: NTIS HC A04/MF A01; Institute of Geodesy, Stuttgart University, Keplerstr. 11, P.O. Box 560, D-7000 Stuttgart 1, Fed. Republic of Germany, 10 DM

A prototype software product is presented which is created to gain a some parts per mission relative accuracy in the processing of undifferenced GPS (global positioning system) carrier beat phase measurements as an alternative concept for high precision static relative positioning. System concept, program structure and computer configuration is reviewed. Conclusions on, the development of the observation equation and use of original undifferenced GPS carrier phase, the application of prediction methods in the mixed model and of estimation procedures in the Gauss-Markov-model, and their applicability on a dynamical analysis of the local displacement field, are given. ESA

N90-14214# Computer Resource Management, Inc., Vienna, VA.
NATIONAL AIRSPACE SYSTEM MONITORING OPERATIONAL CONCEPT
WILLIAM TRENT, RODNEY KUHN, and THOMAS PICKERELL Nov. 1989 44 p
(Contract DTFA01-88-Y-01073)
(NAS-SR-1330; DOT/FAA/DS-89/31) Avail: NTIS HC A03/MF A01

A requirement for the National Airspace System (NAS) is to provide a variety of monitoring services to its users, as identified in the NAS System Requirement Specification, NAS-SR-1000. A concept of operations for monitoring is presented. Monitoring capabilities are described, and the relationships between subsystems, facilities, information, and operators/users are shown. Here the intent is to provide a common perspective for personnel involved in monitoring services, assist in determining whether monitoring procedures meet formal requirements, and support coordination among the organizations involved. Author

05

AIRCRAFT DESIGN, TESTING AND PERFORMANCE

Includes aircraft simulation technology.

A90-16853#
INVESTIGATION ON THE DETERMINATION OF AIRPLANE TAIL LOADS BY FLIGHT TESTS
JICHEN TANG (China Flight Test Research Center, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 10, Oct. 1989, p. B474-B478. In Chinese, with abstract in English.

A technique for determining tail loads of a fighter under different flight conditions is presented. Correlations between tail load and strain response of some specific points of the tail structure are found by calibration tests on the ground. The maneuver loads on the tail are found from correlation equations. Load data of the vertical tail are also given. Author

A90-16856#
THE ANTI-SHIMMY AND BREAK-PROOF STUDY OF NOSE LANDING GEAR
CHAOSHENG JIA and BONAN SHA (Northwestern Polytechnical University, Xian, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 10, Oct. 1989, p. B495-B500. In Chinese, with abstract in English.

By considering the results from experiments and calculations, it is shown that the main cause of damage to nose landing gear is shimmy. By using a simple and reasonable method, the antishimmy and break-proof problem of nose landing gear has been solved. Author

A90-16860#
THE COMPUTER AIDED WEIGHT ENGINEERING OF AIRCRAFT - (CAWE) SYSTEM
GUOAN JIANG and YONG ZHAO (Beijing University of Aeronautics and Astronautics, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 10, Oct. 1989, p. B526-B529. In Chinese, with abstract in English. refs

This paper discusses the technical requirements of the computer-aided Aircraft Weight Engineering (CAWE) software system. A CAWE system developed on a PC is presented, which can solve the weight engineering problems in the conceptual stage of aircraft design. It is capable of copying with aircraft layout, weight prediction, and adjustment of center of gravity. Author

A90-16963*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.
GROUND VIBRATION TEST RESULTS OF A JETSTAR AIRPLANE USING IMPULSIVE SINE EXCITATION
MICHAEL W. KEHOE and DAVID F. VORACEK (NASA, Flight Research Center, Edwards, CA) IN: International Modal Analysis Conference, 7th, Las Vegas, NV, Jan. 30-Feb. 2, 1989, Proceedings. Volume 1. Bethel, CT, Society for Experimental Mechanics, Inc., 1989, p. 101-111. Previously announced in STAR as N89-15909. refs

Structural excitation is important for both ground vibration and flight flutter testing. The structural responses caused by this excitation are analyzed to determine frequency, damping, and mode shape information. Many excitation waveforms have been used throughout the years. The use of impulsive sine (sin omega t)/omega t as an excitation waveform for ground vibration testing and the advantages of using this waveform for flight flutter testing are discussed. The ground vibration test results of a modified JetStar airplane using impulsive sine as an excitation waveform are compared with the test results of the same airplane using multiple-input random excitation. The results indicated that the structure was sufficiently excited using the impulsive sine waveform. Comparisons of input force spectrums, mode shape plots, and frequency and damping values for the two methods of excitation are presented. Author

A90-16983
A COMPONENT MODAL SYNTHESIS TECHNIQUE FOR THE LATERAL VIBRATION ANALYSIS OF AIRCRAFT ENGINE SYSTEMS
Y. G. TSUEI (Cincinnati, University, OH), SHERMAN WANG (IBM Almaden Research Center, San Jose, CA), and ERIC K. L. YEE IN: International Modal Analysis Conference, 7th, Las Vegas, NV, Jan. 30-Feb. 2, 1989, Proceedings. Volume 1. Bethel, CT, Society for Experimental Mechanics, Inc., 1989, p. 377-383.
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A component modal synthesis technique is presented for calculating the dynamics of a rotor system. The rotor system is divided into blade cascades, rotor shafts, and the nonrotating subsystems. The subsystem frequency transfer function matrices, geometric compatibility, and force equilibrium equations are combined to solve the critical speeds of the rotor system. The degrees of freedom in the final critical speed equation are reduced to the number of physical connections between subsystems, and it is much smaller than the total number of substructure modes used in the synthesis or the number of physical degrees of freedom of the entire rotor system. The critical speed solution of the system in different frequency ranges can be independently calculated without previously determining the lower or higher critical speed modes. The interconnecting force vectors at the substructure joints are calculated during the process, and the critical speed modal displacements are recovered by simple multiplications. S.A.V.

A90-17048
FLIGHT OVER THE SEA WITH TWIN OR TRIPLE JET AIRCRAFT [VUELO SOBRE EL MAR CON AVIONES DE DOS O TRES MOTORES]
RODRIGO MARTINEZ-VAL PENALOSA and EMILIO PEREZ COBO (Escuela Tecnica Superior de Ingenieros Aeronauticos, Madrid, Spain) Ingenieria Aeronautica y Astronautica (ISSN 0020-1006), Oct. 1989, p. 6-13. In Spanish. refs
Copyright

The problem of engine failure in twin-jet and triple-jet aircraft over the sea during long range flights is analyzed. The solution can be found in simple equations involving thrust reduction, increase of parasitic resistance, and engine performance variations with altitude and Mach number. An experimental flight with a narrow-body twin-jet aircraft, similar to the A-300, the B-767, the DC-10, or the MD-11, at 35,000 feet and a Mach number M = 0.80 was performed, indicating that a 0.70 ratio between final and initial weight was needed to cover routes of 2,000 to 4,000 nautical miles. The fuel reserve of a passenger aircraft using trans-Atlantic routes of such range is about 5 percent of the initial takeoff weight. The notion of extended range twin operations (ETOPS) is also discussed. C.E.

A90-17307#
AIRCRAFT DESIGN: A CONCEPTUAL APPROACH
DANIEL P. RAYMER (Lockheed Aeronautical Systems Co., Burbank, CA) Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1989, 740 p. refs
Copyright

Practical techniques for the conceptual design of aircraft are presented in a comprehensive introduction for college students. Chapters are devoted to sizing from a conceptual sketch; airfoil and geometry selection; thrust/weight ratio and wing loading; initial sizing; configuration layout and loft; crew station, passengers, and payload; propulsion and fuel-system integration; and landing gear and subsystems. Consideration is given to aerodynamics, propulsion, structures and loads, weights, stability and control, performance and flight mechanics, cost analysis, sizing and trade studies, and VTOL aircraft design. Extensive diagrams, drawings, graphs, photographs, and tables of numerical data are provided. T.K.

A90-17309
BOEING 720B DESIGN MODIFICATION CHALLENGES
Aerospace Engineering (ISSN 0736-2536), vol. 9, Nov. 1989, p. 9-12.
Copyright

Consideration is given to the modification of a Boeing 720B for use as an experimental flying engine test bed. The nose of the aircraft was redesigned to provide an attachment for PT6 and PW100-series turboprop engines. The right forward fuselage was modified to accommodate a PW300 fan engine. Also, the IAE V2500 development engine was installed on the right-hand inboard wing pylon. Problems associated with the modifications are addressed, including aircraft stability, turbulence, and problems with the pitot-static system. Efforts to correct these problems are discussed. R.B.

A90-17312
DAMAGE TOLERANCE ANALYSIS OF DYNAMIC COMPONENTS OF ROTARY WING AIRCRAFT
RAGHUPATI BOORLA (Bell Helicopter Textron, Inc., Fort Worth, TX) American Helicopter Society, Journal (ISSN 0002-8711), vol. 34, Oct. 1989, p. 47-55. refs
Copyright

The feasibility of applying the specifications of MIL-STD-1530A to dynamic components of tiltrotor aircraft was investigated by analyzing a representative sample of components from three significant functional areas of the XV-15 aircraft. The yoke from the hub assembly, the rotating ring from the controls system, and the mast from the drive system were the three components chosen. These components reflect diversity in material (excluding composites) as well as different combinations of mean and oscillatory load levels. The weight penalty estimates were made by comparing the weight of the damage-tolerant configuration with that of a 10,000-hour safe-life configuration. The initial flaw sizes were 0.015 in x 0.030 in for surface flaws, and 0.015 in x 0.015 in for cracks emanating from holes and corners. Of the three

components analyzed, only the yoke has incurred a weight penalty. The rotating ring and mast were shown to be damage-tolerant in their current design configurations. Author

A90-17313* Analytical Services and Materials, Inc., Hampton, VA.
MINIMUM WEIGHT DESIGN OF HELICOPTER ROTOR BLADES WITH FREQUENCY CONSTRAINTS
ADITI CHATTOPADHYAY (Analytical Services and Materials, Inc., Hampton, VA) and JOANNE L. WALSH (NASA, Langley Research Center, Hampton, VA) American Helicopter Society, Journal (ISSN 0002-8711), vol. 34, Oct. 1989, p. 77-82. refs
Copyright

The minimum weight design of helicopter rotor blades subject to constraints on fundamental coupled flap-lag natural frequencies has been studied in this paper. A constraint has also been imposed on the minimum value of the blade autorotational inertia to ensure that the blade has sufficient inertia to autorotate in case of an engine failure. The program CAMRAD has been used for the blade modal analysis and the program CONMIN has been used for the optimization. In addition, a linear approximation analysis involving Taylor series expansion has been used to reduce the analysis effort. The procedure contains a sensitivity analysis which consists of analytical derivatives of the objective function and the autorotational inertia constraint and central finite difference derivatives of the frequency constraints. Optimum designs have been obtained for blades in vacuum with both rectangular and tapered box beam structures. Design variables include taper ratio, nonstructural segment weights and box beam dimensions. The paper shows that even when starting with an acceptable baseline design, a significant amount of weight reduction is possible while satisfying all the constraints for blades with rectangular and tapered box beams. Author

A90-17405
A SMALL INERT GAS GENERATOR
PAUL O. SCHEIE (Texas Lutheran College, Seguin), KENNETH G. IKELS (USAF, School of Aerospace Medicine, Brooks AFB, TX), and CHERIE J. NOLES (Krug International Corp., Technology Services Div., San Antonio, TX) IN: Annual SAFE Symposium, 26th, Las Vegas, NV, Dec. 5-8, 1988, Proceedings. Newhall, CA, SAFE Association, 1989, p. 27-31. refs
Copyright

The pressure-swing absorption technique for aircraft onboard oxygen production can also be used to produce an enriched N/Ar product gas for inerting fuel tanks. Attention is presently given to the identification of variables having a significant effect on inert gas enrichment. Inert gas concentrations were found to be maximized with a combination of bed length and orifice diameter optimizations, in conjunction with optimization of such system parameters as inlet pressure, cycle time, and product flow. A 99-percent inert product gas was obtained. O.C.

A90-17408
LANDING GEAR INTEGRITY - THE BOTTOM LINE OF AIRCRAFT SAFETY
GEORGE J. SPERRY (USAF, Flight Dynamics Laboratory, Wright-Patterson AFB, OH) and RICHARD P. WHITE, JR. (Systems Research Laboratories, Inc., Advanced Systems Development Center, Dayton, OH) IN: Annual SAFE Symposium, 26th, Las Vegas, NV, Dec. 5-8, 1988, Proceedings. Newhall, CA, SAFE Association, 1989, p. 51-60.
Copyright

The USAF Landing Gear Development Facility (LGDF) supports landing gear research, development, qualification, and in-service problem resolution, using a battery of unique test apparatus which provide timely and cost-effective results. In addition, specialized test fixtures and associated instrumentation can be fabricated for specialized landing gear prototype systems as required. Automated data-acquisition and test control systems are employed throughout. O.C.

A90-17417
CANOPY FRAGILIZATION USING EMBEDDED DETONATING CORD
CHARLES A. DIEMAN, JR. (U.S. Navy, Naval Ordnance Station, Indian Head, MD) IN: Annual SAFE Symposium, 26th, Las Vegas, NV, Dec. 5-8, 1988, Proceedings. Newhall, CA, SAFE Association, 1989, p. 143-149.
Copyright

The U.S. Naval Ordnance Station has investigated the feasibility of embedding a detonating cord in aircraft canopies, to ensure their fracture in the course of ejection seat egress through fragilization. Testing of such a system has confirmed that both stretched and as-cast canopies as thick as 0.75 in. can be fractures with substantially lower explosive loads through the use of embedded detonating cords in place of the conventional, surface-mounted detonating cords. O.C.

A90-17421
SAFETY MANAGEMENT IN AIRCRAFT TESTING AND CERTIFICATION
F. A. WIEGERS, R. L. GROSS, A. A. JOHNSON, J. H. SNYDER, and R. J. ZINN IN: Annual SAFE Symposium, 26th, Las Vegas, NV, Dec. 5-8, 1988, Proceedings. Newhall, CA, SAFE Association, 1989, p. 176-179.
Copyright

The Engineering Test Safety (ETS) group of a major U.S. aircraft manufacturer is charged with achieving the safe and cost-effective completion of flight and laboratory tests through the analysis of each program, in order to determine the most effective methods for hazard minimization. ETS encompasses the use of a knowledge base, followed by test analyses, test reviews and monitoring operations, the activities of a consolidated safety council, and incident and accident investigations. O.C.

A90-17461
THE FUNDAMENTALS OF VECTORED PROPULSION
BENJAMIN GAL-OR (Technion - Israel Institute of Technology, Haifa) International Journal of Turbo and Jet-Engines (ISSN 0334-0082), vol. 6, no. 1, 1989, p. 1-15. refs
Copyright

Design development and performance projections are made for prospective military aircraft configurations capable of vectoring all available thrust resources from advanced powerplants to effect STOL and combat supermaneuverability. Rapid nose-pointing-and-shooting maneuvering to effect a 'snapshot' can be achieved by means of post-stall thrust vectoring, and may also be instituted in pure-sideslip maneuvering. Thrust-vectoring RPVs anticipating manned aircraft capabilities have been under developmental testing since 1987. O.C.

A90-17678#
THE MODEL 360 - ADVANCED COMPOSITE HELICOPTER
KEN GRINA IN: Israel Annual Conference on Aviation and Astronautics, 30th, Tel Aviv and Haifa, Israel, Feb. 15, 16, 1989, Collection of Papers. Haifa, Technion - Israel Institute of Technology, 1989, p. 21-29.

The Model 360 is a large transport helicopter whose primary and secondary airframe structures, as well as all dynamic components and structural attachment fittings, are fabricated from composite materials. Advanced vibration-control, flight control, and avionics systems are also incorporated. The primary goal of this structural design program was the development of composite materials design and manufacturing methods, with a view to enhanced dynamic systems and fuselage damage tolerance, and substantial weight and cost reductions from metallic structure levels. O.C.

A90-17679#
THE STRENGTH AND WEAKNESS OF CARBON COMPOSITE STRUCTURES
G. A. O. DAVIES (Imperial College of Science, Technology, and Medicine, London, England) IN: Israel Annual Conference on Aviation and Astronautics, 30th, Tel Aviv and Haifa, Israel, Feb.

15, 16, 1989, *Collection of Papers. Haifa, Technion - Israel Institute* of Technology, 1989, p. 30-39. Research supported by the Ministry of Defence of England. refs

The present evaluation of the most compelling reasons for the use of carbon fibers as reinforcements in polymer-matrix composites for both military and civil aircraft gives attention for the most frequently encountered barriers to full realization of these considerations' projected performance levels. Major difficulties encompass the effects of through-thickness stress fields and low impact resistance. The persistent need for superior theoretical models, in contrast to frequently employed ad-hoc prototype-testing, is highlighted. O.C.

A90-17705#
SIMULATION OF HELICOPTER LANDING ON A SHIP DECK
A. BARSONY-NAGY and R. RIVLIN (MATA Helicopters, Jerusalem, Israel) IN: Israel Annual Conference on Aviation and Astronautics, 30th, Tel Aviv and Haifa, Israel, Feb. 15, 16, 1989, Collection of Papers. Haifa, Technion - Israel Institute of Technology, 1989, p. 279-287. refs

The computer program, DECK simulates the landing of a skid-equipped helicopter on a ship's deck. The simulation calculates the motion of the helicopter beginning from the first contact of the vehicle and the deck, considering the aerodynamic and inertia forces, and the skid reactions. A method was generated and substantiated to evaluate the elastic and friction forces on the skids as functions of the position and motion of the helicopter relative to the ship. Results are presented for the landing of a light helicopter on a small ship. The effects of friction between skids and deck, energy dissipation in the skids and rotor thrust on the landing dynamics of the vehicle are discussed briefly. Conclusions are drawn regarding the applications of the DECK program in establishing safe landing criteria. Author

A90-17867*# Continuum Dynamics, Inc., Princeton, NJ.
NEW FREE-WAKE ANALYSIS OF ROTORCRAFT HOVER PERFORMANCE USING INFLUENCE COEFFICIENTS
TODD R. QUACKENBUSH, DANIEL A. WACHSPRESS (Continuum Dynamics, Inc., Princeton, NJ), and DONALD B. BLISS (Duke University, Durham, NC) Journal of Aircraft (ISSN 0021-8669), vol. 26, Dec. 1989, p. 1090-1097. refs
(Contract NAS2-12148)
Copyright

Free-wake analyses of helicopter rotor wakes in hover using time stepping have been shown to encounter instabilities which preclude convergence to valid free-vortex solutions for rotor-wake geometries. Previous work has demonstrated that these convergence difficulties can be overcome by implementing a new free-wake analysis method based on the use of influence coefficients. The present paper reviews this approach and documents its incorporation into a hover performance analysis called Evaluation of Hover Performance using Influence Coefficients (EHPIC). The technical principles underlying the EHPIC code are described with emphasis on steps taken to develop the single-filament wake models used in previous work into a multifilament wake valid for realistic hover performance predictions. The coupling of the wake model to a lifting surface loads analysis is described, and sample problems are solved that illustrate the robustness of the method. Performance calculations are also undertaken for hover to illustrate the utility of EHPIC in the analysis of rotorcraft performance. Author

A90-18135#
FIGHTER DESIGN FROM THE SOVIET PERSPECTIVE
RICHARD D. WARD (General Dynamics Corp., Fort Worth, TX) AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Conference, Seattle, WA, July 31-Aug. 2, 1989. 26 p.
(AIAA PAPER 89-2074) Copyright

The Soviet weapons development levels necessary to meet Soviet criteria for fighter design are examined. Starting with a comprehensive national military doctrine, the developmental hierarchy is followed through the Soviet approach to fighting wars. The determination of the subsequent weapons requirements and the definition of the design criteria that meet the weapons requirements are discussed. Finally, the approach used by Soviet designers to produce weapons compatible with the military doctrine is addressed. C.D.

A90-18145*# Maryland Univ., College Park.
RESPONSE AND HUB LOADS SENSITIVITY ANALYSIS OF A HELICOPTER ROTOR
JOON W. LIM and INDERJIT CHOPRA (Maryland, University, College Park) (*Structures, Structural Dynamics and Materials* Conference, 28th, Monterey, CA, Apr. 6-8, 1987 and AIAA Dynamics Specialists Conference, Monterey, CA, Apr. 9, 10, 1987, Technical Papers. Part 2B, p. 1093-1102) AIAA Journal (ISSN 0001-1452), vol. 28, Jan. 1990, p. 75-82. Previously cited in issue 14, p. 2106, Accession no. A87-33761. refs
(Contract NAG1-739)
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A90-18488#
DEVELOPMENT OF MILITARY HELICOPTERS
VOLKER VON TEIN (MBB GmbH, Munich, Federal Republic of Germany) Aeronautical Society of India, Journal (ISSN 0001-9267), vol. 41, Aug. 1989, p. 317-336.

The history and future market of military helicopters are discussed together with the roles and types of the U.S. Army and German Army helicopters. Attention is given to features of the PAH 1 antitank helicopter being currently updated, the militarization of the BK 117 helicopter, and several military helicopters planned for the near future, including the light multipurpose helicopter Bo 108, the attack/close-air-support and escort helicopter PAH 2/HAC/HAP, the medium size multipurpose helicopter NH 90, and an air-to-air helicopter. Particular consideration is given to the general requirements for an air-to-air helicopter in terms of agility, survivability, and efficiency, and its major characteristics. Design diagrams are presented. I.S.

A90-18489#
IN PROCESS FAILURE INVESTIGATIONS IN AERONAUTICS
A. K. DAS and PREM BAVEJA (Hindustan Aeronautics, Ltd., Central Laboratory, Bangalore, India) Aeronautical Society of India, Journal (ISSN 0001-9267), vol. 41, Aug. 1989, p. 337-356. Research supported by the Aeronautical Research and Development Board. refs

This paper presents eight individual investigation cases related to aerocraft structural parts or materials. These cases include and inherent through and through discontinuity in aluminum alloy fork forging blanks, discontinuities in milled fittings, linear discontinuities in forged Cr-Mo steel strut blanks, corner cracks in machined Al-Cu alloy plug ends, craters/cracks in machined ball-bearing steel valves, radial cracks in machined steel end-frame parts, hairline cracks in Al-alloy compressor blade blanks, and corrosion pits in Al-Mg pipe. A table is presented that lists the particular defects and defines the causes and remedies to be applied, in reference to the casting, rolling, extruding, forging, machining, and heat treatment processes. I.S.

A90-18606#
THE INVESTIGATION OF STRESS AT AN ENTER-GAS NOZZLE OF MAIN LANDING GEARS FOR FIGHTER AEROPLANES
YONGHUA XIE, SITAO ZHENG, and ZHENYUAN CUI (Northwestern Polytechnical University, Xian, People's Republic of China) *Acta Aeronautica et Astronautica Sinica* (ISSN 1000-6893), vol. 10, June 1989, p. B339-B341. In Chinese, with abstract in English.

The distribution of axial stress at the cross-section of an enter-gas nozzle of main landing gears and the distribution of circumferential stress at a screwed hole of the enter-gas nozzle are investigated by using photoelasticity. The stress intensity factor K(I) of an enter-gas nozzle containing a semielliptic crack is also investigated by using both photoelastic and acoustic technique. The former experimental results are in agreement with analytical results. The difference between the latter experimental techniques

is within 10 percent. The values determined by the experiments are lower than the ultimate values sigma(b) and K(Ic) of the material used in the design of the landing gear. Therefore, the landing gear redesigned is rational and safe. Author

A90-18607#
NUMERICAL APPROACHES FOR SOLVING PARAMETRIC VIBRATION PROBLEMS IN HELICOPTER DYNAMICS
KAITIAN YANG (Chinese Helicopter Research and Development Institute, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 10, June 1989, p. B342-B346. In Chinese, with abstract in English. refs

Two numerical approaches are developed for solving the parametric vibration bending differential equations for blade motion. One is the periodic function, or harmonic, method, and the other is the linear acceleration step-by-step integration procedure. The former has the advantage of saving CPU time and computer storage, but it cannot be used in dealing with unsteady motion and the investigation of the influence of the initial conditions. The linear acceleration step-by-step integration procedure can be used for steady or unsteady vibration, but takes more CPU time than the periodic function method. Two examples are presented using both procedures. S.A.V.

A90-18627#
THE OPTIMUM CONTROL AND ADAPTIVE CONTROL FOR AIRPLANE CABIN PRESSURE
WENJIANG YING (Nanjing Aeronautical Institute, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 10, Aug. 1989, p. B381-B388. In Chinese, with abstract in English. refs

This paper presents a new design for airplane cabin pressure, i.e. the optimum and adaptive control for airplane cabin pressure. A new scheme, the design method, and formulas of this control system are derived by means of the application of the modern control theory. Author

A90-19393#
ROTOR/FUSELAGE VIBRATION ISOLATION STUDIES BY A FLOQUET-HARMONIC ITERATION TECHNIQUE
R. SIVARAMAKRISHNAN, C. VENKATESAN (Hindustan Aeronautics, Ltd., Bangalore, India), and T. K. VARADAN (Indian Institute of Technology, Madras, India) Journal of Aircraft (ISSN 0021-8669), vol. 27, Jan. 1990, p. 81-89. refs
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The equations of motion for the coupled rotor/isolator/fuselage dynamical system are formulated for the prediction of vibrations in helicopters during forward flight. Using a combined Floquet theory/frequency-response technique, the equations are solved to predict the vibratory loads in various locations of the helicopter. In addition, the influence of the isolator on the hub and blade loads is established. Author

A90-19429#
MINIMUM FUEL CRUISE BY PERIODIC OPTIMIZATION
SEIYA UENO Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 37, no. 429, 1989, p. 502-506. In Japanese, with abstract in English. refs

Application of periodic optimization to minimum-fuel aircraft trajectories is discussed. The optimum cruise segment is considered as an unsteady flight. The cruise segment is divided into subarcs in which the same control sequences are used. The solution of the minimum-fuel problem for the subarc optimizes a total trajectory. The zero-order approximate solution is a maximum-thrust ascent and a minimum-thrust descent. Numerical results show that periodic cruise can save 3-4 percent on fuel. Author

A90-19747#
DRAG AND PROPULSIVE EFFICIENCY OF A LIGHT AIRCRAFT BASED ON A NEW FLIGHT TEST TECHNIQUE
JACK NORRIS and ANDREW B. BAUER AIAA, Aerospace Sciences Meeting, 28th, Reno, NV, Jan. 8-11, 1990. 12 p.
(AIAA PAPER 90-0233) Copyright

A new gliding flight test method based on proven zero propeller thrust, yielding airframe required power (gliding sink rate times gross weight) solves the historic need for an economical flight test method for basic propeller airplanes. It defines and separates airframe power and drag from propulsion effects. A check of design assumptions and theoretical calculations becomes possible without the prohibitive costs of wind tunnel testing. The propulsive efficiency, actual airframe drag curve and airframe max L/D speed are exposed. By comparing with theoretically constructed curves, the true lift drag, and V2 drag curves can be defined along with the large differences between powered and unpowered drag. Worthy of broad interest, on the classic light plane tested, the basic parameters were found to be significantly different than would have been predicted by normal assumptions. Much lower propulsive efficiency and a much lower unpowered airframe drag curve were found. Attention is drawn to the large losses exposed, quite possibly generic on single engine planes, and the possibility of correction. Even with inflow losses, significant advantage for pusher designs like the Voyager can be seen. Author

A90-19748#
AERODYNAMIC TESTING OF A NEW SEMI-PRONE EJECTION SEAT DESIGN
L. R. DILLON, P. I. KING, and C. H. SPENNY (USAF, Institute of Technology, Wright-Patterson AFB, OH) AIAA, Aerospace Sciences Meeting, 28th, Reno, NV, Jan. 8-11, 1990. 12 p. refs
(AIAA PAPER 90-0234)

A new semi-enclosed ejection seat that restrains the crewmember in a pronated or forward-leaning position to provide higher g-tolerance and increased windblast protection for ejection at both subsonic and supersonic speeds, was tested experimentally to determine the subsonic aerodynamic characteristics. Wind tunnel testing determined that static pitch stability can be attained at the angle of attack necessary to minimize spinal and visceral injuries during deceleration. Directional stability was also confirmed. In addition, pressure coefficients on the front cowling were measured and compared with a modified version of the paneling code, QUADPAN. The modification included an apparent body region formed by flow separation boundaries observed in water tunnel flow visualization tests. Author

A90-19784*# Vigyan Research Associates, Inc., Hampton, VA.
DESIGN OPTIMIZATION OF NATURAL LAMINAR FLOW FUSELAGES IN COMPRESSIBLE FLOW
SIMHA S. DODBELE (Vigyan Research Associates, Inc., Hampton, VA) AIAA, Aerospace Sciences Meeting, 28th, Reno, NV, Jan. 8-11, 1990. 10 p. refs
(Contract NAS1-18585)
(AIAA PAPER 90-0303)

An optimization method has been developed to design axisymmetric body shapes such as fuselages, nacelles, and external fuel tanks with increased transition Reynolds numbers in subsonic compressible flow. The new design method involves a constraint minimization procedure coupled with analysis of the inviscid and viscous flow regions, and linear stability analysis of the compressible boundary layer. Boundary-layer transition is predicted by a 'hybrid' transition criterion based on Granville's transition criterion and a criterion using linear stability theory coupled with the e(n)-method. A tiptank of a business-jet is used as an example to illustrate that the method can be utilized to design an axisymmetric body shape with extensive natural laminar flow. Boundary layer transition is predicted to occur at a transition Reynolds number of 6.04 x 10 to the 6th on the original tiptank. On the designed body shape, a transition Reynolds number of 7.22 x 10 to the 6th is predicted using compressible linear stability theory coupled with e(n)-method. Author

A90-19875#
AN ADVANCED PNEUMATIC IMPULSE ICE PROTECTION SYSTEM (PIIP) FOR AIRCRAFT
CHARLES A. MARTIN and JAMES C. PUTT (BF Goodrich Co., Aerospace Div., Uniontown, OH) AIAA, Aerospace Sciences

Meeting, 28th, Reno, NV, Jan. 8-11, 1990. 7 p. refs
(AIAA PAPER 90-0492) Copyright

A new impulse-type mechanical ice-removal system considerably different from other dynamic systems, in that a pneumatic rather than an electrical impulse is imparted to the ice-accreting surface to remove accumulated ice, has been developed. The system has demonstrated the capability to remove ice accumulations as thin as 0.030 inches, rendering it viable for ice-sensitive airfoils, while retaining the capability to remove thicker ice of up to 2 inches or more. Author

A90-20012*# Electroimpact, Inc., Seattle, WA.
THIN FILM EDDY CURRENT IMPULSE DEICER
SAMUEL O. SMITH and PETER B. ZIEVE (Electroimpact, Inc., Seattle, WA) AIAA, Aerospace Sciences Meeting, 28th, Reno, NV, Jan. 8-11, 1990. 7 p. refs
(Contract NAS3-25836; NAS3-25555)
(AIAA PAPER 90-0761) Copyright

Two new styles of electrical impulse deicers has been developed and tested in NASA's Icing Research Tunnel. With the Eddy Current Repulsion Deicing Boot (EDB), a thin and flexible spiral coil is encapsulated between two thicknesses of elastomer. The coil, made by an industrial printed circuit board manufacturer, is bonded to the aluminum aircraft leading edge. A capacitor bank is discharged through the coil. Induced eddy currents repel the coil from the aluminum aircraft structure and shed accumulated ice. A second configuration, the Eddy Current Repulsion Deicing-Strip (EDS) uses an outer metal erosion strip fastened over the coil. Opposite flowing eddy currents repel the strip and create the impulse deicing force. The outer strip serves as a surface for the collection and shedding of ice and does not require any structural properties. The EDS is suitable for composite aircraft structures. Both systems successfully dispelled over 95 percent of the accumulated ice from airfoils over the range of the FAA icing envelope. Author

N90-13369*# Princeton Univ., NJ. Dept. of Mechanical and Aerospace Engineering.
TRAJECTORY OPTIMIZATION AND GUIDANCE FOR AN AEROSPACE PLANE Final Report, Sept. 1988 - Aug. 1989
KENNETH D. MEASE and MARK A. VANBUREN Sep. 1989 42 p
(Contract NAG1-907)
(NASA-CR-185884; NAS 1.26:185884) Avail: NTIS HC A03/MF A01 CSCL 01/3

The first step in the approach to developing guidance laws for a horizontal take-off, air breathing single-stage-to-orbit vehicle is to characterize the minimum-fuel ascent trajectories. The capability to generate constrained, minimum fuel ascent trajectories for a single-stage-to-orbit vehicle was developed. A key component of this capability is the general purpose trajectory optimization program OTIS. The pre-production version, OTIS 0.96 was installed and run on a Convex C-1. A propulsion model was developed covering the entire flight envelope of a single-stage-to-orbit vehicle. Three separate propulsion modes, corresponding to an after burning turbojet, a ramjet and a scramjet, are used in the air breathing propulsion phase. The Generic Hypersonic Aerodynamic Model Example aerodynamic model of a hypersonic air breathing single-stage-to-orbit vehicle was obtained and implemented. Preliminary results pertaining to the effects of variations in acceleration constraints, available thrust level and fuel specific impulse on the shape of the minimum-fuel ascent trajectories were obtained. The results show that, if the air breathing engines are sized for acceleration to orbital velocity, it is the acceleration constraint rather than the dynamic pressure constraint that is active during ascent. Author

N90-13370*# Douglas Aircraft Co., Inc., Long Beach, CA. New Commercial Programs.
STUDY OF HIGH-SPEED CIVIL TRANSPORTS Final Report
Washington NASA Dec. 1989 182 p
(Contract NAS1-18378)
(NASA-CR-4235; NAS 1.26:4235) Avail: NTIS HC A09/MF A01 CSCL 01/3

A systems study to identify the economic potential for a high-speed commercial transport (HSCT) has considered technology, market characteristics, airport infrastructure, and environmental issues. Market forecasts indicate a need for HSCT service in the 2000/2010 time frame conditioned on economic viability and environmental acceptability. Design requirements focused on a 300 passenger, 3 class service, and 6500 nautical mile range based on the accelerated growth of the Pacific region. Compatibility with existing airports was an assumed requirement. Mach numbers between 2 and 25 were examined in conjunction with the appropriate propulsion systems, fuels, structural materials, and thermal management systems. Aircraft productivity was a key parameter with aircraft worth, in comparison to aircraft price, being the airline-oriented figure of merit. Aircraft screening led to determination that Mach 3.2 (TSJF) would have superior characteristics to Mach 5.0 (LNG) and the recommendation that the next generation high-speed commercial transport aircraft use a kerosene fuel. The sensitivity of aircraft performance and economics to environmental constraints (e.g., sonic boom, engine emissions, and airport/community noise) was identified together with key technologies. In all, current technology is not adequate to produce viable HSCTs for the world marketplace. Technology advancements must be accomplished to meet environmental requirements (these requirements are as yet undetermined for sonic boom and engine emissions). High priority is assigned to aircraft gross weight reduction which benefits both economics and environmental aspects. Specific technology requirements are identified and national economic benefits are projected. Author

N90-13371# National Aerospace Lab., Amsterdam (Netherlands). Structures and Materials Div.
THE S.D.G., P.S.D. AND THE NONLINEAR AIRPLANE
R. NOBACK 23 Feb. 1988 26 p Presented at the Gust Specialists Research Workshop, Williamsburg, VA, 21 Apr. 1988
(Contract OV/RLD-837)
(NLR-MP-88018-U; ETN-89-95053) Avail: NTIS HC A03/MF A01

The Power Spectral Density (PSD) method and Statistical Discrete Gust (SDG) method of calculating airplane loads due to atmospheric turbulence are compared. They tend to produce the same design loads and can be regarded as equivalent. The SDG method is capable of handling calculations for nonlinear air planes. Determination of design loads using SDG however leads to prohibitively long simulation times. A method is developed which allows the PSD model to define nonlinear airplane design loads. The simulation times are thus reduced. ESA

N90-13372*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.
A SMOKE GENERATOR SYSTEM FOR AERODYNAMIC FLIGHT RESEARCH
DAVID M. RICHWINE, ROBERT E. CURRY, and GENE V. TRACY Sep. 1989 26 p
(NASA-TM-4137; H-1515; NAS 1.15:4137) Avail: NTIS HC A03/MF A01 CSCL 01/3

A smoke generator system was developed for in-flight vortex flow studies on the F-18 high alpha research vehicle (HARV). The development process included conceptual design, a survey of existing systems, component testing, detailed design, fabrication, and functional flight testing. Housed in the forebody of the aircraft, the final system consists of multiple pyrotechnic smoke cartridges which can be fired simultaneously or in sequence. The smoke produced is ducted to desired locations on the aircraft surface. The smoke generator system (SGS) has been used successfully to identify vortex core and core breakdown locations as functions of flight condition. Although developed for a specific vehicle, this concept may be useful for other aerodynamic flight research which requires the visualization of local flows. Author

N90-13373# Department of the Navy, Washington, DC.
APPARATUS FOR COOLING ELECTRONIC COMPONENTS IN AIRCRAFT Patent Application

F. E. ALTOZ, inventor (to Navy) 25 Jan. 1989 27 p Filed 25 Jan. 1989
(AD-D014207; US-PATENT-APPL-SN-304048) Avail: NTIS HC A03/MF A01 CSCL 13/1

A ram air cooling system for cooling electronic components in an aircraft provides automatic switching from a high ram air speed cooling mode (ACM) to a low ram air speed cooling mode (RAM). The cooling system receives variable speed ram air during the flight of the aircraft and includes an automatically controlled valve for either directing high speed ram air to a precooling means prior to cooling the electronic components or directing low speed ram air directly to the electronic components without precooling. The automatically controlled valve is controlled by programmable logic module means for comparing the cooling efficiency of the electronic components by precooled ram air with the cooling efficiency of the electronic components by the non-precooled ram air. The cooling efficiencies are calculated from temperature measurements of the ram air at several locations in the system of the invention. Preferably, the ram air cooling means is an air turbine which extracts energy from the ram air to drive a compressor that compresses and discharges heated air that exists from the housing for the electronic components after the ram air has performed its cooling function. GRA

N90-13375# Human Engineering Labs., Aberdeen Proving Ground, MD.
SOFTWARE AND HARDWARE DESCRIPTION OF THE HELICOPTER MOTION EQUATIONS FOR VAX COMPUTERS Final Report
MARIA DELCLOPEZ Aug. 1989 101 p
(AD-A213248; HEL-TN-8-89) Avail: NTIS HC A06/MF A01 CSCL 12/5

The Human Factors Cockpit Research, Experimentation, and Workload (CREW) Simulator is a fixed base, generic helicopter simulator that provides the flexibility to explore state-of-the-art aircrew/display/control interaction. The CREW simulator involves four major components: the visual system, the graphics system, the data collection, and the flight equations. HEL uses the UH60 Blackhawk version of the standard kinematic equations for an aircraft (herein called HAC equations) when conducting experiments on the CREW simulator. The HAC equations were acquired from NASA Ames, in Mountain View, California, with the objective of simulating aerodynamic characteristics of a helicopter in a part-task simulator for human factors studies related to displays and controls. The HAC equations also allows the simulation of nap-of-the-earth (NOE) flight. The software design and the hardware configuration used to execute the HAC equations on a MicroVAX II VAXLab computer under the VMS operating system using VAX FORTRAN is described. The HAC equations are not described in detail. For more detailed information, refer to McFarland (1975). The objective is to provide internal documentation and also to provide a description of design for others desiring to implement these or similar equations of motion under the VAX/VMS (Virtual Address EXtension/Virtual Memory System) operating system in a real-time, manned interactive simulation. GRA

N90-13376 Virginia Polytechnic Inst. and State Univ., Blacksburg.
EFFICIENT METHODS FOR INTEGRATED STRUCTURAL-AERODYNAMIC WING OPTIMUM DESIGN Ph.D. Thesis
PI-JEN KAO 1989 140 p
Avail: Univ. Microfilms Order No. DA8915725

The large computational costs of integrated multidisciplinary design is analyzed. Efficient techniques are developed to reduce the computational costs associated with integrated structural-aerodynamic design. First, efficient methods for the calculations of the derivatives of the flexibility matrix and the aerodynamic influence coefficient matrix are developed. An adjoint method is used for the flexibility sensitivity, and a perturbation method is used for the aerodynamic sensitivity. Second, a sequential optimization algorithm that employes approximate analysis methods is implemented. Finally, a modular sensitivity analysis, corresponding to the abstraction of a system as an assembly of interacting black boxes, is applied. This method was developed for calculating system sensitivity without modifying disciplinary black box software packages. The modular approach permits the calculation of aeroelastic sensitivities without the expensive calculation of the derivatives of the flexibility matrix and the aerodynamic influence coefficient matrix. Dissert. Abstr.

N90-13377 Georgia Inst. of Tech., Atlanta.
A TECHNIQUE FOR THE PREDICTION OF AERODYNAMICS AND AEROELASTICITY OF ROTOR BLADES Ph.D. Thesis
OH JOON KWON 1988 199 p
Avail: Univ. Microfilms Order No. DA8916159

Some of the computational issues related to coupling of a three-dimensional lifting surface method with an elastic rotor blade model were explored. A thick panel method based on piecewise constant distribution of source and doublet singularities with prescribed tip-vortex geometry and calculated inner wake is used to predict the steady-state response and aeroelastic stability of hingeless rotor blades in the hovering flight conditions. The blade is represented by a geometrically nonlinear beam model which accounts for coupled flap bending, lead-lag bending, and torsion, and allows for moderately large displacements and rotations due to structural deformation. The analysis was carried out for the blade configuration having uniform mass and stiffness, no twist, and no chordwise offsets of the elastic axis, two-dimensional Greenberg theory which uses the simple momentum wake model. Some calculations were done to predict the aerodynamic loads of wings and rigid rotors in hover and in low-speed forward flight for code validation. The flows past two-dimensional airfoils in steady and unsteady harmonic motions were also calculated.
Dissert. Abstr.

N90-13378# Centre d'Essais Aeronautique Toulouse (France). Lab. d'Analyses non Destructives.
NONDESTRUCTIVE ANALYSIS OF AILERON FATIGUE AND AGING IN A MIRAGE F1 [ANALYSE NON DESTRUCTIVE DE COLLAGES AILERON DE FATIGUE VIEILLISSEMENT MIRAGE F1]
IA. ARMANDO Feb. 1989 73 p In FRENCH
(REPT-M6-594000; ETN-90-95715) Avail: NTIS HC A04/MF A01

A signal recognition method used to analyze adhesion efficiency of composite materials used in an aileron is described. Test trials were carried out on a representative test sample. The composite material was investigated using longitudinal ultrascund techniques. The development of the analysis technique is described and the limitations of the method are identified. ESA

N90-13379# Technische Univ., Delft (Netherlands). Dept. of Aerospace Engineering.
SOME NEW TECHNIQUES FOR AIRCRAFT FUSELAGE SKIN TESTS
D. CHEN Jun. 1987 12 p
(LR-547; ETN-90-95990) Avail: NTIS HC A03/MF A01

The fatigue behavior of an aircraft fuselage skin is investigated. Two major aspects of the loading conditions existing in the skin are considered. The biaxial load condition and the curvature effect, are reviewed. Some new testing techniques are introduced. Further studies of these techniques are proposed. ESA

N90-14216*# Purdue Univ., West Lafayette, IN. School of Aeronautics and Astronautics.
DESIGN OF A SPANLOADER CARGO AIRCRAFT Final Report, 1988-1989
TERRENCE A. WEISSHAAR 12 Jun. 1989 25 p
(Contract NASW-4435)
(NASA-CR-186046; NAS 1.26:186046) Avail: NTIS HC A03/MF A01 CSCL 01/3

The design features of an aircraft capable of fulfilling a long haul, high capacity cargo mission are described. This span-loading aircraft, or flying wing, is capable of carrying extremely large payloads and is expected to be in demand to replace the

slow-moving cargo ships currently in use. The spanloader seeks to reduce empty weight by eliminating the aircraft fuselage. Disadvantages are the thickness of the cargo-containing wing, and resulting stability and control problems. The spanloader presented here has a small fuselage, low-aspect ratio wings, winglets, and uses six turbofan engines for propulsion. It will have a payload capacity of 300,000 pounds plus 30 first class passengers and 6 crew members. Its projected market is transportation of freight from Europe and the U.S.A. to countries in the Pacific Basin. Cost estimates support its economic feasibility. J.P.S.

N90-14217# Aeronautical Research Labs., Melbourne (Australia). Aircraft Systems.
ACSIM: AIRCRAFT SIMULATION PROGRAM WITH APPLICATION TO FLIGHT PROFILE GENERATION
A. G. PAGE Jun. 1989 38 p
(AD-A212466; ARL-SYS-TM-106; DODA-AR-005-512) Avail: NTIS HC A03/MF A01 CSCL 01/3

Program AcSim was designed to be used in conjunction with a flight profile generator program (FPG2) which is used with an Inertial Navigation System simulator. Both AcSim and FPG2 were written in FORTRAN-77 on an ELXSI System 6400. AcSim is implemented as a subroutine of FPG2 and is called if the user selects a dynamic maneuver segment to be performed. AcSim calculates the dynamic state of an aircraft for a sequence of user specified control surface deflections. The aircrafts linear accelerations and angular velocities are sent back to FPG2 for subsequent processing. A six-degree-of-freedom model is used to simulate the user-defined aircraft. AcSim implements a State Vector approach to solve the non-linear equations of motion simultaneously using a 4th order Runge-Kutta scheme. An optional Eigen Analysis can be performed which provides the user with longitudinal and lateral characteristic equation, their roots (eigen values), transfer functions and unit impulse response functions for the given flight condition. GRA

N90-14218# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). Flight Mechanics Panel.
FLIGHT IN ADVERSE ENVIRONMENTAL CONDITIONS
J. F. RENAUDIE Oct. 1989 29 p Presented at the Flight Mechanics Panel Symposium in Gol, Norway, 8-11 May 1989
(AGARD-AR-277; ISBN-92-835-0531-X) Copyright Avail: NTIS HC A03/MF A01

Four aspects of adverse environmental conditions of interest to the flight mechanics specialists were addressed by this symposium: atmospheric disturbances, reduced visibility, icing and electromagnetic disturbances. All four of these can seriously affect flight safety, comfort and operational capability. The topic was and still is considered to be particularly relevant to the needs of the military community which is putting increased emphasis on the ability of today's and tomorrow's aircraft to fly safely and effectively in the adverse conditions dealt with in this symposium. Author

N90-14219 Georgia Inst. of Tech., Atlanta.
AN EXPERIMENTAL INVESTIGATION OF THE INTERACTION BETWEEN A MODEL ROTOR AND AIRFRAME IN FORWARD FLIGHT Ph.D. Thesis
ALBERT GERARD BRAND 1989 235 p
Avail: Univ. Microfilms Order No. DA8919733

A series of experiments were conducted in the John J. Harper 7 x 9-foot wind tunnel to measure the interaction effects for an idealized rotor-airframe configuration. Detailed pressure measurements on the airframe surface were correlated with quantitative flow visualization data. Correlations allowed for specific structures in the wake flow to be identified with the corresponding effect measured on the airframe. Impingement of the rotor tip vortex on the airframe surface was found to create a low (instantaneous) pressure region on the surface. The interaction of the vortex sheet structure with the airframe also created a low instantaneous pressure on the surface. The effects of the rotor blade on the airframe were significant. A large positive pressure pulsation occurred on the airframe each time a blade passed over the airframe. Suitable theoretical models for explaining these interaction effects were developed, and a comprehensive data base was generated to allow future analytical efforts for predicting these interactions to be tested. Dissert. Abstr.

N90-14220*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
GLOBAL STRATOSPHERIC CHANGE: REQUIREMENTS FOR A VERY-HIGH-ALTITUDE AIRCRAFT FOR ATMOSPHERIC RESEARCH
1989 41 p Workshop held in Truckee, CA, 15-16 Jul. 1989
(NASA-CP-10041; A-89243; NAS 1.55:10041) Avail: NTIS HC A03/MF A01 CSCL 01/3

The workshop on Requirements for a Very-High-Altitude Aircraft for Atmospheric Research, sponsored by NASA Ames Research Center, was held July 15 to 16, 1989, at Truckee, CA. The workshop had two purposes: to assess the scientific justification for a new aircraft that will support stratospheric research beyond the altitudes accessible to the NASA ER-2; and to determine the aircraft characteristics (e.g., ceiling altitude, payload accommodations, range, flight duration, operational capabilities) required to perform the stratospheric research referred to in the justification. To accomplish these purposes, the workshop brought together a cross-section of stratospheric scientists with several aircraft design and operations experts. The stratospheric scientists included theoreticians as well as experimenters with experience in remote and in situ measurements from satellites, rockets, balloons, aircraft, and the ground. Discussions of required aircraft characteristics focused on the needs of stratospheric research. It was recognized that an aircraft optimal for stratospheric science would also be useful for other applications, including remote measurements of Earth's surface. A brief description of these other applications was given at the workshop. Author

N90-14221 ESDU International Ltd., London (England).
INTRODUCTION TO DATA ITEMS ON FLIGHT PATH OPTIMISATION
Aug. 1989 11 p
(ESDU-89015; ISBN-0-85679-687-5; ISSN-0141-4054) Avail: ESDU

This Data Item 89015, an addition to the Aircraft Performance Subseries, starts by setting out the completely general problem in terms of the equations of motion of the aircraft, the constraints on the state and control variables due to physical or operational limitations, and a performance index which is the quantity to be optimized (for example, time to height). It discusses various simplifications that can then be applied to bring the problem into a solvable form, treating the aircraft as a point mass and ignoring both the rotational motion and airframe flexibility. Although the problem is then reduced to one solvable, it still contains some fourteen equations and some care is needed to justify the use of such complexity; in some cases the performance index will vary quite slowly near the optimum and a trajectory, more easily flow or controlled, a little removed from the true optimum may be acceptable. Finally, the introduction of further simplifications such as assuming lift equals weight, drag is constant at the level-flight value, or small flight path angle, is considered and the value of results obtained is assessed. ESDU

N90-14222# Wichita State Univ., KS. Inst. for Aviation Research.
STALL/SPIN AERODYNAMIC DATA PROJECT Final Report, 1 Oct. 1986 - 30 Sep. 1988
MELVIN H. SNYDER Sep. 1989 123 p
(DOT/FAA/CT-88/29) Avail: NTIS HC A06/MF A01

The purpose was to develop a bank of aerodynamic data including high angle-of-attack aerodynamic characteristics of 2-D airfoils and characteristics of 3-D wings and of complete airplanes beyond the stall. To fill gaps in available literature, flow visualization studies and wind tunnel tests were to be conducted. Also, a flow visualization laboratory was to be established to study wing stall and anti-stall devices. The flow visualization laboratory is in

operation. A bank of 2-D high angle-of-attack airfoil data was compiled. The 3-D data were acquired; water tunnel and wind tunnel reflection plane tests were performed and continue. Data obtained indicated that movable leading-edge control surfaces show promise toward the goal of controlled flight beyond the stall. Author

N90-14223 Georgia Inst. of Tech., Atlanta.
AN ANALYTICAL METHOD FOR THE PREDICTION OF UNSTEADY ROTOR/AIRFRAME INTERACTIONS IN FORWARD FLIGHT Ph.D. Thesis
DIMITRIS N. MAVRIS 1988 314 p
Avail: Univ. Microfilms Order No. DA8916164

A prediction code has been developed at Georgia Tech for the prediction of unsteady aerodynamic rotor-airframe interactions in forward flight. This method is based on the extension and coupling of a lifting line/free-wake rotor analysis (Scully free-wake code) and a source/doublet panel fuselage analysis (VSAERO). Coupling is achieved by iterating on the disturbance velocities induced by the airframe at the rotor inflow plane, and on the effect of the rotor and wake on the airframe. Physical flow features such as the energy addition in the wake and the blade passage effect have been modeled and included in the analysis. Provisions have been made to allow the rotor wake to distort freely in the presence of the airframe. In addition, the code has been extended to account for rotor wake/lifting surface interactions. Preliminary results (both time averaged and unsteady) from this study are presented along with a discussion on possible ways to improve correlations with experimental results. Results from this new code, called GTRAIC (Georgia Tech Rotor Airframe Interaction Code), have been validated against data obtained in the Georgia Tech 2.13 x 2.74 meter wind tunnel for a two bladed teetering rotor mounted over a cylindrical body with a hemispherical nose.
Dissert. Abstr.

N90-14225*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.
FLIGHT EVALUATION OF A PNEUMATIC SYSTEM FOR UNSTEADY PRESSURE MEASUREMENTS USING CONVENTIONAL SENSORS
ROBERT E. CURRY and GLENN B. GILYARD Washington Aug. 1989 20 p Presented at the 4th AIAA Flight Test Conference, San Diego, CA, 18-20 May 1988
(NASA-TM-4131; H-1508; NAS 1.15:4131) Avail: NTIS HC A03/MF A01 CSCL 01/3

A flight experiment was conducted to evaluate a pressure measurement system which uses pneumatic tubing and remotely located electronically scanned pressure transducer modules for in-flight unsteady aerodynamic studies. A parametric study of tubing length and diameter on the attenuation and lag of the measured signals was conducted. The hardware was found to operate satisfactorily at rates of up to 500 samples/sec per port in flight. The signal attenuation and lag due to tubing were shown to increase with tubing length, decrease with tubing diameter, and increase with altitude over the ranges tested. Measurable signal levels were obtained for even the longest tubing length tested, 4 ft, at frequencies up to 100 Hz. This instrumentation system approach provides a practical means of conducting detailed unsteady pressure surveys in flight. Author

N90-14226*# California Polytechnic State Univ., San Luis Obispo. Dept. of Aeronautical Engineering.
PRELIMINARY DESIGN OF FOUR AIRCRAFT TO SERVICE THE CALIFORNIA CORRIDOR IN THE YEAR 2010: THE CALIFORNIA CONDOR, CALIFORNIA SKY-HOPPER, HIGH CAPACITY SHORT RANGE TRANSPORT TILT ROTOR AIRCRAFT NEEDED TO SIMPLIFY INTERCITY TRANSPORTATION
22 May 1989 267 p
(Contract NASW-4435)
(NASA-CR-186232; NAS 1.26:186232) Avail: NTIS HC A12/MF A02 CSCL 01/3

The major objective of this project was to design an aircraft for use in the California Corridor in the year 2010. The design process, completed by students in a senior design class at California Polytechnic State University, San Luis Obispo, used a Class 1 airplane design analysis from Jan Roskam's Airplane Design. The California Condor (CC-38), a 38 passenger, 400 mph aircraft, was designed to meet the needs of tomorrow's passengers while conforming to the California Corridor's restrictions. Assumptions were made using today's technology with forecasts into 21st Century technology. Doubling today's commuter aircraft passenger capacity, travelling at Mach .57 with improved cruise efficiencies of over 10 percent, with the ability to land within field lengths of 4000 feet, are the CC-38's strongest points. The California Condor has a very promising future in helping to relieve the air traffic and airport congestion in the 21st Century. Author

N90-14227# Los Alamos National Lab., NM.
DESIGN AND DEMONSTRATION OF HEAT PIPE COOLING FOR NASP AND EVALUATION OF HEATING METHODS AT HIGH HEATING RATES
MICHAEL A. MERRIGAN and J. TOM SENA 1989 12 p Presented at the 7th National Aero-Space Plane Technology Symposium, Cleveland, OH, 23-27 Oct. 1989
(Contract W-7405-ENG-36)
(DE89-016995; LA-UR-89-2876; CONF-8910203-1) Avail: NTIS HC A03/MF A01

An evaluation of two heating methods for demonstration of NASP leading edge heat pipe technology was conducted. The heating methods were and RF induction heated plasma jet and direct RF induction. Tests were conducted to determine coupling from the argon plasma jet on a surface physically similar to a heat pipe. A molybdenum tipped calorimeter was fabricated and installed in an RF induction heated plasma jet for the test. The calorimetric measurements indicated a maximum power coupling of approximately 500 W/sq cm with the RF plasma jet. The effect of change in gas composition on the heating rate was investigated using helium. An alternative to the plasma heating of a heat pipe tip, an RF concentrator was evaluated for coupling to the hemispherical tip of a heat pipe. A refractory metal heat pipe was designed, fabricated, and tested for the evaluation. The heat pipe was designed for operation at 1400 to 1900 K with power input to 1000 W/sq cm over a hemispherical nose tip. Power input of 800 W/sq cm was demonstrated using the RF concentrator.
DOE

N90-14228*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
AIRDATA CALIBRATION OF A HIGH-PERFORMANCE AIRCRAFT FOR MEASURING ATMOSPHERIC WIND PROFILES
EDWARD A. HAERING, JR. Jan. 1990 27 p Presented at the AIAA 28th Aerospace Sciences meeting, Reno, NV, 8-11 Jan. 1990
(NASA-TM-101714; H-1580; NAS 1.15:101714; AIAA-90-0320)
Avail: NTIS HC A03/MF A01 CSCL 01/3

The research airdata system of an instrumented F-104 aircraft has been calibrated to measure winds aloft in support of the space shuttle wind measurement investigation at the National Aeronautics and Space Administration Ames Research Center Dryden Flight Research Facility. For this investigation, wind measurement accuracies comparable to those obtained from Jimsphere balloons were desired. This required an airdata calibration more accurate than needed for most aircraft research programs. The F-104 aircraft was equipped with a research pilot-static noseboom with integral angle-of-attack and flank angle-of-attack vanes and a ring-laser-gyro inertial reference unit. Tower fly-bys and radar acceleration-decelerations were used to calibrate Mach number and total temperature. Angle of attack and angle of sideslip were calibrated with a trajectory reconstruction technique using a multiple-state linear Kalman filter. The F-104 aircraft and instrumentation configuration, flight test maneuvers, data corrections, calibration techniques, and resulting calibrations and data repeatability are presented. Recommendations for future

airdata systems on aircraft used to measure winds aloft are also given. Author

06

AIRCRAFT INSTRUMENTATION

Includes cockpit and cabin display devices; and flight instruments.

A90-17137
GENERATION OF MOTION CONTROL FOR DIRECTION FINDERS IN A GONIOMETER SYSTEM [FORMIROVANIE UPRAVLENII DVIZHENIEM PELENGATOROV UGLOMERNOI SISTEMY]
A. N. KATULEV and V. V. TUKHVATULIN Radiotekhnika (ISSN 0033-8486), Oct. 1989, p. 3-5. In Russian.
Copyright

A motion-control algorithm is proposed for direction finders which raises the estimation accuracy of the motion parameters of the observed object. This trajectory generation method has been tested for a wide range of operating conditions, and its efficiency has been demonstrated. The proposed algorithm can be used to generate the trajectories of direction finders with allowance for specified constraints in real time. B.J.

A90-19746*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.
PRELIMINARY RESULTS FROM A SUBSONIC HIGH-ANGLE-OF-ATTACK FLUSH AIRDATA SENSING (HI-FADS) SYSTEM - DESIGN, CALIBRATION, ALGORITHM DEVELOPMENT, AND FLIGHT TEST EVALUATION
STEPHEN A. WHITMORE, TIMOTHY R. MOES (NASA, Flight Research Center, Edwards, CA), and TERRY J. LARSON (Analytical Mechanics Associates, Hampton, VA) AIAA, Aerospace Sciences Meeting, 28th, Reno, NV, Jan. 8-11, 1990. 12 p. refs (AIAA PAPER 90-0232) Copyright

A nonintrusive high angle-of-attack flush airdata sensing (HI-FADS) system was installed and flight-tested on the F-18 high alpha research vehicle. This paper discusses the airdata algorithm development and composite results expressed as airdata parameter estimates and describes the HI-FADS system hardware, calibration techniques, and algorithm development. An independent empirical verification was performed over a large portion of the subsonic flight envelope. Test points were obtained for Mach numbers from 0.15 to 0.94 and angles of attack from -8.0 to 55.0 deg. Angles of sideslip ranged from -15.0 to 15.0 deg, and test altitudes ranged from 18,000 to 40,000 ft. The HI-FADS system gave excellent results over the entire subsonic Mach number range up to 55 deg angle of attack. The internal pneumatic frequency response of the system is accurate to beyond 10 Hz. C.D.

N90-13381*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
SILICON-ETALON FIBER-OPTIC TEMPERATURE SENSOR
GLENN BEHEIM, KLAUS FRITSCH, JOSEPH M. FLATICO, and MASSOOD TABIB AZAR (Case Western Reserve Univ., Cleveland, OH.) 1989 8 p Presented at the Fiber Optic and Laser Sensors 7 Conference of the OE/Fibers '89 Symposium, Boston, MA, 5-8 Sep. 1989; sponsored by Society of Photo-Optical Instrumentation Engineers
(NASA-TM-102389; E-5130; NAS 1.15:102389) Avail: NTIS HC A02/MF A01 CSCL 01/4

A temperature sensor is described which consists of a silicon etalon that is sputtered directly onto the end of an optical fiber. A two-layer protective cap structure is used to improve the sensor's long-term stability. The sensor's output is wavelength encoded to provide a high degree of immunity from cable and connector effects. This sensor is extremely compact and potentially inexpensive. Author

N90-13384*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
FLIGHT DECK AUTOMATION: PROMISES AND REALITIES
SUSAN D. NORMAN, ed. and HARRY W. ORLADY, ed. (Orlady Associates, Inc., Los Gatos, CA.) Sep. 1989 200 p Proceedings of a NASA/FAA/Industry Workshop, Carmel Valley, CA, 1-4 Aug. 1988
(NASA-CP-10036; A-89196; NAS 1.55:10036) Avail: NTIS HC A09/MF A02 CSCL 01/4

Issues of flight deck automation are multifaceted and complex. The rapid introduction of advanced computer-based technology onto the flight deck of transport category aircraft has had considerable impact both on aircraft operations and on the flight crew. As part of NASA's responsibility to facilitate an active exchange of ideas and information among members of the aviation community, a NASA/FAA/Industry workshop devoted to flight deck automation, organized by the Aerospace Human Factors Research Division of NASA Ames Research Center. Participants were invited from industry and from government organizations responsible for design, certification, operation, and accident investigation of transport category, automated aircraft. The goal of the workshop was to clarify the implications of automation, both positive and negative. Workshop panels and working groups identified issues regarding the design, training, and procedural aspects of flight deck automation, as well as the crew's ability to interact and perform effectively with the new technology. The proceedings include the invited papers and the panel and working group reports, as well as the summary and conclusions of the conference. Author

N90-14232*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
A CANDIDATE CONCEPT FOR DISPLAY OF FORWARD-LOOKING WIND SHEAR INFORMATION
DAVID A. HINTON Oct. 1989 92 p
(NASA-TM-101585; NAS 1.15:101585; DOT/FAA/DS-89/23)
Avail: NTIS HC A05/MF A01 CSCL 01/4

A concept is proposed which integrates forward-look wind shear information with airplane performance capabilities to predict future airplane energy state as a function of range. The information could be displayed to a crew either in terms of energy height or airspeed deviations. The anticipated benefits of the proposed display information concept are: (1) a wind shear hazard product that scales directly to the performance impact on the airplane and that has intuitive meaning to flight crews; (2) a reduction in flight crew workload by automatic processing of relevant hazard parameters; and (3) a continuous display of predicted airplane energy state if the approach is continued. Such a display may be used to improve pilot situational awareness or improve pilot confidence in wind shear alerts generated by other systems. The display is described and the algorithms necessary for implementation in a simulation system are provided. Author

07

AIRCRAFT PROPULSION AND POWER

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

A90-16696
THE VSCF SYSTEM HAS ARRIVED - THE WAY IN WHICH A NEW CONSTANT-FREQUENCY ELECTRICAL GENERATION SYSTEM IN AERONAUTICS HAS BEEN DEVELOPED [LES VSCF ARRIVENT - COMMENT PREND NAISSANCE UN NOUVEAU SYSTEME DE GENERATION ELECTRIQUE AERONAUTIQUE A FREQUENCE CONSTANTE]
CLAUDE JACQUES (AUXILEC, S.A., Chatou, France) Revue

Scientifique et Technique de la Defense (ISSN 0994-1541), 3rd Quarter, 1989, p. 77-85. In French.
Copyright

The characteristics of the VSCF (variable speed, constant frequency) system, which takes advantage of recent improvements and developments in high-speed electrical technology and power electronics, are described. It has been demonstrated that solid-state electronic converters combined with high-speed alternators running at faster than 24,000 rpm offer a significant weight saving to the onboard generating system and an effective electric starting capability for aircraft engines provided that the cooling system integration in the aircraft is completely optimized. B.J.

A90-16701
SHARING POWER AND PROFIT
BILL SWEETMAN Interavia (ISSN 0020-5168), vol. 44, Nov. 1989, p. 1106-1110.
Copyright

The features of engines being developed for USAF by Pratt and Whitney (P&W) and General Electric (GE) to supply the F-16 aircraft with F100 or F110 power are discussed. Particular consideration is given to the 100-PW-229 (which combines the current F100-PW-220 longer-life core with a new low-pressure section that provides greater 'supercharging' and allows the core to run at a greater proportion of its design capacity) and the F110-GE-129 (which can run faster than the GE-100 engine, and 55-80-K hotter) engines. Presently, the two companies contest to power the Advanced Tactical Fighter (ATF) and the Navy ATF of the 1990s. The approaches of the two companies to the ATF design are different: the P&W F119 is a very low-bypass-ratio turbofan, while the GE F120 is a variable-cycle engine, the first of its kind to be developed for a production application. I.S.

A90-16702
IHPTET SPAWNS ENGINES FOR 21ST CENTURY
BILL SWEETMAN Interavia (ISSN 0020-5168), vol. 44, Nov. 1989, p. 1113-1115.
Copyright

The requirements and characteristic features of engines planned for 21st century by the U.S. Department of Defense's Integrated High-Performance Turbine Engine Technology (IHPTET) are discussed. In a fighter engine, the IHPTET's goal is to double the thrust/weight ratio and decrease fuel consumption by 40 percent, relative to the Advanced Tactical Fighter Engine (ATFE). The future fighter engine will also run hotter for higher speeds, particularly on dry thrust. A helicopter engine would have a 120 percent increase in the power/weight ratio and a 40-percent cut in fuel consumption. The new aircraft materials will include organic and aluminum matrix composites, titanium alloys, and Ti and Ti-Al matrix composites, Ni-Al matrix composites, niobium refractories, silicon carbide and silicon nitride, ceramic matrix composites (CMC), and CMC and carbon-carbon. I.S.

A90-16703
TURBOSHAFTS ON TENTERHOOKS
CHARLES GILSON, RAMON LOPEZ, and BILL SWEETMAN Interavia (ISSN 0020-5168), vol. 44, Nov. 1989, p. 1116-1120.
Copyright

Two European turboshaft engines, MTR390 and RTM322 are presently competing with two U.S. engines in the same power brackets, the T800 and T700/CT7, respectively. The paper describes the salient features of the T800-LHT-800 design and compares these with the design features of the MTR390. The T800, rated at some 900 kW take-off power for a weight of only 136 kg, is expected to enter production phase in 1991, while the first of the MTR390 bench engines are planned to run at MTU Munich before the end of 1989. Many of the MTR390's program goals mirror those of the T800, such as 50-percent power growth within ten years, and heavy emphasis on RAM. I.S.

A90-16823
PAYOFFS IN GROWTH ENGINES
DARRELL O. ROWE, II (GE Aircraft Engines, Cincinnati, OH) Vertiflite (ISSN 0042-4455), vol. 35, Nov.-Dec. 1989, p. 34-38.
Copyright

The development history and future potential of the T700/CT7 family of military-helicopter turbine engines are discussed in detail, with an emphasis on the practical advantages of growth and derivative engines over new designs. Particular attention is given to the qualification of the engine and the aircraft/engine installation, the pilot orientation process, and the overall cost. Graphs and tables are provided. T.K.

A90-16851#
AEROENGINE CONDITION MONITORING AND FAULT DIAGNOSIS SYSTEM
CHUNLIN SUN and ZHAOFU LIN (Civil Aviation Institute of China, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 10, Oct. 1989, p. B459-B467. In Chinese, with abstract in English. refs

Consideration is given to the study of aeroengine condition monitoring and fault diagnosis systems in China. Engine parameter trend analysis, gas passage analysis and the engine vibration analysis are discussed. The study approach and the basic model are presented. Author

A90-17308
AIRCRAFT PROPULSION SYSTEMS TECHNOLOGY AND DESIGN
GORDON C. OATES, ED. (Washington, University, Seattle) Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1989, 534 p. No individual items are abstracted in this volume.
Copyright

Practical techniques for the design of aircraft propulsion systems are reviewed in chapters contributed by leading experts; the book is intended as an introduction for advanced engineering students. Topics discussed include design objectives and strategies, turbopropulsion combustion technology, engine/aircraft performance matching, inlets and inlet/engine integration, the aerodynamics of variable convergent-divergent exhaust nozzles, engine operability, and aeroelasticity and unsteady aerodynamics. Extensive diagrams, drawings, graphs, and photographs are provided. T.K.

A90-17447
COST EFFECTIVE TECHNOLOGY
S. C. MILLER (Rolls-Royce, PLC, Derby, England) Greek General Secretariat for Research and Technology, National Technical University of Athens, CEC, et al., International Symposium on Air Breathing Engines, 9th, Athens, Greece, Sept. 3-8, 1989, Paper. 23 p.
Copyright

The steps involved in defining, developing, and manufacturing a new-design aircraft engine are examined, with a focus on the application of computer technology to optimize the overall process. In this approach, research data are analyzed and incorporated into the CAD/CAM design code; a performance model is developed for validation in an experimental engine; and the same system is used to program state-of-the-art numerically controlled machine tools for large-scale production. Examples involving the EJ200 and RB211 R&D programs and the Advanced Integrated Manufacturing System for turbine disks are presented in extensive graphs, drawings, and diagrams. T.K.

A90-17448#
APPLICATION OF COMPUTATIONAL SYSTEMS TO AIRCRAFT ENGINE COMPONENTS DEVELOPMENT
GEORGES KARADIMAS (SNECMA, Moissy-Cramayel, France) Greek General Secretariat for Research and Technology, National Technical University of Athens, CEC, et al., International Symposium on Air Breathing Engines, 9th, Athens, Greece, Sept. 3-8, 1989, Paper. 12 p. refs

The incorporation of state-of-the-art CFD codes in the CAD/CAM process for aircraft engine components is discussed,

with a focus on recent SNECMA efforts. Particular attention is given to the application of three-dimensional simulations in the design and analysis of fans and unducted fans, compressors, turbines, combustors and afterburners, exhaust nozzles and thrust reversers, and afterbodies. Extensive diagrams, graphs, and sample computer graphics are provided. T.K.

A90-17462* Purdue Univ., West Lafayette, IN.
AEROELASTIC DETUNING FOR STABILITY ENHANCEMENT OF UNSTALLED SUPERSONIC FLUTTER
SANFORD FLEETER (Purdue University, West Lafayette, IN) and DANIEL HOYNIAK (NASA, Lewis Research Center, Cleveland, OH) International Journal of Turbo and Jet-Engines (ISSN 0334-0082), vol. 6, no. 1, 1989, p. 17-26. refs
Copyright

A mathematical model is presented for analyzing the effect of aeroelastic detuning on unstalled supersonic flutter, where the detuning mechanism employed is alternate-blade structural detuning. Two alternative aerodynamic detuning methods are compared: the novel, alternate-chordwise airfoil spacing method, and the alternate circumferential airfoil spacing aerodynamic detuning. A combination of aerodynamic and structural detuning is considered. Relative flutter stability enhancements are assessed for a twelve-blade baseline rotor. O.C.

A90-17688#
ATOMIZATION AND SPRAY RESEARCH FOR GAS TURBINE ENGINES
NORMAN CHIGIER and WILLIAM BROWN (Carnegie-Mellon University, Pittsburgh, PA) IN: Israel Annual Conference on Aviation and Astronautics, 30th, Tel Aviv and Haifa, Israel, Feb. 15, 16, 1989, Collection of Papers. Haifa, Technion - Israel Institute of Technology, 1989, p. 120-124.

A phase/Doppler particle analyzer has been used to make detailed measurements of drop size and velocity distribution in air blast swirl atomizer sprays. Size and velocity PDFs are thereby obtained throughout the spray. The evolution of spray characteristics and changes due to collision, coalescence, dispersion, acceleration, deceleration, and evaporation are analyzed, on the basis of these detailed data. Drag coefficients and drop trajectories are obtained. O.C.

A90-17782#
AN AERODYNAMICAL DESIGN AND CALCULATION METHOD FOR GAS TURBINE WITH COOLING AIR MIXING
JING SHI, JUNSHAN LI (Nanhua Powerplant Research Institute, People's Republic of China), PIYQIA WANG, and SHI JIN (Chinese Academy of Sciences, Computing Center, People's Republic of China) Journal of Aerospace Power (ISSN 1000-8055), vol. 4, Oct. 1989, p. 305-309, 388. In Chinese, with abstract in English.

In order to conduct aerodynamic design and calculation for an air-cooled turbine, coolant and gas flow mixing correlations, which satisfy the mass, momentum, and energy equations, are derived in rotational coordinates. A computer program has been developed. Calculation results indicate that gas flow parameters change considerably in the case of a high coolant mass flow ratio. It is necessary to consider the influence of coolant flow in detail.
Author

A90-17788#
AN EXPERIMENTAL STUDY OF TIP CLEARANCE EFFECTS ON THE PERFORMANCE OF AN AXIAL TRANSONIC TURBINE
ZHONGHU HUANG, YUEQI WANG (Shenyang Aeroengine Research Institute, People's Republic of China), JINGFU YANG, and RUGEN REN (Gas Turbine Establishment, People's Republic of China) Journal of Aerospace Power (ISSN 1000-8055), vol. 4, Oct. 1989, p. 333-336, 390. In Chinese, with abstract in English. refs

In order to investigate the effects of the rotor blade tip clearance on the performance of a highly-loaded axial turbine, a single-stage axial transonic scaled-down turbine with a low aspect has been tested with four rotor tip clearances. The reduced revolutions of the turbine vary from 80 to 110 percent, and the turbine total pressure ratios vary from 2.0 to 4.0. The experimental results are presented and analyzed. The tip clearance effects on the turbine efficiecy are predicted with five empirical and semiempirical expressions, and the results are compared with the present experimental results. Author

A90-17789#
EFFECT OF VANE AND BLADE NUMBERS ON PERFORMANCE OF TRANSONIC TURBINE STAGE
JIANYUAN HAN, JING SHI (Nanhua Powerplant Research Institute, People's Republic of China), XINHUA CHENG (Gas Turbine Research Institute, People's Republic of China), YUEQI WANG, and SHIYING ZHOU (Shengyang Engine Research Institute, People's Republic of China) Journal of Aerospace Power (ISSN 1000-8055), vol. 4, Oct. 1989, p. 337-340, 390. In Chinese, with abstract in English.

Parameters such as throat area, trailing edge block ratio, and profile turning angle at trailing edge have been investigated for different vane and blade numbers, namely 29, 26 vanes and 47, 52, 42 blades. The results of the effect of the vane and blade numbers on the mass flow, reaction, and efficiency of the transonic turbine stage are analyzed. Author

A90-17790#
DESIGN AND CALCULATION OF COMPOSITE AIR-COOLED BLADES IN A HIGHLY-LOADED TRANSONIC TURBINE
HUAYU DENG, CUNLU LIU, MINGJUN LUO, YUFANG LIU (Gas Turbine Establishment, People's Republic of China), QINGMING PENG et al. Journal of Aerospace Power (ISSN 1000-8055), vol. 4, Oct. 1989, p. 341-343, 391. In Chinese, with abstract in English.

A set of calculation methods is presented for predicting coolant mass flow distribution, temperature rise, heat transfer coefficients (internal and external), and temperature field of transonic turbine blades with impingement-convection-film cooling. Various air-cooled schemes have been calculated, and four internal air-cooling structures have been chosen accordingly. The calculation results are compared with the measured wall temperature distributions over turbine blades. Maximum and minimum deviations of the local wall temperature over the turbine vanes and blades are 9.8 and 2 percent and 6.4 and 1.3 percent, respectively. Author

A90-17791#
CALCULATION OF COOLANT FLOW AND HEAT TRANSFER INSIDE COMPOSITE AIR-COOLED TURBINE
HUAYU DENG, YUFANG LIU, MINGJUN LUO (Gas Turbine Establishment, People's Republic of China), and QINGMING PENG Journal of Aerospace Power (ISSN 1000-8055), vol. 4, Oct. 1989, p. 344-346, 391. In Chinese, with abstract in English. refs

A calculation method is presented for the iterative solution of the coolant mass flow distribution, temperature rise, and internal heat transfer coefficient inside composite air-cooled turbine blades. A numerical example is given. The effects of rotation on coolant flow and heat transfer are discussed. The method has been successfully applied to the design of air-cooled turbine blades for the HPPSARP project, and it can also be used in model modification and calculation check. Author

A90-17793#
EXPERIMENTAL INVESTIGATION ON COMPOSITE AIR-COOLED BLADES OF HIGHLY-LOADED TRANSONIC TURBINE
CUNLU LIU, MINGJUN LUO, HUAYU DENG, and YUFANG LIU (Gas Turbine Establishment, People's Republic of China) Journal of Aerospace Power (ISSN 1000-8055), vol. 4, Oct. 1989, p. 351-356, 392. In Chinese, with abstract in English.

Four sets of composite air-cooled blades of a highly-loaded and high temperature transonic turbine with various schemes of film-cooling holes have been designed and fabricated, and have successfully passed a 290-hour test run. Experimental results show that the cooling characteristics of the turbine vanes and blades are superior, as their cooling mass flow ratios are 2-8 and 1-6

percent, respectively. The cooling effectiveness of the turbine vanes and blades is 335-420K, and the wall temperature distributions are uniform. The effects of the parameters of the air-cooled turbine blades on the cooling effectiveness are also considered systematically, based on a large quantity of data obtained from the experiments on four kinds of composite air-cooled transonic turbine vanes and blades. Author

A90-17794#
EXPERIMENTAL INVESTIGATION ON COMPOSITE COOLING OF A TURBINE BLADE
JIRUI ZHENG, HONGHU JI, ZUKAI KONG, and BAOGUAN WANG (Nanjing Aeronautical Institute, People's Republic of China) Journal of Aerospace Power (ISSN 1000-8055), vol. 4, Oct. 1989, p. 357-362, 392. In Chinese, with abstract in English. refs

In view of the whole process of composite cooling on a turbine blade, this paper is composed of three parts. First, the impingement-convection cooling on the internal surface of a blade leading edge is investigated, in effect an empirical expression of internal-local heat transfer coefficients at the stagnation point is formulated, and regularity of their variations along the leading edge region is found. Secondly, the variations of the film-cooling effectiveness along the external surface of the leading edge are investigated according to various blowing ratios when the film jets are ejected from the film holes on the blade. Thirdly, as the film jets impose some disturbances on the main stream, heat transfer is enhanced, and as a result a set of empirical expressions for the external-local heat transfer coefficients are formulated. Author

A90-17795#
RESEARCH ON FILM-COOLING OF TURBINE BLADE
SHAOYAN GE, DENGYUN LIU, JINGZHONG XU, YONGQING YAO, SUQING DENG (Chinese Academy of Sciences, Institute of Engineering Thermophysics, Beijing, People's Republic of China) et al. Journal of Aerospace Power (ISSN 1000-8055), vol. 4, Oct. 1989, p. 363-367, 392. In Chinese, with abstract in English. refs

The effects of discrete film-cooling holes, wall curvature, and pressure gradient on turbine blade film cooling are systematically studied by means of heat-mass analogy, numerical methods, and flow visualization techniques. The flow and heat transfer performances of the cooling film over the flat plate, curved wall, and blade surfaces are investigated. It is proven that the characteristics of discrete-hole film cooling are quite different from those of continuous-slot film cooling in the vicinity of the injection holes because the coolant jets from holes tend to separate from the cooled surfaces. Author

A90-18484#
COMPARISON OF NACA 65, CDA, AND TANDEM BLADED CASCADES
BHASKAR ROY, D. B. GANGAL, and B. V. MARATHE (Indian Institute of Technology, Bombay, India) Aeronautical Society of India, Journal (ISSN 0001-9267), vol. 41, Aug. 1989, p. 289-294. refs

Controlled-diffusion airfoils (CDA) and tandem bladed airfoils were compared with the NACA-65 series bladings in terms of the lift coefficients, blade loading factor, and diffusion factor, by testing the performance of blade sections in a low-speed cascade tunnel. It was found that tandem blades showed low-loss operating range higher than that of NACA 65 blades. The diffusion factor and blade loading factors were higher. At high rotor solidities, the losses remained low even at high positive incidences. The CDA blading showed maximum low-loss operating range with good diffusion factor values. However, because of its low camber of 23 deg, the CDA blading could not be compared with the tandem cascade for blade loading. I.S.

A90-18486#
COMPUTERISED STRUCTURAL ANALYSIS FOR ENGINE COMPONENTS
M. CHANDRASEKARAN (Indian Institute of Technology, Madras, India) and R. PADMANABHAN (Gas Turbine Research Establishment, Bangalore, India) Aeronautical Society of India, Journal (ISSN 0001-9267), vol. 41, Aug. 1989, p. 301-307.

This paper presents the necessity of a powerful computational procedure for the structural analysis of the components/subassemblies of a developmental engine which requires frequent design modifications from the considerations of strength, life, and weight. Modifications are implemented in SAP4, the general-purpose structural analysis program, in order to enhance its capabilities for wide applications to engine components. The development of the preprocessor for SAP4 interaction with computer graphics is also discussed. Author

A90-18526
JET FUTURES
GUY NORRIS Flight International (ISSN 0015-3710), vol. 136, Dec. 12, 1989, p. 31-34.
Copyright

An account is given of the technological development trends in several current next-generation aircraft engine design programs, with respect to component materials and fabrication methods, thermodynamic cycles, turbomachine configurations, and the performance and/or economy improvements anticipated for the aircraft categories and flight regimes considered. Attention is given to the growing use of Ti alloys and ceramic fiber-reinforced composites based on them, ultrahigh-bypass turbofan, propfan, and unducted fan configurations for next-generation airliners, and variable cycle engine concepts for prospective SSTs. O.C.

A90-18594#
GAS TURBINE ENGINE CONDITION MONITORING AND FAULT DIAGNOSTICS
DAGUANG CHEN (Beijing University of Aeronautics and Astronautics, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 10, June 1989, p. B225-B236. In Chinese, with abstract in English. refs

For enhancing the reliability and durability and diminishing direct operating cost of gas turbine engines, a new system, called the engine condition monitoring and fault diagnostic system, has been developed. Extensive experimental research and application experiences verified its effectiveness. Now this system has been widely used on aircraft engines, industrial gas turbine engines and vehicular turbine engines. The function and technical requirements of this system are introduced. Attention is given to the principle and application of gas-path analysis, vibration monitoring, and oil analysis, which are commonly used to compose a gas turbine engine condition monitoring and fault diagnostic system. Author

A90-18600#
DIGITAL CONTROL EXPERIMENT RESEARCH ON THE ENGINE JT15D-4
REI MA, DAZHONG JIANG, YUANYE LI, and HUACONG LE (Northwestern Polytechnical University, Xian, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 10, June 1989, p. B272-B279. In Chinese, with abstract in English. refs

A digital control system study is conducted for the JT15D-4 engine. To improve the reliability of the system, some measures are adopted, such as double-computer-linked communication, condition-performance monitoring, hydromechanical regulation, an alarm activated by software fault diagnosis, and so on. Through digital simulation, half-physical simulation tests, and real runs on an engine test rig, it is verified that the structure and design of the system are correct; it is believed that practical experience will further the present research on full-authority digital control. Author

A90-18613#
THE ESTABLISHMENT OF MATHEMATICAL MODEL OF ENGINE CONTROL SYSTEM AND SIMULATION RESEARCH OF AFTERBURNING DYNAMIC CHARACTERISTICS
KEJIU MAO and XU WANG (Beijing University of Aeronautics and

Astronautics, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 10, July 1989, p. A346-A353. In Chinese, with abstract in English. refs

The static and dynamic mathematical models of a new type of engine and its hydraulic control system are established. A nonlinear mathematical model is used to simulate the engine and afterburning fuel control system. Component characteristics are used to formulate a set of nonlinear equations solved by descending order method. Flow charts for the resulting program are presented. The program is used to perform a detailed analysis of the static and dynamic closed loop characteristics of the engine and its control system under afterburning conditions. C.D.

A90-18624#
THE ANALYSIS AND SOLUTION OF THE PERFORMANCE DETERIORATION PROBLEM OF WP7 ENGINE UNDER THE FULL REHEATING CONDITION
YI SHANG, YANZHONG WANG, and ZIZHONG WU (Nanjing Aeronautical Institute, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 10, Aug. 1989, p. B360-B365. In Chinese, with abstract in English.

The performance deterioration of WP7 engine (i.e., the condition when the turbine exit gas temperature is higher or the thrust is lower than the specific value under full reheating condition) is a key problem which has not been solved for a long time. The causes of this kind of trouble are analyzed by statistical data and theoretical calculations. It is found that the ambient humidity, the performance degeneration of the turbine assembly, the ambient temperature, and the nonuniformity of the field are the main factors that cause the performance deterioration. Some feasible measures are proposed to avoid or lessen this trouble. Author

A90-18635#
BASIC PRINCIPLES OF MEASURING THRUST THROUGH EXHAUST TO INLET TOTAL PRESSURE RATIO - ENGINE PRESSURE RATIO (EPR)
JIYA CUI (Beijing University of Aeronautics and Astronautics, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 10, Aug. 1989, p. B443-B446. In Chinese, with abstract in English.

A90-19005
VELOCITY AND SCALAR MEASUREMENTS IN MODEL AND REAL GAS TURBINE COMBUSTORS
M. V. HEITOR (Lisboa, Universidade Tecnica, Lisbon, Portugal) IN: Instrumentation for combustion and flow in engines; Proceedings of the NATO Advanced Study Institute, Vimeiro, Portugal, Sept. 13-26, 1987. Dordrecht, Kluwer Academic Publishers, 1989, p. 1-44. refs
Copyright

A comprehensive evaluation is made of measurements of the velocity and the scalar characteristics of turbulent reacting flows relevant to gas turbine combustors. Experimental study results indicate that these flows include zones in which turbulent combustion reactions generate both nongradient production and finite rate kinetics effects. Two zones of singular importance are distinguishable: (1) the primary zone, where the turbulent kinetic energy distribution is influenced by the interaction between the large radial main pressure gradient of the swirling flow and the density fluctuations, and (2) the dilution zone, where turbulence generation is related to conventional mechanisms by the interaction of shear stress with shear strain. O.C.

A90-19644#
ACTIVE SOOT REDUCTION IN A SPRAY-FIRED, AXISYMMETRIC MODEL GAS TURBINE COMBUSTOR
B. A. AULT, J. BROUWER, J. E. BOBROW, D. K. EDWARDS, and G. S. SAMUELSEN (California, University, Irvine) AIAA, Aerospace Sciences Meeting, 28th, Reno, NV, Jan. 8-11, 1990. 9 p. Research supported by Parker Hannifin Corp. refs
(AIAA PAPER 90-0039) Copyright

Closed-loop control is implemented on an axisymmetric, swirl-stabilized, model can combustor to minimize soot production. The combustor is operated at a bulk reference velocity of 7.5 m/sec and overall equivalence ratios ranging from 0.25 to 0.40. The control input to the system is the nozzle atomizing airflow rate, and a closed-loop airflow control system with an 11 Hz bandwidth is used to adjust this flow rate to any level commanded by a control computer. Feedback regarding soot production is provided by a radiometer designed and constructed to measure soot radiation, which is mounted on an optical port of the combustor. A C program interprets the radiometer signal and employs a static optimization algorithm to minimize soot by adjusting the nozzle airflow rate. Results show that the optimization algorithm substantially reduces soot production for all operating conditions considered. Author

A90-19764#
LARGE-EDDY SIMULATIONS OF COMBUSTION INSTABILITY IN AN AXISYMMETRIC RAMJET COMBUSTOR
SURESH MENON (Flow Research, Inc., Kent, WA) and WEN-HUEI JOU (Boeing Co., Seattle, WA) AIAA, Aerospace Sciences Meeting, 28th, Reno, NV, Jan. 8-11, 1990. 15 p. refs
(Contract N00019-88-C-0290)
(AIAA PAPER 90-0267) Copyright

The large-eddy simulation (LES) model previously developed for cold flow in an axisymmetric ramjet combustor is extended to include a model for premixed fuel combustion. The combustion model explicitly uses a subgrid-scale local turbulent flame speed in the governing equation. This model not only reduces the computational effort when compared to a model with detailed finite-rate chemical kinetics but also avoids the potential error in the amount of heat release caused by numerical diffusion. Both stable and unstable combustion are simulated with evidence of decaying and growing pressure oscillations, respectively. The observed flow features of unstable combustion, such as a propagating hooked flame and its phase relation with the pressure oscillation, agree with experimental observations. These simulations clearly establish that the LES model contains the essential physics of combustion instability in a ramjet. Although the simulations show general qualitative features of combustion instability, further research is required to take into consideration the important effects of subgrid-scale turbulence on combustion instability. Extensive simulations using the resulting LES model may then lead to a better understanding of the physical processes involved in combustion instability. Author

A90-19805*# Purdue Univ., West Lafayette, IN.
UNSTEADY INCOMPRESSIBLE AERODYNAMICS AND FORCED RESPONSE OF DETUNED BLADE ROWS
HSIAO-WEI D. CHIANG and SANFORD FLEETER (Purdue University, West Lafayette, IN) AIAA, Aerospace Sciences Meeting, 28th, Reno, NV, Jan. 8-11, 1990. 12 p. Research sponsored by NASA. refs
(AIAA PAPER 90-0340) Copyright

A mathematical model is developed and utilized to demonstrate the enhanced forced response behavior associated with aerodynamic, structural, and combined aerodynamic-structural detuning of a loaded rotor operating in an incompressible flow field. The unsteady aerodynamic gust response and oscillating cascade aerodynamics are determined by developing both a complete first-order unsteady aerodynamic analysis and a locally analytical solution in individual grid elements of a body fitted computational grid. The aerodynamic detuning is accomplished by means of alternate circumferential airfoil spacing, with alternate blade structural detuning also considered. The beneficial forced response effects of these detuning techniques are then demonstrated by applying this model to various detuned rotor configurations. Author

A90-19847#
DYNAMIC SIMULATION OF CROSS-SHAFTED PROPULSION SYSTEM FOR TILT NACELLE APPLICATION
W. MILLER, C. SMITH, D. GILMORE, and C. RESNIK (General Electric Co., Lynn, MA) AIAA, Aerospace Sciences Meeting,

28th, Reno, NV, Jan. 8-11, 1990. 11 p. Research sponsored by the U.S. Navy. refs
(AIAA PAPER 90-0439) Copyright

A propulsion system and control were defined for a tilt nacelle Vertical Short Takeoff And Landing (V/STOL) aircraft designated the Grumman Design 698. It was then studied with a newly developed dynamic computer model. The defined system includes two TF34 convertible engines with their fans connected by a common cross-shaft, and is especially sensitive to dynamic response considerations because of stringent roll control and one engine inoperable requirements. Transient simulations of critical flight maneuvers, however, provided the confidence that the system requirements will be met. The dynamic model, which is shown to be a valuable simulation tool for studying the merits of the proposed V/STOL propulsion system design, utilizes unique component level real-time modeling techniques. These modeling techniques not only provide the accurate and efficient calculations needed for the detailed steady-state and transient studies, but also allow for future uses of the model in real-time applications. Author

A90-19852#
NAVIER-STOKES ANALYSIS OF A LOBED MIXER AND NOZZLE
ROBERT E. MALECKI and WESLEY K. LORD (United Technologies Corp., Pratt and Whitney Group, East Hartford, CT) AIAA, Aerospace Sciences Meeting, 28th, Reno, NV, Jan. 8-11, 1990. 13 p. refs
(AIAA PAPER 90-0453) Copyright

The flow through a lobed internal mixer and nozzle for a high bypass-ratio turbofan engine was simulated using a full Navier-Stokes solver and a body-fitted grid. The configuration corresponds to a high penetration mixer tested at model scale as part of the NASA Energy Efficient Engine program. Comparisons are made between the Navier-Stokes solution and detailed experimental measurements obtained in the mixer flow-field, including static pressure variations along both surfaces of the mixer lobes, total pressure contours at the mixer-exit plane, and total temperature contours at the nozzle exit-plane. Values for bypass-ratio, flow coefficient, and thrust coefficient, are compared to experimental values. Good overall agreement between the Navier-Stokes solution and the model test results is demonstrated. Author

A90-19857#
AIR AND SPRAY PATTERNS PRODUCED BY GAS TURBINE HIGH-SHEAR NOZZLE/SWIRLER ASSEMBLIES
T. J. ROSFJORD and J. M. COHEN (United Technologies Research Center, East Hartford, CT) AIAA, Aerospace Sciences Meeting, 28th, Reno, NV, Jan. 8-11, 1990. 11 p. refs
(Contract F33615-85-C-2515)
(AIAA PAPER 90-0465) Copyright

A high-shear nozzle/swirler consists of a centrally mounted fuel nozzle in a compound, radial inflow air swirler. Twenty-one configurations of this device, resulting from use of three fuel injection techniques and seven swirler designs, have been studied to evaluate the uniformity, solidity and cone angle of the produced spray. The fuel nozzle variations resulted in different degrees of interaction between the nozzle spray and swirler airflows. The produced sprays ranged from well-defined, hollow cone sprays to collapsed sprays. The compound, radial inflow swirler provided a convenient means to alter the airflow. Relationships between the swirler parameters and spray patterns were discerned. Author

A90-19895*# North Carolina State Univ., Raleigh.
MACH 6 TESTING OF TWO GENERIC THREE-DIMENSIONAL SIDEWALL COMPRESSION SCRAMJET INLETS IN TETRAFLUOROMETHANE
JOHN N. PERKINS (North Carolina State University, Raleigh) and SCOTT D. HOLLAND AIAA, Aerospace Sciences Meeting, 28th, Reno, NV, Jan. 8-11, 1990. 16 p. Research supported by the U.S. Navy and AFOSR. refs
(Contract NAGW-1072)
(AIAA PAPER 90-0530) Copyright

Three-dimensional sidewall compression scramjet inlets with leading edge sweeps of 30 and 70 degrees have been tested in the Langley Hypersonic CF4 Tunnel at Mach 6 and a ratio of specific heats of 1.2. The effects of cowl position, contraction ratio, and Reynolds number were investigated. The models were instrumented with 42 static pressure orifices distributed on the sidewalls, baseplate, and cowl. Schlieren movies were made of each test for flow visualization of the entrance plane and cowl region. In order to obtain an approximate characterization of the flow field, a modification to two-dimensional inviscid oblique shock theory was derived to accommodate the three-dimensional effects of leading edge sweep. This theory qualitatively predicted the reflected shock structure/sidewall impingement locations and the observed increase in spillage (flow upturning) with increasing leading edge sweep. The primary effect of moving the cowl forward is capturing the flow which would have otherwise spilled out ahead of the cowl. Increasing the contraction ratio (moving the sidewalls closer together) increases the number of internal shock reflections and hence incrementally increases the sidewall pressure distribution. Significant Reynolds number effects were noted over a small range of Reynolds number. Author

N90-13385*# PDA Engineering, Santa Ana, CA.
THE APPLICATION OF CAST SIC/AL TO ROTARY ENGINE COMPONENTS Final Report
H. M. STOLLER, J. R. CARLUCCIO, and J. P. NORMAN 15 Aug. 1986 101 p
(Contract NAS3-24847)
(NASA-CR-179610; NAS 1.26:179610; PDA-86-FR-5333-00-06)
Avail: NTIS HC A06/MF A01 CSCL 21/5

A silicon carbide reinforced aluminum (SiC/Al) material fabricated by Dural Aluminum Composites Corporation was tested for various components of rotary engines. Properties investigated included hardness, high temperature strength, wear resistance, fatigue resistance, thermal conductivity, and expansion. SiC/Al appears to be a viable candidate for cast rotors, and may be applicable to other components, primarily housings. J.P.S.

N90-13386# Advanced Structures Technology, Inc., Phoenix, AZ.
DEVELOPMENT OF AN ADVANCED FAN BLADE CONTAINMENT SYSTEM Final Report, 11 Oct. 1988 - 7 Apr. 1989
ALAN D. LANE Aug. 1989 34 p
(Contract DTRS-57-88-C-00117)
(DOT/FAA/CT-89/20; AST-89-004) Avail: NTIS HC A03/MF A01

The objective was to investigate potential weight savings using a ceramic-based blade containment system. Technology developed to provide light-weight armor for aircraft and aircrew members has shown that systems using ceramics (Al2O3, SiC, and B4C) are more weight efficient than metals (steel, titanium, and aluminum), or polymer fibers (fiberglass and Kevlar). Three primary subtasks were performed: design a ceramic-based fan blade containment system to achieve the maximum possible weight effectiveness; compare the ceramic containment system with current metal and Kevlar systems to quantify the potential weight improvement and corresponding cost impact; and develop a test plan, including the design of test fixtures and test articles to allow verification of improved weight effectiveness of ceramic-based systems Author

N90-13387*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
APPLICATION OF A TWO-DIMENSIONAL UNSTEADY VISCOUS ANALYSIS CODE TO A SUPERSONIC THROUGHFLOW FAN STAGE
RONALD J. STEINKE Nov. 1989 18 p
(NASA-TM-4141; E-4848; NAS 1.15:4141) Avail: NTIS HC A03/MF A01 CSCL 21/5

The Rai ROTOR1 code for two-dimensional, unsteady viscous flow analysis was applied to a supersonic throughflow fan stage design. The axial Mach number for this fan design increases from

2.0 at the inlet to 2.9 at the outlet. The Rai code uses overlapped O- and H-grids that are appropriately packed. The Rai code was run on a Cray XMP computer; then data postprocessing and graphics were performed to obtain detailed insight into the stage flow. The large rotor wakes uniformly traversed the rotor-stator interface and dispersed as they passed through the stator passage. Only weak blade shock losses were computerd, which supports the design goals. High viscous effects caused large blade wakes and a low fan efficiency. Rai code flow predictions were essentially steady for the rotor, and they compared well with Chima rotor viscous code predictions based on a C-grid of similar density. Author

N90-13388*# Pratt and Whitney Aircraft, East Hartford, CT. Commercial Engine Business.
THERMAL BARRIER COATING LIFE PREDICTION MODEL DEVELOPMENT, PHASE 1 Final Report
JEANINE T. DEMASI and MILTON ORTIZ Dec. 1989 338 p
(Contract NAS3-23944)
(NASA-CR-182230; NAS 1.26:182230; PWA-5970-40) Avail: NTIS HC A15/MF A02 CSCL 21/5

The objective of this program was to establish a methodology to predict thermal barrier coating (TBC) life on gas turbine engine components. The approach involved experimental life measurement coupled with analytical modeling of relevant degradation modes. Evaluation of experimental and flight service components indicate the predominant failure mode to be thermomechanical spallation of the ceramic coating layer resulting from propagation of a dominant near interface crack. Examination of fractionally exposed specimens indicated that dominant crack formation results from progressive structural damage in the form of subcritical microcrack link-up. Tests conducted to isolate important life drivers have shown MCrAlY oxidation to significantly affect the rate of damage accumulation. Mechanical property testing has shown the plasma deposited ceramic to exhibit a non-linear stress-strain response, creep and fatigue. The fatigue based life prediction model developed accounts for the unusual ceramic behavior and also incorporates an experimentally determined oxide rate model. The model predicts the growth of this oxide scale to influence the intensity of the mechanic driving force, resulting from cyclic strains and stresses caused by thermally induced and externally imposed mechanical loads. Author

N90-13389*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
STOVL AIRCRAFT SIMULATION FOR INTEGRATED FLIGHT AND PROPULSION CONTROL RESEARCH
JAMES R. MIHALOEW and COLIN K. DRUMMOND 1989 23 p Presented at the 10th Applied Dynamics International Users Society Annual Conference, Keystone, CO, 25-28 Jun. 1989
(NASA-TM-102419; E-5185; NAS 1.15:102419) Avail: NTIS HC A03/MF A01 CSCL 21/5

The United States is in the initial stages of committing to a national program to develop a supersonic short takeoff and vertical landing (STOVL) aircraft. The goal of the propulsion community in this effort is to have the enabling propulsion technologies for this type aircraft in place to permit a low risk decision regarding the initiation of a research STOVL supersonic attack/fighter aircraft in the late mid-90's. This technology will effectively integrate, enhance, and extend the supersonic cruise, STOVL and fighter/attack programs to enable U.S. industry to develop a revolutionary supersonic short takeoff and vertical landing fighter/attack aircraft in the post-ATF period. A joint NASA Lewis and NASA Ames research program, with the objective of developing and validating technology for integrated-flight propulsion control design methodologies for short takeoff and vertical landing (STOVL) aircraft, was planned and is underway. This program, the NASA Supersonic STOVL Integrated Flight-Propulsion Controls Program, is a major element of the overall NASA-Lewis Supersonic STOVL Propulsion Technology Program. It uses an integrated approach to develop an integrated program to achieve integrated flight-propulsion control technology. Essential elements of the integrated controls research program are realtime simulations of the integrated aircraft and propulsion systems which will be used in integrated control concept development and evaluations. This paper describes pertinent parts of the research program leading up to the related realtime simulation development and remarks on the simulation structure to accommodate propulsion system hardware drop-in for real system evaluation. Author

N90-13390*# Southwest Research Inst., San Antonio, TX.
CONSTITUTIVE MODELING FOR ISOTROPIC MATERIALS (HOST) Annual Status Report No. 3
KWAI S. CHAN, ULRIC S. LINDHOLM, S. R. BODNER, JEFF T. HILL, R. M. WEBER, and T. G. MEYER (Pratt and Whitney Aircraft, East Hartford, CT.) Aug. 1986 129 p
(Contract NAS3-23925; SWRI PROJ. 06-7576)
(NASA-CR-179522; SWRI-7576/45; NAS 1.26:179522) Avail: NTIS HC A07/MF A01 CSCL 21/5

The results of the third year of work on a program which is part of the NASA Hot Section Technology program (HOST) are presented. The goals of this program are: (1) the development of unified constitutive models for rate dependent isotropic materials; and (2) the demonstration of the use of unified models in structural analyses of hot section components of gas turbine engines. The unified models selected for development and evaluation are those of Bodner-Partom and of Walker. A test procedure was developed for assisting the generation of a data base for the Bodner-Partom model using a relatively small number of specimens. This test procedure involved performing a tensile test at a temperature of interest that involves a succession of strain-rate changes. The results for B1900+Hf indicate that material constants related to hardening and thermal recovery can be obtained on the basis of such a procedure. Strain aging, thermal recovery, and unexpected material variations, however, preluded an accurate determination of the strain-rate sensitivity parameter is this exercise. The effects of casting grain size on the constitutive behavior of B1900+Hf were studied and no particular grain size effect was observed. A systematic procedure was also developed for determining the material constants in the Bodner-Partom model. Both the new test procedure and the method for determining material constants were applied to the alternate material, Mar-M247 . Test data including tensile, creep, cyclic and nonproportional biaxial (tension/torsion) loading were collected. Good correlations were obtained between the Bodner-Partom model and experiments. A literature survey was conducted to assess the effects of thermal history on the constitutive behavior of metals. Thermal history effects are expected to be present at temperature regimes where strain aging and change of microstructure are important. Possible modifications to the Bodner-Partom model to account for these effects are outlined. The use of a unified constitutive model for hot section component analyses was demonstrated by applying the Walker model and the MARC finite-element code to a B1900+Hf airfoil problem. Author

N90-13391*# Southwest Research Inst., San Antonio, TX.
CONSTITUTIVE MODELING FOR ISOTROPIC MATERIALS (HOST) Annual Report No. 1
ULRIC S. LINDHOLM, KWAI S. CHAN, S. R. BODNER, R. M. WEBER (Pratt and Whitney Aircraft, East Hartford, CT.), K. P. WALKER, and B. N. CASSENTI May 1984 127 p
(Contract NAS3-23925; SWRI PROJ. 06-7576)
(NASA-CR-174718; SWRI-06-7576/13; NAS 1.26:174718) Avail: NTIS HC A07/MF A01 CSCL 21/5

The results of the first year of work on a program to validate unified constitutive models for isotropic materials utilized in high temperature regions of gas turbine engines and to demonstrate their usefulness in computing stress-strain-time-temperature histories in complex three-dimensional structural components. The unified theories combine all inelastic strain-rate components in a single term avoiding, for example, treating plasticity and creep as separate response phenomena. An extensive review of existing unified theories is given and numerical methods for integrating these stiff time-temperature-dependent constitutive equations are discussed. Two particular models, those developed by Bodner and Partom and by Walker, were selected for more detailed

development and evaluation against experimental tensile, creep and cyclic strain tests on specimens of a cast nickel base alloy, B19000+Hf. Initial results comparing computed and test results for tensile and cyclic straining for temperature from ambient to 982 C and strain rates from 10(exp-7) 10(exp-3) s(exp-1) are given. Some preliminary date correlations are presented also for highly non-proportional biaxial loading which demonstrate an increase in biaxial cyclic hardening rate over uniaxial or proportional loading conditions. Initial work has begun on the implementation of both constitutive models in the MARC finite element computer code. Author

N90-13392*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
TWO-DIMENSIONAL ANALYSIS OF TWO-PHASE REACTING FLOW IN A FIRING DIRECT-INJECTION DIESEL ENGINE
H. LEE NGUYEN Dec. 1989 21 p
(NASA-TM-102069; E-4826; NAS 1.15:102069) Avail: NTIS HC A03/MF A01 CSCL 21/5

The flow field, spray penetration, and combustion in two-stroke diesel engines are described. Fuel injection begins at 345 degrees after top dead center (ATDC) and n-dodecane is used as the liquid fuel. Arrhenius kinetics is used to calculate the reaction rate term in the quasi-global combustion model. When the temperature, fuel, and oxygen mass fraction are within suitable flammability limits, combustion begins spontaneously. No spark is necessary to ignite a localized high temperature region. Compression is sufficient to increase the gaseous phase temperature to a point where spontaneous chemical reactions occur. Results are described for a swirl angle of 22.5 degrees. Author

N90-13393*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
A PLANAR REACTING SHEAR LAYER SYSTEM FOR THE STUDY OF FLUID DYNAMICS-COMBUSTION INTERACTION
C. J. MAREK, C. T. CHANG, B. GHORASHI, C. C. WEY, C. WEY, and E. J. MULARZ (Army Aviation Research and Development Command, Cleveland, OH.) 1989 21 p Proposed for presentation at the 23rd International Symposium on Combustion, Orleans, France, 22-27 Jul. 1990; sponsored by Orleans Univ. Prepared in cooperation with Army Aviation Research and Development Command, Cleveland, OH
(Contract DA PROJ. 1L1-61102-AH-45)
(NASA-TM-102422; E-5063; NAS 1.15:102422; AVSCOM-TR-89-C-013) Avail: NTIS HC A03/MF A01 CSCL 21/5

A versatile planar reacting shear layer facility is constructed at NASA-Lewis. The research objectives, as well as design, instrumentations and the operational procedures developed for the system are described. The fundamental governing equations and the type of quantitative information that are needed from experiments are described. Additionally, a review of earlier work is presented. Whenever appropriate, comparisons are made with similar systems in other facilities and the main differences are described. Finally, the nonintrusive measurement techniques (PLIF, PMS, LDV, and Schlieren photography) and the type of experiments that are planned are described. Author

N90-13394*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
RECENT PROGRESS IN RESEARCH PERTAINING TO ESTIMATES OF GAS-SIDE HEAT TRANSFER IN AN AIRCRAFT GAS TURBINE
ROBERT W. GRAHAM 1989 9 p Proposed for presentation at the Turbo Expo, Brussels, Belgium, 11-14 Jun. 1990; sponsored by ASME
(NASA-TM-102460; E-5247; NAS 1.15:102460) Avail: NTIS HC A02/MF A01 CSCL 21/5

A decade ago several important fundamental heat transfer phenomena were identified which were considered basic to the ability to predict heat transfer loads in aircraft gas turbines. The progress in addressing these fundamentals over the past ten years is assessed. Much reseach effort has been devoted to their study in university, industry and government labs and significant progress has been achieved. Advances in computer technology have enabled the modeling of complex 3-D fluid flow in gas turbines so necessary for heat transfer calculations. Advances in instrumentation plus improved data acquisition have brought about more reliable data sets. While much has advanced in the 1980's, much challenging research remains to be done. Several of these areas are suggested. Author

N90-13395# Technische Univ., Delft (Netherlands). Dept. of Aerospace Engineering.
AIRCRAFT PROPULSION: LEADING THE WAY IN AVIATION
H. WITTENBERG Sep. 1987 37 p
(LR-532; ETN-90-95981) Avail: NTIS HC A03/MF A01

Some fundamental aspects of airbreathing propulsion systems are considered with emphasis on fuel economy in relation to the thermal and the propulsion efficiency. The state of the art of piston-engines in general aviation is surveyed and the application of gas turbines in civil transports at high-subsonic speeds is considered. Trends of future developments with respect to ducted- and unducted (propulsion) concepts are discussed. Some features of the propulsion of supersonic transports are reviewed, based on the Concorde, and future developments, and propulsion concepts for hypervelocity vehicles are reviewed. The leading role of propulsion in aviation is emphasized. ESA

N90-14234 Georgia Inst. of Tech., Atlanta.
ACOUSTIC-VORTICAL-COMBUSTION INTERACTION IN A SOLID FUEL RAMJET SIMULATOR Ph.D. Thesis
JAMES ARTHUR DAVIS 1989 190 p
Avail: Univ. Microfilms Order No. DA8919740

The interaction between vortical structures and an externally applied acoustic field in a complex turbulent flow field was investigated. The flow field was produced by a flow of air over a backward facing step in a rectangular section duct. The purposes of this investigation were: (1) to demonstrate the existence of somewhat organized vortical structures in the shear layer; (2) to demonstrate that the vortical structures are influenced (organized) by an applied acoustic field; (3) to determine if the vortical structures in turn affect the applied acoustic field; and (4) to determine if combustion affects the applied acoustic field. By anemometry and acoustic pressure measurement, together with aeroacoustic theory, the first demonstrations were made. However, in the flow field used, without strong downstream constrictions, there was discernible feedback into the acoustic field only in the presence of combustion. The results obtained have application to ramjet type flow fields. Dissert. Abstr.

N90-14235*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
RAMSCRAM: A FLEXIBLE RAMJET/SCRAMJET ENGINE SIMULATION PROGRAM
LEO A. BURKARDT and LEO C. FRANCISCUS 1990 6 p Prepared for presentation at the 35th International Gas Turbine Aeroengine Congress and Exposition, Brussels, Belgium, 11-14 Jun. 1990; sponsored by ASME
(NASA-TM-102451; E-5236; NAS 1.15:102451) Avail: NTIS HC A02/MF A01 CSCL 21/5

With the resurgence of interest in high supersonic and hypersonic flight there is a need to simulate airbreathing engines which may be used in this flight regime. To meet this requirement the RAMSCRAM code was developed. The code calculates 1-D flow properties at each component interface and the overall performance of the engine. It uses equilibrium thermodynamics which accounts for dissociation and allows for any fuel or combination of fuels. The program can simulate ramjet, scramjet, rocket, and ducted rocket engines. Author

N90-14236*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
TEMPORALLY AND SPATIALLY RESOLVED FLOW IN A TWO-STAGE AXIAL COMPRESSOR. PART 2: COMPUTATIONAL ASSESSMENT

KAREN L. GUNDY-BURLET, MAN MOHAN RAI, R. CHARLES STAUTER, and ROBERT P. DRING (United Technologies Research Center, East Hartford, CT.) Jan. 1990 11 p Proposed for presentation at the 35th ASME International Gas Turbine and Aerospace Congress and Exhibition, Brussels, Belgium, 11-14 Jun. 1990
(NASA-TM-102273; A-90048; NAS 1.15:102273) Avail: NTIS HC A03/MF A01 CSCL 21/5

Fluid dynamics of turbomachines are complicated due to aerodynamic interactions between rotors and stators. It is necessary to understand the aerodynamics associated with these interactions in order to design turbomachines that are both light and compact as well as reliable and efficient. The current study uses an unsteady, thin-layer Navier-Stokes zonal approach to investigate the unsteady aerodynamics of a multi-stage compressor. Relative motion between rotors and stators is made possible by use of systems of patched and overlaid grids. Results have been computed for a 2 1/2-stage compressor configuration. The numerical data compares well with experimental data for surface pressures and wake data. In addition, the effect of grid refinement on the solution is studied. Author

08

AIRCRAFT STABILITY AND CONTROL

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

A90-16827#
A SYNTHETIC RESEARCH FOR AIRCRAFT ACTIVE FLUTTER SUPPRESSION
QING CHEN and ZHAOFENG HU (Beijing University of Aeronautics and Astronautics, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 10, Sept. 1989, p. A420-A426. In Chinese, with abstract in English. refs

In this paper, a new idea to investigate the flutter problem is proposed. The new idea is that only a few modes of an aeroelastic system may be studied instead of studying the whole. In the light of it, an approach to analyzing flutter characteristics which combines the merit of graphic and analytic methods is presented. An optimal performance index with clear physical meaning which can overcome some inherent drawbacks of linear quadratic technique is also developed. The paper shows a numerical example of an elastic wing, and some comparisons between this method and 'v-g' method for calculating the critical point (Vf, Wf) are carried out as well. Author

A90-16850
INVESTIGATION OF A NONLINEAR KALMAN FILTER FOR ESTIMATING AIRCRAFT STATE VARIABLES [UNTERSUCHUNG EINES NICHTLINEAREN KALMAN-FILTERS ZUR SCHAETZUNG VON ZUSTANDSGROESSEN EINES FLUGZEUGS]
DA REN (Northwestern Polytechnical University, Xian, People's Republic of China) and R. BROCKHAUS (Braunschweig, Technische Universitaet, Brunswick, Federal Republic of Germany) Zeitschrift fuer Flugwissenschaften und Weltraumforschung (ISSN 0342-068X), vol. 13, Sept.-Oct. 1989, p. 326-333. In German. refs
Copyright

The use of the nonlinear Kalman filter (NKF) for estimating the state variables of aircraft motion is analyzed. The mathematical model of an aircraft and wind disturbances used in the simulation program is presented, along with the mathematical model of the NKF. Four types of simplified wind models are suggested for reducing computational requirements. The estimation of aircraft velocity, angle of attack, and sideslip angle using data obtained by simulation is demonstrated. The effects of varying the initial covariance matrix and the initial state variables are addressed, as are effects caused by uncertainties in the mathematical model, especially model errors due to simplified wind models and uncertain values of the aerodynamic parameters. The results show the usefulness of the NKF. C.D.

A90-16854#
THE ANALYSIS OF ENTRY INTO AND RECOVERY FROM A SPIN FOR THE JJ6 AIRCRAFT
ZHENPING FANG and JIE ZHENG (Beijing University of Aeronautics and Astronautics, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 10, Oct. 1989, p. B479-B488. In Chinese, with abstract in English. refs

The spin behavior of the JJ6 aircraft is analyzed and predicted by bifurcation analysis and catastrophe theory. The mechanism of spin motion and the function of various control surfaces are explored during aircraft entry into and recovery from a spin. The theoretical computation results agree with flight test results in most situations. Author

A90-17698#
TIME-DOMAIN AEROSERVOELASTIC MODELING USING WEIGHTED UNSTEADY AERODYNAMIC FORCES
MORDECHAY KARPEL (Technion - Israel Institute of Technology, Haifa) IN: Israel Annual Conference on Aviation and Astronautics, 30th, Tel Aviv and Haifa, Israel, Feb. 15, 16, 1989, Collection of Papers. Haifa, Technion - Israel Institute of Technology, 1989, p. 203-214. refs

A modeling method for constructing a state-space aeroservoelastic mathematical model for time-domain analysis with a low number of aerodynamic lag states is presented. The modeling method employs the minimum-state method for rational approximation of tabulated unsteady aerodynamic force coefficients at various reduced frequency values. The approximation method is modified to deal with weighted aerodynamic data and with alternative constraint combinations. Two weighting types are analyzed and discussed Author

A90-17703#
RECURSIVE REAL-TIME IDENTIFICATION OF STEP-RESPONSE MATRICES OF HELICOPTERS FOR ADAPTIVE DIGITAL FLIGHT CONTROL
B. PORTER and A. MANGANAS (Salford, University, England) IN: Israel Annual Conference on Aviation and Astronautics, 30th, Tel Aviv and Haifa, Israel, Feb. 15, 16, 1989, Collection of Papers. Haifa, Technion - Israel Institute of Technology, 1989, p. 258-265. refs
(Contract AF-AFOSR-85-0208)

It is shown that, by incorporating on-line recursive identifiers to provide updated step-response matrices for inclusion in digital PID control laws, highly effective adaptive digital set-point tracking controllers can be readily designed for multivariable plants. The effectiveness of such adaptive controllers is illustrated by the design of adaptive direct digital flight control systems for the lateral and longitudinal dynamics of a typical helicopter. Author

A90-17704#
SUPPLEMENTED VISUAL CUES FOR HELICOPTER HOVERING ABOVE A MOVING SHIP DECK
M. NEGRIN, A. GRUNWALD, and A. ROSEN (Technion - Israel Institute of Technology, Haifa) IN: Israel Annual Conference on Aviation and Astronautics, 30th, Tel Aviv and Haifa, Israel, Feb. 15, 16, 1989, Collection of Papers. Haifa, Technion - Israel Institute of Technology, 1989, p. 266-278. refs

Manual, low-altitude lateral hovering of a helicopter above a small, moving ship deck using visual field cues supplemented by superimposed display symbology is investigated. The effect on performance of the information superimposed on the visual field is studied both theoretically and experimentally. In the case of head-up display information, an artificial horizon, a cross indicating the helicopter longitudinal axis, and a rhombus presenting predictive information are investigated. The combination of the inertially stable cube with the cross provides explicit inertial position information. The results clearly show that hovering performance is markedly

improved by including explicit visual information, and is further improved by combining explicit position information with predictive information. C.D.

A90-18584#
THE RESEARCH OF CUBIC SPLINE OPTIMAL TERRAIN FOLLOWING SYSTEM
SHUNDA XIAO and CHUANXIN DING (Northwestern Polytechnical University, Xian, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 10, May 1989, p. A259-A266. In Chinese, with abstract in English.

In this paper, a linear programming algorithm is used instead of a quadratic programming approach to compute the optimal cubic-spline flight path. Feedback gains of the automatic flight control system are determined using classical control theory, significantly decreasing the amount of computation. Hybrid simulation results show that it takes 14.8 sec for a 'super' PC to compute the optimal flight path with a range of 6370 m, which takes an aircraft 20 s to fly over. Thus, the proposed algorithm brings closer to reality the real-time computation of the optimal cubic spline flight path. The proposed algorithm can also ensure an optimal terrain-following flight over a terrain with height changes as great as 1000 m. The maximum error of the resulting terrain-following path in comparison with optimal reference one is less than 10 m, and the normal load falls within the range 0 to 3 g. These results show that the designed system satisfies all the requirements specified for the terrain-following system. C.D.

A90-18592#
DESIGN OF DIRECT LIFT CONTROL SYSTEMS AGAINST VERTICAL GUST
GANG FENG (Nanjing Aeronautical Institute, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 10, May 1989, p. A300-A304. In Chinese, with abstract in English.

This paper discusses conventional aircraft and their control systems against vertical gust. The design of a direct lift control system is introduced, in which the state feedback control is used for eigenstructure assignment in the discrete time domain. Author

A90-18595#
MODAL AGGREGATION AND ITS APPLICATION IN FLIGHT MECHANICS
CHAO HAN (Beijing University of Aeronautics and Astronautics, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 10, June 1989, p. B237-B245. In Chinese, with abstract in English. refs

This paper presents one kind of aggregation for linear system modal reduction. The aggregational matrix of reduced system is given by the solution of a general Lyapunov equation, SA11-A22S-A21 = 0, in which A11, A21 and A22 are the block matrices of the parameter matrix of an initial linear system. Matrix (-S I) is the aggregational matrix. By means of the method given above, the linearized dynamic equations of longitudinal motion and lateral-directional motion of an aircraft are separated, and the approximate formulas of phugoid, short period, roll-spiral and Dutch-roll modes are derived. Some calculation results show that the approximate formulas have good precision, especially increasing the estimation accuracy for the dampings of phugoid and Dutch-roll modes. Author

A90-18601#
THE EIGENVALUE SENSITIVITY ANALYSIS AND DESIGN FOR INTEGRATED FLIGHT/PROPULSION CONTROL SYSTEMS
GONGZHANG SHEN, ZONGJI CHEN, and KEMAO PENG (Beijing University of Aeronautics and Astronautics, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 10, June 1989, p. B280-B287. In Chinese, with abstract in English. refs

Sensitivity approaches are taken to analyze and design an integrated flight/propulsion control system where the interaction between subsystems directly affects the stability property and handling performance of the aircraft. The eigenvalue sensitivity approach is employed to study the effect of coupling parameters on system stability, and the gain sensitivity approach is used to direct the reduced states feedback suboptimal control system design. Simulation results show that the integrated flight/propulsion control system designed by sensitivity approaches yields good performance. Author

A90-18633#
THE INDUCED VELOCITY DISTRIBUTION AND THE FLAP-PITCH-TORSION COUPLING ON THE STABILITY AND CONTROL OF THE HELICOPTER IN FLIGHT CONDITION WITH LATERAL VELOCITY
YIHUA CAO and XINYU XU (Nanjing Aeronautical Institute, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 10, Aug. 1989, p. B432-B438. In Chinese, with abstract in English. refs

A method is given for the calculation of stability and control of a helicopter in flight condition with lateral velocity. The rotary wing dynamic model considered is the model of flap-pitch-torsion coupling. The induced velocity distribution derived by generalized vortex theory is taken into account. Author

A90-19428#
AN ADAPTIVE FLIGHT CONTROL SYSTEM DESIGN FOR NON-MINIMUM PHASE CCV BY RELATIVE ORDER REDUCTION
YUZO SHIMADA, HIROAKI MIYAZAWA, and TAKAHIRO NISHIMURA Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 37, no. 429, 1989, p. 492-501. In Japanese, with abstract in English. refs

This paper presents a new digital adaptive control design for a control-configured vehicle (CCV) that has unstable zeros. The model-reference adaptive flight control system uses a placement method for zeros of the CCV. The method adds the vertical acceleration to the vertical speed signal, and pitch rate and pitch acceleration to the attitude signal from the CCV so as to move the zeros to a more stable region. Computer simulations performed on the Japanese T2 CCV showed remarkable adaptability and resulted in satisfactory CCV modes without any unstable vibration of the flaperon or the elevator. Author

A90-19461
DECOUPLED ULTIMATE BOUNDEDNESS CONTROL OF SYSTEMS AND LARGE AIRCRAFT MANEUVER
SAHJENDRA N. SINGH (Nevada, University, Las Vegas) IEEE Transactions on Aerospace and Electronic Systems (ISSN 0018-9251), vol. 25, Sept. 1989, p. 677-688. refs
Copyright

The robust trajectory control of a class of nonlinear systems which can be decoupled by state-variable feedback is considered. It is assumed that the system matrices are unknown but bounded. A nonlinear control law is derived so that the tracking error in the closed-loop system is uniformly bounded and tends to a certain small neighborhood of the origin. The error dynamics are asymptotically decoupled in an approximate sense. The controller includes a reference trajectory generator and uses the integral feedback of the tracking error. On the basis of this result, a flight control system is designed for the control of roll angle, angle of attack, and sideslip in rapid, nonlinear maneuvers of aircraft. Simulation results are presented to show that large, simultaneous lateral and longitudinal maneuvers can be performed in spite of the uncertainty in the stability derivatives. I.E.

A90-19554*# Kansas Univ. Center for Research, Inc., Lawrence.
ANALYSIS AND DESIGN OF SIDESTICK CONTROLLER SYSTEMS FOR GENERAL AVIATION AIRCRAFT
DANIEL M. MARTIN and DAVID R. DOWNING (University of Kansas Center for Research, Inc., Lawrence) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 13, Jan.-Feb. 1990, p. 16-21. refs
(Contract NAG1-324)

A method to design sidestick controllers for general aviation aircraft with reversible flight controls is proposed. The use of a sidestick in this type of flight vehicle generally increases the stick forces required for maneuvering; this is due to a reduction in the moment arm of application of the force. In the present study, the reduction of stick forces is achieved by incorporating geared tabs in the control-surface design. A complete analysis using the rigid-body aircraft longitudinal equations of motion and stick-force equation in coupled form is carried out. Lateral stick forces are predicted by solving the single-degree-of-freedom roll approximation and aileron stick-force equations. Data are presented for configurations with various tab areas and a wide range of gearing ratios. The results indicate that the method can be used successfully for geared-tab design and stick-force prediction. It is shown that gearing-ratio selection is critical but that tab area does not have a significant impact on the magnitude of stick forces and stick force to stick deflection gradients. Author

A90-19555#
ATTITUDE PROJECTION METHOD FOR ANALYZING LARGE-AMPLITUDE AIRPLANE MANEUVERS
OSAMU KATO (Nagoya University, Japan) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 13, Jan.-Feb. 1990, p. 22-29. refs
Copyright

A method for analyzing large-amplitude airplane maneuvers is described. The concept of attitude projection and its successive trajectory, which is a graphical means for expressing changes in flight attitude, are introduced. Then, a well-known aerobatic maneuver, barrel roll, is analyzed using the method. The numerical calculation used for a large maneuver is presented as an example of the inverse problem in flight mechanics. Author

A90-19577#
ON THE LEVEL 2 RATINGS OF THE COOPER-HARPER SCALE
DAVID J. MOORHOUSE (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 13, Jan.-Feb. 1990, p. 189-191.

The Cooper-Harper (1986) rating scale, which has become the universally accepted tool for defining a pilot's subjective evaluation of aircraft flying qualities, possesses potential ambiguities in the definitions for level 2 ratings. Wording is presently proposed which augments the Cooper-Harper scale in such a way as to aid the assigning of ratings in the level 2 region. This wording is also suggested to be able to help in communications between engineers and pilots, minimizing pilot-rating variability. O.C.

A90-19723#
UH-60 FLIGHT DATA REPLAY AND REFLY SYSTEM STATE ESTIMATOR ANALYSIS
MARK S. WHORTON AIAA, Aerospace Sciences Meeting, 28th, Reno, NV, Jan. 8-11, 1990. 12 p. refs
(AIAA PAPER 90-0181) Copyright

Research currently underway at the University of Alabama Flight Dynamics Lab (UAFDL) investigates concepts for implementation of a ground-based UH-60 Flight Data Replay and Refly System (UH-60 FDRRS). A variation of a Linearized Extended Kalman filter is implemented which utilizes a mathematical model of the UH-60 to accurately re-create a UH-60 helicopter flight based on flight measurements. Presented in this paper is a the development of the UH-60 mathematical model, an experimental verification of the Kalman filter implementation, and an experimental evaluation of filter sensitivity to initial condition errors, measurement sample rate reductions, and model parameter variations. Results indicate that vehicle dynamics are represented with sufficient fidelity by the UH-60 mathematical model for both filter design and piloted simulation, providing a replay and a refly capability. Experimental analysis of the Kalman filter indicates that the current filter exhibits a robust tracking ability for low measurement sample rates; demonstrates relatively fast, stable convergence in the presence of initial condition errors; yet manifests a notable performance degradation due to weight variations. Author

A90-19738#
HIGH ANGLE OF ATTACK FLYING QUALITIES CRITERIA
GREGORY C. KREKELER, JR., DAVID J. WILSON, and DAVID R. RILEY (McDonnell Aircraft Co., Saint Louis, MO) AIAA, Aerospace Sciences Meeting, 28th, Reno, NV, Jan. 8-11, 1990. 12 p. refs
(AIAA PAPER 90-0219) Copyright

Multiple, manned, fixed-base simulations were conducted to investigate longitudinal and lateral flying qualities for the moderate to high angle of attack flight regime. Pilot evaluations were conducted for tasks which represent point and shoot maneuvering at 30 degrees angle of attack. Simulation pilot comments and pilot rating data are compared with current flying qualities criteria including Control Anticipation Parameter (CAP), frequency response envelope, bandwidth, closed loop, modal parameter, and time history criteria. The comparisons showed that Cooper-Harper pilot ratings and comments at high angle of attack correlate with modifications to some of these current criteria. The potential impact of motion cues during high angle of attack maneuvering and the potential risk of using fixed-base simulation in this dynamic environment are addressed. A comparison of fixed-base data with a limited amount of high angle of attack flight test data shows good correlation. Author

A90-19740*# Minnesota Univ., Minneapolis.
SIMPLE ANALYSES OF PATHS THROUGH WINDSHEARS AND DOWNDRAFTS
YIYUAN ZHAO (Minnesota, University, Minneapolis) and A. E. BRYSON (Stanford University, CA) AIAA, Aerospace Sciences Meeting, 28th, Reno, NV, Jan. 8-11, 1990. 10 p. refs
(Contract NAG2-191)
(AIAA PAPER 90-0222) Copyright

Quasi-steady analysis and energy-state approximation are employed to study flight paths through windshears and downdrafts. Takeoff flight is mainly considerd while landing flight is briefly discussed. The relation between angle of attack and airspeed is found to be almost independent of horizontal wind and slightly dependent on vertical wind. In slowly-varying windshears and/or downdrafts, quasi-steady flight can be achieved by flying an aircraft at a lower than nominal climb rate; this will avoid stall. In severe windshears and/or downdrafts, energy-state approximation indicates that descending paths save more energy and provide higher survival capability. Author

A90-19918#
REAL TIME WINDS DATA FOR FLIGHT MANAGEMENT
GARY G. NELSON (Mitre Corp., McLean, VA) AIAA, Aerospace Sciences Meeting, 28th, Reno, NV, Jan. 8-11, 1990. 8 p. refs
(AIAA PAPER 90-0565) Copyright

The forthcoming consolidation of aircraft winds aloft reports will create a real time database of atmospheric state, contrasting with current or future weather forecast products. The real time database creates possibilities for more precise air traffic control and adaptive flight management over short, particularly subhour, predictive lookaheads for aircraft trajectories. This paper presents the results of a simulation model to indicate the gains in the predictability of arrival time at a fixed point using improved winds aloft data, and focuses on the applications for adaptive speed control by flight management systems. Author

A90-19920*# Massachusetts Inst. of Tech., Cambridge.
ANALYSIS OF AIRCRAFT PERFORMANCE DURING LATERAL MANEUVERING FOR MICROBURST AVOIDANCE
DENISE AVILA DE MELO (Embraer, S.A., Sao Jose dos Campos, Brazil) and R. JOHN HANSMAN, JR. (MIT, Cambridge, MA) AIAA, Aerospace Sciences Meeting, 28th, Reno, NV, Jan. 8-11, 1990. 8 p. Research supported by FAA, Embraer, S.A., and MIT. refs
(Contract NGL-22-009-640; NAG1-690)
(AIAA PAPER 90-0568) Copyright

Aircraft response to a severe and a moderate three-dimensional microburst model using nonlinear numerical simulations of a Boeing 737-100 is studied. The relative performance loss is compared for microburst escape procedures with and without lateral

maneuvering. The results show that the hazards caused by the penetration of a microburst in the landing phase are attenuated if lateral escape maneuvers are applied in order to turn the aircraft away from the microburst core rather than flying straight through. If the lateral escape maneuver is initiated close to the microburst core, high bank angles tend to deteriorate aircraft performance. Lateral maneuvering is also found to reduce the advanced warning required to escape from microburst hazards but requires that information of the existence and location of the microburst is available (i.e., remote detection) in order to avoid an incorrect turn toward the microburst core. S.A.V.

N90-13396 Ohio State Univ., Columbus.
AEROELASTIC CONTROL OF COMPOSITE LIFTING SURFACES: INTEGRATED AEROELASTIC CONTROL OPTIMIZATION Ph.D. Thesis
THEODORE NICOLAS DRACOPOULOS 1988 131 p
Avail: Univ. Microfilms Order No. DA8907212

A new design method for aeroelastic control of composite lifting surfaces is developed and demonstrated. The design is posed as an optimization problem to determine the laminate design and the control law which maximize the critical aeroelastic speed of an actively controlled composite lifting surface without excessive expenditure of control energy. Aeroelastic tailoring and optimum control design are investigated in a formal optimization procedure. An analytical investigation, preliminary to the development of the integrated aeroelastic control optimization method, was conducted to study the effects of the interaction between laminate and active control designs on the aeroelastic stability and control performance of actively controlled composite plates. The integrated aeroelastic control optimization method is formulated and illustrated for composite lifting surfaces simulated by rectangular symmetric cantilevered composite plates, with structural and control constraints. The formulation incorporated the Rayleigh-Ritz theory, and optimum control design. The effectiveness of the method was evaluated by comparing the optimum designs obtained by the method with designs obtained by a design procedure using aeroelastic tailoring and optimum control design as well but in a non-integrated fashion. Dissert. Abstr.

N90-13397 Purdue Univ., West Lafayette, IN.
DISCRETIZATION AND MODEL REDUCTION FOR A CLASS OF NONLINEAR SYSTEMS Ph.D. Thesis
ANDREW MARK KING 1988 160 p
Avail: Univ. Microfilms Order No. DA8911935

Nonlinear analysis for control design is required in many modern engineering systems. Strict performance requirements over wide ranges of operation cannot be met using linear models. The lack of structure in nonlinear models has hindered the development of analysis techniques. Many engineering systems are computer controlled so that methods of attaining structured discrete-time nonlinear models are needed. Many of these nonlinear models have high model order, and effective methods for order reduction need to be developed. Both the discretization problem and the model reduction problem for a large class of nonlinear systems are addressed. A method was developed for discretizing linear-analytic continuous-time systems. The solution for the class of nonlinear systems can be expressed as a Volterra series. The result is a state-affine discrete-time system that represents an exact discretization of a specific number of terms in the Volterra series solution of a given linear-analytic continuous-time system. An algorithm is present for constructing low order approximations of state-affine discrete-time systems. The model reduction algorithm for state-affine systems is based on a new approach for constructing q-Markov covariance equivalent realizations of linear discrete-time systems. In the linear discrete-time case, the algorithm solves a model reduction problem and a partial realization problem. Dissert. Abstr.

N90-13398# Dynamic Controls, Inc., Dayton, OH.
ADVANCED ACTUATION SYSTEMS DEVELOPMENT, VOLUME 2 Final Report, May 1983 - Jan. 1987
GAVIN D. JENNEY, HARRY W. SCHREADLEY, JOHN A. ANDERSON, WILLIAM G. TALLEY, and CARL A. ALLBRIGHT Aug. 1989 374 p
(Contract F33615-83-C-3600; AF PROJ. 2403)
(AD-A213378; WRDC-TR-89-3076-VOL-2) Avail: NTIS HC A16/MF A02 CSCL 01/4

This report describes six different research and development activities in flight control actuation. The activities are: (1) the development and test of a unique linear actuator sealing system for high pressure systems, (2) the development and test of a digital servovalve using piezo-controlled high speed solenoid valves, (3) the performance evaluation of an F-15 rudder actuator under applied loads, (4) the performance evaluation of a Mission Adaptive Wing section under different load conditions, (5) the evaluation of output impedance modification of an electrohydraulic actuator for flutter suppression, and (6) the development and test of a direct drive valve and electronics (analog and digital) for an F-16 Horizontal Tail/Flaperon actuator. GRA

N90-13399# Air Force Armament Lab., Eglin AFB, FL.
AN AUTOPILOT DESIGN METHODOLOGY FOR BANK-TO-TURN MISSILES Interim Report, Mar. 1988 - Apr. 1989
ROGER L. SMITH Aug. 1989 108 p
(AD-A213379; AD-E801979; AFATL-TR-89-49) Avail: NTIS HC A06/MF A01 CSCL 16/2

Complete use of the multiinput/multioutput (MIMO) capability of modern control theory is utilized by employing a 3-axis, fully coupled autopilot design for the extended medium range air-to-air technology (EMRAAT) airframe. With the exception of the drag equation, all nonlinear dynamics (including coriolis and gyroscopic terms) are retained prior to model linearization. Discrete linear quadratic regulator theory is used for controller designs. Gain scheduling is addressed in a stochastic manner allowing large random parametric variations in missile roll, pitch, yaw rates, angle-of-attack, and sideslip. This is in contrast to most modern methodologies which in spite of the MIMO capability of modern control separate one axis from the other two (either roll from yaw/pitch or pitch from yaw/roll) in a decoupled design strategy. GRA

N90-13400# Cranfield Inst. of Tech., Bedford (England). College of Aeronautics.
ON THE APPLICATION OF MODIFIED STEPWISE REGRESSION FOR THE ESTIMATION OF AIRCRAFT STABILITY AND CONTROL PARAMETERS Quarterly Report No. 2, Jan. - Apr. 1989
H. A. HINDS and M. V. COOK Apr. 1989 48 p
(Contract MOD-2082/192)
(REPT-8905; ISBN-1-871315-03-4; ETN-90-95932) Avail: NTIS HC A03/MF A01

Progress made during the quarter Jan. to Apr. 1989 on research into a modified stepwise regression method for estimating the stability and control derivatives of a British Aerospace Hawk aircraft, from data obtained by use of a scaled model on a dynamic wind tunnel test rig, is discussed. The objectives are described and the program status is reported as running on schedule. Future objectives are outlined. ESA

N90-14239 ESDU International Ltd., London (England).
HINGE MOMENT COEFFICIENT DERIVATIVES FOR TRAILING-EDGE CONTROLS ON WINGS AT SUBSONIC SPEEDS
Jul. 1989 20 p Supersedes ESDU-Aero-C.04.01.05 and ESDU-Aero-C.04.01.00
(ESDU-89009; ESDU-AERO-C.04.01.05; ESDU-AERO-C.04.01.00; ISBN-0-85679-680-8; ISSN-0141-397X) Avail: ESDU

This Data Item 89009, an addition to the Aerodynamic Subseries, provides a prediction method for full span and part span sealed controls that can also be used for elevators and rudders. Data for two-dimensional flow, assumed constant over the span of the control, are corrected for induced angle of attack and induced camber on the basis of lifting surface theory, and Prandtl-Glauert laws similarity are used to correct for

compressibility. The part span correction for controls extending spanwise from any station to near the tip is empirical. Sketches compare predictions by the method with experimental data extracted from the literature and show the derivative with deflection within 0.05 per radian. The range of geometrics used in developing the method included wing aspect ratios of 2 to 8, half chord sweeps up to 50 degrees and thickness/chord ratio of 0.06 to 0.14. The two-dimensional data, including if required the effect of either nose or Irving internal balance, are available in other ESDU documents in the Subseries. A worked example illustrates the use of the method. ESDU

N90-14240 ESDU International Ltd., London (England).
EXAMPLE OF PROCEDURE IN CALCULATION OF CONTROL HINGE MOMENTS
Aug. 1989 19 p Supersedes ESDU-Aero-C.04.01.09
(ESDU-89010; ESDU-AERO-C.04.01.09; ISBN-0-85679-681-6; ISSN-0141-397X) Avail: ESDU

This Data Item 89010, an addition to the Aerodynamic Subseries, gives calculation sheets for estimating hinge moment coefficients for trailing-edge controls on a wing, tailplane, or fin. Values to be entered on the sheets can be extracted from other ESDU documents in the Subseries, and the calculation is divided into four steps. The first sheet gives the routine for the two-dimensional characteristics, which may include the effect of a nose or an Irving internal balance. The next sheet deals with establishing the three-dimensional values of the derivatives using the values from the first sheet. The third sheet calculates the increment to the derivatives from a horn balance and the last sheet provides the procedure for treating the effect of a tab. A worked example illustrates the use of the calculation procedures. ESDU

N90-14242 Georgia Inst. of Tech., Atlanta.
A HELICOPTER FLIGHT PATH CONTROLLER DESIGN VIA A NONLINEAR TRANSFORMATION TECHNIQUE Ph.D. Thesis
MICHAEL WILLIAM HEIGES 1989 248 p
Avail: Univ. Microfilms Order No. DA8919742

Helicopters are highly nonlinear systems to control. They require significant pilot effort in elaborate stability augmentation systems. Current generation flight control systems are synthesized based on approximate linearized models of the aircraft. As a result, gain scheduling must be used to accommodate changes in the dynamic behavior as a flight regime changes. To overcome this difficulty, nonlinear transformation theory is used to develop a controller that gives the desired response in all flight modes. Additionally, singular perturbation theory is employed to simplify the transformation process. Simulations are conducted to evaluate the performance of the controller and its sensitivity to plant parameter uncertainty. Dissert. Abstr.

N90-14243*# Old Dominion Univ., Norfolk, VA. Dept. of Electrical and Computer Engineering.
GUIDANCE AND CONTROL STRATEGIES FOR AEROSPACE VEHICLES Progress Report, 1 Jul. - 31 Dec. 1989
J. L. HIBEY, D. S. NAIDU, and C. D. CHARALAMBOUS Dec. 1989 100 p
(Contract NAG1-736)
(NASA-CR-186195; NAS 1.26:186195) Avail: NTIS HC A05/MF A01 CSCL 01/3

A neighboring optimal guidance scheme was devised for a nonlinear dynamic system with stochastic inputs and perfect measurements as applicable to fuel optimal control of an aeroassisted orbital transfer vehicle. For the deterministic nonlinear dynamic system describing the atmospheric maneuver, a nominal trajectory was determined. Then, a neighboring, optimal guidance scheme was obtained for open loop and closed loop control configurations. Taking modelling uncertainties into account, a linear, stochastic, neighboring optimal guidance scheme was devised. Finally, the optimal trajectory was approximated as the sum of the deterministic nominal trajectory and the stochastic neighboring optimal solution. Numerical results are presented for a typical vehicle. A fuel-optimal control problem in aeroassisted noncoplanar orbital transfer is also addressed. The equations of motion for the atmospheric maneuver are nonlinear and the optimal (nominal) trajectory and control are obtained. In order to follow the nominal trajectory under actual conditions, a neighboring optimum guidance scheme is designed using linear quadratic regulator theory for onboard real-time implementation. One of the state variables is used as the independent variable in reference to the time. The weighting matrices in the performance index are chosen by a combination of a heuristic method and an optimal modal approach. The necessary feedback control law is obtained in order to minimize the deviations from the nominal conditions. Author

09

RESEARCH AND SUPPORT FACILITIES (AIR)

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

A90-16855#
ANALYSIS METHODS OF TIE-DOWN LOADS AND AIRFRAME STRESS FOR SHIPBOARD-HELICOPTERS
SHULING SUN, SHILIN TIAN, and LAN HUANG (Chinese Helicopter Research and Development Institute, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 10, Oct. 1989, p. B489-B494. In Chinese, with abstract in English. refs

The tie-down of shipboard-helicopters is a key problem which concerns the link between the shipboard-system and the helicopter-system. The features of tie-down are moving base, carrying ability in one direction of tie-down equipment, and the nonlinear relation of landing gear load-displacement. Loads of tie-down equipment and the stress of the helicopter airframe are calculated. Author

A90-17346
CRYOGENIC WIND TUNNELS
HIDEO SAWADA Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 35, June 1987, p. 285-293. In Japanese, with abstract in English. refs
Copyright

The paper describes the 0.1 x 0.1 m transonic cryogenic wind tunnel at the Japanese National Aerospace Laboratory. It describes the fully automatic control system implemented using a microcomputer. It also decribes a heated external balance successfully used in tests with the tunnel at cryogenic conditions. Author

A90-17413
BOEING TRANSONIC WINDBLAST GENERATOR SYSTEM (BTWGS)
W. M. STERRY and ROBERT J. MONDRZYK (Boeing Environmental Test Laboratories, Seattle, WA) IN: Annual SAFE Symposium, 26th, Las Vegas, NV, Dec. 5-8, 1988, Proceedings. Newhall, CA, SAFE Association, 1989, p. 113-121.
Copyright

The recently developed Boeing Transonic Windblast Generator System is a Ludwieg tube-type system capable of generating short-duration windblast velocities to 700 knots equivalent air speed. It was designed for simulating the windblast effects on crew escape and life support systems under ejection conditions. The system consists of a 4-ft diameter supply tube which can be configured up to 300 ft long and pressurized to 400 psi. Burst diaphragms control the flow into a plenum chamber which contains a stilling section, flow straightening tubes, and screens to reduce turbulence prior to expansion through an exhaust nozzle. Nozzles with 18 and 60 sq ft of area are available for testing at different velocities. Tests with dry nitrogen as the test gas have shown no vapor condensation in the core flow to restrict visibility during

testing. Capabilities of ancillary data acquisition system and peripheral equipment are described. Representative velocity-time and velocity-distance profiles obtained with the high speed nozzle are presented. Author

A90-17426
A DESCRIPTION OF THE NAVAL AIR DEVELOPMENT CENTER'S EJECTION TOWER AND CRASH TEST FACILITIES AND THEIR USES
J. D. GLATZ (U.S. Navy, Naval Air Development Center, Warminster, PA) IN: Annual SAFE Symposium, 26th, Las Vegas, NV, Dec. 5-8, 1988, Proceedings. Newhall, CA, SAFE Association, 1989, p. 200-204.
Copyright

The design and development of Aviation Life Support Equipment (ALSE) relies heavily on early test and evaluation to verify that a design approach is feasible. This paper describes the performance capabilities of the Naval Air Development Center's (NADC) Ejection Tower and Crash Test Facilities, and examines the role of these unique facilities in the design/development process of ALSE. These facilities, intended to simulate the operational initial ejection and mishap (crash) environment, must be able to: produce accurate, repeatable acceleration-time profiles; record transient data with a state-of-the-art instrumentation/data acquisition system; and replicate aircrew inertial response using bio-fidelic test dummies. They give the NADC ALSE design engineer the opportunity to assess new technology through in-house experiments that simulate operational conditions. Author

A90-17431
WATER TEST FACILITIES FOR AVIATION LIFE SUPPORT EQUIPMENT
WILLIAM A. MAWHINNEY (U.S. Navy, Naval Air Development Center, Warminster, PA) IN: Annual SAFE Symposium, 26th, Las Vegas, NV, Dec. 5-8, 1988, Proceedings. Newhall, CA, SAFE Association, 1989, p. 250-255.
Copyright

A variety of Naval Air Development Center water test facilities for the research, development, test and evaluation (RDT&E) of aviation life support equipment are described. At the Warminster facilities in Pensylvania, Navy aircraft fly over-water missions, and R&D tests are conducted on systems to support those missions and life support equipment to enhance aircrew survival in an open-ocean environment. About 9 miles from Warminster is the Oreland water test facility with a floating barge laboratory and a nearby 300 x 700 x 65 feet deep water lake, suitable for water deployment or water impact testing. The land-based and sea-going facilities at both Key West, Florida and St. Croix, Virgin Islands support RDT&E activity in an operational environment. C.E.

A90-19012
FUTURE TEST RIGS
A. CADIOU (ONERA, Chatillon-sous-Bagneux, France) IN: Instrumentation for combustion and flow in engines; Proceedings of the NATO Advanced Study Institute, Vimeiro, Portugal, Sept. 13-26, 1987. Dordrecht, Kluwer Academic Publishers, 1989, p. 215-226.
Copyright

An account is given of a novel, highly automated gas turbine combustor test rig devised by ONERA researchers for testing of an advanced unducted fan engine's combustion chamber design. The automation of the test apparatus and its instrumentation not only allows experimental design to be simplified, but opens onto the possibility of securing identical experimental conditions over entire series of tests; this may prove extremely important in comparative performance studies of different combustor/fuel injector configurations. The enabling factor for the automation employed is the extremely accurate regulation of flows made possible by the air and kerosene feed valves used. O.C.

A90-19629*# San Diego State Univ., CA.
APPLICATION OF PANEL METHODS TO WIND-TUNNEL WALL INTERFERENCE CORRECTIONS
LINDSEY BROWNE (San Diego State University, CA) and JOSEPH KATZ AIAA, Aerospace Sciences Meeting, 28th, Reno, NV, Jan. 8-11, 1990. 8 p. refs
(Contract NCC2-458)
(AIAA PAPER 90-0007)

Wind-tunnel wall interference effects were estimated using numerical solutions capable of computing the flow field over complex three-dimensional bodies. This approach was then tested by applying it to two typical wind tunnel experiments involving a high-lift wing and a fighter airplane model. In both cases, the static pressure signature along the test section walls was measured and computed for additional validation. The wind-tunnel wall correction method described here, which inherently includes effects of lift and blockage, provides more details than previous semiempirical methods. V.L.

A90-19675#
DEVELOPMENT OF THE UTA HYPERSONIC SHOCK TUNNEL
W. S. STUESSY, R. G. MURTUGUDDE, F. K. LU, and D. R. WILSON (Texas, University, Arlington) AIAA, Aerospace Sciences Meeting, 28th, Reno, NV, Jan. 8-11, 1990. 15 p. refs
(AIAA PAPER 90-0080) Copyright

The development of a new hypersonic shock tunnel facility at the Aerodynamics Research Center of the University of Texas at Arlington is described in this paper. The shock tunnel employs a 400 atm (6000 psi) helium-air shock tube driver operated in the reflected mode, and is capable of simulating hypersonic flight at Mach numbers ranging from 5 to 16. The operational theory, test facility development and estimated facility performance are presented, together with test results from the initial facility calibration at Mach 8. Author

A90-19728*# Tennessee Univ., Tullahoma.
INVESTIGATION OF ADAPTIVE-WALL WIND TUNNELS WITH TWO MEASURED INTERFACES
C. F. LO and S. J. WANG (Tennessee, University, Tullahoma) AIAA, Aerospace Sciences Meeting, 28th, Reno, NV, Jan. 8-11, 1990. 11 p. refs
(Contract NAG2-551)
(AIAA PAPER 90-0186) Copyright

An adaptive wall wind tunnel with two measured interfaces has been studied using two interface static pressure measurements near the tunnel walls. An iterative procedure with static pressure measurements on two interfaces is described. The functional relationships of static pressure on two measured interfaces for the exterior region are presented. The convergence of the selected iterative procedure is proved analytically. The one-step convergence formulae are obtained and validated by the simulation of a numerical wind tunnel. Experimental investigation has been conducted with a two-dimensional airfoil model of NASA 0012 at a supercritical Mach number. The results have indicated that the selected procedure is feasible to speed up the flow convergence to the unconfined condition in applying the one-step convergence formulae. Author

N90-13401*# Tennessee Univ., Tullahoma. Center for Aerospace Research.
A WALL INTERFERENCE ASSESSMENT/CORRECTION INTERFACE MEASUREMENT SYSTEM FOR THE NASA/ARC 12-FT PWT Final Report
31 Jul. 1989 44 p
(Contract NAG2-551)
(NASA-CR-185474; NAS 1.26:185474) Avail: NTIS HC A03/MF A01 CSCL 14/2

Development of complex air vehicle configurations is placing increasing demands on wind tunnel testing capabilities. A major area of concern is wall induced interference. Recent developments in wall interference technology provide a means for assessing and correcting for the wall induced interference using information contained in the distribution of flow variables measured at, or near, the wall. The restoration of the NASA-ARC 12-ft pressure wind tunnel (PWT) provides an opportunity to incorporate a measurement system with which wall interference

assessment/correction (WIAC) technology can be applied. In this first phase of the development of a WIAC system for the PWT, the design criteria for the placement and the geometry of wall static pressure orifices were determined with a three step approach. First, the operational environment of the PWT was analyzed as to the requirements for the WIAC system. Second, appropriate wall interference theories were evaluated against the requirements determined from the operational environment. Third, the flow about representative models in the PWT was calculated and, specifically, the pressure signatures at the location of the test section wall were obtained. The number of discrete pressure measurements and their locations were determined by curve fitting the pressure distribution through the discrete measurements and evaluating the resulting error. K.C.D.

N90-13402# Army Tank-Automotive Command, Warren, MI.
USER'S MANUAL FOR THE RIDE MOTION SIMULATOR Final Report, Sep. 1988 - Aug. 1989
ALEXANDER A. REID Aug. 1989 119 p
(AD-A212855; TACOM-TR-13464) Avail: NTIS HC A06/MF A01 CSCL 13/6

This report presents a complete user's manual for the Ride Motion Simulator (RMS). The report details the system description, hazard controls, facility configuration and maintenance, standard operating procedures and proficiency of operator's criteria. This report contains the following information: a physical description of the simulator with emphasis upon the safety features; and a description of system operation including safety procedures. The RMS is a four degree of freedom simulator capable of recreating the ride of any army vehicle. GRA

N90-13403*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
A VAPOR GENERATOR FOR TRANSONIC FLOW VISUALIZATION
ROBERT A. BRUCE, ROBERT W. HESS, and JOSE A. RIVERA, JR. Oct. 1989 19 p
(NASA-TM-101670; NAS 1.15:101670) Avail: NTIS HC A03/MF A01 CSCL 14/2

A vapor generator was developed for use in the NASA Langley Transonic Dynamics Tunnel (TDT). Propylene glycol was used as the vapor material. The vapor generator system was evaluated in a laboratory setting and then used in the TDT as part of a laser light sheet flow visualization system. The vapor generator provided satisfactory seeding of the air flow with visible condensate particles, smoke, for tests ranging from low subsonic through transonic speeds for tunnel total pressures from atmospheric pressure down to less than 0.1 atmospheric pressure. Author

N90-13404*# Thiokol Corp., Brigham City, UT. Space Operations.
SYSTEMS TUNNEL LINEAR SHAPED CHARGE LIGHTNING STRIKE Final Test Report
M. COOK Aug. 1989 26 p
(Contract NAS8-30490)
(NASA-CR-183832; NAS 1.26:183832; TWR-19872) Avail: NTIS HC A03/MF A01 CSCL 14/2

Simulated lightning strike testing of the systems tunnel linear shaped charge (LSC) was performed at the Thiokol Lightning Test Complex in Wendover, Utah, on 23 Jun. 1989. The test article consisted of a 160-in. section of the LSC enclosed within a section of the systems tunnel. The systems tunnel was bonded to a section of a solid rocket motor case. All test article components were full scale. The systems tunnel cover of the test article was subjected to three discharges (each discharge was over a different grounding strap) from the high-current generator. The LSC did not detonate. All three grounding straps debonded and violently struck the LSC through the openings in the systems tunnel floor plates. The LSC copper surface was discolored around the areas of grounding strap impact, and arcing occurred at the LSC clamps and LSC ends. This test verified that the present flight configuration of the redesigned solid rocket motor systems tunnel, when subjected to simulated lightning strikes with peak current levels within 71 percent of the worst-case lightning strike condition of NSTS-07636, is adequate to prevent LSC ignition. It is therefore recommended that the design remain unchanged. Author

N90-13406 Georgia Inst. of Tech., Atlanta.
DYNAMIC TESTING TECHNIQUES AND APPLICATIONS FOR AN AEROELASTIC ROTOR TEST FACILITY Ph.D. Thesis
MOSTAFA HASHEMI-KIA 1988 319 p
Avail: Univ. Microfilms Order No. DA8916156

A package is produced which provides operational capabilities for the new Georgia Tech Aeroelastic Rotor Test Facility. This package is constructed in a manner such that it: (1) provides sufficient and accurate calibration data for all the facility components that can be used for current and future applications; (2) illustrates test procedures for various dynamic tests for a variety of controlled test conditions; (3) validates test procedures by performing dynamic tests on a scaled model rotor; and (4) complements the experimental data by performing correlations with an analytical model. Various analytical tools and experimental test setups are used to calibrate and make major changes in the loop gain setting of the hydraulic actuator-servo systems to satisfy the test requirements. Different procedures are used to calibrate the data acquisition path, swashplate, and the rotor system. Test procedures for four types of dynamic tests are developed. These test procedures are checked through experiments on a scale model rotor. Extensive analysis and tests are performed to determine both the theoretical and experimental natural frequencies, mode shapes, and dampings of the rotor test stand. Dissert. Abstr.

N90-13407*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
A TWO-DIMENSIONAL ADAPTIVE-WALL TEST SECTION WITH VENTILATED WALLS IN THE AMES 2- BY 2-FOOT TRANSONIC WIND TUNNEL
EDWARD T. SCHAIRER, GEORGE LEE, and T. KEVIN MCDEVITT (Complere, Inc., Palo Alto, CA.) Aug. 1989 59 p
(NASA-TM-102207; A-89195; NAS 1.15:102207) Avail: NTIS HC A04/MF A01 CSCL 14/2

The first tests conducted in the adaptive-wall test section of the Ames Research Center's 2- by 2-Foot Transonic Wind Tunnel are described. A procedure was demonstrated for reducing wall interference in transonic flow past a two-dimensional airfoil by actively controlling flow through the slotted walls of the test section. Flow through the walls was controlled by adjusting pressures in compartments of plenums above and below the test section. Wall interference was assessed by measuring (with a laser velocimeter) velocity distributions along a contour surrounding the model, and then checking those measurements for their compatibility with free-air far-field boundary conditions. Plenum pressures for minimum wall interference were determined from empirical influence coefficients. An NACA 0012 airfoil was tested at angles of attach of 0 and 2, and at Mach numbers between 0.70 and 0.85. In all cases the wall-setting procedure greatly reduced wall interference. Wall interference, however, was never completely eliminated, primarily because the effect of plenum pressure changes on the velocities along the contour could not be accurately predicted. Author

N90-13408# Royal Aircraft Establishment, Farnborough (England).
HELICOPTER ROTOR TEST RIG (ROTEST) IN DNW: APPLICATION AND RESULTS
H.-J. LANGER, G. BRAUN, B. JUNKER, R. W. QUARTERMAINE, ed., and R. J. MARSHALL, ed. Feb. 1989 18 p Transl. into ENGLISH from DGLR, Jahrestagung, Bonn, West Germany, 30 Sep. - 2 Oct. 1985 Original language document was announced in IAA as A86-35166
(RAE-TRANS-2171; BR112013; DGLR-PAPER-85-113) Avail: NTIS HC A03/MF A01

The model standardization and functioning of the helicopter test installation RoTeSt in DNW is discussed. The choice of standardization factors for the different aspects of the installation is addressed, and a block diagram of the installation signal flow

is given. Tests conducted on various rotors in the installation's wind tunnel are reviewed, showing results on the relation between model rotor operation points and flight states, on the derivative of the longitudinal angle of control as a function of velocity, on correction values for rotor angle of attack for various measuring section configurations and mast angles of inclination, and on the effect of tunnel temperature on the rotor thrust for constant rotational speed. Comparison results for various rotors are given, including accelerations, dynamic momentum behavior, and measurements of downwash. IAA

N90-13409# Loughborough Univ. of Technology (England). Dept. of Transport Technology.
AIRCRAFT/AIRPORT COMPATIBILITY: SOME STRATEGIC, TACTICAL, AND OPERATIONAL ISSUES
ROBERT CAVES Jun. 1989 28 p Presented at the 3rd National Seminar on Airports and Air Transport, Sao Jose dos Campos, Brazil, 26-28 Apr. 1989
(TT-8902; ISBN-0-904947-14-9; ETN-90-95935) Copyright
Avail: NTIS HC A03/MF A01

Strategic and operational aspects of the relationship between aircraft and airports are examined. Strategically, historic difficulties in achieving compatibility are discussed and careful attention to controlling the use of ever larger aircraft is suggested. Further potential in vertical and short takeoff and landing aircraft, for solving the long term pressures of system capacity, total system cost, noise and safety, is proposed. Operationally, runway safety, accommodating larger aircraft and apron space efficiency, are highlighted. Minimization of problems of both airside geometry and apron space efficiency are proposed by development of aircraft with high ratios of payload to span. ESA

N90-13410# Technische Univ., Delft (Netherlands). Dept. of Aerospace Engineering.
MATHEMATICAL MODEL IDENTIFICATION FOR FLIGHT SIMULATION, BASED ON FLIGHT AND TAXI TESTS
M. BAARSPUL, J. A. MULDER, A. H. M. NIEUWPOORT, and J. H. BREEMAN Feb. 1989 33 p Presented at the International Conference on Flight Simulation: Recent Developments in Technology and Use, London, England, 12-13 Apr. 1988 Previously announced in IAA as A89-48833
(LR-550; ETN-90-95993) Avail: NTIS HC A03/MF A01

Tasks carried out to develop the mathematical model and data package for the Citation 500 full flight simulator are described. The a priori models of the aerodynamics, engines, mass properties, flight control system and landing gear are outlined. The high accuracy measurement system and the flight test program are discussed. The data analysis and mathematical model development are described using the aerodynamic lift coefficient as an example. Offline and online flight simulation used for model evaluation are discussed and model validation is described with some results outlined. ESA

N90-14244*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
CRYOGENIC TEMPERATURE EFFECTS ON STING-BALANCE DEFLECTIONS IN THE NATIONAL TRANSONIC FACILITY
THOMAS G. POPERNACK, JR. and JERRY B. ADCOCK Jan. 1990 12 p
(NASA-TM-4157; L-16626; NAS 1.15:4157) Avail: NTIS HC A03/MF A01 CSCL 14/2

An investigation was conducted at the National Transonic Facility (NTF) to document the change in sting-balance deflections from ambient to cryogenic temperatures. Space limitations in some NTF models do not allow the use of on-board angle of attack instrumentation. In order to obtain angle of attack data, pre-determined sting-balance bending data must be combined with arc sector angle measurements. Presently, obtaining pretest sting-balance data requires several cryogenic cycles and cold loadings over a period of several days. A method of reducing the calibration time required is to obtain only ambient temperature sting-balance bending data and correct for changes in material properties at cryogenic temperatures. To validate this method, two typical NTF sting-balance combinations were tested. The test results show excellent agreement with the predicted values and the repeatability of the data was 0.01 degree. Author

N90-14245*# Southampton Univ. (England).
TECHNIQUES FOR EXTREME ATTITUDE SUSPENSION OF A WIND TUNNEL MODEL IN A MAGNETIC SUSPENSION AND BALANCE SYSTEM Ph.D. Thesis
DAVID HUW PARKER Oct. 1989 274 p
(Contract NSG-7523)
(NASA-CR-181895; NAS 1.26:181895) Avail: NTIS HC A12/MF A02 CSCL 14/2

Although small scale magnetic suspension and balance systems (MSBSs) for wind tunnel use have been in existence for many years, they have not found general application in the production testing of flight vehicles. One reason for this is thought to lie in the relatively limited range of attitudes over which a wind tunnel model may be suspended. Modifications to a small MSBS to permit the suspension and control of axisymmetric models over angles of attack from less than zero to over ninety degrees are reported. Previous work has shown that existing arrangement of ten electromagnets was unable to generate one of the force components needed for control at extreme attitudes. Examination of possible solutions resulted in a simple alteration to rectify this deficiency. To generate the feedback signals to control the suspended model, an optical position sensing system using collimated laser beams and photodiode arrays was installed and tested. An analytical basis was developed for distributing the demands for force and moment needed for model stabilization amonge the electromagnets over the full attitude range. This was implemented by an MSBS control program able to continually adjust the distribution for the instantaneous incidence in accordance with prescheduled data. Results presented demonstrate rotations of models from zero to ninety degrees at rates up to ninety degrees per second, with pitching rates rising to several hundred degrees per second in response to step-change demands. A study of a design for a large MSBS suggests that such a system could be given the capability to control a model in six degrees of freedom over an unlimited angle of attack range. Author

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ASTRONAUTICS

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

A90-17003
MAVIS FLIGHT LOAD SIMULATION
O. BRUNNER (ESTEC, Noordwijk, Netherlands) and K. ECKHARD (MBB-ERNO Raumfahrttechnik GmbH, Bremen, Federal Republic of Germany) IN: International Modal Analysis Conference, 7th, Las Vegas, NV, Jan. 30-Feb. 2, 1989, Proceedings. Volume 2. Bethel, CT, Society for Experimental Mechanics, Inc., 1989, p. 757-764.
Copyright

Test facilities for simulation of earthquake excitations provide useful capabilities for spacecraft transient testing. The Multi Axis Vibration System (MAVIS) operates with a 6-DOF base motion of a hydraulic exciter system. A test fixture has been designed to simulate Shuttle bay payload interfaces. An actuator and control system are provided for the realization of tests with redundant interface forces when performing multi axis dynamic tests on Shuttle payloads. Control loop optimization and safety provisions have been considered. Tests have been performed with a Spacelab Pallet. A transient load is introduced on the platform in three translational directions, and additional transient loads are

introduced on the redundant interface. Other tests performed include the test facility upgraded to three translational and three rotational freedoms. C.E.

A90-19938#
AERODYNAMIC CONTROL OF NASP-TYPE VEHICLES THROUGH VORTEX MANIPULATION
T. T. NG (Eidetics International, Inc., Torrance, CA) AIAA, Aerospace Sciences Meeting, 28th, Reno, NV, Jan. 8-11, 1990. 13 p. refs
(AIAA PAPER 90-0594) Copyright

The flow around a NASP-type configuration was studied using water tunnel flow visualization. The naturally occurring forebody vortex asymmetry can cause asymmetry in the wing vortices. A control technique based on manipulating the vortices by blowing was investigated. For control of the wing vortices aft blowing was found to be effective in delaying breakdown on the wing. Forward blowing can induce a local vortex breakdown. Blowing was found to be very effective in controlling the forebody vortices. Author

N90-14268*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
SLUSH HYDROGEN (SLH2) TECHNOLOGY DEVELOPMENT FOR APPLICATION TO THE NATIONAL AEROSPACE PLANE (NASP)
RICHARD L. DEWITT, TERRY L. HARDY, MARGARET V. WHALEN, and G. PAUL RICHTER Jul. 1989 19 p Presented at the Cryogenic Engineering Conference, Los Angeles, CA, 24-28 Jul. 1989; sponsored by the California Univ. at Los Angeles
(NASA-TM-102315; E-5001; NAS 1.15:102315) Avail: NTIS HC A03/MF A01 CSCL 22/2

The National Aerospace Plane (NASP) program is giving us the opportunity to reach new unique answers in a number of engineering categories. The answers are considered enhancing technology or enabling technology. Airframe materials and densified propellants are examples of enabling technology. The National Aeronautics and Space Administration's Lewis Research Center has the task of providing the technology data which will be used as the basis to decide if slush hydrogen (SLH2) will be the fuel of choice for the NASP. The objectives of this NASA Lewis program are: (1) to provide, where possible, verified numerical models of fluid production, storage, transfer, and feed systems, and (2) to provide verified design criteria for other engineered aspects of SLH2 systems germane to a NASP. This program is a multiyear multimillion dollar effort. The present pursuit of the above listed objectives is multidimensional, covers a range of problem areas, works these to different levels of depth, and takes advantage of the resources available in private industry, academia, and the U.S. Government. The NASA Lewis overall program plan is summarized. The initial implementation of the plan will be unfolded and the present level of efforts in each of the resource areas will be discussed. Results already in hand will be pointed out. A description of additionally planned near-term experimental and analytical work is described. Author

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CHEMISTRY AND MATERIALS

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

A90-17281
EFFECT OF PRESSURE AND TEMPERATURE ON RESIDUE FORMATION IN AVIATION KEROSENES [VLIIANIE DAVLENIIA I TEMPERATURY NA OBRAZOVANIE OSADKOV V AVIATSIONNYKH KEROSINAKH]
V. A. ASTAF'EV, S. N. KRYLOV, V. G. GORODETSKII, and V. A. GLADKIKH Khimiia i Tekhnologiia Topliv i Masel (ISSN 0023-1169), no. 11, 1989, p. 21, 22. In Russian. refs
Copyright

Results of a study of service conditions on the formation of residue in aviation kerosenes are reported. In particular, it is noted that, under static and dynamic conditions, the amount of residue increases with temperature to a certain point and then decreases, The mechanisms of the extremal temperature dependence of residue formation are examined. Data are also presented on the effect of pressure on thermal oxidation stability of aviation kerosenes. V.L.

A90-17291
LOW-EXPANSION MMCS BOOST AVIONICS
ALAN L. GEIGER and MICHAEL JACKSON (Advanced Composite Materials Corp., Greer, SC) Advanced Materials and Processes (ISSN 0882-7958), vol. 136, July 1989, p. 23, 24, 26, 27, 30.
Copyright

An account is given of the development status and characteristic performance levels of MMCs for aerospace electronic packaging; such hermetically sealed package materials must possess, in addition to low density, controlled coefficient of thermal expansion, good thermal conductivity, and good corrosion resistance. Attention is given to an Al-alloy matrix/SiC/elemental Si composite which can be vacuum hot-pressed to 98 percent of theoretical density with 55-vol pct reinforcement content. Prototype heat sinks, heat pipes, and microcircuit packages fabricated from this material are being evaluated. O.C.

A90-17294* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
TBCS FOR BETTER ENGINE EFFICIENCY
WILLIAM J. BRINDLEY and ROBERT A. MILLER (NASA, Lewis Research Center, Cleveland, OH) Advanced Materials and Processes (ISSN 0882-7958), vol. 136, Aug. 1989, p. 29-33. refs
Copyright

State-of-the-art thermal barrier coatings (TBCs) developed for aircraft engines can achieve both hot-section component operating temperature reductions and superior oxidation resistance. Such TBCs typically consist of two layers: a metallic, often NiCrAlY 'bond' inner layer in contact with the superalloy structural component, and an outer, insulating ceramic layer. A ceramic frequently used in this role due to its high durability is plasma-sprayed ZrO2, partially stabilized with 6-8 wt pct Y2O3. TBCs can also be useful in nonaircraft gas turbines, which frequently use highly contaminated fuels. O.C.

A90-17297
ADVANCED MATERIALS TO FLY HIGH IN NASP
TERENCE M. F. RONALD (USAF, National Aerospace Plane Joint Program Office, Wright-Patterson AFB, OH) Advanced Materials and Processes (ISSN 0882-7958), vol. 135, May 1989, p. 29, 30, 33, 34, 37.
Copyright

The airframe primary structure envisioned for the National Aerospaceplane Program's X-30 hypersonic test vehicle will depart from Space Shuttle Orbiter design practices in being an uninsulated, loadbearing hot structure that is actively cooled by hydrogen fuel to maintain material temperatures within the requisite mechanical-property range. The projected structural design entails high-stiffness, thin-gage feedstocks that can be economically fabricated into loadbearing components. Primary candidate materials are rapidly solidified Ti-aluminide alloys, MMCs based on Ti aluminides, carbon/carbon composites, and CMCs. O.C.

A90-17298
MATERIALS PACE AEROSPACE TECHNOLOGY
J. J. DE LUCCIA, R. E. TRABOCCO, J. WALDMAN (U.S. Navy, Naval Air Development Center, Warminster, PA), and J. F. COLLINS (U.S. Navy, Naval Air Systems Command, Washington, DC) Advanced Materials and Processes (ISSN 0882-7958), vol. 135,

May 1989, p. 39, 40, 43 (3 ff.).
Copyright

Naval aircraft operate in an intensely hostile environment; the marine atmosphere creates severe corrosion problems that are exacerbated by sulfur compounds and other gases emitted by smokestacks and engine exhausts. A characterization of the development status of engine structural materials and of primary and secondary airframe structural materials in naval aircraft use is presented. The first widespread use of graphite/epoxy composites was in the F/A-18; the AV-8B airframe employs 26 wt pct composites, and the V-22 tilt-rotor VTOL has reached a level of 40 wt pct composites. Thermoplastic matrix composites are promising materials for future use. O.C.

A90-17300
ORGANIC COATINGS - FIRST LINE OF DEFENSE
C. R. HEGEDUS, D. F. PULLEY, S. J. SPADAFORA, A. T. ENG, and D. J. HIRST (U.S. Navy, Naval Air Development Center, Warminster, PA) Advanced Materials and Processes (ISSN 0882-7958), vol. 135, May 1989, p. 62-64, 67, 68, 71, 72. refs
Copyright

The standard organic coating system applied to aluminum structures of U.S. Navy aircraft for nearly 20 years consists of an epoxy primer and a polyurethane topcoat; this has a lifetime of 4-6 years. Strontium chromate is the most important of the pigments used, due to its excellent corrosion-inhibition characteristics. Chromates passivate the metal surface through the anodic reaction inhibition function of their ions. Chemically stable titanium dioxide is the main pigment used in white and gray topcoats. Optimum protection against rain erosion is furnished by either clear or pigmented elastomeric tapes. O.C.

A90-17922
THE CASE FOR TITANIUM
IAN PARKER Aerospace Composites and Materials (ISSN 0954-5832), vol. 1, Fall 1989, p. 28-30, 32.
Copyright

The properties of titanium alloys, metallurgy considerations, and alloy classifications are discussed with particular reference to aviation engine and airframe applications. The fact that titanium can be superplastically formed and diffusion bonded and also used in metal matrix composites makes this material particularly useful in aerospace applications. Examples of specific applications of titanium alloys are given, and possible future developments are outlined. V.L.

A90-17924
DEVELOPING ALUMINIUM
GEORGE MARSH Aerospace Composites and Materials (ISSN 0954-5832), vol. 1, Fall 1989, p. 40, 41, 43, 44.
Copyright

Recent developments in aluminum alloys intended for use as a structural material in aerospace applications are briefly reviewed. In particular, attention is given to improvements in conventional aluminum alloys, development of aluminum alloys with a specific set of properties, aluminum-lithium alloys, and improved non-conventional aluminum alloys, such as rapidly quenched and vapor deposited alloys. The discussion also covers hybrid materials, such as aramid aluminum laminates, and the use of aluminum alloys as a composite matrix material. V.L.

A90-17925
SAFER PRIMERS FROM 3M
IAN PARKER Aerospace Composites and Materials (ISSN 0954-5832), vol. 1, Fall 1989, p. 45-49.
Copyright

Three water-thinned primers for aircraft have been developed which are safer to use than the currently used organic solvent thinned primers. In addition, a method is being developed for applying one of these primers by a cathodic electrophoretical process rather than by spraying. This gives better control of the primer coating thickness, avoids air bubbles and other imperfections, reduces the time of application, and makes it possible to coat areas that are not accessible to spraying. Results of tests of the physical properties of the primers are presented. V.L.

A90-17962
A NEW GENERATION OF INNOVATIVE ULTRA-ADVANCED INTELLIGENT COMPOSITE MATERIALS FEATURING ELECTRO-RHEOLOGICAL FLUIDS - AN EXPERIMENTAL INVESTIGATION
M. V. GANDHI, B. S. THOMPSON (Michigan State University, East Lansing), and S. B. CHOI Journal of Composite Materials (ISSN 0021-9983), vol. 23, Dec. 1989, p. 1232-1255. Research supported by the Michigan State Department of Commerce. refs
(Contract DAAL03-88-K-0163)
Copyright

A new generation of revolutionary, intelligent, ultra-advanced composite materials featuring electro-rheological fluids is proposed herein for the active continuum vibrational control of structural and mechanical systems. This paper reports on a pioneering proof-of-concept experimental investigation focused on evaluating the static and elastodynamic transient response characteristics of cantilevered beams fabricated in this new class of materials. The results of this investigation clearly demonstrate for the first time the ability to dramatically change the vibrational characteristics of beam-like specimens fabricated in ultra-advanced composite materials by changing the electrical field imposed on the fluid. The capability of these materials to interface with modern solid-state electronics can be exploited by extending the fundamental phenomenological work presented herein by the successful incorporation of intelligent sensor technologies and modern control strategies in order to significantly accelerate the evolution of this innovative class of multi-functional, dynamically-tunable, ultra-advanced, intelligent composite materials for military, aerospace, advanced manufacturing applications. Author

A90-18603#
APPLICATION INVESTIGATION ON SUPERPLASTIC FORMING/DIFFUSION BONDING COMBINED TECHNOLOGY OF TITANIUM ALLOY TC4
BAOREN WANG and WENHAI JI (Beijing Aeronautical Manufacturing Technology Research Institute, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 10, June 1989, p. B309-B314. In Chinese, with abstract in English. refs

This paper briefly introduces the practicability of superplastic forming/diffusion bonding (SPF/DB) of TC4 (Ti-6Al-4V) titanium alloy sheet and the effect of the main processing factors, such as forming temperature, compression rate, pressure and holding time, on SPF and SPF/DB. The processing condition for some airframes and loading doors are described, and reasonable processing parameters and procedures are provided. The problems of blowing bulging input gas, high-temperature protection, and mold unloading of parts and their solutions, are provided. Test results show that obvious technical and economic benefit can be obtained. Author

A90-19006
COMBUSTION OSCILLATIONS IN DUCTS
S. SIVASEGARAM and J. H. WHITELAW (Imperial College of Science, Technology, and Medicine, London, England) IN: Instrumentation for combustion and flow in engines; Proceedings of the NATO Advanced Study Institute, Vimeiro, Portugal, Sept. 13-26, 1987. Dordrecht, Kluwer Academic Publishers, 1989, p. 45-54. refs
(Contract N00014-84-G-0185)
Copyright

A series of measurements has been carried out with ducted flames and has quantified the relative importance of longitudinal-acoustic, Helmholtz and aerodynamic-shedding oscillations. The paper reviews the results and discusses their implications for ram-jets and thrust augmentors. Author

A90-19149* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
ANALYSIS OF WHISKER-TOUGHENED CERAMIC COMPONENTS - A DESIGN ENGINEER'S VIEWPOINT
STEPHEN F. DUFFY, JANE M. MANDERSCHEID, and JOSEPH L. PALKO (NASA, Lewis Research Center; Cleveland State University, OH) American Ceramic Society Bulletin (ISSN 0002-7812), vol. 68, Dec. 1989, p. 2078-2083. refs
Copyright

The analysis of components fabricated from whisker-toughened ceramic matrix composites requires a departure from the 'factor-of-safety' design philosophy prevalent in the design of metallic structural component, which are more tolerant of flaws. A public-domain computer algorithm has been developed which, in conjunction with a general-purposed FEM program, can predict the fast-fracture reliability of a structural component under multiaxial loading conditions. The present version of the algorithm, designated 'Toughened Ceramics Analysis and Reliability Evaluation of Structures', accounts for material symmetry imposed by whisker orientation; the processes of crack deflection and crack pinning are also addressed. O.C.

A90-19153* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
OBSERVATIONS ON THE BRITTLE TO DUCTILE TRANSITION TEMPERATURES OF B2 NICKEL ALUMINIDES WITH AND WITHOUT ZIRCONIUM
S. V. RAJ, R. D. NOEBE, and R. BOWMAN (NASA, Lewis Research Center, Cleveland, OH) Scripta Metallurgica (ISSN 0036-9748), vol. 23, Dec. 1989, p. 2049-2054. refs
Copyright

The effect of a zirconium addition (0.05 at. pct) to a stoichiometric NiAl alloy on the brittle-to-ductile transition temperature (BDTT) of this alloy was investigated. Constant velocity tensile tests were conducted to fracture between 300 and 1100 K under initial strain rate 0.00014/sec, and the true stress and true strain values were determined from plots of load vs time after subtracting the elastic strain. The inelastic strain was measured under a traveling microscope. Microstructural characterization of as-extruded and fractured specimens was carried out by SEM and TEM. It was found that, while the addition of 0.05 at. pct Zr strengthened the NiAl alloy, it increased its BDTT; this shift in the BDTT could not be attributed either to variations in grain size or to impurity contents. Little or no room-temperature ductility was observed for either alloy. I.S.

A90-19713#
SIMULTANEOUS CARS MEASUREMENTS OF TEMPERATURE AND H2, H2O CONCENTRATIONS IN HYDROGEN-FUELED SUPERSONIC COMBUSTION
TORGER J. ANDERSON and ALAN C. ECKBRETH (United Technologies Research Center, East Hartford, CT) AIAA, Aerospace Sciences Meeting, 28th, Reno, NV, Jan. 8-11, 1990. 12 p. refs
(Contract F33615-86-C-2695)
(AIAA PAPER 90-0158) Copyright

Coherent anti-Stokes Raman spectroscopy (CARS) has been used to measure H2 and H2O concentrations and N2 temperature simultaneously in an H2-fueled, air-fed supersonic combustor. Profiles of each parameter at selected axial locations were generated by translating the measurement point vertically across the combustor at varying conditions of total temperature and equivalence ratio. The baseline combustor experiment contributes to an understanding of mixing and combustion processes and a data base for refining two-dimensional CFD codes. The combustor, the dual Stokes CARS system, and the techniques employed are described. Sample results and potential improvements are also discussed. Author

A90-19966#
NUMERICAL MODELING OF A FLAME IN A CONFINED, UNSTABLE SHEAR LAYER
LUC BAUWENS (California, University, Berkeley) and JOHN W. DAILY (Colorado, University, Boulder) AIAA, Aerospace Sciences Meeting, 28th, Reno, NV, Jan. 8-11, 1990. 11 p. refs
(AIAA PAPER 90-0647) Copyright

A numerical model of the flow and a flame in a low Mach number experimental ramjet combustor is presented. Boundary conditions correspond to a fixed mass outflow of burnt mixture, through a choked nozzle. The flame is modeled by a sheet algorithm. It allows for advection by the flow field, and burning under a fixed normal propagation speed. The flame representation allows for discontinuities in the flame direction. The flow is dominated by the inlet shear layer instability. For the flow field, a direct simulation is implemented. Results show a strong relationship between the vorticity field and the flame geometry. In the absence of some external forcing, the model does not lead to large-scale combustion instabilities. However, if an external forcing is imposed, the evolution of the numerically determined flame shape reproduces experimental results. Author

N90-13617# Technische Univ., Delft (Netherlands). Dept. of Aerospace Engineering.
REPAIR OF COMPOSITES BY MEANS OF WET-LAY-UP
J. A. KREBBEKX Mar. 1988 52 p
(LR-551; ETN-90-95994) Avail: NTIS HC A04/MF A01

The repair of damaged composites used in airplanes at a reasonable cost is studied. Theoretical aspects of repair such as, types of damage, repair methods, and parameters influencing the optimum wet-lay-up repair, are considered. Practical aspects of reparation, including the sanding of carbon-epoxy laminates and the wet-lay-up of the patches are discussed. A specimen fabrication procedure and forces working therein, and results of testing of undamaged and damaged panels, are described. Comparison of results is given. The results are concluded as being better in reality by a better redistribution of the stresses due to the better dimensions of the part in which the repair is made. ESA

N90-13627# Carnegie-Mellon Univ., Pittsburgh, PA. Intelligent Sensors Lab.
GAS IDENTIFICATION SYSTEM USING GRADED TEMPERATURE SENSOR AND NEURAL NET INTERPRETATION
LANWAI WONG, TOSHIKAZU TAKEMORI, and M. W. SIEGEL Jul. 1989 19 p
(AD-A213359; CMU-RI-TR-89-20) Avail: NTIS HC A03/MF A01 CSCL 13/12

The demand for selectively sensing vapors and gases is keen. For example, it would be valuable to distinguish toxic exhaust gases from fuel vapors and warn of either of these in the passenger compartment of automobiles, boats, and airplanes. Similarly, it is important for a domestic gas leakage detection system to avoid false alarms by differentiating between the odors of alcoholic beverages and the utility gases. An innovative approach is described for enhancing the selectively of an integrated multi-element thick film gas sensor. A temperature gradient maintained along the sensor surface induces spatial sensitivity and selectivity gradients. The response map of the sensor is examined in the vapor of several organic compounds and their binary mixtures. Subtle but recognizable and separable signatures are observed. Emphasis is on identification, since quantitation of identified mixtures is straightforward. An effective and robust classification technique using a neural network trained via the back propagation method is described. GRA

N90-13636*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
THERMAL BARRIER COATINGS FOR GAS TURBINE AND DIESEL ENGINES
ROBERT A. MILLER, WILLIAM J. BRINDLEY, and M. MURRAY BAILEY 1989 9 p Presented at the 11th Workshop on Ceramic Coatings for Wear and Thermal Applications, Edmonton, Alberta, 16-17 Oct. 1989; sponsored by the Canadian Univ.-Industry-Council on Advanced Ceramics
(NASA-TM-102408; E-5160; NAS 1.15:102408) Avail: NTIS HC A02/MF A01 CSCL 11/6

The present state of development of thin thermal barrier coatings for aircraft gas turbine engines and thick thermal barrier coatings for truck diesel engines is assessed. Although current thermal barrier coatings are flying in certain gas turbine engines, additional advances will be needed for future engines. Thick thermal barrier coatings for truck diesel engines have advanced to the point where they are being seriously considered for the next generation of engine. Since coatings for truck engines is a young field of inquiry, continued research and development efforts will be required to help bring this technology to commercialization.
Author

N90-13638# Northwestern Univ., Evanston, IL. Center for Quality Engineering and Failure Prevention.
REFLECTION BY DEFECTIVE DIFFUSION BONDS Interim Report
JAN D. ACHENBACH and YONGLIN XU 15 Aug. 1989 7 p
(Contract N00014-89-J-1362)
(AD-A212995; NU-CENTER-QEFP-1989-3) Avail: NTIS HC A02/MF A01 CSCL 11/6

The reflection of ultrasonic wave motion by planar defect distributions is investigated, with a view towards a method to detect and characterize bond-plane defects and with an ultimate objective of providing information on the bond strength of metal to metal bonds. The primary concern is with an approximate approach to analyze reflection by cavities and cracks which are distributed in a bond plane. The results show some of the characteristic features of reflection with variation of such parameters as angle of incidence, frequency, defect size, defect shape and defect spacing. Metal to metal bonds by the diffusion welding process are becoming more frequently used for the fabrication of complicated parts, such as integrally bladed compressor and turbine rotors in gas turbine engines. Diffusion bonds may, however, have three kinds of defects: volumetric defects (voids, inclusions), crack-like defects, and crystalline grains. GRA

N90-13677# Swedish Defence Research Establishment, Stockholm.
THERMOCHEMICAL CALCULATIONS WITH INERT COMPOUNDS
TORSTEN LILJEGREN Jun. 1989 28 p In SWEDISH; ENGLISH summary
(FOA-C-20759-2.1; ISSN-0347-3694; ETN-90-95523) Avail: NTIS HC A03/MF A01

The combustion of fuel-rich propellants can often be incomplete due to low reaction rate of any component. A method is described to compute the combustion temperature if a component is inert or reacts only partly, whereas equilibrium between the combustion products is assumed. Examples of computations are given: composite propellants with high contents of aluminum; fuel-rich boron propellants for ramjet engines; incomplete combustion of carbon in ramjet engines. The results of such computations are valuable for judgment of the feasibility of efficient combustion and for design of combustion chambers. ESA

N90-14304 Virginia Polytechnic Inst. and State Univ., Blacksburg.
FATIGUE ANALYSIS AND RECONSTRUCTION OF HELICOPTER LOAD SPECTRA Ph.D. Thesis
ABOLHASSAN KHOSROW KHOSROVANEH 1989 163 p
Avail: Univ. Microfilms Order No. DA8913748

Helicopter load histories applied to notched metal samples were taken as examples, and their fatigue lives were predicted by using a simplified version of the local strain approach. This simplified method requires an input load history in the form of the rain-flow matrix and places bounds on the fatigue life. A peak-valley reconstructed history was generated based on the standard spectrum Helix. A second history studied was a more irregular one based on actual flight data. It was used to generate three reconstructed histories based on three principles: peak-valley, to-from, and rain-flow. Emphasis is given to the rain-flow reconstruction method, and different reconstruction methods based on rain-flow cycle counting are presented. Life predictions are presented for all of the above cases, and the comparison with test data and other considerations suggest that the most promising reconstruction approach is one based on rain-flow cycle counting. Finally, a method is presented which reconstructs a history with the same rain-flow cycles and also the same distribution of relative time increments between adjacent peaks and valleys. This reconstructed history gives the same fatigue life as the original history. Dissert. Abstr.

N90-14330# Royal Aircraft Establishment, Farnborough (England). Materials and Structures Dept.
DIFFUSION BONDING OF METALS
P. G. PARTRIDGE *In* AGARD, Superplasticity 29 p Sep. 1989
Copyright Avail: NTIS HC A11/MF A02

The need to reduce the cost and weight of aerospace metallic structures has led to increased interest in solid state and liquid phase diffusion bonding processes, especially in combination with superplastic forming. The bonding mechanisms and bonding techniques are reviewed and the process variables that affect metals. The importance of quality control and the limitations of current NDE techniques for diffusion bonding are emphasized. Finally some trends and priorities in diffusion bonding technology are indicated. Author

N90-14385# Pennsylvania State Univ., University Park. Coll. of Earth and Mineral Sciences.
THERMAL STABILITY OF JET FUEL Quarterly Report No. 3, Apr. - Jun. 1989
S. ESER, J. PERISON, R. M. COPENHAVER, and H. H. SCHOBERT 1989 23 p
(Contract DE-AC22-88PC-88827)
(DE90-001160; DOE/PC-88827/T3) Avail: NTIS HC A03/MF A01

The overall objective of this program is to investigate the effect of chemical components on the thermal stability of jet fuel. Specific objectives include the determination of the high temperature thermal stability of a suite of model compounds typical of those present as trace contaminants in the fuel, investigation of the thermal stability of various fractions of a coal-derived and a petroleum-derived JP-8 jet fuel, the determination of the thermal stability of the unfractionated fuels, and the development of the relationship between the stability of the whole material and the behavior of model compounds of fuel fractions. DOE

12

ENGINEERING

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

A90-16718
A REFINED OPTIMALITY CRITERION TECHNIQUE APPLIED TO AIRCRAFT WING STRUCTURAL DESIGN
INE-WEI LIU and CHIEN-CHANG LIN (National Chunghsing University, Taichung, Republic of China) Computers and Structures (ISSN 0045-7949), vol. 33, no. 2, 1989, p. 427-434. Sponsorship: National Science Council of the Republic of China. refs
(Contract NSC-CS76-0210-D005-01)
Copyright

A technique combining the finite element method, refined optimality criterion method, sensitivity analysis and FORTRAN-77 is used to develop a modular computer program 'ARS 4' (Automatic Resizing System 4) for the optimization of aircraft wing structures subjected to size, stress, displacement, and buckling constraints. The refined optimality criterion technique is an algorithm combining a criterion based on the Kuhn-Tucker conditions and the technique

of fully-stressed design. For the moment, ARS 4 provides truss element, beam element, eight-node isoparametric plate element, constant strain triangular membrane, and quadrilateral membrane (or shear panel element) and uses the 'grouping' technique for the design variables (sizes). Numerical results for a triple-spar wing structure and an aerobatic wing structure demonstrate the efficiency of this technique. Author

A90-16725
FLUTTER ANALYSIS OF COMPOSITE PANELS USING HIGH-PRECISION FINITE ELEMENTS
KUO-JIUN LIN, PONG-JEU LU, and JIANN-QUO TARN (National Cheng Kung University, Tainan, Republic of China) Computers and Structures (ISSN 0045-7949), vol. 33, no. 2, 1989, p. 561-574. Sponsorship: National Science Council of the Republic of China. refs
(Contract NSC-CS77-0210-D006-14)
Copyright

A high-precision 18-DOF triangular thin plate FEM procedure is presented for studying the panel flutter of composite thin plates. Classical lamination theory, together with linearized piston theory, is used to study the effects of aerodynamic damping, boundary constraint, flow orientation, composite filament angle, and orthotropic modulus ratio on the flutter characteristics of both isotropic and composite panels. The numerical results indicate that aerodynamic damping, which enlarges the flutter boundary, is generally beneficial. The panels with stronger structural boundary constraint possess a better capacity to resist flutter instability. Author

A90-16858#
THE DESIGN AND STUDY OF THE INFORMATION TRANSFER MECHANISM FOR A DISTRIBUTED AVIONICS SYSTEM
WEIHONG LONG, JICHANG KANG, ZHAOXUAN HAN, and YI WANG (Northwestern Polytechnical University, Xian, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 10, Oct. 1989, p. B509-B514. In Chinese, with abstract in English. refs

This paper introduces a 1553B-based experimental prototype distributed avionics system, and discusses its related components of the information transfer mechanism, such as the protocol of the bus communication, the communication program and the bus interface unit. After having analyzed the shortcoming of the conventional synchronous bus control strategy, this paper presents a bus control strategy of polling combined with command responses which can raise the efficiency of bus data transfer. Author

A90-16962
MODAL CHARACTERISTICS OF SWEPT PLATE FLUTTER MODELS
G. E. MADDUX and R. M. FRENCH (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) IN: International Modal Analysis Conference, 7th, Las Vegas, NV, Jan. 30-Feb. 2, 1989, Proceedings. Volume 1. Bethel, CT, Society for Experimental Mechanics, Inc., 1989, p. 95-100.
Copyright

This paper presents the results of an experimental study conducted to verify the modal predictive capability of a finite element program called ASTROS which is used to perform flutter analyses. Modal surveys were conducted on a series of flat swept-wing models made of aluminum and steel with sweep angles of 0, 15, 30, 45, and 60 deg. The testing was done using the relatively new techniques of video holography. Author

A90-16979
PRACTICAL SUGGESTIONS FOR MODIFYING MATH MODELS TO CORRELATE WITH ACTUAL MODAL TEST RESULTS
I. U. OJALVO, T. TING, D. PILON (Bridgeport, University, CT), and WILLIAM TWOMEY (Sikorsky Aircraft, Stratford, CT) IN: International Modal Analysis Conference, 7th, Las Vegas, NV, Jan. 30-Feb. 2, 1989, Proceedings. Volume 1. Bethel, CT, Society for Experimental Mechanics, Inc., 1989, p. 347-354. refs
Copyright

A finite-element-based code for modifying math models to obtain improved correlation with modal tests has been under development over the past three years. This paper presents several practical features which have been incorporated into this computer program to facilitate its use with actual modal test data. Results obtained when applying this code to a helicopter-blade physical test data are presented. Author

A90-16986
COMPARISON OF THE ANALYTICAL AND EXPERIMENTAL MODES OF A MODEL AIRPLANE USING FINITE ELEMENT ANALYSIS AND MULTI-REFERENCE TESTING
LES GOLDBERG (Structural Measurement Systems, Inc., Albany, NY) IN: International Modal Analysis Conference, 7th, Las Vegas, NV, Jan. 30-Feb. 2, 1989, Proceedings. Volume 1. Bethel, CT, Society for Experimental Mechanics, Inc., 1989, p. 437-441.
Copyright

A correlation was done on a model airplane between the results of a Finite Element Analysis (FEA) and experimental modal analysis. An all-metal model airplane which was axisymmetric about its fuselage was used to intentionally excite the repeated roots of the structure. Multiple reference Frequency Response Function (FRF) measurements were made on the experimental model to see if the repeated roots could be identified using a polyreference curve fitting technique. The paper discusses the importance of FEA for modal parameter identification and verification, transducer mounting problems, and discrepancies between the analytical and experimental solutions. Author

A90-17009
FLUTTER ANALYSIS ON A NON-LINEAR WING MODEL
FRANCESCA M. CURA and LUIGI GARIBALDI (Torino, Politecnico, Turin, Italy) IN: International Modal Analysis Conference, 7th, Las Vegas, NV, Jan. 30-Feb. 2, 1989, Proceedings. Volume 2. Bethel, CT, Society for Experimental Mechanics, Inc., 1989, p. 874-877. refs
Copyright

A numerical nonlinear flutter analysis approach is described which is based on the use of describing functions (DFs) combined with a structural dynamic modification of the system under test. The a priori concentrated nonlinearity is located in the aircraft wing model. Flutter equations are first used to construct the aerodynamic model; the DF simulating nonlinear stiffness is then introduced in the model. Amplitude and stiffness values are then compared with the computed ones in an iterative sequence until convergence is reached. B.J.

A90-17026
VIBRATION ANALYSIS OF AIRCRAFT PANELS
XUANLI HU and DEPEI DAI (Xian Jiaotong University, People's Republic of China) IN: International Modal Analysis Conference, 7th, Las Vegas, NV, Jan. 30-Feb. 2, 1989, Proceedings. Volume 2. Bethel, CT, Society for Experimental Mechanics, Inc., 1989, p. 1192-1198. Research supported by the National Natural Science Foundation of China. refs
Copyright

A new dynamic analytical method which is based on 'modified variational method' has been developed. In the formulation, skin is allowed to have any prescribed thickness variation, any number of frames and stringers of arbitrary nonuniform cross section and spacing, and any number of concentrated masses. The frames/stringers attached to skin are treated as curved/straight thin-walled, open-section beams. By this method, the natural frequencies and normal modes of aircraft panels having different size and additives (stringers or frames or stringers and frames) were estimated. The effect of frames and stringers on the the natural frequencies and normal modes of aircraft panel was also discussed. Finally, theoretical estimates were compared with experiments. Author

A90-17175
JETS, VORTICES, AND TURBULENCE [STRUI, VIKHRI, TURBULENTNOST']

V. A. GUDKOV (AN SSSR, Sektor Mekhaniki Neodnorodnykh Sred, Moscow, USSR) Priroda (ISSN 0032-874X), Nov. 1989, p. 33-37. In Russian.
Copyright

The physics of jets and vortices is discussed in relation to the formation of turbulence structure, and the discussion is illustrated by a number of flow visualizations. It is suggested that the fluorescent-jet technique can be used to elucidate processes of interest to aircraft designers and industrial chemists. B.J.

A90-17293
SPF/DB TAKES OFF
E. J. TUEGEL, M. O. PRUITT, and L. D. HEFTI (McDonnell Aircraft Co., Saint Louis, MO) Advanced Materials and Processes (ISSN 0882-7958), vol. 136, July 1989, p. 36-41.
Copyright

Although Ti-alloys are more costly than Al-alloys, Ti structures fabricated via SPF/DB processes have been found to compete in weight and even in cost with conventional Al-alloy structures in which a significant portion of manufacturing costs are due to assembly rather than materials. SPF/DB facilitates the forming of complex components and integral structures, which would otherwise require expensive fabrication and/or assembly, in a single operation involving a single fabrication tool. Attention is given to the illustrative case of an F-15E's SPF/DB Ti-alloy aft fuselage structure, combining 15-percent weight savings with 44-percent cost savings. O.C.

A90-17305
RADAR SYSTEMS
PAUL A. LYNN New York, Van Nostrand Reinhold, 1989, 159 p. refs
Copyright

The design and operation of state-of-the-art radar systems are examined in an introduction for advanced undergraduate and graduate students of engineering. The emphasis is on pulsed radars for ATC applications, and chapters are devoted to the radar equation, operational and siting factors, radar hardware, signal processing and display, secondary radar, and surveillance radar for ATC. Diagrams, drawings, graphs, photographs, and a set of sample problems with solutions are provided. T.K.

A90-17370
SENSITIVITY AND OPTIMIZATION OF COMPOSITE STRUCTURES IN MSC/NASTRAN
GOPAL K. NAGENDRA (MacNeal-Schwendler Corp., Los Angeles, CA) and CLAUDE FLEURY (California, University, Los Angeles) Finite Elements in Analysis and Design (ISSN 0168-874X), vol. 5, Oct. 1989, p. 223-235. refs
Copyright

The main purpose of this paper is to present the considerations and the resultant approach used to implement design sensitivity capability for composites into a large-scale, general-purpose finite element system (MSC/NASTRAN). The design variables for composite can be lamina thicknesses, orientation angles, material properties, or a combination of all three. As a secondary goal, the sensitivity analysis has been coupled with a general-purpose optimizer to validate sensitivity analysis results and also to demonstrate how easy it is to couple to an optimizer once a general sensitivity capability is available. This preliminary version of the optimizer is capable of dealing with minimum weight structural design with a rather general design variable linking capability at the element level or the system level. Only sizing type of design variables (i.e., lamina thicknesses) can be handled by the optimizer. Test cases have been run and validated by comparison with independent finite element packages. The linking of a design sensitivity capability for composites in MSC/NASTRAN with an optimizer would give designers a powerful, automated tool to carry out practical optimization design of real-life, complicated composite structures. Author

A90-17372
DYNAMIC STRUCTURAL CORRELATION VIA NONLINEAR PROGRAMMING TECHNIQUES
T. TING and I. U. OJALVO (Bridgeport, University, CT) Finite Elements in Analysis and Design (ISSN 0168-874X), vol. 5, Oct. 1989, p. 247-256. Research supported by the Connecticut State Department of Higher Education and United Technologies Corp. refs
Copyright

A solution to the correlation between structural dynamic test results and finite element analyses of the same components is presented in this paper. Basically, the method can be catagorized as a Levenberg-Marquardt type Gauss-Newton method which requires only the differences between FE modal analyses and test results and their first derivatives with respect to preassigned design variables. With proper variable normalization and equation scaling, the method has been made numerically better-conditioned and the inclusion of the Levenberg-Marquardt technique overcomes any remaining difficulty encountered in inverting singular or near-singular matrices. An important feature is that each iteration requires only one function evaluation along with the associated design sensitivity analysis and so the procedure is computationally efficient. Author

A90-17683#
THE EFFECT OF IMPACT LOADING ON RESIDUAL STRENGTH OF CFRP COMPOSITE BEAMS
ORI ISHAI (Technion - Israel Institute of Technology, Haifa) and AVIAD SHRAGAI IN: Israel Annual Conference on Aviation and Astronautics, 30th, Tel Aviv and Haifa, Israel, Feb. 15. 16, 1989, Collection of Papers. Haifa, Technion - Israel Institute of Technology, 1989, p. 80-83. refs

The present investigation of the effect of flexural impact loading on the damage characteristics and the residual compressive strength (RCS) of CFRP composite beam specimens establishes that the shear-delamination mechanism prevailing in the case of clamped beams is the most effective mechanism in RCS reduction. The presence of tough adhesive interlayers delayed and in some cases prevented interlaminar damage formation and growth under flexure and compressive loading. Relationships among flexural energy, damage characteristics, and RCS, may yield a sensitive tool for damage-tolerance evaluation in composites. O.C.

A90-17684#
THEORETICAL MODELLING OF COMPOSITE ROTATING BEAMS
O. RAND (Technion - Israel Institute of Technology, Haifa) IN: Israel Annual Conference on Aviation and Astronautics, 30th, Tel Aviv and Haifa, Israel, Feb. 15, 16, 1989, Collection of Papers. Haifa, Technion - Israel Institute of Technology, 1989, p. 84-95. refs

The paper presents a theoretical modeling of rotating slender composite beams operating under combined transverse, torsional and centrifugal loads. In addition to the classical degrees of freedom, the model includes an arbitrary description of the warping displacements which enables complete representation of both torsional and bending related shear stresses and resultant loads. Consequently, all the composite related characteristics including the involved extension/twisting and bending/twisting coupling effects are adequately modeled. A differential equilibrium equation in the axial direction is used along with integral forms of equilibrium equations in the transverse and torsional directions. The main coupling effects are demonstrated as functions of the involved material elastic moduli. A first order tailoring of rotating helicopter blades in hover is also presented and discussed. Author

A90-17865#
DIRECT SEARCH METHOD TO AEROELASTIC TAILORING OF A COMPOSITE WING UNDER MULTIPLE CONSTRAINTS
KOJI ISOGAI (National Aerospace Laboratory, Tokyo, Japan) Journal of Aircraft (ISSN 0021-8669), vol. 26, Dec. 1989, p. 1076-1080. refs
Copyright

In order to avoid the possible breakdown of usual optimization methods using gradient information, which is caused by a discontinuous behavior of the flutter velocity as a function of design variables, a feasibility study is made using a direct search method that does not depend on the derivatives of objective/constraint functions. The complex method, as one candidate for such a method, is applied to the minimum weight design of high-aspect-ratio forward/aft swept wings under strength and aeroelastic constraits. It is shown that the complex method is very effective and robust in finding the optimum fiber orientations and the thickness distributions of the upper/lower skin panels of the wing box, especially when the flutter velocity is one of the constraint functions. The deficiency of the complex method is that the rate of convergence rapidly degrades with increasing number of design variables. Author

A90-17918
COOKING AN AEROPLANE
PETER DONALDSON Aerospace Composites and Materials (ISSN 0954-5832), vol. 1, Fall 1989, p. 6-10.
Copyright
The use of the autoclave process for curing components of composite materials used in aircraft is discussed. In particular, attention is given to the required modifications to the traditional autoclave process, the development of a 100-psi autoclave for the forming of aircraft components, curing process control, and the development of large autoclaves for curing large (up to 60 ft long) aircraft components. The discussion also covers the use of computer-based autoclave control systems. V.L.

A90-17920
LOOKING INSIDE A STRUCTURE
IAN PARKER Aerospace Composites and Materials (ISSN 0954-5832), vol. 1, Fall 1989, p. 14-16, 18-20, 22.
Copyright
Un updated version of the computer-based Automated Ultrasonic Scanning systems (AUSS) for the inspection of aircraft composite parts and assemblies is described. The fifth-generation system, AUSS-V, is a computer-controlled contour-following system specifically designed for the inspection of adhesively bonded composite assemblies having complex contoured shapes. The ultrasonic frequencies used are in the 0.4-15 MHz range and inspect for delaminations, porosity, disbonds, voids, ply slippage, and foreign materials. The data are processed and displayed in near real time. V.L.

A90-17993#
POSTBUCKLING BEHAVIOR OF LAMINATED PLATES USING A DIRECT ENERGY-MINIMIZATION TECHNIQUE
PIERRE J. MINGUET, JOHN DUGUNDJI, and PAUL LAGACE (MIT, Cambridge, MA) AIAA Journal (ISSN 0001-1452), vol. 27, Dec. 1989, p. 1785-1792. Research sponsored by FAA. refs
(Contract N00019-85-C-0090)
Copyright
The postbuckling behavior of rectangular, flat, laminated, or sandwich plates is investigated using a model including the different anisotropic material coupling terms, the effect of transverse shear deformation, nonlinear strains, and initial out-of-plane imperfections. The Rayleigh-Ritz method is used to discretize the problem and, instead of solving a set of partial-differential equations, a direct energy-minimization technique is used to solve the problem numerically. The solution procedure used is described in detail in the first part of this paper, and the results obtained for three example problems are presented in the second part. These results correlate well with corresponding experimental data that are also presented. Author

A90-18169
PREDICTING CRACK GROWTH UNDER THERMO-MECHANICAL CYCLING
THEODORE NICHOLAS (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH), MICHAEL L. HEIL (USAF, Aeronautical Systems Div., Wright-Patterson AFB, OH), and GEORGE K. HARITOS (USAF, Office of Scientific Research, Bolling AFB, Washington, DC) International Journal of Fracture (ISSN 0376-9429), vol. 41, Nov. 1989, p. 157-176. refs
(Contract AF PROJECT 2302P1)
Copyright
Load-controlled tests were conducted on Inconel 718 under thermomechanical fatigue (TMF) to evaluate crack growth rate as a function of phase angle between load and temperature. A model is developed to predict TMF crack growth rates based solely on isothermal data. The model uses a linear summation concept based on contributions to crack growth of the two dominant mechanisms which are active at the minimum and maximum temperature of the cycle: mechanical fatigue and environmentally assisted crack growth. It was found that damage which contributes significantly to crack growth occurs only during the increasing load portion of a TMF cycle and only while the time-dependent contribution is an increasing function. A discussion of the dominant mechanisms and a comprehensive review of the literature in TMF crack growth is presented. Applicability of the modeling concepts to other materials is discussed. Author

A90-18262
BOUNDARY INTEGRAL EQUATIONS METHOD FOR COMPRESSIBLE NAVIER-STOKES EQUATIONS
HUI-LIU ZHANG and ZUO-SHENG YANG (Nanjing Aeronautical Institute, People's Republic of China) IN: Finite element analysis in fluids; Proceedings of the Seventh International Conference on Finite Element Methods in Flow Problems, Huntsville, AL, Apr. 3-7, 1989. Huntsville, AL, University of Alabama in Huntsville Press, 1989, p. 252-257. refs
Copyright
In this paper, the Boundary Integral Equations Method (BIEM) for solving two-dimensional compressible laminar Navier-Stokes Equations was presented. By using local linearizing techniques, the governing equations were transformed into linear partial differential equations with variable coefficients, their fundamental solutions were constructed by using the composite algebraic method proposed by Vasilach. Based on these fundamental solutions, the integral representations for the Navier-Stokes Equations were established. Two numerical examples for compressible viscous flows about circular cylinder and NACA 0012 airfoil at low Reynolds number had been carried out. Comparison between present results and other computational results show the validity of BIEM for compressible Navier-Stokes flow problems. Author

A90-18264
UPWIND ADAPTIVE FINITE ELEMENT INVESTIGATIONS OF THE TWO-DIMENSIONAL REACTIVE INTERACTION OF SUPERSONIC GASEOUS JETS
D. CHARGY, A. DERVIEUX, and B. LARROUTUROU (INRIA, Valbonne, France) IN: Finite element analysis in fluids; Proceedings of the Seventh International Conference on Finite Element Methods in Flow Problems, Huntsville, AL, Apr. 3-7, 1989. Huntsville, AL, University of Alabama in Huntsville Press, 1989, p. 290-295. refs
Copyright
An upwind FEM is developed for numerically simulating the two-dimensional transonic flow of a reactive gaseous mixture. The method uses a triangular finite-element mesh, with an adaptive procedure based on mesh refinement by triangle division and an upwind nonoscillatory scheme based on an approximate Riemann solver for the evaluation of the convective terms for all species. Results concerning the reactive interaction of two supersonic gaseous jets are presented. Author

A90-18302
NUMERICAL METHODS TO SOLVE THE INCOMPRESSIBLE EULER AND NAVIER-STOKES EQUATIONS IN 3D WITH APPLICATIONS
PETER ELIASSON and ARTHUR RIZZI (Flygtekniska Forsoksanstalten, Bromma, Sweden) IN: Finite element analysis in fluids; Proceedings of the Seventh International Conference on

Finite Element Methods in Flow Problems, Huntsville, AL, Apr. 3-7, 1989. Huntsville, AL, University of Alabama in Huntsville Press, 1989, p. 818-823. refs
Copyright

Numerical methods that solve either the incompressible Euler equations or the N-S equations in two or three dimensions are reviewed. Attention is given to some applications of this work to the capturing of a vortex sheet shed from the leading edge of a delta wing and the prediction of water flow through the blade rotor of a pump. More recent work using this approach to solve the steady incompressible N-S equation is then considered. A k-epsilon turbulence model is incorporated into the code, and results are presented for the standard problem of flow over a backward-facing step. Finally, it is shown how the method can be extended to the treatment of the unsteady N-S equations by developing a Poisson equation for the pressure. B.J.

A90-18340
FINITE ELEMENT ANALYSIS OF THE FLOW OF A PROPELLER ON A SLENDER BODY WITH A TWO-EQUATION TURBULENCE MODEL

S. J. KIM (Daewoo Aerospace Research and Development Centre, Republic of Korea) and J. A. SCHETZ (Virginia Polytechnic Institute and State University, Blacksburg) IN: Finite element analysis in fluids; Proceedings of the Seventh International Conference on Finite Element Methods in Flow Problems, Huntsville, AL, Apr. 3-7, 1989. Huntsville, AL, University of Alabama in Huntsville Press, 1989, p. 1541-1550. refs
Copyright

Earlier works on turbulence modeling are restricted either by inviscid assumption or by a crude treatment of the wall effect on turbulence transport. This work aims at treatment of turbulence generated by a propeller in action and the wall effect by solving the Navier-Stokes and two turbulence transport equations down to the wall. An existing finite element code was modified with a low Reynolds number form for an appropriate treatment of wall influences on turbulence transport, which produces a better solution and provides an easier imposition of boundary conditions by solving up to the wall with no-slip boundary conditions. The numerical simulation of the stern region flow of a streamlined body resulted in an excellent agreement with the measured data. Turbulent shear flows past a propeller at the rear end of the same slender body, modeled by an actuator disk, were successfully solved at two rotational speeds, self-propelled and 100 percent overthrusted. A generic ducted propeller case was also solved. C.E.

A90-18343
FINITE ELEMENT SIMULATION OF COMPRESSIBLE TURBULENT FLOWS - VALIDATION AND APPLICATION TO INTERNAL AERODYNAMIC IN GAS-TURBINE ENGINES

G. BRUN (Societe Metraflu, Ecully, France), M. BUFFAT, D. JEANDEL (Lyon, Ecole Centrale, Ecully, France), J. L. SCHULTZ, and M. DESAULTY (SNECMA, Moissy-Cramayel, France) IN: Finite element analysis in fluids; Proceedings of the Seventh International Conference on Finite Element Methods in Flow Problems, Huntsville, AL, Apr. 3-7, 1989. Huntsville, AL, University of Alabama in Huntsville Press, 1989, p. 1592-1597. refs
Copyright

A numerical approach able to describe the flow around the combustion chamber of a gas turbine engine is discussed. An axisymmetric method is proposed, based on a finite element method which allows a precise description of complex geometries. A two-equation model of turbulence is used with equilibrium laws in the vicinity of the solid boundaries. The model is based on a semiimplicit time scheme and a discretization of the domain into triangular elements with linear interpolations. An application to a typical annular combustor is presented. C.E.

A90-18406
DESIGN AND EVALUATION OF GRAPHITE/EPOXY TRUSS CORE SANDWICH PANELS

H. MASAEDA, M. YANASE, and Y. HIROSE (Kawasaki Heavy Industries, Ltd., Aircraft Div., Kakamigahara, Japan) IN: Japan-U.S. Conference on Composite Materials, 4th, Washington, DC, June 27-29, 1988, Proceedings. Lancaster, PA, Technomic Publishing Co., Inc., 1989, p. 904-913.
Copyright

With a view to developing an efficient stiffened panel configuration for graphite/epoxy composites, truss core sandwich panels were designed and fabricated for evaluation. Compression and shear tests showed good correlation with analytical results, except for the local compression buckling case. In the latter case, test results were slightly higher than the analytical results due to a conservative assumption about support conditions. V.L.

A90-18407
THE STATIC AEROELASTIC BEHAVIOR OF SWEPTFORWARD COMPOSITE WING STRUCTURES TAKING INTO ACCOUNT THEIR WARPING RESTRAINT EFFECT

L. LIBRESCU and S. THANGJITHAM (Virginia Polytechnic Institute and State University, Blacksburg) IN: Japan-U.S. Conference on Composite Materials, 4th, Washington, DC, June 27-29, 1988, Proceedings. Lancaster, PA, Technomic Publishing Co., Inc., 1989, p. 914-922. refs
Copyright

An exact approach to the aerolastic spanwise lift distribution and divergence instability of swept (aft and back) uniform composite wing structure is developed in this paper. The approach based on the Laplace transform technique enables one to solve in a unified manner both aeroelastic problems. The analysis encompasses the cases of free and restrained warping models for the wing twist. Numerical results are finally presented to demonstrate the effects played by the fiber-orientation, ply lay-up, warping restraint and wing geometry both on the subcritical static aeroelastic response and on the divergence instability of composite swept wings.
Author

A90-18442
NUMERICAL STUDY OF BALANCED PATCH REPAIRS TO CRACKED SHEETS

A. YOUNG, D. P. ROOKE (Royal Aerospace Establishment, Farnborough, England), and D. J. CARTWRIGHT (Bucknell University, Lewisburg, PA) Aeronautical Journal (ISSN 0001-9240), vol. 93, Nov. 1989, p. 327-334. Research supported by the Ministry of Defence Procurement Executive. refs
Copyright

The effects on the stress intensity factor of bonding repair patches over a crack in a large sheet under uniaxial loading are studied using two simple numerical models. The variation of the stress intensity factor with increasing crack length is investigated and results for repairs involving large elliptical patches are found to agree with a closed-form approximation. Further cases are considered where the patch is either rectangular in shape or less than a certain critical size. For such repairs the closed-form approximation for the stress intensity factor is shown to be unsuitable.
Author

A90-18507#
TURBULENT BOUNDARY LAYER DEVELOPMENT IN THE PRESENCE OF SMALL ISOLATED TWO-DIMENSIONAL SURFACE DISCONTINUITIES

D. J. COCKRELL (Leicester, University, England), H. H. NIGIM (Birzeit University, Jordan), and M. A. ALHUSEIN (Mu'tah University, Al-Karak, Jordan) ASME, Transactions, Journal of Fluids Engineering (ISSN 0098-2202), vol. 111, Dec. 1989, p. 472-477. refs
Copyright

Surface discontinuities arising on aircraft wings, where the wing forms a junction with an auxiliary lifting surface, are idealized into shapes whose drag coefficients, when they have been isolated from their surrounding surfaces, have been previously determined and tabulated. By making appropriate assumptions about the boundary layer characteristics in the vicinity of the discontinuities and then adopting appropriate integral boundary layer prediction techniques, methods are developed for continuing the boundary layer prediction process across them and then downstream of

them. The computations compare well with the experimental results, even for comparatively large discontinuities. The technique is recommended for use in a predictive role. S.A.V.

A90-18580#
AEROELASTIC TAILORING APPLIED TO COMPOSITE WING
DE GUAN and KE ZHONG (Beijing University of Aeronautics and Astronautics, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 10, May 1989, p. A221-A226. In Chinese, with abstract in English.

Some results of aeroelastic tailoring of a sweptback wing with medium aspect ratio and composite skin and metal frame are presented. Using the Tsai-Hill criterion, the strength critical elements were resized. Then the flutter or aileron effectiveness critical elements were redesigned by the uniform-flutter velocity or uniform-aileron effectiveness derivative criteria. Author

A90-18632#
THE APPLICATION AND DESIGN OF LARGE INTEGRAL PANELS FOR SH-5 AIRCRAFT
ZHIFANG LAN (Mechanical Institute of Central China, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 10, Aug. 1989, p. B419-B424. In Chinese, with abstract in English. refs

In this paper, the structure of the large integral panel of SH-5 aircraft, its efficiency and design method, are described. The integral panel design is combined with numerical control process, shot shaping, and flat extrusion production of ribbed panel blanks. The empirical formula and data for calculating secant yield strength, the formula and curves for computing the effective width, and the overall collapse curves, are also given. Author

A90-19004
INSTRUMENTATION FOR COMBUSTION AND FLOW IN ENGINES; PROCEEDINGS OF THE NATO ADVANCED STUDY INSTITUTE, VIMEIRO, PORTUGAL, SEPT. 13-26, 1987
D. F. G. DURAO, ED. (Lisboa, Universidade Tecnica, Lisbon, Portugal), J. H. WHITELAW, ED. (Imperial College of Science, Technology, and Medicine, London, England), and P. O. WITZE, ED. (Sandia National Laboratories, Livermore, CA) Institute sponsored by NATO. Dordrecht, Kluwer Academic Publishers (NATO ASI Series. Volume E154), 1989, 403 p. For individual items see A90-19005 to A90-19012.
Copyright

The present conference on instrumentation for gas turbine combustors' combustion and flow, and for the combustion and flow in reciprocating internal combustion engines, gives attention to combustion oscillations in ducts, laser diagnostics for gas turbine thermometry, the application of Raman processes, qualitative two- and three-dimensional measurement methods, laser velocimetry for combustion, and future gas turbine combustor test rig configurations. Also discussed are laser instrumentation for production reciprocating engines, refractive-index matching for LDV measurements near walls in complex geometries, the experimental investigation and numerical prediction of dispersed two-phase flows, temperature measurements using CARS, and internal combustion engine ion-probe diagnostics. O.C.

A90-19639#
TURBULENCE MODELING FOR IMPINGING JETS
ROBERT E. CHILDS (Nielsen Engineering and Research, Inc., Mountain View, CA) AIAA, Aerospace Sciences Meeting, 28th, Reno, NV, Jan. 8-11, 1990. 10 p. Research supported by DARPA and USAF. refs
(AIAA PAPER 90-0022) Copyright

Turbulence in the impinging jet flows associated with vertical or short takeoff and landing aircraft is modeled very poorly by existing models. Extensions to the k-epsilon model are presented which are designed to account for streamline curvature, large-scale mixing, and anisotropy. These extensions provide significant improvement in the model's ability to predict some aspects of these flows. Requirements for further model development are identified. Author

A90-19674*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
NUMERICAL SIMULATION OF THE ACTUATION SYSTEM FOR THE ALDF'S PROPULSION CONTROL VALVE
JOHN J. KORTE (NASA, Langley Research Center, Hampton, VA) AIAA, Aerospace Sciences Meeting, 28th, Reno, NV, Jan. 8-11, 1990. 10 p. refs
(AIAA PAPER 90-0079) Copyright

A numerical simulation of the actuation system for the propulsion control valve (PCV) of the NASA Langley Aircraft Landing Dynamics Facility was developed during the preliminary design of the PCV and used throughout the entire project. The simulation is based on a predictive model of the PCV which is used to evaluate and design the actuation system. The PCV controls a 1.7 million-pound thrust water jet used in propelling a 108,000-pound test carriage. The PCV can open and close in 0.300 second and deliver over 9,000 gallons of water per sec at pressures up to 3150 psi. The numerical simulation results are used to predict transient performance and valve opening characteristics, specify the hydraulic control system, define transient loadings on components, and evaluate failure modes. The mathematical model used for numerically simulating the mechanical fluid power system is described, and numerical results are demonstrated for a typical opening and closing cycle of the PCV. A summary is then given on how the model is used in the design process. S.A.V.

A90-19850#
HYDRAULIC ANALOGY APPLICATION IN THE STUDY OF A TWO-PHASE MIXTURE COMBUSTION FLOW
F. M. YU (National Cheng Kung University, Tainan, Republic of China) and YUH-WEN CHEN AIAA, Aerospace Sciences Meeting, 28th, Reno, NV, Jan. 8-11, 1990. 8 p. refs
(AIAA PAPER 90-0451) Copyright

A hydraulic analogy method is presented for the investigation of a two-phase mixture combustion flow. Using this method, the study of the supersonic combustion flow can be achieved by a simple water table experiment. The water table system includes two streams of water flow. One is the main channel, or primary, flow, and the other is the stream which adds to the main flow, called the secondary flow. The combined effects of friction, internal drag, and changes in total temperature and mass flow rate in the combustible gas flow are simulated by a change in the secondary water flow rate. Three experiments are carried out on the water table with analagous combustion zone inlet Mach numbers of 1.6, 1.8, and 2.0. The analagous combustion zone outlet Mach numbers and the ratios of the outlet to the inlet properties, which vary with the addition of heat in the combustion zone, are investigated. At the three inlet Mach numbers all the thermodynamic characteristics show similarity to Rayleigh flow. However, at the same outlet Mach numbers, all the characteristics, except the density ratio, have higher values than the Rayleigh flow. S.A.V.

A90-19956*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.
COMPENSATING FOR PNEUMATIC DISTORTION IN PRESSURE SENSING DEVICES
STEPHEN A. WHITMORE (NASA, Flight Research Center, Edwards, CA) and CORNELIUS T. LEONDES (California, University, Los Angeles) AIAA, Aerospace Sciences Meeting, 28th, Reno, NV, Jan. 8-11, 1990. 19 p. refs
(AIAA PAPER 90-0631) Copyright

A general numerical technique for obtaining unsteady pressure measurements using conventional pressure sensing technology has been developed. A pneumatic distortion model, based on the Navier-Stokes equations of momentum and continuity, was reduced to a low-order, state-variable model retaining most of the dynamic characteristics of the full model. The reduced-order model is coupled with results from minimum variance estimation theory to develop an algorithm to compensate the effects of pneumatic distortion. Both postflight and real-time algorithms were developed and evaluated using simulated and flight data. C.E.

A90-19984*# Ohio State Univ., Columbus.
COMPRESSIBILITY EFFECTS IN FREE SHEAR LAYERS
M. SAMIMY (Ohio State University, Columbus) and G. S. ELLIOTT AIAA, Aerospace Sciences Meeting, 28th, Reno, NV, Jan. 8-11, 1990. 10 p. refs
(Contract N00014-87-K-0169; NAG3-764)
(AIAA PAPER 90-0705) Copyright

High-Reynolds-number compressible free shear layers were studied experimentally to explore the effects of compressibility on the turbulence field. A reduction in both the level and the lateral extent of turbulence fluctuations with increasing convective Mach number (Mc) (reported earlier for Mc of 0.51 and 0.64) is much higher at Mc of 0.86. The higher-order moments of turbulence fluctuations such as skewness and flatness show that the intermittency due to the excursion of large-scale structures into the free streams at the edge of shear layers was significantly reduced (both in the level and the extent) due to increased Mc.
Author

N90-13344# Aix-Marseilles Univ. (France). Inst. de Mecanique Statistique de la Turbulence.
LASER APPLICATIONS IN SUPERSONIC UNSTEADY FLOW
M. ELENA *In* VKI, Measurement Techniques in Aerodynamics 20 p 1989
Avail: NTIS HC A23/MF A03

The measurements of supersonic unsteady flow velocities, applying laser Doppler anemometry, are dicussed. This method allows the study of high turbulence levels. The advantages and disadvantages of the method are given. The difficulties created by high velocities and rapid spatial changes in velocity or flow direction are considered. Three dimensional flow measurements are shown to be difficult with this technique. Moreover, the deterioration of the signal to noise ratio is observed near the walls. It is suggested that the seeding effect and the particle response be checked for a given wind tunnel and laser Doppler anemometry system.
ESA

N90-13348# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Cologne (Germany, F.R.). Inst. fuer Antriebstechnik.
LASER TWO FOCUS TECHNIQUES
R. SCHODL *In* VKI, Measurement Techniques in Aerodynamics 96 p 1989
Avail: NTIS HC A23/MF A03

The development of the laser two focus velocimetry are reviewed. The fundamentals of this nonintrusive fluid flow velocity measurement technique are described. Emphasis is placed upon the advances of this technique. Results of measurements in a very small flow channel and in a small turbocharger compressor rotor are presented. The influence of beam diameter - beam separation ratio on the measuring accuracy and on the measuring time is treated. A multicolor two dimensional system with selectable beam separation is presented. The laser Doppler and the laser two focus techniques are compared.
ESA

N90-13725# Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, Goettingen (Germany, F.R.). Abteilung Instabilitaeten und Abloesung.
GENERALIZED SIMILARITY SOLUTIONS FOR THREE DIMENSIONAL, LAMINAR, STEADY, COMPRESSIBLE BOUNDARY LAYER FLOWS ON SWEPT PROFILE CYLINDERS
VIKTOR SALJNIKOV and UWE DALLMANN Jan. 1928 103 p In GERMAN; ENGLISH summary Report will also be announced as translation (ESA-TT-1190)
(DLR-FB-89-34; ISSN-0171-1342; ETN-90-95843) Avail: NTIS HC A06/MF A01; DLR, VB-PL-DO, Postfach 90 60 58, 5000 Cologne, Fed. Republic of Germany, 34.50 DM

A method of generalized similarity which allows one to derive solutions of the laminar, steady, compressible, and 3-D boundary layer equations for swept wing configurations is presented. The model configuration is an infinitely long swept profile cylinder within ideal gas flow with a dynamic viscosity which depends linearly on the temperature. The pressure distribution, Pr and Ma numbers, as well as the sweep angle and temperature boundary conditions, can be chosen arbitrarily. A universal mathematical model is derived which is integrated numerically. In view of transonic swept wings these numerical calculations are performed for various values. The influence of Mach number, sweep angle, and changes of wall temperature on the characteristic boundary layer properties between the stagnation and the separation points are investigated.
ESA

N90-13727# Technische Univ., Delft (Netherlands).
MULTIGRID AND DEFECT CORRECTION FOR THE STEADY NAVIER-STOKES EQUATIONS: APPLICATIONS TO AERODYNAMICS Ph.D. Thesis
BAREND KOREN 1989 132 p
(ETN-90-96011) Avail: NTIS HC A07/MF A01

High speed gas flows, applying the steady Navier-Stokes equations, are described. On the basis of the Hemker-Sperkreijse method, a procedure which is suitable for an accurate and efficient computation of Euler and Navier-Stokes equations, is proposed. The transonic wind tunnel flow, and transonic, subsonic and supersonic airfoil flows are studied, from the steady Euler equations concept. The practical interest of the Navier-Stokes method is analyzed. Subsonic and supersonic flat plate flows and hypersonic flat plate flow, are examined. It is shown that the method does not have an upper bound in Reynolds number.
ESA

N90-13728# Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, Goettingen (Germany, F.R.). Gruppe Transition und Turbulenz.
NUMERICAL SIMULATION OF TRANSITION IN THREE-DIMENSIONAL BOUNDARY LAYERS Ph.D. Thesis - Karlsruhe Univ.
FRIEDRICH MEYER Jun. 1989 104 p In GERMAN; ENGLISH summary Original contains color illustrations
(DLR-FB-89-12; ISSN-0171-1342; ETN-90-96049) Avail: NTIS HC A06/MF A01; DLR, VB-PL-DO, Postfach 90 60 58, 5000 Cologne, Fed. Republic of Germany, 40 DM

Linear and nonlinear stages of laminar-turbulent transition in three-dimensional boundary-layers, initiated by crossflow instability, are investigated by linear stability analysis and numerical simulation of the incompressible Navier-Stokes equations. The conditions in the numerical calculations are adapted to the DLR (Deutsche forschungsanstalt fur Luft und Raumfarhrt) swept flat plate transition experiment. Falkner-Skan-Cooke similarity profiles are used to describe the parallel basic flow. A quasi-two-dimensional treatment of the problem yields nonlinear saturation of the stationary crossflow vortices. The nonlinear interaction of stationary vortices with traveling disturbances is then investigated. The evolution of the mean flow, fluctuations and instantaneous velocity is documented. The development of the disturbances strongly depends on the initial disturbances. Good agreement is observed between simulation and experiment. The nonlinear development initiates a marked deformation of the streamwise and crossflow profiles and an increase of the mean wall shear.
ESA

N90-13744*# Arizona State Univ., Tempe. Dept. of Mechanical and Aerospace Engineering.
NAVIER-STOKES SIMULATION OF THE CROSSFLOW INSTABILITY IN SWEPT-WING FLOWS Final Report
HELEN L. REED Oct. 1989 59 p
(Contract NAG1-874)
(NASA-CR-186122; NAS 1.26:186122) Avail: NTIS HC A04/MF A01 CSCL 20/4

The computational modeling of the transition process characteristic of flows over swept wings are described. Specifically, the crossflow instability and crossflow/T-S wave interactions are analyzed through the numerical solution of the full three-dimensional Navier-Stokes equations including unsteadiness, curvature, and sweep. This approach is chosen because of the complexity of the problem and because it appears that linear stability theory is insufficient to explain the discrepancies between different experiments and between theory and experiments. The leading edge region of a swept wing is considered in a

three-dimensional spatial simulation with random disturbances as the initial conditions. The work has been closely coordinated with the experimental program of Professor William Saric, examining the same problem. Comparisons with NASA flight test data and the experiments at Arizona State University were a necessary and an important integral part of this work. Author

N90-13750*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
CONVECTIVE HEAT TRANSFER MEASUREMENTS FROM A NACA 0012 AIRFOIL IN FLIGHT AND IN THE NASA LEWIS ICING RESEARCH TUNNEL
PHILIP E. POINSATTE, G. JAMES VANFOSSEN, and KENNETH J. DEWITT (Toledo Univ., OH.) 1989 20 p Presented at the 28th Aerospace Sciences Meeting, Reno, NV, 8-11 Jan. 1990; sponsored by AIAA
(NASA-TM-102448; E-5232; NAS 1.15:102448) Avail: NTIS HC A03/MF A01 CSCL 20/4

Local heat transfer coefficients were measured on a smooth and roughened NACA 0012 airfoil. Heat transfer measurements on the 0.533 m chord airfoil were made both in flight on the NASA Lewis Twin Otter Icing Research Aircraft and in the NASA Lewis Icing Research Tunnel (IRT). Roughness was obtained by the attachment of uniform 2 mm diameter hemispheres to the airfoil surface in 4 distinct patterns. Flight data were taken for the smooth and roughened airfoil at various Reynolds numbers based on chord in the range 1.24 to 2.50 x 10(exp 6) and at various angles of attack up to 4 deg. During these flight tests, the free stream velocity turbulence intensity was found to be very low (less than 0.1 percent). Wind tunnel data were acquired in the Reynolds number range 1.20 to 4.25 x 10(exp 6) and at angles of attack from -4 to 8 deg. The turbulence intensity in the IRT was 0.5 to 0.7 percent with the cloud generating sprays off. A direct comparison was made between the results obtained in flight and in the IRT. The higher level of turbulence in the IRT vs. flight had little effect on the heat transfer for the lower Reynolds numbers but caused a moderate increase in heat transfer at the high Reynolds numbers. Roughness generally increased the heat transfer. Author

N90-13797*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
LIQUID WATER CONTENT AND DROPLET SIZE CALIBRATION OF THE NASA LEWIS ICING RESEARCH TUNNEL
ROBERT F. IDE (Army Aviation Research and Development Command, Cleveland, OH.) 1989 28 p Presented at the 28th Aerospace Sciences Meeting, Reno, NV, 8-11 Jan. 1990; sponsored by AIAA Prepared in cooperation with Army Aviation Research and Development Command, Cleveland, OH
(Contract DA PROJ. 1L1-62209-A47-A)
(NASA-TM-102447; E-5231; NAS 1.15:102447;
AVSCOM-TM-89-C-014; AIAA-90-0669) Avail: NTIS HC A03/MF A01 CSCL 14/2

The icing research tunnel at the NASA Lewis Research Center underwent a major rehabilitation in 1986 to 1987, necessitating recalibration of the icing cloud. The methods used in the recalibration, including the procedure used to establish a uniform icing cloud and the use of a standard icing blade technique for measurement of liquid water content are described. PMS Forward Scattering Spectrometer and Optical Array probes were used for measurement of droplet size. Examples of droplet size distributions are shown for several median volumetric diameters. Finally, the liquid water content/droplet size operating envelopes of the icing tunnel are shown for a range of airspeeds and are compared to the FAA icing certification criteria. Author

N90-13812# Structural Integrity Associates, Inc., San Jose, CA.
STRESS INTENSITY FACTORS FOR CRACKING METAL STRUCTURES UNDER RAPID THERMAL LOADING. VOLUME 2: THEORETICAL BACKGROUND Final Report, Oct. 1987 - Apr. 1989
AN-YU KUO, PETER C. RICCARDELLA, SHU S. TANG, CURTIS S. CARNEY, and REJI JOHN Aug. 1989 452 p Prepared in cooperation with Dayton Univ., OH
(Contract F33615-87-C-3250)
(AD-A213297; SIR-89-023-VOL-2; WRDC-TR-89-3074-VOL-2)
Avail: NTIS HC A20/MF A03 CSCL 13/13

An SBIR Phase 2 study has been conducted on a novel method of calculating cracktip stress intensity factors for cracked metal structures under rapid thermal pulse loadings. The work couples a Green's function integration technique for transient thermal stresses with the well-known influence function approach for calculating stress intensity factors. A total of seven most commonly used crack models were investigated in this study. A computer program implementing the methodology designated THERMO-K, was developed and delivered with the Phase 2 project report. Temperature, stress and stress intensity factor solutions predicted by THERMO-K for all seven crack models have been verified by comparing them with finite element results or experimental measurements. Operable on an IBM-pc or compatible, the program demonstrates the ability to accurately calculate stress intensity factors, with very short turnaround times, and immediate graphics visualization of the results. Based on the success of this Phase 2 study, it is concluded that the computer program THERMO-K resulting from this study is an easy to use, fast, and accurate tool, for predicting stress intensity factors for a wide range of metallic (or other) structures of interest to the Air Force, under rapid thermal pulses. GRA

N90-13814*# Textron Bell Helicopter, Fort Worth, TX.
INVESTIGATION OF DIFFICULT COMPONENT EFFECTS ON FINITE ELEMENT MODEL VIBRATION PREDICTION FOR THE BELL AG-1G HELICOPTER. VOLUME 2: CORRELATION RESULTS Final Report
R. V. DOMPKA Oct. 1989 211 p
(Contract NAS1-17496)
(NASA-CR-181916-VOL-2; NAS 1.26:181916-VOL-2;
BHT-699-099-251-VOL-2) Avail: NTIS HC A10/MF A02 CSCL 20/11

Under the NASA-sponsored DAMVIBS (Design Analysis Methods for VIBrationS) program, a series of ground vibration tests and NASTRAN finite element model (FEM) correlations were conducted on the Bell AH-1G helicopter gunship to investigate the effects of difficult components on the vibration response of the airframe. Previous correlations of the AG-1G showed good agreement between NASTRAN and tests through 15 to 20 Hz, but poor agreement in the higher frequency range of 20 to 30 Hz. Thus, this effort emphasized the higher frequency airframe vibration response correlations and identified areas that need further R and T work. To conduct the investigations, selected difficult components (main rotor pylon, secondary structure, nonstructural doors/panels, landing gear, engine, furl, etc.) were systematically removed to quantify their effects on overall vibratory response of the airframe. The entire effort was planned and documented, and the results reviewed by NASA and industry experts in order to ensure scientific control of the testing, analysis, and correlation exercise. In particular, secondary structure and damping had significant effects on the frequency response of the airframe above 15 Hz. Also, the nonlinear effects of thrust stiffening and elastomer mounts were significant on the low frequency pylon modes below main rotor 1p (5.4 Hz). The results of the NASTRAN FEM correlations are given. Author

N90-13816# Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, Brunswick (Germany, F.R.). Abteilung Strukturberechnung.
GENERAL BUCKLING TESTS WITH THIN-WALLED SHELLS
HERMANN KLEIN Apr. 1989 23 p
(DLR-MITT-89-13; ISSN-0176-7739; ETN-90-95847) Avail: NTIS HC A03/MF A01; DLR, VB-PL-DO, Postfach 90 60 58, 5000 Cologne, Fed. Republic of Germany, 18 Deutsche Marks

Hints are given for the preparation, execution and evaluation of buckling tests with thin-walled shells. Controlling of load, displacement, and boundary conditions are discussed. Buckling tests in the Deutsche Forschungsanstalt fur Luft-und Raumfahrt

(DLR) are given as examples for the buckling behavior of real shells. The role of imperfections and load interferences in influencing behavior and why their sensitivity depends on the properties of the shell and the test are discussed. ESA

N90-13817*# Florida Atlantic Univ., Boca Raton. Center for Acoustics and Vibrations.
MOBILITY POWER FLOW ANALYSIS OF AN L-SHAPED PLATE STRUCTURE SUBJECTED TO ACOUSTIC EXCITATION Progress Report, Jun. - Dec. 1989
J. M. CUSCHIERI Dec. 1989 35 p
(Contract NAG1-685)
(NASA-CR-186130; NAS 1.26:186130) Avail: NTIS HC A03/MF A01 CSCL 20/11

An analytical investigation based on the Mobility Power Flow method is presented for the determination of the vibrational response and power flow for two coupled flat plate structures in an L-shaped configuration, subjected to acoustical excitation. The principle of the mobility power flow method consists of dividing the global structure into a series of subsystems coupled together using mobility functions. Each separate subsystem is analyzed independently to determine the structural mobility functions for the junction and excitation locations. The mobility functions, together with the characteristics of the junction between the subsystems, are then used to determine the response of the global structure and the power flow. In the coupled plate structure considered here, mobility power flow expressions are derived for excitation by an incident acoustic plane wave. In this case, the forces (acoustic pressures) acting on the structure are dependent on the response of the structure because of the scattered pressure component. The interaction between the structure and the fluid leads to the derivation of a corrected mode shape for the plates' normal surface velocity and also for the structure mobility functions. The determination of the scattered pressure components in the expressions for the power flow represents an additional component in the power flow balance for the source plate and the receiver plate. This component represents the radiated acoustical power from the plate structure. Author

N90-13820*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.
APPLICATION OF FRACTURE MECHANICS AND HALF-CYCLE METHOD TO THE PREDICTION OF FATIGUE LIFE OF B-52 AIRCRAFT PYLON COMPONENTS
W. L. KO, A. L. CARTER, W. W. TOTTON, and J. M. FICKE Sep. 1989 80 p
(NASA-TM-88277; H-1383; NAS 1.15:88277) Avail: NTIS HC A05/MF A01 CSCL 20/11

Stress intensity levels at various parts of the NASA B-52 carrier aircraft pylon were examined for the case when the pylon store was the space shuttle solid rocket booster drop test vehicle. Eight critical stress points were selected for the pylon fatigue analysis. Using fracture mechanics and the half-cycle theory (directly or indirectly) for the calculations of fatigue-crack growth ,the remaining fatigue life (number of flights left) was estimated for each critical part. It was found that the two rear hooks had relatively short fatigue life and that the front hook had the shortest fatigue life of all the parts analyzed. The rest of the pylon parts were found to be noncritical because of their extremely long fatigue life associated with the low operational stress levels. Author

N90-13822# Technische Univ., Delft (Netherlands). Dept. of Aerospace Engineering.
AN EVALUATION OF A FATIGUE CRACK GROWTH PREDICTION MODEL FOR VARIABLE-AMPLITUDE LOADING (PREFFAS)
J. SCHIJVE Dec. 1987 35 p
(LR-537; ETN-90-95984) Avail: NTIS HC A03/MF A01

A prediction model for fatigue crack growth (PREFFAS) under stationary variable amplitude load histories with a short recurrence (for example flight simulation loading) is described and analyzed. It is a cycle-by-cycle prediction model based on crack closure. Consequences, limitations and possible extensions are discussed. The model is applied to a series of simplified flight simulation tests. ESA

N90-14404# Federal Aviation Administration, Atlantic City, NJ.
DATA LINK PROCESSOR (DLP) OPERATIONAL TEST AND EVALUATION/INTEGRATION TEST PLAN
NORMAN W. WATTS and NOEL A. DOUCETT (System Engineering and Integration, Atlantic City, NJ.) Dec. 1989 64 p
(DOT/FAA/CT-TN89/32) Avail: NTIS HC A04/MF A01

The provision for two way communication with aircraft, via a digital data link, has long been considered a means of providing significant enhancements for safe and efficient flight operations. The Data Link Processor (DLP) being tested will initially perform the ground based data link processing functions necessary to provide appropriately equipped aircraft with pilot requested aviation weather data from a National Weather Data Base via the Mode Select Beacon System (Mode S). The weather data base will contain six products: Surface Observations (SA), Terminal Forecasts (FT), Pilot Reports (UA), Wind and Temperature Aloft Forecasts (FD), Radar Summaries (SD), and Hazardous Weather Advisories. The DLP Operational Test and Evaluation and/or Integration Test Plan depicts all systems that interface with the DLP, and identifies the data that will be communicated between them. This plan sets forth and defines the philosophy, approach, methods, organization, and schedules for the verification of the DLP requirements. This plan provides sufficient detail to define and direct the development of detailed test procedures and to identify the allocation of resources required to support those tests. Author

N90-14453*# Clemson Univ., SC. Radar Systems Lab.
ADAPTIVE CLUTTER REJECTION FILTERS FOR AIRBORNE DOPPLER WEATHER RADAR APPLIED TO THE DETECTION OF LOW ALTITUDE WINDSHEAR
BYRON M. KEEL 4 Dec. 1989 190 p
(Contract NAG1-928)
(NASA-CR-186211; NAS 1.26:186211; TR-11) Avail: NTIS HC A09/MF A01 CSCL 17/9

An optimum adaptive clutter rejection filter for use with airborne Doppler weather radar is presented. The radar system is being designed to operate at low-altitudes for the detection of windshear in an airport terminal area where ground clutter returns may mask the weather return. The coefficients of the adaptive clutter rejection filter are obtained using a complex form of a square root normalized recursive least squares lattice estimation algorithm which models the clutter return data as an autoregressive process. The normalized lattice structure implementation of the adaptive modeling process for determining the filter coefficients assures that the resulting coefficients will yield a stable filter and offers possible fixed point implementation. A 10th order FIR clutter rejection filter indexed by geographical location is designed through autoregressive modeling of simulated clutter data. Filtered data, containing simulated dry microburst and clutter return, are analyzed using pulse-pair estimation techniques. To measure the ability of the clutter rejection filters to remove the clutter, results are compared to pulse-pair estimates of windspeed within a simulated dry microburst without clutter. In the filter evaluation process, post-filtered pulse-pair width estimates and power levels are also used to measure the effectiveness of the filters. The results support the use of an adaptive clutter rejection filter for reducing the clutter induced bias in pulse-pair estimates of windspeed. Author

N90-14497 Mississippi State Univ., State College.
A DYNAMIC MULTIBLOCK APPROACH TO SOLVING THE UNSTEADY EULER EQUATIONS ABOUT COMPLEX CONFIGURATIONS Ph.D. Thesis
ABDOLLAH ARABSHAHI 1989 126 p
Avail: Univ. Microfilms Order No. DA8917049

The objective is the development of a numerical method which can accurately and economically solve the unsteady Euler equations for three-dimensional flow fields around complex configurations, particularly a generic aircraft with a store in the

captive and vertical launch position. A cell centered finite volume spatial discretization is applied to the three-dimensional, time-dependent, Euler equations written in general time-dependent curvilinear coordinates. Two algorithms are presented for solving the system of Euler equations. The first algorithm is based on flux-vector splitting while the second algorithm is based on flux-difference splitting using Roe averaged variables. For both algorithms, an implicit upwind biased approach is employed to integrate the spatially discretized equations in time. The multiblock technique utilizes the concept of decomposing the flow field between the surfaces of the configuration and some outer far field boundary into a set of blocks. Calculated results compared with experimental data indicate that the present Euler solver can calculate transonic flow fields efficiently and accurately over complex geometries. Furthermore, the results demonstrate how computational fluid dynamics (CFD) can be used to accurately simulate steady and, for the first time, unsteady fluid flow over a complete wing-pylon-store configuration with the store in the captive and vertical launch positions. Dissert. Abstr.

N90-14511*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

THERMAL/STRUCTURAL ANALYSES OF SEVERAL HYDROGEN-COOLED LEADING-EDGE CONCEPTS FOR HYPERSONIC FLIGHT VEHICLES

HERBERT J. GLADDEN, MATTHEW E. MELIS, THEODORE T. MOCKLER, and MIKE TONG (Sverdrup Technology, Inc., Cleveland, OH.) 1990 16 p Presented at the 28th Aerospace Sciences Meeting, Reno, NV, 8-11 Jan. 1990; sponsored by AIAA Original contains color illustrations

(NASA-TM-102391; E-4788; NAS 1.15:102391; AIAA-90-0053) Avail: NTIS HC A03/MF A01 CSCL 20/4

The aerodynamic heating at high flight Mach numbers, when shock interference heating is included, can be extremely high and can exceed the capability of most conventional metallic and potential ceramic materials available. Numerical analyses of the heat transfer and thermal stresses are performed on three actively cooled leading-edge geometries (models) made of three different materials to address the issue of survivability in a hostile environment. These analyses show a mixture of results from one configuration to the next. Results for each configuration are presented and discussed. Combinations of enhanced internal film coefficients and high material thermal conductivity of copper and tungsten are predicted to maintain the maximum wall temperature for each concept within acceptable operating limits. The exception is the TD nickel material which is predicted to melt for most cases. The wide range of internal impingement film coefficients (based on correlations) for these conditions can lead to a significant uncertainty in expected leading-edge wall temperatures. The equivalent plastic strain, inherent in each configuration which results from the high thermal gradients, indicates a need for further cyclic analysis to determine component life. Author

N90-14617*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

COMPARISON OF TWO DROPLET SIZING SYSTEMS IN AN ICING WIND TUNNEL

J. R. OLDENBURG and R. F. IDE (Army Aviation Systems Command, Cleveland, OH.) 1990 19 p Presented at the 28th Aerospace Sciences Meeting, Reno, NV, 8-11 Jan. 1990; sponsored by AIAA

(Contract DA PROJ. 1L1-62209-A4-7A)

(NASA-TM-102456; E-5240; NAS 1.15:102456; AVSCOM-TM-89-C-015; AIAA-90-0668) Avail: NTIS HC A03/MF A01 CSCL 13/2

A comparison between the Phase Doppler Analyzer and the combined measurements from the Particle Measuring Systems Forward Scattering Spectrometer Probe and the Optical Array Probe was conducted in an icing wind tunnel using NASA Icing Research Tunnel spray nozzles to produce the icing cloud. Clouds with a range of volume median diameters from 10 to greater than 50 microns were used for the instrument comparisons. A comparison of the volume median diameter from the Phase Doppler Particle Analyzer and only the Forward Scattering Spectrometer Probe indicated agreement up to 18 microns. A combined volume median diameter was calculated from the droplet distribution of the Optical Array Probe and the Forward Scattering Spectrometer Probe. A comparison of the combined volume median diameters and the Phase Doppler Particle Analyzer volume median diameters showed agreement up to 30 microns with the agreement deteriorating rapidly above 30 microns. Droplet distributions from the Phase Doppler Particle Analyzer, the Forward Scattering Spectrometer Probe, and Optical Array Probe are presented. Author

N90-14641*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

THERMAL FATIGUE DURABILITY FOR ADVANCED PROPULSION MATERIALS

GARY R. HALFORD Oct. 1989 13 p Presented at the Australian Aeronautical Conference, Melbourne, Australia, 9-11 Oct. 1989; sponsored in part by The Inst. of Engineers, Australia; The Royal Aeronautical Society; and The Aeronautical Research Lab.

(NASA-TM-102348; E-5057; NAS 1.15:102348) Avail: NTIS HC A03/MF A01 CSCL 20/11

A review is presented of thermal and thermomechanical fatigue (TMF) crack initiation life prediction and cyclic constitutive modeling efforts sponsored recently by the NASA Lewis Research Center in support of advanced aeronautical propulsion research. A brief description is provided of the more significant material durability models that were created to describe TMF fatigue resistance of both isotropic and anisotropic superalloys, with and without oxidation resistant coatings. The two most significant crack initiation models are the cyclic damage accumulation model and the total strain version of strainrange partitioning. Unified viscoplastic cyclic constitutive models are also described. A troika of industry, university, and government research organizations contributed to the generation of these analytic models. Based upon current capabilities and established requirements, an attempt is made to project which TMF research activities most likely will impact future generation propulsion systems. Author

N90-14656*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

CONCURRENT PROCESSING ADAPTATION OF AEROPLASTIC ANALYSIS OF PROPFANS

DAVID C. JANETZKE and DURBHA V. MURTHY (Toledo Univ., OH.) Jan. 1990 24 p Prepared for presentation at the 31st Structures, Structural Dynamics, and Materials Conference, Long Beach, CA, 2-4 Apr. 1990; cosponsored by AIAA, ASME, ASCE, AHS, and ASC

(Contract NAG3-742)

(NASA-TM-102455; E-5105; NAS 1.15:102455) Avail: NTIS HC A03/MF A01 CSCL 20/11

Discussed here is a study involving the adaptation of an advanced aeroelastic analysis program to run concurrently on a shared memory multiple processor computer. The program uses a three-dimensional compressible unsteady aerodynamic model and blade normal modes to calculate aeroelastic stability and response of propfan blades. The identification of the computational parallelism within the sequential code and the scheduling of the concurrent subtasks to minimize processor idle time are discussed. Processor idle time in the calculation of the unsteady aerodynamic coefficients was reduced by the simple strategy of appropriately ordering the computations. Speedup and efficiency results are presented for the calculation of the matched flutter point of an experimental propfan model. The results show that efficiencies above 70 percent can be obtained using the present implementation with 7 processors. The parallel computational strategy described here is also applicable to other aeroelastic analysis procedures based on panel methods. Author

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GEOSCIENCES

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

A90-19733#
A PROGRAM TO IMPROVE AIRCRAFT ICING FORECASTS
W. R. SAND, M. K. POLITOVICH, and R. M. RASMUSSEN (National Center for Atmospheric Research, Boulder, CO) AIAA, Aerospace Sciences Meeting, 28th, Reno, NV, Jan. 8-11, 1990. 7 p. Research supported by the National Center for Atmospheric Research and NSF. refs
(Contract DOT-FA01-89-Z-02062)
(AIAA PAPER 90-0196) Copyright

The development, objectives, facilities, and participants involved in a planned cooperative research program to study aircraft icing formation and related subjects are discussed. The scientific goals of the program include improving understanding of the winter storm icing environment, characterizing droplet size distribution, analyzing large supercooled droplet regions, quantifying the effect of terrain on the icing environment, developing numerical simulations of supercooled liquid water regions, evaluating existing instruments, and developing new instruments. C.D.

A90-19917*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
A MONTE CARLO SIMULATION TECHNIQUE FOR LOW-ALTITUDE, WIND-SHEAR TURBULENCE
ROLAND L. BOWLES (NASA, Langley Research Center, Hampton, VA), TONY R. LAITURI (Ford Motor Co., Dearborn, MI), and GEORGE TREVINO (Michigan Technological University, Houghton) AIAA, Aerospace Sciences Meeting, 28th, Reno, NV, Jan. 8-11, 1990. 9 p. refs
(AIAA PAPER 90-0564) Copyright

A case is made for including anisotropy in a Monte Carlo flight simulation scheme of low-altitude wind-shear turbulence by means of power spectral density. This study attempts to eliminate all flight simulation-induced deficiencies in the basic turbulence model. A full-scale low-altitude wind-shear turbulence simulation scheme is proposed with particular emphasis on low cost and practicality for near-ground flight. The power spectral density statistic is used to highlight the need for realistic estimates of energy transfer associated with low-altitude wind-shear turbulence. The simulation of a particular anisotropic turbulence model is shown to be a relatively simple extension from that of traditional isotropic (Dryden) turbulence. S.A.V.

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MATHEMATICAL AND COMPUTER SCIENCES

Includes mathematical and computer sciences (general); computer operations and hardware; computer programming and software; computer systems; cybernetics; numerical analysis; statistics and probability; systems analysis; and theoretical mathematics.

A90-16857#
A SEPARATED ALGORITHM AND APPLICATIONS TO FLIGHT TEST
ZHONGKE SHI and PEIDE WANG (Northwestern Polytechnical University, Xian, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 10, Oct. 1989, p. B501-B508. In Chinese, with abstract in English. refs

This paper presents a new separated bias identification and state estimation algorithm used for both the flight state estimation and instrumentation errors identification. To get high accuracy, U-D factorization methods are applied to improving the computational stability and efficiency. A discrete-time model of aircraft motion is used for decreasing modeling errors. This new approach is compared with the conventional method using digital simulation and actual flight test data compatibility check. The calculative results show that the new method can provide more consistent results than the usual one for different initial values and noise statistics. The approach can also be used for compatibility checking of low sampled flight test data. C.D.

A90-18050* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
APPLICATIONS OF FUZZY SETS TO RULE-BASED EXPERT SYSTEM DEVELOPMENT
ROBERT N. LEA (NASA, Johnson Space Center, Houston, TX) (NASA, Bendix Field Engineering Corp., Computer Sciences Corp., et al., Annual Goddard Conference on Space Applications of Artificial Intelligence, Greenbelt, MD, May 16, 17, 1989) Telematics and Informatics (ISSN 0736-5853), vol. 6, no. 3-4, 1989, p. 403-406. Previously announced in STAR as N89-26606. refs
Copyright

Problems of implementing rule-based expert systems using fuzzy sets are considered. A fuzzy logic software development shell is used that allows inclusion of both crisp and fuzzy rules indecision making and process control problems. Results are given that compare this type of expert system to a human expert in some specific applications. Advantages and disadvantages of such systems are discussed. Author

A90-18444
AN APPLICATION OF SQP AND ADA TO THE STRUCTURAL OPTIMISATION OF AIRCRAFT WINGS
M. C. BARTHOLOMEW-BIGGS (Hatfield Polytechnic, England) Aeronautical Journal (ISSN 0001-9240), vol. 93, Nov. 1989, p. 344-350. refs
Copyright

Two versions of the Sequential Quadratic Programming technique for constrained optimization are described and used to solve some minimum weight design calculations for aircraft wings. The problems and the solution methods are described and discussed in some detail: but the main feature of the work is the use of the programming language Ada for writing the necessary software. Some features of the language are illustrated which appear to be valuable for many kinds of numerical computation. In particular, it is also shown that Ada facilitates the calculation of the partial derivatives of function and constraint expressions which are required in optimization calculations but which are often quite difficult to obtain in practice. Author

A90-19630*# Old Dominion Univ., Norfolk, VA.
APPLICATIONS OF LAGRANGIAN BLENDING FUNCTIONS FOR GRID GENERATION AROUND AIRPLANE GEOMETRIES
JAMSHID S. ABOLHASSANI, IDEEN SADREHAGHIGHI, SURENDRA N. TIWARI (Old Dominion University, Norfolk, VA), and ROBERT E. SMITH (NASA, Langley Research Center, Hampton, VA) AIAA, Aerospace Sciences Meeting, 28th, Reno, NV, Jan. 8-11, 1990. 12 p. refs
(Contract NCC1-68)
(AIAA PAPER 90-0009)

A simple procedure has been developed and applied for the grid generation around an airplane geometry. This approach is based on a transfinite interpolation with Lagrangian interpolation for the blending functions. A monotonic rational quadratic spline interpolation has been employed for the grid distributions. Author

A90-19821#
USE OF COMPUTER-AIDED VIDEO DISPLAY TECHNOLOGY IN AVIATION WEATHER LITIGATION
PETER H. HILDEBRAND AIAA, Aerospace Sciences Meeting, 28th, Reno, NV, Jan. 8-11, 1990. 5 p.
(AIAA PAPER 90-0373) Copyright

The use of Computer-Aided Video Display technology in aviation weather litigation is presented from the point of view of a weather expert, using examples from the Delta 191 litigation. The major aspects of use of Computer-Aided Video Display include modeling and visualization of the weather and aircraft and data base management of information including model output, visualizations, but also including other information such as photographs, text, or any other information which can be displayed on a TV screen. The use of a computer-controlled, random access display storage medium, such as video disk, provides for a flexible use of the information in court. Author

N90-13990*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.
A KNOWLEDGE-BASED SYSTEM DESIGN/INFORMATION TOOL FOR AIRCRAFT FLIGHT CONTROL SYSTEMS
DALE A. MACKALL and JAMES G. ALLEN (Draper, Charles Stark Lab., Inc., Cambridge, MA) Oct. 1989 19 p Presented at the 7th AIAA Computers in Aerospace Conference, Monterey, CA, 4-6 Oct. 1989 Previously announced in IAA as A90-10491
(NASA-TM-101704; H-1546; NAS 1.15:101704) Avail: NTIS HC A03/MF A01 CSCL 09/2

Research aircraft have become increasingly dependent on advanced control systems to accomplish program goals. These aircraft are integrating multiple disciplines to improve performance and satisfy research objectives. This integration is being accomplished through electronic control systems. Because of the number of systems involved and the variety of engineering disciplines, systems design methods and information management have become essential to program success. The primary objective of the system design/information tool for aircraft flight control system is to help transfer flight control system design knowledge to the flight test community. By providing all of the design information and covering multiple disciplines in a structured, graphical manner, flight control systems can more easily be understood by the test engineers. This will provide the engineers with the information needed to thoroughly ground test the system and thereby reduce the likelihood of serious design errors surfacing in flight. The secondary objective is to apply structured design techniques to all of the design domains. By using the techniques in the top level system design down through the detailed hardware and software designs, it is hoped that fewer design anomalies will result. The flight test experiences of three highly complex, integrated aircraft programs are reviewed: the X-29 forward-swept wing, the advanced fighter technology integration (AFTI) F-16, and the highly maneuverable aircraft technology (HiMAT) program. Significant operating anomalies and the design errors which cause them, are examined to help identify what functions a system design/information tool should provide to assist designers in avoiding errors. Author

N90-13995*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.
A KNOWLEDGE-BASED FLIGHT STATUS MONITOR FOR REAL-TIME APPLICATION IN DIGITAL AVIONICS SYSTEMS
E. L. DUKE, J. D. DISBROW, and G. F. BUTLER (Royal Aerospace Establishment, Farnborough, England) Oct. 1989 14 p Presented at the MILCOMP'89 Conference, London, England, 26-28 Sep. 1989
(NASA-TM-101710; H-1568; NAS 1.15:101710) Avail: NTIS HC A03/MF A01 CSCL 09/2

The Dryden Flight Research Facility of the National Aeronautics and Space Administration (NASA) Ames Research Center (Ames-Dryden) is the principal NASA facility for the flight testing and evaluation of new and complex avionics systems. To aid in the interpretation of system health and status data, a knowledge-based flight status monitor was designed. The monitor was designed to use fault indicators from the onboard system which are telemetered to the ground and processed by a rule-based model of the aircraft failure management system to give timely advice and recommendations in the mission control room. One of the important constraints on the flight status monitor is the need to operate in real time, and to pursue this aspect, a joint research activity between NASA Ames-Dryden and the Royal Aerospace Establishment (RAE) on real-time knowledge-based systems was established. Under this agreement, the original LISP knowledge base for the flight status monitor was reimplemented using the intelligent knowledge-based system toolkit, MUSE, which was developed under RAE sponsorship. Details of the flight status monitor and the MUSE implementation are presented. Author

N90-14031*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
LABORATORY TEST METHODOLOGY FOR EVALUATING THE EFFECTS OF ELECTROMAGNETIC DISTURBANCES ON FAULT-TOLERANT CONTROL SYSTEMS
CELESTE M. BELCASTRO Nov. 1989 20 p
(NASA-TM-101665; NAS 1.15:101665) Avail: NTIS HC A03/MF A01 CSCL 12/2

Control systems for advanced aircraft, especially those with relaxed static stability, will be critical to flight and will, therefore, have very high reliability specifications which must be met for adverse as well as nominal operating conditions. Adverse conditions can result from electromagnetic disturbances caused by lightning, high energy radio frequency transmitters, and nuclear electromagnetic pulses. Tools and techniques must be developed to verify the integrity of the control system in adverse operating conditions. The most difficult and illusive perturbations to computer based control systems caused by an electromagnetic environment (EME) are functional error modes that involve no component damage. These error modes are collectively known as upset, can occur simultaneously in all of the channels of a redundant control system, and are software dependent. A methodology is presented for performing upset tests on a multichannel control system and considerations are discussed for the design of upset tests to be conducted in the lab on fault tolerant control systems operating in a closed loop with a simulated plant. Author

N90-14713*# Sverdrup Technology, Inc., Cleveland, OH.
USER'S GUIDE TO PMESH: A GRID-GENERATION PROGRAM FOR SINGLE-ROTATION AND COUNTERROTATION ADVANCED TURBOPROPS Final Report
SAIF A. WARSI Dec. 1989 25 p
(Contract NAS3-24105)
(NASA-CR-185156; E-5152; NAS 1.26:185156) Avail: NTIS HC A03/MF A01 CSCL 09/2

A detailed operating manual is presented for a grid generating program that produces 3-D meshes for advanced turboprops. The code uses both algebraic and elliptic partial differential equation methods to generate single rotation and counterrotation, H or C type meshes for the z - r planes and H type for the z - theta planes. The code allows easy specification of geometrical constraints (such as blade angle, location of bounding surfaces, etc.), mesh control parameters (point distribution near blades and nacelle, number of grid points desired, etc.), and it has good runtime diagnostics. An overview is provided of the mesh generation procedure, sample input dataset with detailed explanation of all input, and example meshes. Author

N90-14843*# Hampton Univ., VA. Dept. of Applied Mathematics.
A TWO DIMENSIONAL POWER SPECTRAL ESTIMATE FOR SOME NONSTATIONARY PROCESSES M.S. Thesis
GREGORY L. SMITH 1989 73 p
(Contract NAG1-768)
(NASA-CR-186100; NAS 1.26:186100) Avail: NTIS HC A04/MF A01 CSCL 12/1

A two dimensional estimate for the power spectral density of a nonstationary process is being developed. The estimate will be applied to helicopter noise data which is clearly nonstationary. The acoustic pressure from the isolated main rotor and isolated tail rotor is known to be periodically correlated (PC) and the combined noise from the main and tail rotors is assumed to be correlation autoregressive (CAR). The results of this nonstationary analysis will be compared with the current method of assuming that the data is stationary and analyzing it as such. Another method

of analysis is to introduce a random phase shift into the data as shown by Papoulis to produce a time history which can then be accurately modeled as stationary. This method will also be investigated for the helicopter data. A method used to determine the period of a PC process when the period is not know is discussed. The period of a PC process must be known in order to produce an accurate spectral representation for the process. The spectral estimate is developed. The bias and variability of the estimate are also discussed. Finally, the current method for analyzing nonstationary data is compared to that of using a two dimensional spectral representation. In addition, the method of phase shifting the data is examined. Author

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PHYSICS

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

A90-16692
SYNTHETIC HOLOGRAPHY APPLIED TO HEAD-UP DISPLAYS [HOLOGRAPHIE SYNTHETIQUE APPLIQUEE AUX VISUALISATIONS TETE HAUTE]
J. P. GERBE (Thomson-CSF, Paris, France) Revue Scientifique et Technique de la Defense (ISSN 0994-1541), 2nd Quarter, 1989, p. 49-53. In French.
Copyright
This paper describes a method of achieving optical holographic elements, for a given phase function, by the recording of the interference phenomenon between two complex waves (analog hologram) and the use of a computer-generated hologram (synthetic hologram) to create one of the two necessary waves. The design and the method of realization of the hologram generated by a computer are described. The applications to head-up displays and the performances obtained are also discussed. S.A.V.

A90-16825
RECENT RESEARCH ON EXTERNAL HELICOPTER NOISE AT ONERA
SERGE LEWY (ONERA, Chatillon-sous-Bagneux, France) Vertiflite (ISSN 0042-4455), vol. 35, Nov.-Dec. 1989, p. 56-61. refs
Copyright
Recent ONERA theoretical and experimental investigations of helicopter external noise and its suppression are reviewed. Topics addressed include generalized programs for the prediction of rotor tone noise, noise from blade-vortex interactions, high-speed noise, and turboshaft-engine noise. Diagrams, drawings, graphs, and photographs are provided. T.K.

A90-17861#
NOISE PREDICTION OF A COUNTER-ROTATION PROPFAN
K. KAWACHI (Tokyo, University, Japan), Y. NAKAMURA (Ishikawajima-Harima Heavy Industries Co., Ltd., Tokyo, Japan), and T. WATANABE Journal of Aircraft (ISSN 0021-8669), vol. 26, Dec. 1989, p. 1049, 1050. Previously cited in issue 04, p. 568, Accession no. A88-16527.
Copyright

A90-17984*# Virginia Polytechnic Inst. and State Univ., Blacksburg.
FREE-FIELD CORRECTION FACTOR FOR SPHERICAL ACOUSTIC WAVES IMPINGING ON CYLINDERS
C. R. FULLER (Virginia Polytechnic Institute and State University, Blacksburg) AIAA Journal (ISSN 0001-1452), vol. 27, Dec. 1989, p. 1722-1726. Previously cited in issue 04, p. 571, Accession no. A88-16574. refs
(Contract NAG1-390)
Copyright

A90-17998*# Florida Atlantic Univ., Boca Raton.
SOUND RADIATION FROM AN AIRFOIL ENCOUNTERING AN OBLIQUE GUST IN ITS PLANE OF MOTION
STEWART A. L. GLEGG (Florida Atlantic University, Boca Raton) AIAA Journal (ISSN 0001-1452), vol. 27, Dec. 1989, p. 1820-1822.
(Contract NAG1-715)
Copyright
An evaluation is conducted of the acoustic field radiated when an airfoil encounters a gust in the plane of motion, with a view to the prediction of helicopter tail rotor noise. The analysis is based on the unsteady thickness noise theory of Glegg (1987). Sound radiation is shown to be dominated by the transient effect of the blade tip moving into the velocity deficit, so that the effects of blade rotation are not important. O.C.

A90-18448
SOME PROCESSES OF SOUND GENERATION IN A VORTEX-AIRFOIL SYSTEM WITH PARALLEL AXES
H.-M. LENT, K. F. LOEHR, G. E. A. MEIER, and U. SCHIEVELBUSCH (Max-Planck-Institut fuer Stroemungsforschung, Goettingen, Federal Republic of Germany) Journal d'Acoustique (ISSN 0988-4319), vol. 2, Dec. 1989, p. 365-367.
Copyright
Experimental results on the interaction of a vortex with an airfoil in a compressible flow are presented. Different methods of vortex generation were used. Mainly two different kinds of sound generation mechanisms during the interaction were observed with a Mach-Zehnder interferometer. Author

A90-18449
PREDICTION OF THE INTERACTION NOISE EMITTED BY HELICOPTER FENESTRONS [PREDICTION DU BRUIT D'INTERACTION RAYONNE PAR LES FENESTRONS D'HELICOPTERES]
FRANCETTE FOURNIER and MICHEL ROGER (Lyon, Ecole Centrale, Ecully, France) Journal d'Acoustique (ISSN 0988-4319), vol. 2, Dec. 1989, p. 393-399. In French. refs
Copyright
This paper is concerned with the sound generation from a helicopter fenestron due to rotor-stator interactions. Two mechanisms are investigated: (1) the rotor noise due to potential disturbances created by the cylindric struts (transmission shaft and support arm) located behind the rotorplane, and (2) the stator noise resulting from the interaction with the rotor viscous wakes. Each mechanism is theoretically analyzed. The models employed give a simple expression of the acoustic field without requiring adjustable parameters and thus can be used as prediction methods. Author

A90-18450
POSSIBILITY OF ACTIVE PROPELLER-NOISE SUPPRESSION IN PISTON-ENGINE AIRCRAFT BY CHANGING THE PHASE RELATION BETWEEN THE PROPELLER AND EXHAUST SIGNALS [MOEGLICHKEIT EINER AKTIVEN PROPELLERGERAEUSCH-DAEMPFUNG BEI KOLBENMOTORGETRIEBENEN FLUGZEUGEN DURCH AENDERUNG DER PHASENBEZIEHUNG PROPELLER-/MOTORAUSLASSSIGNAL]
MICHAEL KALLERGIS (DLR, Institut fuer Entwurfsaerodynamik, Brunswick, Federal Republic of Germany) Journal d'Acoustique (ISSN 0988-4319), vol. 2, Dec. 1989, p. 401-406. In German. refs
Copyright
A study is made of the feasibility of attenuating propeller farfield noise by a superposition of the exhaust noise from the piston engine with the propeller noise in such a way as to produce a destructive interference. A potentially promising method lies in the adjustment of the relative circumferential position of the propeller blades so that sound and antisound combine for 'zero sound output'. To substantiate the approach, a Cessna 207T was used as test aircraft. Flight tests were then conducted for various relative

blade positions and acoustic measurements made; preliminary data indicate a difference of 3 to 4 dB between particularly good and bad relative propeller-blade positions. Author

A90-18599#
PREDICTION OF TRANSMISSION LOSS THROUGH AN AIRCRAFT SIDEWALL USING STATISTICAL ENERGY ANALYSIS
RUISEN MING and JINCAI SUN (Northwestern Polytechnical University, Xian, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 10, June 1989, p. B264-B271. In Chinese, with abstract in English. refs

The transmission loss of randomly incident sound through an aircraft sidewall is investigated using statistical energy analysis. Formulas are also obtained for the simple calculation of sound transmission loss through single- and double-leaf panels. Both resonant and nonresonant sound transmissions can be easily calculated using the formulas. The formulas are used to predict sound transmission losses through a Y-7 propeller airplane panel. The panel measures 2.56 m x 1.38 m and has two windows. The agreement between predicted and measured values through most of the frequency ranges tested is quite good. S.A.V.

A90-19385*# United Technologies Research Center, East Hartford, CT.
ROTOR NOISE DUE TO ATMOSPHERIC TURBULENCE INGESTION. I - FLUID MECHANICS
J. C. SIMONICH, R. K. AMIET, R. H. SCHLINKER (United Technologies Research Center, East Hartford, CT), and E. M. GREITZER (MIT, Cambridge, MA) Journal of Aircraft (ISSN 0021-8669), vol. 27, Jan. 1990, p. 7-14. Previously cited in issue 22, p. 3337, Accession no. A86-45479. refs
(Contract NAS1-17096)
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A90-19386*# United Technologies Research Center, East Hartford, CT.
ROTOR NOISE DUE TO ATMOSPHERIC TURBULENCE INGESTION. II - AEROACOUSTIC RESULTS
R. K. AMIET, J. C. SIMONICH, and R. H. SCHLINKER (United Technologies Research Center, East Hartford, CT) Journal of Aircraft (ISSN 0021-8669), vol. 27, Jan. 1990, p. 15-22. Previously cited in issue 22, p. 3334, Accession no. A86-45404. refs
(Contract NAS1-17096)
Copyright

A90-19770*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
A KINEMATICAL/NUMERICAL ANALYSIS OF ROTOR-STATOR INTERACTION NOISE
AKIL A. RANGWALLA and MAN MOHAN RAI (NASA, Ames Research Center, Moffett Field, CA) AIAA, Aerospace Sciences Meeting, 28th, Reno, NV, Jan. 8-11, 1990. 17 p. Research supported by NASA. refs
(AIAA PAPER 90-0281) Copyright

In this study, the unsteady, thin-layer Navier-Stokes equations are solved using a system of patched grids for a rotor-stator configuration of an axial turbine. The study examines the plurality of spinning modes that are present in such an interaction. The propagation of these modes is analyzed and appropriate grid spacing chosen in the far upstream and downstream regions to attenuate reflections from the computational boundaries. In addition, radiating boundary conditions are implemented based on the farfield acoustical behavior of the flow field. Results in the form of pressure amplitudes and the spectra of turbine tones are presented. Numerical results and experimental data are compared wherever possible. The numerical results are also shown to conform with the predictions of a kinematical analysis of the flowfield. Author

A90-19772#
SARL NOISE MEASUREMENTS
THOMAS TIGHE and RALPH SHIMOVETZ (USAF, Wright Research and Development Center, Wright-Patterson AFB, OH) AIAA, Aerospace Sciences Meeting, 28th, Reno, NV, Jan. 8-11, 1990. 9 p. refs
(AIAA PAPER 90-0285)

Preliminary noise measurements made in the test section of the Subsonic Aerodynamic Research Laboratory (SARL) indicate that acoustic tones are of a magnitude that may be detrimental to the low turbulence design requirements. Peaks of 137 dB at 207 Hz blade passage frequency (BPF) in the test section indicate acoustic particle velocity ratios (u/U) on the order of 0.00246 (1.141 ft/sec at U = 465 ft/sec). This level is five times the desired turbulence velocity level in the test section which has been designed to be (u/U) = 0.05 percent. The possible sources of the measured noise levels in the test section (TS) are: (1) fan noise caused by the fluctuation forces on the rotor/stator interactions and fluctuating mass flows, (2) turbulent boundary layer flow radiating noise into the area of the TS, (3) TS pressure rake apparatus generating aeroacoustic turbulent wakes, and (4) radiation of acoustic waves from the tunnel walls due to structural vibration. Author

A90-19815#
SUPERSONIC JET NOISE REDUCTION BY A POROUS SINGLE EXPANSION RAMP NOZZLE
K. J. YAMAMOTO, M. J. DONELSON (Douglas Aircraft Co., Long Beach, CA), and R. W. WLEZIEN (McDonnell Douglas Research Laboratories, Saint Louis, MO) AIAA, Aerospace Sciences Meeting, 28th, Reno, NV, Jan. 8-11, 1990. 10 p. Research supported by the McDonnell Douglas Independent Research and Development Program. refs
(AIAA PAPER 90-0366) Copyright

A shock noise reduction concept for supersonic rectangular jets is investigated for high speed civil transport (HSCT) applications. The noise reduction efficiency of a porous single external expansion ramp nozzle (SERN) with a 5:1 aspect ratio is experimentally investigated at both design and off-design pressure ratios. Porosity is implemented as a regular array of discrete holes in the ramp surface. Near- and far-field acoustic measurements, axial static pressure profiles, and Schlieren flow visualization are used to characterize the noise reduction mechanisms of the porous ramp. Solid ramp configurations are shown to dramatically reduce screech tones relative to a free rectangular jet. Surface porosity produces additional noise reduction by decreasing shock cell strength and consequently the magnitude of shock-associated noise. At a typical takeoff condition, approximately three EPNL dB reduction is estimated with 8 percent porosity ramp relative to no-ramp configuration. Author

A90-19817*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
A STUDY OF THE LIMITATIONS OF LINEAR THEORY METHODS AS APPLIED TO SONIC BOOM CALCULATIONS
CHRISTINE M. DARDEN (NASA, Langley Research Center, Hampton, VA) AIAA, Aerospace Sciences Meeting, 28th, Reno, NV, Jan. 8-11, 1990. 11 p. refs
(AIAA PAPER 90-0368) Copyright

Current sonic boom minimization theories have been reviewed to emphasize the capabilities and flexibilities of the methods. Flexibility is important because it is necessary for the designer to meet optimized area constraints while reducing the impact on vehicle aerodynamic performance. Preliminary comparisons of sonic booms predicted for two Mach 3 concepts illustrate the benefits of shaping. Finally, for very simple bodies of revolution, sonic boom predictions were made using two methods - a modified linear theory method and a nonlinear method - for signature shapes which were both farfield N-waves and midfield waves. Preliminary analysis on these simple bodies verified that current modified linear theory prediction methods become inadequate for predicting midfield signatures for Mach numbers above 3. The importance of impulse is sonic boom disturbance and the importance of three-dimensional effects which could not be simulated with the bodies of revolution will determine the validity of current modified

linear theory methods in predicting midfield signatures at lower Mach numbers. Author

N90-14074# Ecole Centrale de Lyon (France). Lab. de Mecanique des Fluides et d'Acoustique.
A MODEL SUITABLE FOR PREDICTING THE NOISE ASSOCIATED WITH THE DUCTED TAIL ROTOR OF A HELICOPTER Ph.D. Thesis [MISE AU POINT D'UNE METHODE DE CALCUL ADAPTEE AU BRUIT DES FENESTRONS D'HELICOPTERES]
FRANCETTE FOURNIER 1988 162 p In FRENCH
(ECL-88-09; ETN-90-95765) Avail: NTIS HC A08/MF A01

Different fenestron configurations are studied experimentally. The measured acoustical characteristics include frequency spectra and directivity for several pitch angles of the rotor blades. The primary noise sources discussed include the rotor noise due to ingestion of preturbulence, the stator noise due to interaction with rotor created viscous wakes, and the noise due to the presence of transmission shaft and support arm in the stator. A method is developed to take into account the wakes and the potential field. Good agreement is found between experiment and theory. ESA

N90-14866*# *Boeing Commercial Airplane Co., Seattle, WA.*
EVALUATION OF ANALYSIS TECHNIQUES FOR LOW FREQUENCY INTERIOR NOISE AND VIBRATION OF COMMERCIAL AIRCRAFT
A. E. LANDMANN, H. F. TILLEMA, and S. E. MARSHALL Oct. 1989 73 p Prepared in cooperation with Cambridge Collaborative, Inc., MA
(Contract NAS1-18027)
(NASA-CR-181851; NAS 1.26:181851) Avail: NTIS HC A04/MF A01 CSCL 20/1

The application of selected analysis techniques to low frequency cabin noise associated with advanced propeller engine installations is evaluated. Three design analysis techniques were chosen for evaluation including finite element analysis, statistical energy analysis (SEA), and a power flow method using element of SEA (computer program Propeller Aircraft Interior Noise). An overview of the three procedures is provided. Data from tests of a 727 airplane (modified to accept a propeller engine) were used to compare with predictions. Comparisons of predicted and measured levels at the end of the first year's effort showed reasonable agreement leading to the conclusion that each technique had value for propeller engine noise predictions on large commercial transports. However, variations in agreement were large enough to remain cautious and to lead to recommendations for further work with each technique. Assessment of the second year's results leads to the conclusion that the selected techniques can accurately predict trends and can be useful to a designer, but that absolute level predictions remain unreliable due to complexity of the aircraft structure and low modal densities. Author

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SOCIAL SCIENCES

Includes social sciences (general); administration and management; documentation and information science; economics and cost analysis; law and political science; and urban technology and transportation.

A90-19819#
LITIGATION AND THE NATIONAL WEATHER SERVICE
JAMES T. SKEEN, JR. (U.S. National Weather Service, Silver Spring, MD) AIAA, Aerospace Sciences Meeting, 28th, Reno, NV, Jan. 8-11, 1990. 5 p.
(AIAA PAPER 90-0371)

This paper describes the impact of litigation of the National Weather Service. The involvement of agency personnel in litigation-related activities is detailed and selected lawsuits are reviewed. It is hypothesized that emerging new technologies such as Doppler weather radar and automated surface observing systems will create a greater presumption of negligence when weather-related accidents occur. Author

N90-14153*# Allied-Signal Aerospace Co., Phoenix, AZ. Garrett Auxiliary Power Div.
ADVANCED TURBINE TECHNOLOGY APPLICATIONS PROJECT (ATTAP) Annual Report, 1988
Apr. 1989 249 p
(Contract DEN3-335)
(NASA-CR-185109; DOE/NASA/0335-1; NAS 1.26:185109; GARRETT-31-8071(1)) Avail: NTIS HC A11/MF A02 CSCL 10/2

Work to develop and demonstrate the technology of structural ceramics for automotive engines and similar applications is described. Long-range technology is being sought to produce gas turbine engines for automobiles with reduced fuel consumption and reduced environmental impact. The Advanced Turbine Technology Application Project (ATTAP) test bed engine is designed such that, when installed in a 3,000 pound inertia weight automobile, it will provide low emissions, 42 miles per gallon fuel economy on diesel fuel, multifuel capability, costs competitive with current spark ignition engines, and noise and safety characteristics that meet Federal standards. Author

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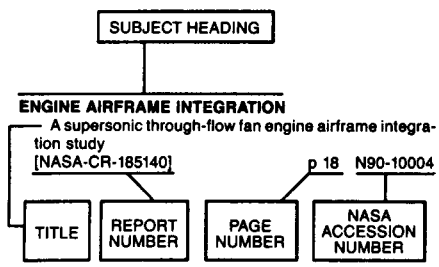

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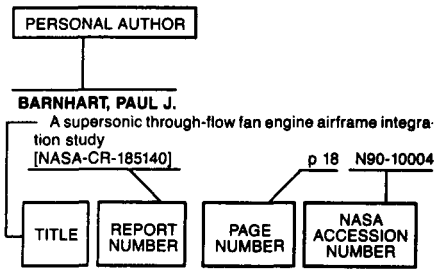

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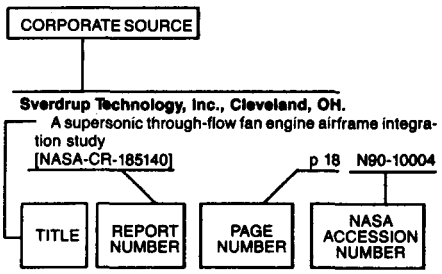

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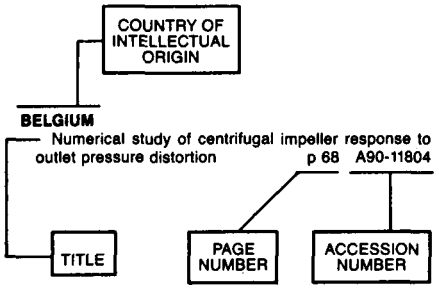

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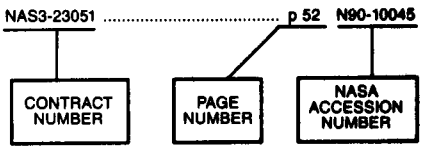

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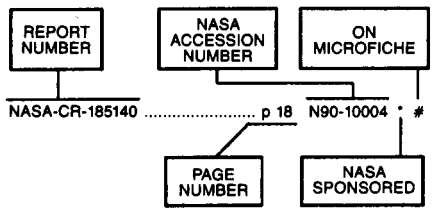

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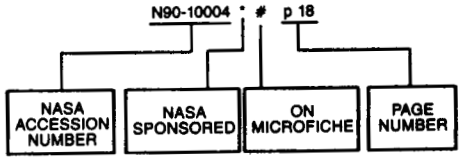

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