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A Continuing Bibliography with Indexes

NASA SP-7037(218)
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National Aeronautics and Space Administration

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ACCESSION NUMBER RANGES

Accession numbers cited in this Supplement fall within the following ranges.

STAR (N-10000 Series)	N87-23570 — N87-25266
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NASA SP-7037(218)

AERONAUTICAL ENGINEERING

A CONTINUING BIBLIOGRAPHY WITH INDEXES

(Supplement 218)

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 September 1987 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 469 reports, journal articles and other documents originally announced in September 1987 in *Scientific and Technical Aerospace Reports (STAR)* or in *International Aerospace Abstracts (IAA).*

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

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

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

An annual cummulative index will be published.

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

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TYPICAL REPORT CITATION AND ABSTRACT

NASA SPONSORED

ON MICROFICHE

ACCESSION NUMBER → N87-10039*# National Aeronautics and Space Administration. ← CORPORATE SOURCE
Langley Research Center, Hampton, Va.
TITLE → **WIND-TUNNEL INVESTIGATION OF THE FLIGHT CHARACTERISTICS OF A CANARD GENERAL-AVIATION AIRPLANE CONFIGURATION** — PUBLICATION DATE
AUTHOR → D. R. SATRAN Oct. 1986 60 p — AVAILABILITY SOURCE
REPORT NUMBERS → (NASA-TP-2623; L-15929; NAS 1.60:2623) Avail: NTIS HC
PRICE CODE → A04/MF A01 CSCL 01A ← COSATI CODE

A 0.36-scale model of a canard general-aviation airplane with a single pusher propeller and winglets was tested in the Langley 30- by 60-Foot Wind Tunnel to determine the static and dynamic stability and control and free-flight behavior of the configuration. Model variables made testing of the model possible with the canard in high and low positions, with increased winglet area, with outboard wing leading-edge droop, with fuselage-mounted vertical fin and rudder, with enlarged rudders, with dual deflecting rudders, and with ailerons mounted closer to the wing tips. The basic model exhibited generally good longitudinal and lateral stability and control characteristics. The removal of an outboard leading-edge droop degraded roll damping and produced lightly damped roll (wing rock) oscillations. In general, the model exhibited very stable dihedral effect but weak directional stability. Rudder and aileron control power were sufficiently adequate for control of most flight conditions, but appeared to be relatively weak for maneuvering compared with those of more conventionally configured models.
Author

TYPICAL JOURNAL ARTICLE CITATION AND ABSTRACT

NASA SPONSORED

ACCESSION NUMBER → A87-11487* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
COMPUTATION OF TURBULENT SUPERSONIC FLOWS AROUND POINTED BODIES HAVING CROSSFLOW SEPARATION ← TITLE
AUTHORS → D. DEGANI and L. B. SCHIFF (NASA, Ames Research Center, Moffett Field, CA) ← AUTHOR'S AFFILIATION
JOURNAL TITLE → Journal of Computational Physics (ISSN 0021-9991), vol 66, Sept. 1986, p. 173-196. refs

The numerical method developed by Schiff and Sturek (1980) on the basis of the thin-layer parabolized Navier-Stokes equations of Schiff and Steger (1980) is extended to the case of turbulent supersonic flows on pointed bodies at high angles of attack. The governing equations, the numerical scheme, and modifications to the algebraic eddy-viscosity turbulence model are described; and results for three cones and one ogive-cylinder body (obtained using grids of 50 nonuniformly spaced points in the radial direction between the body and the outer boundary) are presented graphically and compared with published experimental data. The grids employed are found to provide sufficient spatial resolution of the leeward-side vortices; when combined with the modified turbulence model, they are shown to permit accurate treatment of flows with large regions of crossflow separation. T.K.

AERONAUTICAL ENGINEERING

A Continuing Bibliography (Suppl. 218)

OCTOBER 1987

01

AERONAUTICS (GENERAL)

A87-40386#
POSSIBLE SOLUTIONS TO FUTURE AIRSPACE AND AIRPORT CONGESTION - AN AIRCRAFT MANUFACTURER'S CONTRIBUTION
PETER JOST (Airbus Industrie Canada, Montreal) (CASI, Annual General Meeting, 33rd, Vancouver, Canada, May 12, 1986) Canadian Aeronautics and Space Journal (ISSN 0008-2821), vol. 32, Sept. 1986, p. 240-246.

The role of the manufacturer in easing airspace and airport congestion is studied. The factors which limit the ATC are discussed. The subsystems and system elements of an air transport system are described. Examples revealing ways in which manufacturers can contribute to overcoming airport and airway congestion and maintaining a functioning air transport system are presented. Consideration is given to the use of bigger aircraft and reliever airports, and improving takeoff and climb performance, ground handling, and navigation aids. I.F.

A87-40840#
PACE OF STRUCTURAL MATERIALS SLOWS FOR COMMERCIAL TRANSPORTS
ALAN S. BROWN Aerospace America (ISSN 0740-722X), vol. 25, June 1987, p. 18-21, 28.

The fall of fuel prices in recent years is noted to have reduced the cost effectiveness of advanced composite materials' substitution for aluminum alloy in primary and secondary airframe structures; by comparison with 1980, when the figures were reversed, the 15-year cost of a transport aircraft is currently divided into 46 percent initial price and only 23 percent fuel. It is speculated, however, that composite parts costs 60-75 times greater than those of aluminum alloy will not prevent composite materials from retaining their former inroads in such applications as control surfaces. Advancements in thermoplastic matric composites are also expected to yield substantial manufacturing cost reductions. Currently very expensive Al-Li alloy components will be rendered more economical through the use of superplastic forming. O.C.

A87-41027#
EUROPE'S TILT-ROTOR - THE GAUNTLET IS TAKEN UP
GIOVANNI DE BRIGANTI Rotor and Wing International (ISSN 0191-6408), vol. 21, June 1987, p. 28, 29.

The European Future Advanced Rotorcraft 'Eurofar' program encompasses seven companies from five nations and is charged with investigation of the feasibility of a European tilt-rotor aircraft's production by the year 2000, in response to the possibility of a civilian version of the V-22 Osprey tilt-rotor. Preliminary specifications are for an 8800-lb normal payload aircraft with a 315-knot cruise speed and a normal cruise range of 620 miles. Powerplants will be of 3000 shp each, with 33-ft rotor diameter; a passenger capacity of 19 is anticipated. O.C.

A87-41028#
A U.S. CIVIL TILT-ROTOR - IS THE GAUNTLET THROWN?
KATHLEEN KOCKS Rotor and Wing International (ISSN 0191-6408), vol. 21, June 1987, p. 30-32.

In order to determine the national implications of a civilian tilt-rotor aircraft, NASA, the FAA and the DOD have sponsored a study of commercial markets for a range of potential tilt-rotor configurations. The scalings of the six aircraft studied would respectively accommodate 10, 19, 31, 39, 52, and 75 passengers; the 31-, 39, and 52-passenger aircraft would be derivatives of the V-22 Osprey military tilt-rotor. The primary driver for this line of research is the possibility of relieving airport congestion in the near future, especially in short-haul transport between urban centers. O.C.

02

AERODYNAMICS

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

A87-39409#
TRANSONIC WING DESIGN - OFF-DESIGN EFFICIENCY AND EFFECT OF FICTITIOUS GAS PARAMETER
ZIQIANG ZHU (Beijing Institute of Aeronautics and Astronautics, People's Republic of China) and H. SOBIECZKY (DFVLR, Cologne, West Germany) Acta Aeronautica et Astronautica Sinica, vol. 8, March 1987, p. A189-A194. In Chinese, with abstract in English. refs

The fictitious gas design method for supercritical wings is used with viscous-inviscid interaction. The effects of fictitious gas parameter and performance at off-design conditions are discussed for a selected baseline wing. Results show that effects of fictitious gas parameter are similar to that in 2-D flow and better performance is obtained for certain values of the parameter. Good performance at off-design condition can be obtained if M-alpha(infinity) is not far from M-alpha(DES). Author

A87-39429#
FIRST-ORDER VISCOUS FLOW PREDICTIONS WITH SYMMETRIC AND AFT-LOADED AIRFOILS
G. JOHNSTON and D. W. ZINGG (Toronto, University, Canada) Canadian Aeronautics and Space Journal (ISSN 0008-2821), vol. 33, March 1987, p. 20-25. refs

Calculated results are compared with experimental data for two dissimilar airfoil sections, the symmetric RAE 101 section and the NLF(1)-0416 section, which has considerable aft-loading. The predictions were obtained using an interactive method for fully-attached incompressible flow which solves the first-order boundary layer equations and utilizes the first-order displacement effect matching condition on the body and the wake. Calculations were performed both with and without a curvature corection to the pressures and a corresponding condition in the wake. The results show that the curvature correction leads to improved predictions of lift, moment, and pressure, particularly for the aft-loading section. However, the drag coefficients are consistently underestimated using the Squire-Young formula. This occurs primarily because the momentum thickness is underestimated at the trailing edge. It is concluded that the high flow curvature associated with the trailing edge region causes these inaccuracies and therefore that a viscous calculation of at least second-order is required for accurate drag prediction. Author

A87-39483#

PREDICTING PROPELLER BLADE LOADS WITHOUT TESTING

Aerospace Engineering (ISSN 0736-2536), vol. 7, April 1987, p. 4-9.

Propeller design tradeoff studies formerly dependent on the results of preliminary wind tunnel testing may now be conducted on the basis of low order aerodynamic flow codes predicting propeller flow fields. The quadrilateral element panel, or 'Quadpan' method, gives attention to the aerodynamic, aeroelastic, and acoustic interactions between aircraft wing, fuselage, propeller, and engine. Quadpan models of the P-3C naval patrol aircraft have been used to predict the effect of such parameters as pitch and yaw angles, engine shaft horsepower, configuration and Mach number on the prop flow field. Rigid blade loads were calculated for all three orthogonal components, using the Quadpan-predicted propeller disk inflow velocity fields. O.C.

A87-39526#

AERODYNAMIC COEFFICIENTS OF A THIN ELLIPTIC WING IN UNSTEADY MOTION

A. HAUPTMAN and T. MILOH (Tel Aviv University, Israel) AIAA Journal (ISSN 0001-1452), vol. 25, June 1987, p. 769-774. refs

An analytic solution is presented for the linearized lifting surface problem of a thin wing with an elliptic planform in unsteady incompressible flow. The analysis is based on the expansion of the acceleration potential in an infinite series of ellipsoidal harmonics and extends the steady analysis, recently developed by the authors, to the unsteady flow regime. Explicit expressions are obtained for both the starting lift in the case of impulsive acceleration and for the lift due to constant acceleration. The exact solution thus obtained is valid for the whole range of aspect ratios. The analytic result for the starting lift may thus be regarded as a new generalization of the classical Wagner's two-dimensional solution for planforms of finite aspect ratio. Author

A87-39527#

TWO-DIMENSIONAL TURBULENT SEPARATED FLOW

ROGER L. SIMPSON (Virginia Polytechnic Institute and State University, Blacksburg) (AIAA, Aerospace Sciences Meeting, 23rd, Reno, NV, Jan. 14-17

A87-39528*# United Technologies Research Center, East Hartford, Conn.

INVESTIGATION OF TWO-DIMENSIONAL SHOCK-WAVE/BOUNDARY-LAYER INTERACTIONS

STANLEY A. SKEBE (United Technologies Research Center, East Hartford, CT), ISAAC GREBER (Case Western Reserve University, Cleveland, OH), and WARREN R. HINGST (NASA, Lewis Research Center, Cleveland, OH) AIAA Journal (ISSN 0001-1452), vol. 25, June 1987, p. 777-783. Previously cited in issue 06, p. 701, Accession no. A84-17881. refs

(Contract NAG3-61; NAG3-102)

A87-39529#

MULTIGRID APPROXIMATE FACTORIZATION SCHEME FOR TWO-ELEMENT AIRFOIL FLOWS

G. VOLPE (Grumman Corporate Research Center, Bethpage, NY) AIAA Journal (ISSN 0001-1452), vol. 25, June 1987, p. 784-791. Previously cited in issue 18, p. 2569, Accession no. A84-39317. refs

A87-39531#

ACCURATE TRANSONIC WAVE DRAG PREDICTION USING SIMPLE PHYSICAL MODELS

JOSEF MERTENS, KARL D. KLEVENHUSEN, and HEINZ JAKOB (Messerschmitt-Boelkow-Blohm GmbH, Bremen, West Germany) AIAA Journal (ISSN 0001-1452), vol. 25, June 1987, p. 799-805. BMFT-supported research. Previously cited in issue 07, p. 837, Accession no. A86-19921. refs

A87-39536#

COMPUTATION OF LOW-SPEED FLOW WITH HEAT ADDITION

CHARLES L. MERKLE and YUN-HO CHOI (Pennsylvania State University, University Park) AIAA Journal (ISSN 0001-1452), vol. 25, June 1987, p. 831-838. refs

(Contract AF-AFOSR-82-0196)

A perturbation expansion is used to obtain a system of conservation laws for compressible flows that is valid at arbitrarily low Mach numbers. These equations are rendered hyperbolic by adding an artificial time derivative to the energy equation, thus introducing pseudoacoustic waves with a speed the same order as the particle velocity. Traditional time-iterative schemes are shown to be effective in solving this system numerically. Stability calculations of the complete vector system indicate unconditional stability at all Mach numbers in the absence of gravity, but the source term introduced by buoyancy becomes destabilizing at Froude numbers below about 1. This instability is amplified by approximate factorization thus precluding solutions with gravity below this Mach number level. Computations of strong heat addition in low-Mach-number flow both with and without gravity confirm the stability predictions. Convergent solutions are maintained and are used to show the effect of gravity on such flowfields. Author

A87-39544#

ANALYTIC NEAR-FIELD BOUNDARY CONDITIONS FOR TRANSONIC FLOW COMPUTATIONS

P. NIEDERDRENK (DFVLR, Institut fuer theoretische Stroemungsmechanik, Goettingen, West Germany) and E. WEDEMEYER (DFVLR, Institut fuer experimentelle Stroemungsmechanik, Goettingen, West Germany) AIAA Journal (ISSN 0001-1452), vol. 25, June 1987, p. 884-886. refs

By replacing the full linear far-field solution with simple analytical relations at subcritical flow boundaries, the numerical computation of transonic flow is concentrated to its nonlinear domain. Overall grid size is thereby reduced, yielding either an improvement in computation time while keeping the numerical solution fixed, or a better resolution in virtually the same computational time when the number of points is kept fixed. O.C.

A87-39547#

EFFECTS OF PITOT PROBE SHAPE ON MEASUREMENT OF FLOW TURBULENCE

RICHARD C. JENKINS (Grumman Corporate Research Center, Bethpage, NY) AIAA Journal (ISSN 0001-1452), vol. 25, June 1987, p. 889-892. refs

Attention is given to some of the effects of enclosing a semiconductor strain gage-type pressure transducer within various different pitot tip housings, in order to improve its response for mean and fluctuating pressure measurements. Measurements taken with these probes and with a hot film anemometer along the centerline of a free jet have furnished a relationship between the fluctuation levels of freestream velocity and total pressure. O.C.

A87-39646#

TRANSONIC FLUTTER ANALYSIS USING THE EULER EQUATIONS

ODDVAR O. BENDIKSEN (Princeton University, NJ) and KENNETH A. KOUSEN AIAA, Dynamics Specialists Conference, Monterey, CA, Apr. 9, 10, 1987. 12 p. refs

(AIAA PAPER 87-0911)

An investigation of transonic flutter of typical section wing models is presented. The unsteady aerodynamic loads are obtained by solving the Euler equations using the finite volume scheme on a moving mesh. No assumptions of small displacements are made, and the tangent flow boundary condition is satisfied on the exact instantaneous position of the airfoil surface. Aeroelastic stability is determined by integrating the coupled equations of motion for the fluid and structure forward in time. Results from the present flutter calculations using the Euler equations are in reasonable agreement with previously published calculations based on transonic small disturbance theories, except in regions where strong shocks are present. The nonlinear effect of large displacements is investigated, including a search for subcritical flutter instabilities. In most of the cases studied, the nonlinear dependence of the flutter speed on amplitudes appears relatively moderate or small. Author

A87-39708#

EXPERIMENTAL ANALYSIS OF THE FLOW THROUGH A THREE-DIMENSIONAL TRANSONIC CHANNEL

R. BENAY, J. DELERY, and T. POT (ONERA, Chatillon-sous-Bagneux, France) (NATO, AGARD, Specialists Meeting on Transonic and Supersonic Phenomena in Turbomachines, 68th, Neubiberg, West Germany, Sept. 10-12, 1986) La Recherche Aerospatiale (English Edition) (ISSN 0379-380X), no. 6, 1986, p. 11-26. refs

The three-dimensional flow resulting from a shock-wave/turbulent-boundary-layer interaction occurring in a transonic channel has been investigated on the basis of surface pressure measurements, surface visualizations, and field measurements obtained by three-component laser velocimetry. The results show the existence of a lambda-shock pattern analogous to that observed in a two-dimensional transonic channel, although in the present case, shocks are replaced by continuous recompressions in the vicinity of the channel side walls. In addition, in the separated regions that form on the upper and lower walls, the boundary layer is found to be thickened with a major dip in the longitudinal velocity profiles. R.R.

A87-39709#

COMPUTATION OF INTERNAL FLOWS AT HIGH REYNOLDS NUMBER BY NUMERICAL SOLUTION OF THE NAVIER-STOKES EQUATIONS

L. CAMBIER, B. ESCANDE, and J. P. VEUILLOT (ONERA, Chatillon-sous-Bagneux, France) (NATO, AGARD, Specialists Meeting on Transonic and Supersonic Phenomena in Turbomachines, 68th, Neubiberg, West Germany, Sept. 10-12, 1986) La Recherche Aerospatiale (English Edition) (ISSN 0379-380X), no. 6, 1986, p. 27-44. Research supported by the Delegation Generale pour l'Armement and DRET. refs

This paper concerns the computation of turbulent flows at high Reynolds numbers by numerical solution of the Navier-Stokes equations, averaged and complemented by a model of turbulence, and presents the resulting data for an internal aerodynamics application. The computation method is first briefly reviewed, characterized by a subdomain approach and the use of a simple numerical scheme combined with a dichotomy subgridding technique to describe the fine viscous layers. Computed data is presented for turbulent transonic flows with wall laws on an industrial configuration for a compressor cascade at various operating speeds. At the end, detailed experimental data are given for the problem of shock wave-boundary layer interaction in a two-dimensional transonic channel, for comparison of an algebraic model of turbulence and of a (k, epsilon) model. Author

A87-39813*# Sverdrup Technology, Inc., Cleveland, Ohio.

EULER ANALYSIS OF TRANSONIC PROPELLER FLOWS

J. M. BARTON, O. YAMAMOTO (Sverdrup Technology, Inc., Middleburg Heights, OH), and L. J. BOBER (NASA, Lewis Research Center, Cleveland, OH) Journal of Propulsion and Power (ISSN 0748-4658), vol. 3, May-June 1987, p. 277-282. Previously cited in issue 21, p. 3041, Accession no. A85-43977. refs
(Contract NAS3-24105)

A87-39889*# Vigyan Research Associates, Inc., Hampton, Va.

SHAPING OF AIRPLANE FUSELAGES FOR MINIMUM DRAG

S. S. DODBELE, C. P. VAN DAM (Vigyan Research Associates, Inc., Hampton, VA), P. M. H. W. VIJGEN (Kansas, University, Lawrence), and B. J. HOLMES (NASA, Langley Research Center, Hampton, VA) Journal of Aircraft (ISSN 0021-8669), vol. 24, May 1987, p. 298-304. Previously cited in issue 07, p. 833, Accession no. A86-19809. refs
(Contract NAG1-345; NAS1-17926)

A87-39890#

EXPERIMENTAL STUDY OF AIRFOIL PERFORMANCE WITH VORTEX GENERATORS

M. B. BRAGG and G. M. GREGOREK (Ohio State University, Columbus) Journal of Aircraft (ISSN 0021-8669), vol. 24, May 1987, p. 305-309. refs

The canard airfoil from the Voyager aircraft was tested in Ohio State University's subsonic wind tunnel. This highly optimized laminar flow section had good clean airfoil performance, but suffered severe lift and drag penalties with early boundary-layer transition. These performance penalties resulted from a midchord boundary-layer separation. An experimental program was conducted to document this problem and then to design and test vortex generators in order to improve the tripped airfoil performance while having the least effect on the clean airfoil. A set of properly designed vortex generators were found to increase the lift and reduce the drag of the contaminated airfoil. A brief study documented a significant drag rise due to a rough surface in the turbulent boundary-layer regions. Author

A87-39894#

NORMAL-FORCE CHARACTERISTICS OF SHARP-EDGED DELTA WINGS AT SUPERSONIC SPEEDS

ERIK S. LARSON (Flygtekniska Forsksanstalten, Bromma, Sweden) Journal of Aircraft (ISSN 0021-8669), vol. 24, May 1987, p. 328-334. Sponsorship: Forsvarets Materielverk. Previously cited in issue 08, p. 1035, Accession no. A87-22491. refs
(Contract FMV-AU-2154)

A87-39924#

ON THE NON-UNIQUENESS OF SOLUTIONS FOR BOUNDARY VALUE PROBLEMS IN TRANSONIC FLOWS

M. RUZICKA (Statni Vyzkumny Ustav Stavby Stroju, Prague, Czechoslovakia) Archiwum Mechaniki Stosowanej (ISSN 0373-2029), vol. 38, no. 4, 1986, p. 347-358.

The application of the theory of functionals to transonic-flow problems is investigated analytically. A functional for transonic flow fields is derived and shown to be a weak solution of the continuity equation for certain boundary conditions, the critical points being, in general, the saddle points of the functional. The analysis is applied to five sample problems: a Ko-Tamada gas, isentropic subsonic flow of an ideal gas, isentropic channel flow of an ideal gas, two-dimensional cascade flow with abscissa-shaped profiles and zero circulation, and two-dimensional transonic cascade flow with abscissa-shaped profiles and nonzero circulation such that the inlet and outlet angles are equal. Several possible ambiguities are identified and discussed, and the need to take nonzero viscosity into account is indicated. T.K.

A87-40079*# Arizona State Univ., Tempe.

STABILITY AND TRANSITION OF THREE-DIMENSIONAL FLOWS

H. L. REED and W. S. SARIC (Arizona State University, Tempe) IN: U.S. National Congress of Applied Mechanics, 10th, Austin, TX, June 16-20, 1986, Proceedings . New York, American Society of Mechanical Engineers, 1987, p. 457-468. refs
(Contract NAG1-402; NAG1-280)

The role of secondary instabilities in the transition to turbulence in three-dimensional boundary layers (especially in swept-wing flows) is characterized, reviewing the results of recent theoretical and experimental investigations. Consideration is given to cross-flow vortices, boundary-layer profile measurements, flow visualization, spanwise wavelength determinations, interactions,

problems involving rotating disks and cones, and leading-edge contamination. All of the flows investigated are shown to exhibit streamwise vorticity and to depend strongly on initial conditions.
T.K.

A87-40082*# United Technologies Research Center, East Hartford, Conn.
UNSTEADY AERODYNAMICS OF BLADE ROWS
J. M. VERDON (United Technologies Research Center, East Hartford, CT) IN: U.S. National Congress of Applied Mechanics, 10th, Austin, TX, June 16-20, 1986, Proceedings . New York, American Society of Mechanical Engineers, 1987, p. 485-497. Research supported by the United Technologies Corp., U.S. Navy, and NASA. refs

The requirements placed on an unsteady aerodynamic theory intended for turbomachinery aeroelastic applications are discussed along with a brief description of the various theoretical models that are available to address these requirements. The main emphasis is placed on the description of a linearized inviscid theory which fully accounts for the effects of a nonuniform mean or steady flow on unsteady aerodynamic response. Although this theory has been developed primarily for blade flutter prediction, more general equations are presented which account for unsteady excitations due to incident external aerodynamic disturbances as well as those due to blade motions. The resulting equations consist of a system of three field equations along with conditions imposed at blade, wake and shock surfaces and in the far field. These equations can be solved to determine the fluctuations in all fluid dynamic properties throughout the required solution domain. Example solutions are presented to demonstrate several effects associated with nonuniform steady flows on the linearized unsteady aerodynamic response to prescribed blade motions. Author

A87-40083#
ASPECTS OF UNSTEADY TRANSONIC FLOW
D. NIXON (Nielsen Engineering and Research, Inc., Mountain View, CA) IN: U.S. National Congress of Applied Mechanics, 10th, Austin, TX, June 16-20, 1986, Proceedings . New York, American Society of Mechanical Engineers, 1987, p. 499-513. refs

The most pronounced feature of transonic flow is the presence of shock waves which have a considerable effect on the airflow. In unsteady flows these shock waves oscillate and give rise to types of flow that are not commonplace in other speed regimes. Some of these phenomena are the unsteady shock boundary layer interaction, limit cycle oscillations due to flutter, and fluid mechanic 'resonance' about a rigid airfoil. In certain cases, for a harmonically oscillating airfoil, the shock motions are quite complex with the three different types of shock motion classified by Tijdeman. This paper describes the physical phenomena that appear in unsteady transonic flow; in particular, those topics noted above. The second part of the paper concerns the governing equations necessary to model these phenomena and the progress being made in the solution of these equations. Author

A87-40085*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
BIFURCATIONS IN UNSTEADY AERODYNAMICS
M. TOBAK (NASA, Ames Research Center, Moffett Field, CA) and A. UNAL (Santa Clara, University, CA) IN: U.S. National Congress of Applied Mechanics, 10th, Austin, TX, June 16-20, 1986, Proceedings . New York, American Society of Mechanical Engineers, 1987, p. 527-536. Previously announced in star as N87-11697. refs

Nonlinear algebraic functional expansions are used to create a form for the unsteady aerodynamic response that is consistent with solutions of the time dependent Navier-Stokes equations. An enumeration of means of invalidating Frechet differentiability of the aerodynamic response, one of which is aerodynamic bifurcation, is proposed as a way of classifying steady and unsteady aerodynamic phenomena that are important in flight dynamics applications. Accommodating bifurcation phenomena involving time dependent equilibrium states within a mathematical model of the aerodynamic response raises an issue of memory effects that becomes more important with each successive bifurcation
Author

A87-40273*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
EVALUATION OF THREE NUMERICAL METHODS FOR PROPULSION INTEGRATION STUDIES ON TRANSONIC TRANSPORT CONFIGURATIONS
STEVEN F. YAROS, JOHN R. CARLSON (NASA, Langley Research Center, Hampton, VA), and BALASUBRAMANYAN CHANDRASEKARAN (Vigyan Research Associates, Inc., Hampton, VA) AIAA, Applied Aerodynamics Conference, 4th, San Diego, CA, June 9-11, 1986. 23 p. Previously announced in STAR as N86-27209. refs
(AIAA PAPER 86-1814)

An effort has been undertaken at the NASA Langley Research Center to assess the capabilities of available computational methods for use in propulsion integration design studies of transonic transport aircraft, particularly of pylon/nacelle combinations which exhibit essentially no interference drag. The three computer codes selected represent state-of-the-art computational methods for analyzing complex configurations at subsonic and transonic flight conditions. These are: EULER, a finite volume solution of the Euler equation; VSAERO, a panel solution of the Laplace equation; and PPW, a finite difference solution of the small disturbance transonic equations. In general, all three codes have certain capabilities that allow them to be of some value in predicting the flows about transport configurations, but all have limitations. Until more accurate methods are available, careful application and interpretation of the results of these codes are needed. Author

A87-40827#
AN ASSYMPTOTIC THEORY OF WIND-TUNNEL-WALL INTERFERENCE ON SUBSONIC SLENDER BODIES
N. D. MALMUTH (Rockwell International Science Center, Thousand Oaks, CA) Journal of Fluid Mechanics (ISSN 0022-1120), vol. 177, April 1987, p. 19-35. refs

An asymptotic theory of solid cylindrical wind-tunnel-wall interference about subsonic slender bodies has been developed. The basic approximation used is one of large wall-radius to body-length ratio. Matched asymptotic expansions show that in contrast to the analogous two-dimensional problem of a confined airfoil, three regions exist. Besides the incompressible crossflow and nearly axisymmetric zones, a wall layer exists where reflection in the wall of the line source representing the body becomes of dominant importance. From the theory, the interference pressures are shown to be approximately constant for closed bodies. Also demonstrated is that D'Alembert's paradox holds for interference drag of such shapes. Numerical studies comparing the exact theory to the asymptotic model which provides drastic simplifications, show that the latter can be used with reasonable accuracy to describe flows, even where the characteristic tunnel-radius to body-length ratio is as low as 1.5. Author

A87-40871#
IMPROVING THE ACCURACY AND CUTTING THE TIME REQUIRED IN NUMERICAL INVESTIGATION OF TRANSONIC FLOW OF GAS IN TURBOMACHINE CASCADES
A. B. BOGOD, A. V. GRANOVSKII, and A. M. KARELIN (Teploenergetika, vol. 33, no. 8, 1986, p. 48-52) Thermal Engineering (ISSN 0040-6015), vol. 33, Aug. 1986, p. 433-437. Translation. refs

The Godunov-Kolgan procedure (Tilliaeva, 1986) was used to generate an algorithm for calculating transonic gas flow in turbomachine cascades. The calculations procedure involved 'freezing' the minimum values of increments. The new values were calculated not at each time stratum but through a previously prescribed number of strata. Calculation with the 'frozen' values of increments ensured rapid monotonic convergence of solutions to steady solutions with practically any prescribed degree of accuracy; stability was preserved with the Durant numbers equal to about unity. The numerical results compared well with published experimental results on three different cascades. Compared with the time used to calculate flow by the original Godunov method, the time of calculations with the newly developed algorithm was reduced 6- to 10-fold. I.S.

A87-40922#

COEFFICIENTS FOR CALCULATING THE INDUCED ANGLE OF ATTACK AND INDUCED DRAG OF STRAIGHT WINGS OF LARGE ASPECT RATIO [SOUCINITELE PRO VYPOCET INDUKOVANEHO UHLU NABEHU A INDUKOVANEHO ODPORU PRIMYCH KRIDEL VELKYCH STIHLOSTI]

ZDENEK PATEK Zpravodaj VZLU (ISSN 0044-5355), no. 1, 1987, p. 17-22. In Czech. refs

A87-41157*# General Electric Co., Cincinnati, Ohio.

AERODYNAMIC INSTABILITY PERFORMANCE OF AN ADVANCED HIGH-PRESSURE-RATIO COMPRESSION COMPONENT

W. M. HOSNY and W. G. STEENKEN (General Electric Co., Aircraft Engine Business Group, Cincinnati, OH) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 15 p. refs

(Contract NAS3-24083; NAS3-24211)

(AIAA PAPER 86-1619)

The data acquisition and reduction, test procedures, and results of in-stall and in-surge testing of a NASA high-pressure-ratio compression component are discussed, in addition to the compressor-rig configuration and instrumentation used. Data analysis revealed information about rotating stall hysteresis, rotating stall development and cessation times, and rotating-stall-cell flow blockage. It is found that hysteresis exists in the work coefficient as well as in the pressure coefficient. Airflow rakes were designed to study the in-surge transient response of the compressor. The quasi-steady compressor characteristics underlying the transient-surge data were investigated using a parameter-identification technique. R.R.

A87-41238#

CURRENT STATUS AND FUTURE DIRECTIONS OF COMPUTATIONAL TRANSONICS

A. JAMESON (Princeton University, NJ) IN: Computational mechanics - Advances and trends; Proceedings of the Session - Future Directions of Computational Mechanics of the ASME Winter Annual Meeting, Anaheim, CA, Dec. 7-12, 1986 . New York, American Society of Mechanical Engineers, 1986, p. 329-367. refs

Mathematical models of transonic flow are reviewed and design principles are proposed to guide the development of appropriate numerical methods. Discretization procedures are presented for rectilinear and triangular or tetrahedral meshes. Alternative methods of adding dissipation are discussed, including procedures for constructing total variation diminishing schemes. A variety of explicit and implicit time stepping schemes are reviewed. Trade-offs between efficiency and computational cost are considered, and a general acceleration method using multiple grids is presented. Finally the problem of predicting the flow past a complete aircraft is examined, leading to an assessment of various directions of improvement. Author

A87-41249#

MEASUREMENT OF THE DRAG OF VARIOUS THREE-DIMENSIONAL EXCRESCENCES IN TURBULENT BOUNDARY LAYERS

L. GAUDET (Royal Aircraft Establishment, Bedford, England) Aeronautical Journal (ISSN 0001-9240), vol. 91, April 1987, p. 170-182. refs

Measurements are described of the drags of various forms of three-dimensional excrescence mounted on balances installed in the walls of the working section of the RAE 8 X 8-ft wind tunnel. The tests cover a range of Mach numbers between 0.2 and 2.8 and a range of Reynolds numbers. The excrescences tested include circular cylinders and wings mounted normal to the surface, fairing shapes, and mushroom-shaped rivet heads. For excrescences which are small compared with the boundary-layer thickness, the scale effects are correlated in terms of the wall variables of the turbulent boundary layer. For circular cylinders and wings which protrude well into or beyond the boundary layer, the drag may be determined by using a drag defect relationship. The fairings tested comprise half-bodies of revolution with pointed or rounded ends and bodies of rectangular (including square) section with pointed ends. Author

A87-41268#

ON THE BOUNDARY ELEMENT METHOD FOR COMPRESSIBLE FLOW ABOUT BODIES

ZUOSHENG YANG (Nanjing Aeronautical Institute, People's Republic of China) IN: Boundary elements VII; Proceedings of the Seventh International Conference, Como, Italy, Sept. 24-27, 1985. Volume 2 . Berlin and New York, Springer-Verlag, 1985, p. 9-45 to 9-48. refs

The possibility of formulating boundary integral representations for compressible flow about bodies valid throughout the transonic Mach number is explored by considering the case of steady nonviscous compressible flow. A set of nonlinear algebraic equations is obtained which may be solved iteratively by a well-developed conjugate gradient method or steep descent method. A sample solution is presented for a circular cylinder at rest in a compressible inviscid fluid which is also at rest. C.D.

A87-41411#

MULTIGRID METHODS FOR CALCULATING THE LIFTING POTENTIAL INCOMPRESSIBLE FLOWS AROUND THREE-DIMENSIONAL BODIES

W. HACKBUSCH (Kiel, Universitaet, West Germany) and Z. P. NOWAK (Warszawa, Politechnika, Warsaw, Poland) IN: Multigrid methods II; Proceedings of the Second European Conference, Cologne, West Germany, Oct. 1-4, 1985 . Berlin and New York, Springer-Verlag, 1986, p. 135-148. refs

Thr problem of the lifting potential incompressible flow around three-dimensional bodies is formulated, and multigrid methods for calculating such flows are discussed. The discretization method for solving such problems is briefly considered. Sample calculation results are presented for flow around an elliptic wing with axis ratio 1/5 and for the NACA 0012 cross section. C.D.

A87-41419#

FAS MULTIGRID EMPLOYING ILU/SIP SMOOTHING - A ROBUST FAST SOLVER FOR 3D TRANSONIC POTENTIAL FLOW

A. J. VAN DER WEES (Nationaal Lucht- en Ruimtevaartlaboratorium, Emmeloord, Netherlands) IN: Multigrid methods II; Proceedings of the Second European Conference, Cologne, West Germany, Oct. 1-4, 1985 . Berlin and New York, Springer-Verlag, 1986, p. 315-331. Research supported by the Nederlands Instituut voor Vliegtuigontwikkeling en Ruimtevaart. refs

Results are shown for the multigrid ILU/SIP method for the solution of transonic potential flow around realistic wings embedded in boundary-conforming curvilinear grids. The flow equation, discretization, grid generation, boundary conditions, multigrid method, linearization, algorithm, properties, and applications of ILU/SIP are discussed. A local mode analysis of the ILU/SIP smoothing properties is reviewed, and a stability analysis of SIP in hyperbolic regions is summarized. Experiments using ILU/SIP are described. ILU/SIP is found to be very efficient and robust for the solution of elliptic and mixed elliptic/hyperbolic potential flow problems. The best performance for three-dimensional problems is obtained by performing an a priori grid optimization, for which requirements are derived. C.D.

A87-41510#

SIMULATION STUDIES OF VORTEX DYNAMICS OF A LEADING EDGE FLAP

H. K. CHENG, R. H. EDWARDS, and Z. X. JIA (Southern California, University, Los Angeles) IN: Studies of vortex dominated flows; Proceedings of the Symposium, Hampton, VA, July 9-11, 1985 . New York, Springer-Verlag, 1987, p. 195-221. refs
(Contract AF-AFOSR-85-0318)

The leading edge flap as a concept for the generation and trapping of vortices to enhance lift is considered, and the nonlinear stability of bifurcating states arising in an incompressible plane flow satisfying the Kutta condition at the trailing edges of both the airfoil and the leading-edge flap is studied. Using a separation-vortex model, solutions on the hysteresis loop are found to be stable and to be recoverable from the evolution of time-dependent solutions. Results for a point-vortex method are found to agree with the separation-vortex model up to periods comparable with the flow-transit time, and to predict higher vortex lift for longer periods. R.R.

A87-41511#

METHODS FOR NUMERICAL SIMULATION OF LEADING EDGE VORTEX FLOW

H. W. M. HOEIJMAKERS (Nationaal Lucht- en Ruimtevaartlaboratorium, Amsterdam, Netherlands) In: Studies of vortex dominated flows; Proceedings of the Symposium, Hampton, VA. July 9-11, 1985. New York, Springer-Verlag, 1987, p. 223-269. refs.

A review is presented of computational methods to simulate the aerodynamics of configurations with leading-edge vortex flow. The various methods in use at present are discussed in some detail, primarily with a view toward three-dimensional steady flow applications. The strengths and weaknesses of the methods are indicated and results of different methods are compared and discussed. Author

A87-41512*# Massachusetts Inst. of Tech., Cambridge.

COMPARISON OF MEASURED AND COMPUTED PITOT PRESSURES IN A LEADING EDGE VORTEX FROM A DELTA WING

EARLL M. MURMAN and KENNETH G. POWELL (MIT, Cambridge, MA) IN: Studies of vortex dominated flows; Proceedings of the Symposium, Hampton, VA, July 9-11, 1985 . New York, Springer-Verlag, 1987, p. 270-281. refs
(Contract NAG1-358)

Calculations are presented for a 75-deg swept flat plate wing tested at a freestream Mach number of 1.95 and 10 degrees angle of attack. Good agreement is found between computational data and previous experimental pitot pressure measurements in the core of the vortex, suggesting that the total pressure losses predicted by the Euler equation solvers are not errors, but realistic predictions. Data suggest that the magnitude of the total pressure loss is related to the circumferential velocity field through the vortex, and that it increases with angle of attack and varies with Mach number and sweep angle. R.R.

A87-41626#

ANALYSIS OF A DELTA WING WITH LEADING-EDGE FLAPS

SEJONG OH and D. TAVELLA (Stanford University, CA) (Applied Aerodynamics Conference, 4th, San Diego, CA, June

A87-41627#

IMPROVEMENTS ON A GREEN'S FUNCTION METHOD FOR THE SOLUTION OF LINEARIZED UNSTEADY POTENTIAL FLOWS

PAOLO MANTEGAZZA (Milano, Politecnico, Milan, Italy) and GIAMPIERO BINDOLINO Journal of Aircraft (ISSN 0021-8669), vol. 24, June 1987, p. 355-361. refs

Through the combination of a lifting surface approximation, functional variable linking, and multipole expansions, the computational efficiency of Morino's (1975) method can be improved sufficiently, without compromise of its precision, to allow aeroelastic calculations for both simple and complex aircraft configurations. The numerical examples presented demonstrate the usefulness of the concepts employed for the case of unsteady airload calculations. Attention is given to the variable linking adopted for a fully flapped wing, and a quadratic patch for the calculation of potential derivatives. O.C.

A87-41630*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

ACCURATE NUMERICAL SOLUTIONS FOR TRANSONIC VISCOUS FLOW OVER FINITE WINGS

V. N. VATSA (NASA, Langley Research Center, Hampton, VA) Journal of Aircraft (ISSN 0021-8669), vol. 24, June 1987, p. 377-385. Previously cited in issue 17, p. 2467, Accession no. A86-38423. refs

A87-41632*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

CALCULATION OF TRANSONIC STEADY AND OSCILLATORY PRESSURES ON A LOW ASPECT RATIO MODEL

ROBERT M. BENNETT, ELEANOR C. WYNNE (NASA, Langley Research Center, Hampton, VA), and DENNIS G. MABEY (Royal Aircraft Establishment, Bedford, England) (International Symposium on Aeroelasticity and Structural Dynamics, 2nd, Aachen, West Germany, Apr. 1-3, 1985, Collected Papers, p. 1-16) Journal of Aircraft (ISSN 0021-8669), vol. 24, June 1987, p. 392-398. Previously cited in issue 11, p. 1979, Accession no. A86-33227. refs

A87-41634#

THICK SUPERCRITICAL AIRFOILS WITH LOW DRAG AND NATURAL LAMINAR FLOW

B. EGGLESTON, R. J. D. POOLE (de Havilland Aircraft of Canada, Ltd., Downsview, Canada), D. J. JONES, and M. KHALID (National Research Council of Canada, Ottawa) (ICAS, Congress, 15th, London, England, Sept. 7-12, 1986, Proceedings. Volume 1, p. 60-66) Journal of Aircraft (ISSN 0021-8669), vol. 24, June 1987, p. 405-411. Research supported by the de Havilland Aircraft of Canada, Ltd., National Research Council of Canada, and Boeing of Canada, Ltd. Previously cited in issue 24, p. 3529, Accession no. A86-48981. refs

A87-41635#

OPTIMUM FLAP SCHEDULES AND MINIMUM DRAG ENVELOPES FOR COMBAT AIRCRAFT

B. RAJESWARI (National Aeronautical Laboratory, Bangalore, India) and K. R. PRABHU (Kentron, Inc., Hampton, VA) Journal of Aircraft (ISSN 0021-8669), vol. 24, June 1987, p. 412-414. refs

A simple analytical method having its basis in linear theory is presently used to determine the optimum flap schedule in high performance military aircraft equipped with both leading and trailing edge flaps, in order to maximize lift-to-drag ratio. The resultant lift-dependent drag polar can also be determined. Attention is given to a comparison of the drag envelope for the F-16 aircraft with and without programmable leading edge flaps. O.C.

A87-41667#

INFLUENCE OF YAW AND INCIDENCE ON BASE DRAG OF RECTANGULAR WINGS

S. D. SHARMA (Indian Institute of Science, Bangalore, India) Zeitschrift fuer Flugwissenschaften und Weltraumforschung (ISSN 0342-068X), vol. 11, Jan.-Feb. 1987, p. 19-22. refs

Base pressure measurements of rectangular wing models with plain and castellated blunt trailing edges at various angles of incidence and yaw (sweep-back) are reported here. The efficacy of castellations, a simple device to reduce base drag at low speeds, is found to be independent of whether the wing configuration is two-dimensional wing or finite wing. However, the mean base pressure at zero yaw and incidence increases by about 20 percent in case of both the plain and the castellated bases when changing over to finite wing from a two-dimensional wing. The mean base pressure of the plain base is found to be more sensitive than that of the castellated base to any change in incidence and yaw. The efficacy of castellations is found to be maximum only at zero yaw and incidence and reduces to about half at near optimum combination of incidence and yaw. Author

A87-41670#

EXPERIMENTAL AND THEORETICAL STUDIES ON VORTEX FORMATION OVER DOUBLE DELTA WINGS [EXPERIMENTELLE UND THEORETISCHE UNTERSUCHUNGEN UEBER DIE WIRBELBILDUNG AN DOPPELDELTAFLUEGELN]

U. BRENNENSTUHL (Volkswagen AG, Wolfsburg, West Germany) and D. HUMMEL (Braunschweig, Technische Universitaet, Brunswick, West Germany) Zeitschrift fuer Flugwissenschaften und Weltraumforschung (ISSN 0342-068X), vol. 11 Jan.-Feb. 1987, p. 37-49. In German. refs

Details of the flow field have been investigated for a double-delta wing of aspect ratio 2.05 using a half-model in a 1.3 m wind tunnel. Supplementary theoretical investigations were carried out using a nonlinear vortex lattice method in which the two primary vortices were modelled by concentrated single vortices fed with circulation from the wing leading edge by plane vortex sheets. This model leads to two separate vortices on each wing half at low angles of attack and to the formation of a combined vortex on each side at high angles of attack. These theoretical results are in good agreement with the experimental ones. C.D.

A87-41683*# Vigyan Research Associates, Inc., Hampton, Va.

LOSS OF LIFT DUE TO THICKNESS FOR LOW-ASPECT-RATIO WINGS IN INCOMPRESSIBLE FLOW

S. S. DODBELE (Vigyan Research Associates, Inc., Hampton, VA) and A. PLOTKIN (San Diego State University, CA) Journal of Engineering Mathematics (ISSN 0022-0833), vol. 21, no. 1, 1987, p. 3-16. refs

(Contract NCC1-41)

The problem under consideration is a numerical study of the effects of thickness on lift for low-aspect-ratio wings in steady incompressible inviscid flow at moderate angles of attack. At these angles of attack the flow separates along the leading edge giving rise to a lift substantially higher than that computed by classical attached-flow potential theory. The problem is treated as a perturbation expansion in a small thickness parameter. The lifting elements of the flow are modeled using a nonlinear vortex-lattice method which replaces the leading and trailing-edge vortex sheets by segmented straight vortex filaments. The thickness elements of the flow are modeled with a mean-plane source distribution and a modification to the wing boundary conditions. Results are obtained for wings with biconvex and NACA 0012 sections which compare well with available experimental data. The important observation that the effect of thickness is to decrease the lift is made. Author

A87-41847#

CALCULATION OF THE AERODYNAMIC CHARACTERISTICS OF A HELICOPTER ROTOR UNDER CONDITIONS OF ATMOSPHERIC GUSTS [K RASCHETU AERODINAMICHESKIKH KHARAKTERISTIK NESUSHCHEGO VINTA VERTOLETA PRI VOZDEISTVII NA NEGO ATMOSFERNYKH PORYVOV]

N. A. GRITSENKO, V. V. KOZIN, and M. I. NISHT Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza (ISSN 0568-5281), Mar.-Apr. 1987, p. 153-158. In Russian.

A numerical method is presented for calculating the nonstationary aerodynamic characteristics of a helicopter rotor gradually enveloped by an atmospheric gust incoming from an arbitrary direction. The problem is solved for an incompressible medium using a nonlinear formulation. Flow around each rotor blade is modeled by a system of discrete vortices, and allowance is made for the distortion of the trailing vortex of the blades due to the effect of the gust. V.L.

A87-42051#

COMPUTATIONAL FLUID DYNAMICS CONFERENCE, 8TH, HONOLULU, HI, JUNE 9-11, 1987, TECHNICAL PAPERS

Conference sponsored by AIAA. New York, American Institute of Aeronautics and Astronautics, 1987, 845 p. *For individual items see A87-42052 to A87-42125.*

The present conference on CFD methods considers upwind schemes for the solution of the Navier-Stokes (N-S) equations, separated flow simulations using the vortex method on a hypercube, a hybrid expert system for complex CFD problems, three-dimensional hypersonic flow simulations with an implicit upwind N-S method, conservation cells for finite volume calculations, three-dimensional mesh generation, and an extended grid-embedding scheme for viscous flows. Attention is also given to unsteady incompressible flow algorithms based on artificial compressibility, difference schemes for the three-dimensional Euler equations, combustor flow computations in general coordinates, a multigrid Euler method for fighter configurations, a prediction method for supersonic/hypersonic inviscid flow, adaptive methods for high Mach number reacting flow, low Mach number compressible flow solutions in constricted ducts, and the evaluation of flow topology for numerical data. O.C.

A87-42061*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

APPLICATION OF AN UPWIND ALGORITHM TO THE THREE-DIMENSIONAL PARABOLIZED NAVIER-STOKES EQUATIONS

SCOTT L. LAWRENCE, DENNY S. CHAUSSEE (NASA, Ames Research Center, Moffett Field, CA), and JOHN C. TANNEHILL (Iowa State University of Science and Technology, Ames) IN: Computational Fluid Dynamics Conference, 8th, Honolulu, HI, June 9-11, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 112-125. Research supported by the Iowa State University of Science and Technology. refs

(Contract NCA2-IR-340-501)

(AIAA PAPER 87-1112)

A new computer code for the solution of the three-dimensional parabolized Navier-Stokes equations has been developed. The code employs a state-of-the-art upwind algorithm to capture strong shock waves. The algorithm is implicit, uses finite volumes, and is second-order accurate in the crossflow directions. The new code is validated through application to laminar hypersonic flows past two simple body shapes: a circular cone of 10 deg half-angle, and a generic all-body hypersonic vehicle. Cone flow solutions were computed at angles of attack of 12, 20, and 24 deg and results are in agreement with experimental data. Results are also presented for the flow past the all-body vehicle at angles of incidence of 0 and 10 deg. Author

A87-42063*# PEDA Corp., Palo Alto, Calif.

THREE DIMENSIONAL HYPERSONIC FLOW SIMULATIONS WITH THE CSCM IMPLICIT UPWIND NAVIER-STOKES METHOD

JORGE BARDINA and C. K. LOMBARD (PEDA Corp., Palo Alto, CA) IN: Computational Fluid Dynamics Conference, 8th, Honolulu, HI, June 9-11, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 143-152. refs

(Contract NAS2-12243; F49620-85-C-0081)

(AIAA PAPER 87-1114)

The Bardina and Lombard (1985) three-dimensional CSCM Navier-Stokes method is presently extended to the simulation of complex hypersonic reentry vehicle external flows at angle of attack. The robust stability of the method derives from the combination of conservative implicit upwind flux difference splitting with a three-dimensional diagonally-dominant approximate factorization and relaxation scheme and characteristic-based implicit boundary approximations. The method's efficiency derives from an implicit symmetric Gauss-Seidel 'method of planes' relaxation scheme with alternating directional space marching sweeps along the flow coordinate direction. O.C.

A87-42064*# Stanford Univ., Calif.
COMPUTATIONAL FLUID DYNAMICS NEAR THE CONTINUUM LIMIT
ROBERT W. MACCORMACK, DEAN R. CHAPMAN (Stanford University, CA), and TAHIR GOKCEN IN: Computational Fluid Dynamics Conference, 8th, Honolulu, HI, June 9-11, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 153-158. refs
(Contract NCA2-142)
(AIAA PAPER 87-1115)

Two dimensional Navier-Stokes equations for a perfect gas are solved for hypersonic flow over a flat plate at Reynolds numbers ranging from continuum to the free molecule flow. In the transition flow regime, new slip boundary conditions are introduced, which reduce to the well-known slip conditions of Maxwell at small Knudsen numbers and yield the correct shear stress and heat transfer in the limiting case of free molecule flow. Comparison of the computed results with the existing experimental data and Monte Carlo calculations indicates that the continuum Navier-Stokes equations give surprisingly realistic results throughout the transition flow regime, when the new slip boundary conditions are used. Author

A87-42070*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
A NEW ALGORITHM FOR THE NAVIER-STOKES EQUATIONS APPLIED TO TRANSONIC FLOWS OVER WINGS
PETER M. GOORJIAN (NASA, Ames Research Center, Moffett Field, CA) IN: Computational Fluid Dynamics Conference, 8th, Honolulu, HI, June 9-11, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 230-236. refs
(AIAA PAPER 87-1121)

A new algorithm has been developed for the Navier-Stokes equations. For the convective terms, this algorithm employs flux vector splitting together with a locally rotated coordinate system that is aligned with the streamwise direction. The algorithm has been implemented into a Navier-Stokes code, the NASA Ames Research Center's TNS code, and several cases of steady flow have been calculated. The results show improvements over the original method in the code. First, in a case of separated flow, there is better agreement with the experimental results and also there is an absence of numerical oscillations that occur with the original method. Second, in a case with a strong supersonic to subsonic shock wave, comparisons show an improvement in the resolution of the shock wave and the reexpansion singularity. Author

A87-42074*# Old Dominion Univ., Norfolk, Va.
GRID GENERATION AND INVISCID FLOW COMPUTATION ABOUT CRANKED-WINGED AIRPLANE GEOMETRIES
L.-E. ERIKSSON (Old Dominion University, Norfolk, VA), R. E. SMITH (NASA, Langley Research Center, Hampton, VA), M. R. WIESE, and N. FARR (Computer Sciences Corp., El Segundo, CA) IN: Computational Fluid Dynamics Conference, 8th, Honolulu, HI, June 9-11, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 272-282. refs
(AIAA PAPER 87-1125)

An algebraic grid generation procedure that defines a patched multiple-block grid system suitable for fighter-type aircraft geometries with fuselage and engine inlet, canard or horizontal tail, cranked delta wing and vertical fin has been developed. The grid generation is based on transfinite interpolation and requires little computational power. A finite-volume Euler solver using explicit Runge-Kutta time-stepping has been adapted to this grid system and implemented on the VPS-32 vector processor with a high degree of vectorization. Grids are presented for an experimental aircraft with fuselage, canard, 70-20-cranked wing, and vertical fin. Computed inviscid compressible flow solutions are presented for Mach 2 at 3.79, 7 and 10 deg angles of attack. Conmparisons of the 3.79 deg computed solutions are made with available full-potential flow and Euler flow solutions on the same configuration but with another grid system. The occurrence of an unsteady solution in the 10 deg angle of attack case is discussed. Author

A87-42076#
TIME-ACCURATE EULER EQUATIONS SOLUTIONS ON DYNAMIC BLOCKED GRIDS
DAVE M. BELK (USAF, Armament Laboratory, Eglin AFB, FL) and DAVID L. WHITFIELD (Mississippi State University, Mississippi State) IN: Computational Fluid Dynamics Conference, 8th, Honolulu, HI, June 9-11, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 292-302. refs
(AIAA PAPER 87-1127)

An implicit, two-factor, split flux, finite volume Euler equations solution algorithm on blocked grids is applied to the time-accurate calculation of transonic aerodynamics about a NACA0012 airfoil and a rectangular planform supercritical wing undergoing pitch oscillations. Accuracy of various techniques for transfer of information between blocks is analyzed and verified by comparing multiblock airfoil solutions with equivalent one-block solutions. It is shown that maintaining synchronized dependent variables and approximating the solution vector required at block boundaries with whatever information is currently available from adjoining blocks gives unsteady results that compare well with unblocked results even for cases with a shock wave passing through the block boundary. Unsteady calculations of transonic flow over a rectangular planform supercritical wing were compared to experimental results. Good agreement in magnitude and phase of the pressure on the wing was obtained except where the shock wave was misplaced by the inviscid theory. Author

A87-42091#
MULTIGRID ACCELERATION OF A RELAXATION PROCEDURE FOR THE RNS EQUATIONS
A. HIMANSU and S. G. RUBIN (Cincinnati, University, OH) IN: Computational Fluid Dynamics Conference, 8th, Honolulu, HI, June 9-11, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 478-489. refs
(Contract N00014-79-C-0849; F49620-85-C-0027)
(AIAA PAPER 87-1145)

The multigrid method is applied to obtain significant improvements in the convergence rate of an iterative relaxation procedure for the numerical solution of the Reduced Navier-Stokes (RNS) equations. The iterative algorithm uses 'streamwise' marching sweeps, in a line-relaxation mode, to determine the pressure field. With the use of the multigrid procedure, considerable computational work x memory efficiency results for both inviscid transonic flow and laminar viscous flow with strong interaction. In addition to application of the standard FAS multigrid technique (full-coarsening), a modified technique involving multigridding in only the streamwise direction (semicoarsening) is investigated. The latter is shown to be significantly better for flow behavior that is sensitive to grid stretching in the direction normal to the body surface. The problems considered in this study include trailing-edge flow (where the pressure gradient is singular), separated flow in a Carter-Wornom trough, and transonic inviscid flow over a parabolic-arc airfoil. Author

A87-42095#
AN IMPLICIT, UPWIND, FINITE-VOLUME METHOD FOR SOLVING THE THREE-DIMENSIONAL, THIN-LAYER NAVIER-STOKES EQUATIONS
BOYD GATLIN and DAVID L. WHITFIELD (Mississippi State University, Mississippi State) IN: Computational Fluid Dynamics Conference, 8th, Honolulu, HI, June 9-11, 1987, Technical Papers . New York, American Institute of—Aeronautics and Astronautics, 1987, p. 516-526. refs
(Contract F08635-84-0228)
(AIAA PAPER 87-1149)

The finite volume scheme presented for the steady-state solution of the thin-layer, three-dimensional Navier-Stokes equations in general curvilinear coordinates treats viscous and diffusive terms explicitly, so that only a small computational time

requirement increase is required for a viscous rather than inviscid solution on a given grid. Because the implicit portion of the scheme is approximately factored into two terms, according to the signs of the eigenvalues of the convective flux Jacobian matrices, only upper- and lower-block triangular systems need to be solved. The overall method is second-order accurate in computational space, and the converged solution is independent of the time-step.
O.C.

A87-42096#
UPWIND FORMULATIONS FOR THE EULER EQUATIONS IN STEADY SUPERSONIC FLOWS
NICOLA BOTTA and MAURIZIO PANDOLFI (Torino, Politecnico, Turin, Italy) IN: Computational Fluid Dynamics Conference, 8th, Honolulu, HI, June 9-11, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 527-536. refs
(AIAA PAPER 87-1150)
The Euler equations which describe the steady supersonic flow can be rearranged in order to emphasize the role of propagating signals. Such an analysis, the formulation, suggests upwind criteria in the approximation of derivatives with finite differences. Formulations founded on both the quasi-linear and divergence forms of the governing equations are considered. A numerical procedure based on these formulations is used as a tool for understanding the 'Eulerian' physics of the flow about a pointed cone at incidence. The generation and development of embedded cross-flow shocks and related spiral entropy singularities are investigated. Author

A87-42098*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
EXTENSION AND APPLICATIONS OF FLUX-VECTOR SPLITTING TO UNSTEADY CALCULATIONS ON DYNAMIC MESHES
W. KYLE ANDERSON, JAMES L. THOMAS, and CHRISTOPHER L. RUMSEY (NASA, Langley Research Center, Hampton, VA) IN: Computational Fluid Dynamics Conference, 8th, Honolulu, HI, June 9-11, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 546-558. refs
(AIAA PAPER 87-1152)
The Van Leer method of flux-vector splitting for the Euler equations is extended for use on moving meshes and all the properties of the original splittings are maintained. The solution is advanced in time with an implicit, approximately factored algorithm. The use of multiple grids to reduce the computer time is investigated. A substantial reduction in computer time to resolve a pitching cycle is easily obtained with virtually no loss in accuracy. A subiterative procedure to eliminate factorization and linearization errors so that larger time steps can be used is also investigated. Subsequent computations show good agreement with experimental data for transonic and supersonic airfoils and wings undergoing forced pitching oscillation. Author

A87-42099#
A FAST IMPLICIT MAF SCHEME FOR SOLVING 3D TRANSONIC POTENTIAL FLOW IN TURBOMACHINES
JIALIN ZHANG (Chinese Academy of Sciences, Institute of Engineering Thermophysics, Beijing, People's Republic of IN: Computational Fluid Dynamics Conference, 8th, Honolulu, HI, June 9-11, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 559-566. refs
(AIAA PAPER 87-1153)
Based on the AF2 scheme and the multiple grid scheme, a fast implicit multigrid approximate factorization (MAF) scheme for solving the 3D conservative full potential equation expressed with respect to nonorthogonal curvilinear coordinates has been developed and is presented in this paper. The new MAF scheme has been used to solve the 3D transonic flow within DFVLR axial-flow single-stage compressor rotor, and the computed results have been compared with the DFVLR data and the results computed by the AF2 scheme. Results show both substantial improvement in convergence speed, stability and precision for the new algorithm relative to the AF2 algorithm and good agreement with the DFVLR data. Author

A87-42100*# Vigyan Research Associates, Inc., Hampton, Va.
SOLUTION OF THE SURFACE EULER EQUATIONS FOR ACCURATE THREE-DIMENSIONAL BOUNDARY-LAYER ANALYSIS OF AERODYNAMIC CONFIGURATIONS
V. IYER (Vigyan Research Associates, Inc., Hampton, VA) and J. E. HARRIS (NASA, Langley Research Center, Hampton, VA) IN: Computational Fluid Dynamics Conference, 8th, Honolulu, HI, June 9-11, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 567-577. refs
(Contract NAS1-17919)
(AIAA PAPER 87-1154)
The three-dimensional boundary-layer equations in the limit as the normal coordinate tends to infinity are called the surface Euler equations. The present paper describes an accurate method for generating edge conditions for three-dimensional boundary-layer codes using these equations. The inviscid pressure distribution is first interpolated to the boundary-layer grid. The surface Euler equations are then solved with this pressure field and a prescribed set of initial and boundary conditions to yield the velocities along the two surface coordinate directions. Results for typical wing and fuselage geometries are presented. The smoothness and accuracy of the edge conditions obtained are found to be superior to the conventional interpolation procedures. Author

A87-42101*# Iowa State Univ. of Science and Technology, Ames.
A SIMULTANEOUS VISCOUS-INVISCID INTERACTION CALCULATION PROCEDURE FOR TRANSONIC TURBULENT FLOWS
D. LEE and R. H. PLETCHER (Iowa State University of Science and Technology, Ames) IN: Computational Fluid Dynamics Conference, 8th, Honolulu, HI, June 9-11, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 578-586. refs
(Contract NAG2-152)
(AIAA PAPER 87-1155)
A new simultaneous viscous-inviscid interaction scheme has been developed for the analysis of steady turbulent transonic separated flows. The viscous and inviscid solutions are coupled through the displacement concept using a transpiration velocity. The local solutions of the full potential and boundary-layer equations are treated simultaneously using the finite-difference method. The displacement thickness is treated as an unknown and is obtained as a part of the solution through a global iteration procedure of the space marching scheme. The Cebeci-Smith and Johnson-King models are used to simulate the turbulence. The computational examples showed that the simultaneous method is more efficient and robust than the semi-inverse method for transonic flows with a strong interaction. Author

A87-42104#
CALCULATIONS OF UNSTEADY NAVIER-STOKES EQUATIONS AROUND AN OSCILLATING 3-D WING USING MOVING GRID SYSTEM
JIRO NAKAMICHI (National Aerospace Laboratory, Chofu, Japan) IN: Computational Fluid Dynamics Conference, 8th, Honolulu, HI, June 9-11, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 608-616. refs
(AIAA PAPER 87-1158)
The purpose of the present paper is to show some solutions of unsteady Navier-Stokes equations around a low-aspect-ratio wing undergoing pitching motions. The present program is based upon the thin layer Navier-Stokes equations and the Beam-Warming ADI diagonal form is employed for the equations. The scheme is combined with a moving grid system presented below. The aerodynamics obtained by the present code are compared with experimental data. The effects of the leading edge vortex on the unsteady aerodynamics, which can not be predicted by inviscid model, are computed. Author

A87-42105#
AN EFFICIENT PROCEDURE FOR THE NUMERICAL SOLUTION OF THREE-DIMENSIONAL VISCOUS FLOWS
L. N. SANKAR (Georgia Institute of Technology, Atlanta), S. Y. RUO (Lockheed-Georgia Co., Marietta), B. E. WAKE, and J. WU IN: Computational Fluid Dynamics Conference, 8th, Honolulu, HI, June 9-11, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 617-626. Research supported by the Lockheed-Georgia Co. and U.S. Army. refs
(AIAA PAPER 87-1159)
A solution procedure is described for the numerical solution of steady and unsteady compressible viscous flow past wing-alone, and rotor configurations. This procedure solves the three-dimensional unsteady Navier-Stokes equations in a body-fitted coordinate system. A finite difference procedure of second order spatial accuracy and first order temporal accuracy is used to discretize the governing equations, and a hybrid time marching scheme is used to advance the solution from one time level to the next. This procedure lends itself to efficient solution on the current generation vector machines. In unsteady applications involving oscillating wing surfaces or rotating rotor blades, the surface motion is treated exactly, by allowing the body-fitted grid to rotate or deform. Sample steady and unsteady calculations are presented for fixed and rotary wing configurations. Detailed surface pressure and integrated load comparisons with experiments are given. Author

A87-42106#
A NEW MULTIGRID EULER METHOD FOR FIGHTER-TYPE CONFIGURATIONS
G. VOLPE, M. J. SICLARI (Grumman Corporate Research Center, Bethpage, NY), and A. JAMESON (Princeton University, NJ) IN: Computational Fluid Dynamics Conference, 8th, Honolulu, HI, June 9-11, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 627-646. refs
(AIAA PAPER 87-1160)
Transonic and supersonic flows over isolated wings and fighter-type aircraft configurations are computed through the numerical solution of the compressible Euler equations. Appropriate single-mesh topologies are used in combination with a new multigrid time-stepping scheme for solving the Euler equations. C-H or C-O meshes are used for the isolated wing. A novel H-O type mesh is introduced to discretize the space about a fighter aircraft. The H-O type mesh is obtained by a sequence of two-dimensional mappings which generate separate O-meshes around successive cross sections of the aircraft. The finite volume method, which has proved quite insensitive to mesh topology, uses a five-stage Runge-Kutta time-stepping scheme to integrate the equations. Acceleration to the steady state solution is obtained by maximizing the local time step, implicit smoothing of the residuals, enthalpy damping, and an efficient multigrid technique. Results are presented for a variety of wing and aircraft configurations. Author

A87-42107*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
NUMERICAL SIMULATION OF TRANSONIC PROPELLER FLOW USING A THREE-DIMENSIONAL SMALL DISTURBANCE CODE EMPLOYING NOVEL HELICAL COORDINATES
AARON SNYDER (NASA, Lewis Research Center, Cleveland, OH) IN: Computational Fluid Dynamics Conference, 8th, Honolulu, HI, June 9-11, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 647-666. Previously announced in STAR as N87-19350. refs
(AIAA PAPER 87-1162)
The numerical simulation of three-dimensional transonic flow about propeller blades is discussed. The equations for the unsteady potential flow about propellers is given for an arbitrary coordinate system. From this the small disturbance form of the equation is derived for a new helical coordinate system. The new coordinate system is suited to propeller flow and allows cascade boundary conditions to be applied straightforward. A numerical scheme is employed which solves the steady flow as an asymptotic limit of unsteady flow. Solutions are presented for subsonic and transonic flow about a 5 percent thick bicircular arc blade of an eight bladed cascade. Both high and low advance ratio cases are given which include a lifting case as well as nonlifting cases. The nonlifting cases are compared to solutions from a Euler code. Author

A87-42109#
FULL-POTENTIAL FLOW COMPUTATIONS USING CARTESIAN GRIDS
S. S. DESAI, R. RANGARAJAN, J. P. SINGH, and K. S. RAVICHANDRAN (National Aeronautical Laboratory, Bangalore, India) IN: Computational Fluid Dynamics Conference, 8th, Honolulu, HI, June 9-11, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 677-686. Research supported by the Aeronautical Research and Development Board. refs
(AIAA PAPER 87-1164)
The main thrust of this paper has been the exploitation of Cartesian grids in the numerical solution of transonic full potential equation. Notwithstanding the present-day popularity for the use of body-wrapped coordinate systems in the context of Computational Fluid Dynamics, concerted effort has been made here to work with Cartesian grids for a variety of flow situations: aerofoils, axisymmetric flows, wings and wing-body combinations. One reason for this is that the codes based on these grids become amenable to computers with limited storage and speed. Several cases are presented here for each of the above flow situations. The results clearly demonstrate the efficacy of Cartesian grids for dealing with complex geometries and also underscore their use in the design of computer codes usable as engineering tools. Author

A87-42110#
ACCURATE, EFFICIENT PREDICTION METHOD FOR SUPERSONIC/HYPERSONIC INVISCID FLOW
A. VERHOFF and P. J. O'NEIL (McDonnell Aircraft Co., Saint Louis, MO) IN: Computational Fluid Dynamics Conference, 8th, Honolulu, HI, June 9-11, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 687-695. refs
(AIAA PAPER 87-1165)
A spatial marching method has been developed to numerically solve the Euler equations for supersonic and hypersonic flow. The equations are formulated in terms of Riemann-type variables using a local streamline coordinate system. Expressed in this way, the equations model wave propagation in a very physical manner with no high Mach number restrictions. The numerical solution procedure is easily coded and high efficiency is achieved on a vector processor such as a CRAY-XMP or CYBER-205. The procedure has been coupled with a versatile grid generation method which automatically sections complex cross-sectional grids into simpler domains on the basis of singular geometry points, such as sharp internal or external corners. The method is validated by comparison with analytic cone solutions and test data for several realistic wing/body configurations. Real gas results are presented for a cone along with a demonstration that the procedure can be extended to incorporate parabolized viscous terms. Author

A87-42112#
ADAPTATION METHODS FOR A NEW NAVIER-STOKES ALGORITHM
JOHN G. KALLINDERIS and JUDSON R. BARON (MIT, Cambridge, MA) IN: Computational Fluid Dynamics Conference, 8th, Honolulu, HI, June 9-11, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 705-716. refs
(Contract AF-AFOSR-82-0136)
(AIAA PAPER 87-1167)
In the present adaptation techniques for two-dimensional viscous flow computation, an initially coarse grid is automatically embedded locally via a feature detection algorithm in order to yield accurate boundary layer region predictions. While the full Navier-Stokes equations are in this way solved for substantially viscous regions, the treatment of the remaining areas is reduced to the Euler equations. The basic algorithm uses a novel finite

volume scheme that has been developed for the discretization of the viscous terms and possesses the conservation property that is required in the presence of shocks. The cases of circular arc cascades in both subsonic and supersonic flow are treated.
O.C.

A87-42114*# Old Dominion Univ., Norfolk, Va.
GRID ADAPTION FOR HYPERSONIC FLOW
JAMSHID S. ABOLHASSANI, SURENDRA N. TIWARI (Old Dominion University, Norfolk, VA), and ROBERT E. SMITH (NASA, Langley Research Center, Hampton, VA) IN: Computational Fluid Dynamics Conference, 8th, Honolulu, HI, June 9-11, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 726-737. refs
(Contract NCC1-68)
(AIAA PAPER 87-1169)

The methods of grid adaption are reviewed and a method is developed with the capability of adaption to several flow variables. This method is based on a variational approach and is an algebraic method which does not require the solution of partial differential equations. Also the method has been formulated in such a way that there is no need for any matrix inversion. The method is used in conjunction with the calculation of hypersonic flow over a blunt nose body. The equations of motion are the compressible Navier-Stokes equations where all viscous terms are retained. They are solved by the MacCormack time-splitting method. A movie has been produced which shows simultaneously the transient behavior of the solution and the grid adaption. Author

A87-42116*# Wales Univ., Swansea.
AN ADAPTIVE FINITE ELEMENT SCHEME FOR THE EULER AND NAVIER-STOKES EQUATIONS
K. MORGAN, J. PERAIRE (University of Wales, Swansea), R. R. THAREJA, and J. R. STEWART (PRC Kentron, Inc., Hampton, VA) IN: Computational Fluid Dynamics Conference, 8th, Honolulu, HI, June 9-11, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 749-757. refs
(Contract NAGW-478)
(AIAA PAPER 87-1172)

The implementation of two explicit finite element schemes for the solution of the compressible Euler and Navier-Stokes equations is presented. The schemes can be employed with general unstructured triangular meshes in two dimensions. Either scheme can therefore be used as the basic solver in a solution adaptive mesh procedure in a direct manner. The particular adaptive approach which is advocated here is intended for the solution of steady state problems only and involves an adaptive regeneration of the grid at prescribed stages during the false transient. The grid regeneration is accomplished by a mesh generator which has the capability of generating triangular grids over computational domains of arbitrary shape. The procedure is illustrated by solving transonic flows over multi-airfoil configurations and high speed flows, involving shock interactions, past circular cylinders.
Author

A87-42118#
LOW MACH NUMBER COMPRESSIBLE FLOW SOLUTIONS IN CONSTRICTED DUCTS
JOHN A. EKATERINARIS, N. L. SANKAR, and DON P. GIDDENS (Georgia Institute of Technology, Atlanta) IN: Computational Fluid Dynamics Conference, 8th, Honolulu, HI, June 9-11, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 768-777. refs
(AIAA PAPER 87-1174)

The compressible time-dependent Navier-Stokes equations were solved numerically for flows in circular constricted ducts. Two types of constricted duct geometries were employed: a smooth cosine form constriction and a step-like constriction. Time asymptotic steady-state solutions have been obtained for low Mach number flows. The computations were performed with an implicit approximate factorization algorithm. The application of the inflow-outflow boundary conditions was critical for convergence to the steady state. The numerical solution correctly predicted the pressure rise and the resulting flow separation in the expanding part of the duct. The low Mach number solutions for ducts with smooth constriction have been compared with experimental data for liquid flows and with results for incompressible flow solutions. Finally, the results for the flow in a duct with a step constriction are given. It is concluded that a low Mach number compressible approach may be applied to the studies of unsteady flow phenomena with success. Author

A87-42119#
DIRECT SIMULATION OF HIGH REYNOLDS NUMBER FLOWS USING A NEW INTEGRO-DIFFERENTIAL SOLVER
HIROSHI TOKUNAGA, NOBUYUKI SATOFUKA (Kyoto Institute of Technology, Matsugasaki, Japan), and TAKAO YOSHIKAWA IN: Computational Fluid Dynamics Conference, 8th, Honolulu, HI, June 9-11, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 778-788. refs
(AIAA PAPER 87-1175)

A new integro-differential solver for calculating high Reynolds number flows along bodies has been developed. The vorticity transport equation is solved by using rational Runge-Kutta time stepping scheme and the pseudo-unsteady Poisson equation is also solved by the same scheme with both a implicit residual averaging and a local time stepping. The present solver is successfully applied to the flow along a circular cylinder at the Reynolds number 3000 and the flow along NACA 0012 airfoil at the Reynolds number 100,000. As the result the unsteady separation is calculated accurately, and the efficiency of the present method is shown. Author

A87-42310*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
DISPLACEMENT SURFACE CALCULATIONS FOR A HYPERSONIC AIRCRAFT
PAMELA F. RICHARDSON (NASA, Langley Research Center, Hampton, VA) and JOSEPH H. MORRISON (Analitical Services and Materials, Inc., Hampton, VA) AIAA, Fluid Dynamics, Plasma Dynamics, and Lasers Conference, 19th, Honolulu, HI, June 8-10, 1987. 14 p. refs
(AIAA PAPER 87-1190)

A method is presented to calculate the three-dimensional displacement surface about a hypersonic aircraft. This calculation requires a flow-field-solution to at least the thin-layer Navier-Stokes equations about the aircraft as input. An upwind, finite-volume code developed at NASA Langley Research Center was used to obtain the flow-field solution. The displacement surface is the three-dimensional counterpart to the two-dimensional displacement thickness. Flow-field solutions, along with the displacement surface calculations, are presented for a generic hypersonic aircraft at a Mach number of 24.5 and angle of attack of zero and one degree. Author

A87-42311#
HYPERSONIC LAMINAR STRONG INTERACTION THEORY AND EXPERIMENT REVISITED USING A NAVIER-STOKES CODE
R. RAY, J. ERDOS, and M. V. PULSONETTI (General Applied Science Laboratories, Inc., Ronkonkoma, NY) AIAA, Fluid Dynamics, Plasma Dynamics, and Lasers Conference, 19th, Honolulu, HI, June 8-10, 1987. 15 p. refs
(Contract F33615-85-C-0104; F33657-87-D-2048)
(AIAA PAPER 87-1191)

A Navier-Stokes (N-S) code was compared with hypersonic, laminar, cold-wall, flat plate, and compression corner data and good agreement was found at a Mach number of 14.1. Good agreement was found with both the self-induced interaction on the flat plate and the corner flow interactions, including separation. It is suggested that the discrepancies found at a Mach number of 18.9 can be resolved via an N-S analysis of the shock tunnel itself. K.K.

A87-42312#

PRELIMINARY APPLICATIONS OF HOLOGRAPHIC INTERFEROMETRY TO STUDY HYPERSONIC REGIONS OF SHOCK WAVE/BOUNDARY LAYER INTERACTION

GEORGE HAVENER (New York State University, Binghamton; Calspan-UB Research Center, Buffalo, NY), MICHAEL S. HOLDEN (Calspan-UB Research Center, Buffalo, NY), and DAVE AZEVEDO (New York, State University, Buffalo) AIAA, Fluid Dynamics, Plasma Dynamics, and Lasers Conference, 19th, Honolulu, HI, June 8-10, 1987. 24 p. refs
(Contract F49620-85-C-0130-P00002)
(AIAA PAPER 87-1194)

Holographic interferometry was applied to study the flow field in regions of shock wave/boundary layer interaction in a hypersonic shock tunnel at Mach numbers of 11 and 13 and Reynolds numbers up to 3 x 10 to the 7th, nominally. Flow field studies were made for flat plate/wedge, cone/flare, and two-dimensional incident shock configurations. The primary contribution obtained from the holographic data is flow visualization, which clearly shows qualitative details on the shock structures throughout the separation regions. The quantitative evaluations of the interferograms were made difficult by edge effects and three-dimensional flow effects on two-dimensional models and by refraction effects in regions of high-density gradients close to the wall. I.S.

A87-42313#

TRANSONIC ANALYSIS FOR COMPLEX AIRPLANE CONFIGURATIONS

K. KUSUNOSE, D. L. MARCUM, H. C. CHEN, and N. J. YU (Boeing Co., Seattle, WA) AIAA, Fluid Dynamics, Plasma Dynamics, and Lasers Conference, 19th, Honolulu, HI, June 8-10, 1987. 9 p. Research supported by the Boeing Co. refs
(AIAA PAPER 87-1196)

A new transonic flow analysis program that solves the Euler equations has been developed. The program is capable of analyzing flows over aft-mounted propfan airplane configurations at arbitrary freestream conditions, including sideslip, and at various propeller power settings. This capability includes cases where each of the airplane's engines have different power settings. Extensive analysis of the propeller power effect on airplane aerodynamics and lateral and directional stability has been conducted, and some typical results are presented in this paper. A streamline tracing capability is demonstrated. To account for viscous effects, the Euler solver is coupled with a boundary-layer method. Some preliminary Euler/boundary-layer coupled results are also presented. Author

A87-42314*# Mississippi State Univ., Mississippi State.

THREE-DIMENSIONAL UNSTEADY EULER SOLUTIONS FOR PROPFANS AND COUNTER-ROTATING PROPFANS IN TRANSONIC FLOW

D. L. WHITFIELD (Mississippi State University, Mississippi State), T. W. SWAFFORD (Sverdrup Technology, Inc., Arnold Air Force Station, TN), R. A. MULAC (Sverdrup Technology, Inc., Cleveland, OH), D. M. BELK (USAF, Armament Laboratory, Eglin AFB, FL), and J. M. JANUS AIAA, Fluid Dynamics, Plasma Dynamics, and Lasers Conference, 19th, Honolulu, HI, June 8-10, 1987. 15 p. refs
(Contract NAG3-767)
(AIAA PAPER 87-1197)

An Euler code designed for computing the unsteady, three-dimensional, transonic flow about single-rotating and counter-rotating propfans using dynamic blocked-grids is presented. The algorithm is a finite volume, flux-split, upwind, implicit scheme and solves the equations which have been written in a time-dependent curvilinear coordinate system. Relative motion of the blades for counter-rotating configurations is handled by requiring that grid lines be aligned after each discrete rotation of fore and aft rotor grid blocks. The method by which information is passed across block interfaces, as well as how downstream characteristic outflow boundary conditions which enforce simple radial equilibrium are implemented, is discussed. Comparisons of computed flow-field parameters and propfan performance with experimental data indicate good overall agreement between predictions and measurements. Author

A87-42315#

NAVIER-STOKES CALCULATIONS OF TRANSONIC VISCOUS FLOW ABOUT WING-BODY CONFIGURATIONS

J. E. DEESE and R. K. AGARWAL (McDonnell Douglas Research Laboratories, Saint Louis, MO) AIAA, Fluid Dynamics, Plasma Dynamics, and Lasers Conference, 19th, Honolulu, HI, June 8-10, 1987. 11 p. refs
(AIAA PAPER 87-1200)

Transonic flowfields about transport and fighter aircraft are modeled using the thin-layer and slender-layer approximations to the unsteady compressible Reynolds-averaged Navier-Stokes equations. The equations are solved by an explicit multi-stage Runge-Kutta time-stepping method using a finite-volume formulation on body-conforming curvilinear grids. Convergence acceleration and vectorization enhance code efficiency. Microtasking allows effective use of all available processors on a Cray X/MP-48. Results are compared with experimental data for typical fighter and transport configurations. Author

A87-42317#

COMPUTATIONS OF THREE-DIMENSIONAL CAVITY FLOW AT SUBSONIC AND SUPERSONIC MACH NUMBERS

N. E. SUHS (Calspan Corp., Arnold Air Force Station, TN) AIAA, Fluid Dynamics, Plasma Dynamics, and Lasers Conference, 19th, Honolulu, HI, June 8-10, 1987. 10 p. refs
(AIAA PAPER 87-1208)

A computational capability for predicting the flow field in a three-dimensional cavity has been developed. The chimera embedded grid scheme is used to simplify grid generation. An implicit Navier-Stokes code with a thin-layer approximation is used. Computations for a three-dimensional rectangular cavity are made and compared to experimental data at Mach numbers of 0.74 and 1.5. Author

A87-42326#

NAVIER-STOKES COMPUTATION OF TRANSONIC VORTICES OVER A ROUND LEADING EDGE DELTA WING

BERNHARD MULLER and ARTHUR RIZZI (Flygtekniska Forsoksanstalten, Bromma, Sweden) AIAA, Fluid Dynamics, Plasma Dynamics, and Lasers Conference, 19th, Honolulu, HI, June 8-10, 1987. 12 p. Research supported by the Styrelsen for Teknisk Utveckling and NSF. refs
(AIAA PAPER 87-1227)

A three-dimensional Navier-Stokes solver has been developed to simulate laminar compressible flow over quadrilateral wings. The finite volume technique is employed for spatial discretization with a novel variant for the viscous fluxes. An explicit three-stage Runge-Kutta scheme is used for time integration taking local time steps according to the linear stability condition derived for application to the Navier-Stokes equations. The code is applied to compute primary and secondary separation vortices at transonic speeds over a 65 deg swept delta wing with round leading edges and cropped tips. The results are compared with experimental data and Euler solutions, and Reynolds number effects are investigated. Author

A87-42327*# Stanford Univ., Calif.

SLENDER DELTA WING AT HIGH ANGLES OF ATTACK - A FLOW VISUALIZATION STUDY

A. AYOUB (Stanford University, CA) and B. G. MCLACHLAN (NASA, Ames Research Center, Moffett Field, CA) AIAA, Fluid Dynamics, Plasma Dynamics, and Lasers Conference, 19th, Honolulu, HI, June 8-10, 1987. 17 p. refs
(AIAA PAPER 87-1230)

The flow past a delta wing of aspect ratio one is examined at angles of attack ranging from 25 deg to 90 deg. On the basis of detailed observations of the flow in a water channel, using laser-induced fluorescence, four angle of attack flow regimes are identified, in addition to the well known regime of a stable pair of leading edge vortices. These are: a regime where the two leading

edge vortices break down independently, primarily into the spiral form; a regime where spiral and bubble breakdowns alternate periodically on the two sides of the wing, accompanied by an antisymmetric motion in the chordwise direction of the two points of breakdown; a regime where a single streamwise vortex springing from the wing apex alternates in sign at irregular intervals; and finally, a regime dominated by a wake bubble and the relatively small scale vortices arising from the instability of its boundary.
Author

A87-42328*# Notre Dame Univ., Ind.
EXPERIMENTAL STUDY OF THE VELOCITY FIELD ON A DELTA WING
F. M. PAYNE, T. T. NG, and R. C. NELSON (Notre Dame, University, IN) AIAA, Fluid Dynamics, Plasma Dynamics, and Lasers Conference, 19th, Honolulu, HI, June 8-10, 1987. 15 p. refs
(Contract NAG2-258)
(AIAA PAPER 87-1231)

An experimental study of the leading edge vortices on delta wings at large angles of incidence is presented. A combination of flow visualization, seven-hole pressure probe surveys and laser velocimeter measurements were used to study the leading edge vortex formation and breakdown for a set of delta wings. The delta wing models were thin flat plates with sharp leading edges having sweep angles of 70, 75, 80, and 85 degrees. The flow structure was examined for angles of incidence from 10 to 40 degrees and chord Reynolds numbers from 85,000 to 640,000. Vortex breakdown was observed on all the wings tested. Both bubble and spiral modes of breakdown were observed. The visualization and wake survey data shows that when vortex breakdown occurs the core flow transforms abruptly from a jet-like flow to a wake-like flow. The result also revealed that probe induced vortex breakdown was more steady than the natural breakdown.
Author

A87-42335#
UNSTEADY FULL POTENTIAL AEROELASTIC COMPUTATIONS FOR FLEXIBLE CONFIGURATIONS
H. IDE (Rockwell International Corp., Los Angeles, CA) and V. J. SHANKAR (Rockwell International Science Center, Thousand Oaks, CA) AIAA, Fluid Dynamics, Plasma Dynamics, and Lasers Conference, 19th, Honolulu, HI, June 8-10, 1987. 10 p. Research supported by the Rockwell International Independent Research and Development Program. refs
(AIAA PAPER 87-1238)

An aerodynamic/aeroelastic computer program based on an unsteady full potential concept is presented for static and dynamic flexible wing configurations at Mach numbers ranging from transonic to supersonic conditions. The dynamic response of a flexible wing above and below its flutter point is demonstrated. The results indicate that the nonlinear effect is strong near $M = 1.0$, and that flexibility plays a very significant part in the nonlinear effect.
C.D.

A87-42336*# Naval Ship Research and Development Center, Bethesda, Md.
TRANSONIC CHARACTERISTICS OF A HUMPED AIRFOIL
TSZE C. TAI, GREGORY G. HUSON (David W. Taylor Naval Ship Research and Development Center, Bethesda, MD), RAYMOND M. HICKS (NASA, Ames Research Center, Moffett Field, CA), and GERALD M. GREGOREK (Ohio State University, Columbus) AIAA, Fluid Dynamics, Plasma Dynamics, and Lasers Conference, 19th, Honolulu, HI, June 8-10, 1987. 12 p. refs
(Contract NAVAIR TASK AIR-931L; NAVY PROJECT WR02302)
(AIAA PAPER 87-1239)

A humped airfoil concept to improve the performance of supercritical airfoils at off-design conditions in transonic maneuver is introduced. Theoretical aspects of the airfoil and recent results of experimental tests conducted in the high Reynolds number transonic wind tunnels at both NASA Ames Research Center and The Ohio State University are presented. Experimental evidence has shown that the humped airfoil generally has more favorable transonic characteristics in off-design high supercritical flow conditions than a regular supercritical airfoil.
Author

A87-42337*# Sterling (Walter V.), Inc., Palo Alto, Calif.
UNSTEADY TRANSONIC FLOW SIMULATION ON A FULL-SPAN-WING-BODY CONFIGURATION
GURU P. GURUSWAMY (Sterling Federal Systems, Inc., Palo Alto, CA) and PETER M. GOORJIAN (NASA, Ames Research Center, Moffett Field, CA) AIAA, Fluid Dynamics, Plasma Dynamics, and Lasers Conference, 19th, Honolulu, HI, June 8-10, 1987. 14 p. USAF-supported research. refs
(AIAA PAPER 87-1240)

The presence of a body influences both the aerodynamic and aeroelastic performance of wings. Such effects are more pronounced in the transonic regime. To accurately account for the effect of the body, particularly when the wings are experiencing asymmetric modal motions, it is necessary to model the full configuration in the nonlinear transonic regime. In this study, full-span-wing-body configurations are simulated for the first time by a theoretical method that uses the unsteady potential equations based on the small-disturbance theory. The body geometry is modeled exactly as the physical shape, instead of as a rectangular box, which has been done in the past. Steady pressure computations for wing-body configurations compare well with the available experimental data. Unsteady pressure computations when the wings are oscillating in asymmetric modes show significant influence of the body.
Author

A87-42338*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
A FINITE VOLUME EULER CALCULATION OF THE AERODYNAMICS OF TRANSONIC AIRFOIL-VORTEX INTERACTION
MURALI DAMODARAN (NASA, Ames Research Center, Moffett Field, CA; Cornell University, Ithaca, NY) and DAVID A. CAUGHEY (Cornell University, Ithaca, NY) AIAA, Fluid Dynamics, Plasma Dynamics, and Lasers Conference, 19th, Honolulu, HI, June 8-10, 1987. 12 p. refs
(Contract NAG2-218)
(AIAA PAPER 87-1244)

Unsteady inviscid transonic airfoil-vortex interaction is numerically analyzed by solving the two-dimensional unsteady Euler equations in integral form using a finite volume scheme. The solution procedure is based on an explicit Runge-Kutta time-stepping scheme wherein the spatial terms are central-differenced and a combination of second- and fourth-differences in the flow variables is used to form the numerical dissipation terms to stabilize the scheme. A velocity decomposition technique is applied to alleviate the problem of vortex diffusion by the numerical dissipation terms and to treat the interaction of a Rankine vortex with an airfoil accurately. Results obtained are compared with available numerical data.
Author

A87-42339*# Ohio State Univ., Columbus.
FREE-WAKE ANALYSIS OF A ROTOR IN HOVER
C. S. CHEN, H. R. VELKOFF (Ohio State University, Columbus), and C. TUNG (NASA, Ames Research Center; U.S. Army, Aeroflightdynamics Directorate, Moffett Field, CA) AIAA, Fluid Dynamics, Plasma Dynamics, and Lasers Conference, 19th, Honolulu, HI, June 8-10, 1987. 9 p. refs
(AIAA PAPER 87-1245)

A numerical method based on the axisymmetric, incompressible Navier-Stokes equations is combined with a lifting surface code to predict the vortex wake of hovering rotors. The lifting surface code, AMI Hover, is used to obtain the circulation distribution on the blade. This circulation distribution is fed into the Navier-Stokes code to compute the vortex wake under this specified circulation distribution. An iteration approach is used between these two codes to converge the circulation distribution and the shape of the vortex wake. A relaxation scheme is developed to resolve the instability encountered among the tip vortices. A reconcentration scheme is used to solve the diffusion problem due to the strong artificial viscosity. The results from the present method are compared with experimental data obtained by smoke-flow visualization and hot-wire measurements for several rotor blade configurations. The comparisons show that the present method is able to predict the complex wake system shed by a hovering rotor. Author

A87-42340*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

INTERACTION OF AN OSCILLATING VORTEX WITH A TURBULENT BOUNDARY LAYER

RUSSELL V. WESTPHAL (NASA, Ames Research Center, Moffett Field, CA) and RABINDRA D. MEHTA (Stanford University, CA) AIAA, Fluid Dynamics, Plasma Dynamics, and Lasers Conference, 19th, Honolulu, HI, June 8-10, 1987. 11 p. refs
(Contract NCC2-294)
(AIAA PAPER 87-1246)

The effects on mean flow and turbulence caused by meander of a vortex embedded in a two-dimensional boundary layer were investigated experimentally by driving a forced lateral oscillation of the vortex generator. Upstream, the vorticity contours without forcing were found to be round. The forced vortex generator oscillation caused a flattening of the time-averaged vorticity contours and changes in some of the Reynolds stresses. The results indicate that the unforced vortex did not meander significantly upstream, and that the effects of meander can be understood qualitatively from production of Reynolds stresses by the forced motion acting with the exiting three-dimensional velocity field. Farther downstream, the observed differences in the mean vorticity and Reynolds stresses caused by forcing were smaller, mainly because the vortex was substantially diffused at this station, resulting in smaller mean velocity gradients. C.D.

A87-42347#

AN INTEGRAL METHOD FOR THREE-DIMENSIONAL TURBULENT BOUNDARY LAYER WITH LARGE CROSSFLOW

TSZE C. TAI (David W. Taylor Naval Ship Research and Development Center, Bethesda, MD) AIAA, Fluid Dynamics, Plasma Dynamics, and Lasers Conference, 19th, Honolulu, HI, June 8-10, 1987. 9 p. refs
(Contract NAVAIR TASK AIR-931; NAVY PROJECT F1132)
(AIAA PAPER 87-1254)

The problem of excessive resultant velocity by using a two-dimensional profile in three-dimensional boundary layers is addressed. To allow large crossflow variation, two steps are taken: (1) the two-dimensional profile is applied to the resultant flow and a modified Mager crossflow formula is adopted and (2) a viscous streamline coordinate system is employed. A three-dimensional integral boundary-layer procedure based on the new arrangement is developed. Two test cases are considered: an inclined prolate spheroid and a swept wing. Calculated results on turbulent boundary layers are compared with those obtained using the previous methods. Author

A87-42351*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

SEPARATION CONTROL OVER AN AIRFOIL AT HIGH ANGLES OF ATTACK BY SOUND EMANATING FROM THE SURFACE

L. S. HUANG, L. MAESTRELLO, and T. D. BRYANT (NASA, Langley Research Center, Hampton, VA) AIAA, Fluid Dynamics, Plasma Dynamics, and Lasers Conference, 19th, Honolulu, HI, June 8-10, 1987. 7 p. refs
(AIAA PAPER 87-1261)

Active control by sound emanating from a narrow gap in the vicinity of the leading edge of a symmetrical airfoil is used to study the influence of sound on the pressure distribution and the wake at high angles of attack. The results from experiments conducted at a Reynolds number based on the chord of 35,000 show that, with injection of sound at twice the shedding frequency of the shear layer, the region of separation becomes drastically reduced. The shear layer is found to be very sensitive to sound excitation in the vicinity of the separation point. The excitation sufficiently alters the global circulation to cause an increase in lift and reduction in drag. Furthermore, experimental results describing stall and post-stall conditions compare well with the limited data available and indicate that stall is delayed by sound injection into the separated region. Author

A87-42352#

PASSIVE DRAG REDUCTION ON A COMPLETE NACA 0012 AIRFOIL AT TRANSONIC MACH NUMBERS

H. T. NAGAMATSU, T. W. TRILLING (Rensselaer Polytechnic Institute, Troy, NY), and J. A. BOSSARD (Aerojet Corp., Sacramento, CA) AIAA, Fluid Dynamics, Plasma Dynamics, and Lasers Conference, 19th, Honolulu, HI, June 8-10, 1987. 11 p. refs
(Contract DAAG29-82-K-0093)
(AIAA PAPER 87-1263)

A transonic wind tunnel investigation of passive shock wave/boundary layer control of a complete NACA 0012 airfoil with a porous surface is presented. Schlieren photographs show that the normal shock was changed to a lambda shock wave over the porous surface. It is found that over the porous surface the Mach number decreases from a supersonic flow to nearly sonic velocity ahead of the terminating normal shock wave (minimizing the boundary layer separation), and that the lambda shock wave minimizes the entropy losses through the shock wave. Both of these effects tend to decrease the transonic drag. At a freestream Mach number of 0.82, the introduction of a porous surface resulted in a drag reduction of about 19 percent for a 2-deg angle of attack, and of about 25 percent for a 4-deg angle of attack. R.R.

A87-42354#

EXPERIMENTAL STUDIES OF AIRFOIL PERFORMANCE AND FLOW STRUCTURES ON A LOW REYNOLDS NUMBER AIRFOIL

FEI-BIN HSIAO, ZEN TANG (National Cheng Kung University, Tainan, Republic of China), and CHIN-FUNG LIU AIAA, Fluid Dynamics, Plasma Dynamics, and Lasers Conference, 19th, Honolulu, HI, June 8-10, 1987. 10 p. Sponsorship: National Science Council of the Republic of China. refs
(Contract NSC-75-0401-E006-13)
(AIAA PAPER 87-1267)

The airfoil performance and flow structures of a model with a NACA 63(3)-018 airfoil section is studied experimentally in a wind tunnel. The pressure distributions, boundary layer profiles, and the corresponding aerodynamic properties are measured at various angles of attack, and at the Reynolds number range from 300,000 to 750,000 based on the wind chord. Data indicate that the flow field over the airfoil appears to be transitional in the operating range. The flow starts to separate from the airfoil surface after the pressure gradient becomes positive and, then, reattaches to form a laminar separation bubble. The spectral analysis of the fluctuating velocities in the recirculating region also clearly ascertains the existence of the prevailing vortices. Meanwhile, the hysteresis phenomenon in the nonlinear range of the lift curves with angle of attack is noted, especially in the low Reynolds number range. Author

A87-42355*# United Technologies Research Center, East Hartford, Conn.

ANALYSIS OF CROSSOVER BETWEEN LOCAL AND MASSIVE SEPARATION ON AIRFOILS

MARK BARNETT (United Technologies Research Center, East Hartford, CT) AIAA, Fluid Dynamics, Plasma Dynamics, and Lasers Conference, 19th, Honolulu, HI, June 8-10, 1987. 13 p. refs
(Contract NAS1-16585)
(AIAA PAPER 87-1268)

The occurrence of massive separation on airfoils operating at high Reynolds number poses an important problem to the aerodynamicist. In the present study, the phenomenon of crossover, induced by airfoil thickness, between local separation and massive separation is investigated for low speed (incompressible), symmetric flow past realistic airfoil geometries. This problem is studied both for the infinite Reynolds number asymptotic limit using triple-deck theory and for finite Reynolds number using interacting boundary-layer theory. Numerical results are presented which illustrate how the flow evolves from local to massive separation as the airfoil thickness is increased. The results of the triple-deck and the interacting boundary-layer analyses are found to be in qualitative agreement for the NACA four digit series and an uncambered supercritical airfoil. The effect of turbulence on the evolution of the flow is also considered. Solutions are presented for turbulent flows past a NACA 0014 airfoil and a circular cylinder. For the latter case, the calculated surface pressure distribution is found to agree well with experimental data if the proper eddy pressure level is specified. Author

A87-42362*# Washington Univ., Seattle.

FURTHER EXPERIMENTS ON SUPERSONIC TURBULENT FLOW DEVELOPMENT IN A SQUARE DUCT

D. O. DAVIS and F. B. GESSNER (Washington, University, Seattle) AIAA, Fluid Dynamics, Plasma Dynamics, and Lasers Conference, 19th, Honolulu, HI, June 8-10, 1987. 10 p. refs
(Contract NCA2-IR-850-401)
(AIAA PAPER 87-1287)

The mean-flow structure of supersonic, turbulent, adiabatic-wall flow in a square duct is investigated experimentally over a development length x/D = 0-50 for a uniform flow, Mach 3.9 condition at the duct inlet. The results show that a secondary flow cell structure develops which is similar to that for the incompressible case. Development of the primary flow is influenced by the combined effects of the secondary flow and the streamwise adverse pressure gradient. Total pressure, axial mean velocity, and Mach number profiles are presented which show that the outer flow is sensitive primarily to the streamwise pressure gradient, while flow in the near-wall region is dominated by the secondary flow. Axial mean-velocity profiles plotted in terms of van Driest-scaled variables show that a well-defined log-law region exists in the near-wall layer. This region exists in the presence of a secondary flow which continuously modifies spanwise wall shear stress behavior along the length of the duct. Author

A87-42363#

NUMERICAL SIMULATION OF SUPERSONIC FLOW OVER A THREE-DIMENSIONAL CAVITY

DONALD P. RIZZETTA (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) AIAA, Fluid Dynamics, Plasma Dynamics, and Lasers Conference, 19th, Honolulu, HI, June 8-10, 1987. 13 p. refs
(AIAA PAPER 87-1288)

A numerical solution is presented for the unsteady flow over a three-dimensional cavity at a freestream Mach number of 1.5 and Reynolds number of 1.09 x 10 to the 6th. The self-sustained oscillatory motion within the cavity is generated numerically by integration of the time-dependent compressible three-dimensional Reynolds averaged Navier-Stokes equations. Effects of fine-scale turbulence are simulated via a simple algebraic closure model. Details of the flowfield structure are elucidated, and it is verified that the fundamental behavior of the unsteady phenomena is two-dimensional. Comparison with experimental data is made in terms of the mean static pressure and overall acoustic sound pressure levels within the cavity, as well as with the acoustic frequency spectra of the oscillation along the cavity floor and rear bulkhead. Author

A87-42377#

TURBULENCE STRUCTURE NEAR THE NOSE OF A WING-BODY JUNCTION

WILLIAM J. DEVENPORT and ROGER L. SIMPSON (Virginia Polytechnic Institute and State University, Blacksburg) AIAA, Fluid Dynamics, Plasma Dynamics, and Lasers Conference, 19th, Honolulu, HI, June 8-10, 1987. 15 p. refs
(Contract N60921-83-G-A165-B02)
(AIAA PAPER 87-1310)

The time-dependent and time-averaged properties of a wing-body junction flow formed around a cylindrical wing with a 1.5:1 elliptical nose and a NACA 0020 tail are being studied. In this paper measurements made with a three-component laser Doppler anemometer in the plane of symmetry immediately upstream of the wing are presented and discussed. These measurements have been used to estimate the production and advection terms of the turbulence kinetic-energy equation. In the plane of symmetry the time-mean flow is dominated by an intense junction vortex. Histograms of velocity fluctuations measured near the upstream end of this vortex are bimodal (double-peaked), implying the presence of a coherent junction structure in the instantaneous flow. Author

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VORTEX SIMULATION OF THREE-DIMENSIONAL MIXING LAYERS

OSAMU INOUE (NASA, Ames Research Center, Moffett Field, CA) AIAA, Fluid Dynamics, Plasma Dynamics, and Lasers Conference, 19th, Honolulu, HI, June 8-10, 1987. 24 p. refs
(AIAA PAPER 87-1311)

Spanwise structures of 'nominally' two-dimensional (2D), spatially growing, turbulent mixing layers are simulated numerically by a three-dimensional (3D) vortex method. Small-amplitude 3D disturbances are introduced into an otherwise 2D flow field. Results show that a large-scale spanwise variation of the flow field is produced because of amplification of initial disturbances. Pairs of counterrotating streamwise vortices are formed as a result of stretching of primary spanwise vortices. The streamwise vortices are formed at a fixed spanwise location which depends on initial disturbances. The calculated magnitude of streamwise vorticity is close to that of the spanwise vorticity. The results also suggest that the presence of background disturbances may be essential for the formation of streamwise vortices. The results are in good qualitative agreement with experiments. Author

A87-42380#

NUMERICAL SIMULATION OF THREE-DIMENSIONAL FLOW FIELDS IN TURBOMACHINERY BLADE ROWS USING THE COMPRESSIBLE NAVIER-STOKES EQUATIONS

S. V. SUBRAMANIAN and R. BOZZOLA (Textron, Inc., Avco Lycoming Textron Div., Stratford, CT) AIAA, Fluid Dynamics, Plasma Dynamics, and Lasers Conference, 19th, Honolulu, HI, June 8-10, 1987. 10 p. refs
(AIAA PAPER 87-1314)

Performance characteristics of the three-dimensional LYCVIS3D computer program, for the modeling of viscous flowfields in stationary and rotating turbomachinery blade rows, are discussed. The full three-dimensional time-dependent compressible Navier-Stokes equations are expressed in cylindrical coordinates and solved using a four-stage Runge-Kutta numerical integration scheme. Computational results are presented for the cases of a fully subsonic axial-flow turbine stator vane cascade, a large-scale low-velocity linear turbine cascade, and a low-aspect-ratio transonic compressor rotor with multiple shocks in the flowfield. Good agreement is found between numerical predictions and laser anemometry and cascade tunnel measurements. R.R.

A87-42391#

AIRFOIL DYNAMIC STALL AT CONSTANT PITCH RATE AND HIGH REYNOLDS NUMBER

PETER F. LORBER and FRANKLIN O. CARTA (United Technologies Research Center, East Hartford, CT) AIAA, Fluid Dynamics, Plasma Dynamics, and Lasers Conference, 19th, Honolulu, HI, June 8-10, 1987. 12 p. refs
(Contract F49620-84-C-0082)
(AIAA PAPER 87-1329)

The aerodynamics of dynamic stall penetration at constant pitch rate and high Reynolds number (2 x 10 to the 6th - 4 x 10 to the 6th) is investigated experimentally with a view to improving the accuracy of the modeling of conditions during aircraft post stall maneuvers and during helicopter high-speed forward flight. Results for moderate Mach numbers (0.2-0.4) indicate that the unsteady aerodynamic response near stall is strongly dependent on the characteristics of the leading-edge stall vortex. The vortex is strengthened when the pitch rate is increased and weakened when the Mach number is increased or when the motion is started close to the steady-state stall angle. A periodic pressure oscillation occurs after stall at high pitch angle and moderate Reynolds number, the oscillation frequency being close to that predicted for a von Karman vortex street. V.L.

A87-42394#
DYNAMIC STALL VORTEX DEVELOPMENT AND THE SURFACE PRESSURE FIELD OF A PITCHING AIRFOIL
J. A. ALBERTSON, T. R. TROUTT (Washington State University, Pullman), W. D. SIURU (Colorado, University, Colorado Springs), and J. M. WALKER (USAF, Frank J. Seiler Research Laboratory, Colorado Springs, CO) AIAA, Fluid Dynamics, Plasma Dynamics, and Lasers Conference, 19th, Honolulu, HI, June 8-10, 1987. 9 p. refs
(Contract F49620-85-C-0013)
(AIAA PAPER 87-1333)

A detailed examination of simultaneous digitally enhanced flow visualization results and surface pressure measurements was conducted to develop insight into the relationships between dynamic stall vortex development and airfoil surface pressure levels. The experimental situation involved a two-dimensional NACA 0015 airfoil driven at constant pitching rates over attack angles from zero to 60 degrees. Specific attention was focussed on moderately low nondimensional pitch rates such that only a single dynamic vortex was present on the airfoil surface at any instant in time. The analyses show that the development of a dynamic stall vortex over the top surface of the airfoil does not enhance the instantaneous lift. The initiation of the dynamic stall vortex appears to correspond closely to a leveling of the lift curve as a function of attack angle. Later rapid growth of the stall vortex is found to accompany a decrease in lift. The eventual detachment of the stall vortex from the airfoil is observed to correspond to a simultaneous decrease in the pressure drag on the airfoil. Author

A87-42395#
THREE-DIMENSIONAL TRANSITION STUDIES AT ONERA/CERT
D. ARNAL and J. C. JUILLEN (ONERA, Centre d'Etudes et de Recherches de Tolouse, France) AIAA, Fluid Dynamics, Plasma Dynamics, and Lasers Conference, 19th, Honolulu, HI, June 8-10, 1987. 11 p. refs
(AIAA PAPER 87-1335)

The paper presents a survey of experimental activities related with the problem of the laminar-turbulent transition on a swept wing, in incompressible flow. The experiments described below were performed on a classical, symmetric ONERA D profile and on a ONERA D profile with a cambered leading edge. The aim is to obtain a better understanding of the physical phenomena, as well as to collect data in order to check the efficiency of practical calculation methods. The main topics investigated in this paper are: the interaction between streamwise and crossflow instabilities, the problems related with leading edge contamination and the measurement of the extent of the transition region. Author

A87-42397#
ANALYSIS AND SIMPLIFIED PREDICTION OF PRIMARY INSTABILITY OF THREE-DIMENSIONAL BOUNDARY-LAYER FLOWS
U. DALLMANN (DFVLR Institut fuer theoretische Stroemungsmechanik, Goettingen, West Germany) and H. BIELER (Messerschmitt-Boelkow-Blohm GmbH, Bremen, West Germany) AIAA, Fluid Dynamics, Plasma Dynamics, and Lasers Conference, 19th, Honolulu, HI, June 8-10, 1987. 11 p. refs
(AIAA PAPER 87-1337)

The crossflow instability of three-dimensional stationary incompressible boundary-layer flows is studied, and a spectral analysis of the associated eigenvalue problem of linear stability theory is presented. Good agreement is found between the results of primary linear stability theory and data from a DFVLR-transition experiment (Bippes and Nitschke-Kowsky, 1987; Nitschke-Kowsky, 1986) where a three-dimensional boundary layer is investigated on a swept plate. Based on the Faulkner-Skan-Cooke velocity profiles, a semiempirical correlation for instability prediction is proposed which allows simplification in the calculation of critical Reynolds number. R.R.

A87-42398#
THEORETICAL INVESTIGATION OF SECONDARY INSTABILITY OF THREE-DIMENSIONAL BOUNDARY-LAYER FLOWS
T. M. FISCHER and U. DALLMANN (DFVLR, Institut fuer theoretische Stroemungsmechanik, Goettingen, West Germany) AIAA, Fluid Dynamics, Plasma Dynamics, and Lasers Conference, 19th, Honolulu, HI, June 8-10, 1987. 12 p. refs
(AIAA PAPER 87-1338)

In a three-dimensional boundary-layer flow, stationary so-called crossflow vortices appear, which can be described successfully by a linear stability theory. However, the transition of the laminar flow to a turbulent flow is governed by nonlinear interactions between stationary vortex structures and instationary disturbances. In order to incorporate such interactions into a transition model, the classical primary-stability theory is extended by a theory of secondary instability. Here a new basic flow, which is composed of the three-dimensional boundary-layer flow plus a primary disturbance corresponding to the stationary crossflow vortices, is investigated for instability. Results of a secondary-stability analysis for the flow over the swept DFVLR-F5 model wing show the importance of certain disturbances within the boundary layer, which are waves traveling preferably oblique to the potential flow direction. Author

A87-42401#
VORTEX INTERACTION EFFECTS ON THE LIFT/DRAG RATIO OF CLOSE-COUPLED CANARD CONFIGURATIONS
WLADIMIRO CALARESE (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) AIAA, Fluid Dynamics, Plasma Dynamics, and Lasers Conference, 19th, Honolulu, HI, June 8-10, 1987. 14 p. refs
(AIAA PAPER 87-1344)

An experimental investigation is conducted into the interaction and consequences for flight characteristics of vortices shed by the leading edges of canards and wings in close-coupled configuration. Tunnel and model size effects, Mach number, angle-of-attack, and the effect of spanwise blowing on vortex interactions have been analyzed; flow visualization was by means of oil flow and laser light sheets. While a coplanar canard produced a small favorable interaction between leading edge vortices, an offset canard yielded a considerable lift/drag ratio increase. O.C.

A87-42402#
AN INVESTIGATION OF THE PARALLEL BLADE-VORTEX INTERACTION IN A LOW-SPEED WIND TUNNEL
DONALD D. SEATH, JAI-MOO KIM, and DONALD R. WILSON (Texas, University, Arlington) AIAA, Fluid Dynamics, Plasma Dynamics, and Lasers Conference, 19th, Honolulu, HI, June 8-10, 1987. 11 p. refs
(Contract DAAG29-84-K-0131)
(AIAA PAPER 87-1345)

Low-speed wind tunnel tests were performed using an impulsively pitched wing to study the parallel blade-vortex interaction in helicopter rotor blades. A time history of the pressure distribution on a pressure-tapped wing model, acquired as the starting vortex passed over the wing, showed that the pressure change near the leading edge increased linearly as the reduced frequency of the vortex generator increased over the 0.28-0.55 range, and that a higher reduced frequency produced a stronger vortex, thus producing a larger pressure change near the leading edge of the wing. The effect of maximum vortex generator pitch angle on the downstream wing surface pressure change was found to increase as the pitch angle increased from 10-20 deg. R.R.

A87-42409#

TRANSONIC NOZZLE FLOW INSTABILITY DUE TO SHOCK WAVE/CONDENSATION FRONT INTERACTION

N. A. EVANS (Sandia National Laboratories, Albuquerque, NM) AIAA, Fluid Dynamics, Plasma Dynamics, and Lasers Conference, 19th, Honolulu, HI, June 8-10, 1987. 11 p. Research supported by the Electric Power Research Institute. refs
(AIAA PAPER 87-1355)

A physically based postulate is offered for the occurrence of a new type of transonic-nozzle-flow instability when operation is such that a condensation front interacts with a separate gasdynamic shock wave. A simplified, but reasonable, analysis is described and shows support for the postulate. Finally, results are presented from a systematic experimental investigation in steam flow which confirms the occurrence of the instability. With reduced wall boundary layers, the intensity and spatial extent of the shock-wave/condensation-front interaction (based on the rms value of unsteady wall pressure measurements) was 60 percent greater than the corresponding shock-wave/boundary-layer interaction in superheated flow. Author

A87-42410#

RESPONSE OF TRANSONIC DIFFUSER FLOWS TO ABRUPT INCREASES OF BACK PRESSURE - WALL PRESSURE MEASUREMENTS

T. J. BOGAR and M. SAJBEN (McDonnell Douglas Corp., Saint Louis, MO) AIAA, Fluid Dynamics, Plasma Dynamics, and Lasers Conference, 19th, Honolulu, HI, June 8-10, 1987. 7 p. refs
(Contract NG0530-83-C-0186)
(AIAA PAPER 87-1356)

The propagation of compression pulses in a supercritically operated transonic diffuser was investigated by use of pressure measurements along the top wall of the model. The pulses were generated at the downstream end of the diffuser by the abrupt injection of a secondary flow of air. Two types of waves were observed: (1) an upstream-traveling acoustic wave and (2) a downstream-traveling convective wave which resulted from the impingement of the acoustic wave on the shock. Wave speeds were determined for a range of diffuser pressure ratios including separated, strong-shock flows and fully attached, weak-shock flows. Streamwise distributions of initial and reflected pulse amplitudes were determined for one weak and one strong-shock case over a 3-to-1 range of initial pulse strengths. Author

A87-42418#

THE ROLE OF EXPERIMENTAL AERODYNAMICS IN FUTURE TRANSPORT AIRCRAFT DESIGN

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(AIAA PAPER 87-1371)

The development and adaptation of new wind-tunnel and flight-test measuring techniques is discussed. Piezoelectric foils were used in industrial wind-tunnel testing for transition detection while the computational Preston-tube method was used for wall shear stress measurements on a transport aircraft. Investigations with a mobile turbulence measurement system are described as well as the results of Reynold stress measurements performed in the wake of the wing of an Airbus research model. K.K.

A87-42419#

APPLICATION OF TOMOGRAPHY IN 3-D TRANSONIC FLOWS

DARIUSH MODARRESS and HUNG TAN (Spectron Development Laboratories, Inc., Costa Mesa, CA) AIAA, Fluid Dynamics, Plasma Dynamics, and Lasers Conference, 19th, Honolulu, HI, June 8-10, 1987. 8 p. refs
(Contract DAAG29-85-C-0012)
(AIAA PAPER 87-1374)

A three-dimensional transonic flow field around the tip of a revolving airfoil was investigated using a newly developed holographic tomography method. Data in the form of interferograms at forty different angles were obtained in an anechoic hover chamber at the NASA Ames Research Center and were used to reconstruct the three-dimensional density field, utilizing a modified version of the algebraic reconstruction technique. It was demonstrated that this reconstruction code has a high numerical stability and is capable of reconstructing phase objects using few projections or a very limited viewing angle. The results of the reconstructed velocity field showed the three-dimensionality of the flow field near the tip region. A slanted shock wave was present, reaching about a chord length beyond the airfoil. I.S.

A87-42422*# Analytical Services and Materials, Inc., Hampton, Va.

MULTISCALE TURBULENCE EFFECTS IN UNDEREXPANDED SUPERSONIC JETS

KHALED S. ABDOL-HAMID (Analytical Services and Materials, Inc., Hampton, VA) and RICHARD G. WILMOTH (NASA, Langley Research Center, Hampton, VA) AIAA, Fluid Dynamics, Plasma Dynamics, and Lasers Conference, 19th, Honolulu, HI, June 8-10, 1987. 14 p. refs
(AIAA PAPER 87-1377)

A modified version of the multiscale turbulence model of Hanjalic has been applied to the problem of underexpanded supersonic jets. In particular, the shock-cell decay resulting from shock-mixing layer interactions has been studied for both mildly interacting and strongly resonant jet conditions. A version of the Hanjalic model which accounts for nonequilibrium energy transfer between two spectral scales of turbulence was incorporated into an existing shock-capturing, parabolized Navier-Stokes computational model in order to perform numerical experiments. Results are presented for nominal initial jet Mach numbers of 2.0, 1.4, and 1.0 and are compared to experiments and to predictions made using single-scale models. The results show significant effects of multi-spectral turbulent energy transfer on the predicted shock-cell decay particularly for the lower jet Mach numbers. Author

A87-42423#

NUMERICAL AND EXPERIMENTAL STUDIES ON CHOKED UNDEREXPANDED JETS

TAKUYA MATSUDA, YOSHIKUNI UMEDA, RYUJI ISHII (Kyoto University, Japan), KEISUKE SAWADA (Kawasaki Heavy Industries, Ltd., Aircraft Engineering Div., Karamigahara, Japan), and ATSUHIKO YASUDA AIAA, Fluid Dynamics, Plasma Dynamics, and Lasers Conference, 19th, Honolulu, HI, June 8-10, 1987. 12 p. refs
(AIAA PAPER 87-1378)

Axisymmetric underexpanded supersonic jets are investigated numerically and experimentally. The Osher upwind scheme is applied to solve the Euler equations for a compressible ideal gas. It is shown that the numerical results are very sensitive to the choice of the boundary conditions imposed on the artificially introduced numerical boundaries. The boundary condition giving best results is found to be the ambient gas condition. It is shown that the global jet structure with a nearly regular shock pattern, which is stable and steady itself, is destabilized by the vortex rings (Kelvin-Helmholtz roll-up) on the jet boundary. These vortices produce shocks inside the jet, which are convected downstream with eddies. This strongly suggests that a time-independent or a time-converged solution cannot be expected without making a suitable time-averaging of the time-dependent solutions. Author

A87-42442*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.

STABILITY OF AXISYMMETRIC BOUNDARY LAYERS ON SHARP CONES AT HYPERSONIC MACH NUMBERS

LESLIE M. MACK (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) AIAA, Fluid Dynamics, Plasma Dynamics, and Lasers Conference, 19th, Honolulu, HI, June 8-10, 1987. 14 p. USAF-supported research. refs
(AIAA PAPER 87-1413)

The stability of sharp-cone boundary layers at zero angle of attack is investigated. Standard linear stability theory is used to perform a numerical study at an edge Mach number M(e) of 6.8 of normal-mode stability characteristics on an adiabatic-wall cone with special reference to the conditions of the stability experiment of Stetson et al. (1983). Comparisons of the calculations with experimental measurements bring out major areas of disagreement which remain to be resolved even in this simple case. Finally, a series of calculations of both cone and flat-plate N factors at M(e) of 4.5, 5.8, and 6.8 is used to study the relation between transition on a cone and flat plate based on stability theory. C.D.

A87-42448#

COMPUTATION OF FLOW AROUND AN NACA0012 AIRFOIL AT HIGH ANGLE OF ATTACK

YOSHIFUMI SHIDA and KUNIO KUWAHARA (Tokyo, University, Japan) AIAA, Fluid Dynamics, Plasma Dynamics, and Lasers Conference, 19th, Honolulu, HI, June 8-10, 1987. 7 p. refs
(AIAA PAPER 87-1425)

Transonic flow around an NACA0012 airfoil at high angle of attack is simulated by solving the two-dimensional Navier-Stokes equations. The block pentadiagonal matrix scheme is employed. Periodic phenomena of shock-wave vortex interaction are observed. For comparison, computation of subsonic flow has been done. Small vortices are observed between the leading edge and the center of the chord. Author

A87-42449#

UNSTEADY TRANSONIC FLOW WITH SHOCKS AROUND OSCILLATING AIRFOILS AND CASCADES - A VARIATIONAL THEORY

GAO-LIAN LIU (Shanghai Institute of Mechanical Engineering, People's Republic of China) AIAA, Fluid Dynamics, Plasma Dynamics, and Lasers Conference, 19th, Honolulu, HI, June 8-10, 1987. 10 p. refs
(AIAA PAPER 87-1426)

In this paper, a general family (containing some free parameters) of generalized variational principles (VPs) established together with its derived subgeneralized VP series for the entitled problem, taking full advantage of two powerful means the functional variation with variable domain and the natural boundary/interface condition. As a result, almost all boundary conditions and matching conditions across unknown oscillating shocks and free trailing vortex sheets have been converted into natural ones. The suction and injection along airfoil surface for boundary layer control or blade cooling are accounted for. This theory is aimed at providing a sound theoretical basis for introducing finite element method and other direct variational methods into unsteady aerodynamics and can be extended further to unsteady flow past three-dimensional wings and rotor bladings. Author

A87-42450#

AN EULER SOLVER FOR CALCULATING THE FLOWFIELD OF A HELICOPTER ROTOR IN HOVER AND FORWARD FLIGHT

RAMESH K. AGARWAL and JERRY E. DEESE (McDonnell Douglas Research Laboratories, Saint Louis, MO) AIAA, Fluid Dynamics, Plasma Dynamics, and Lasers Conference, 19th, Honolulu, HI, June 8-10, 1987. 10 p. refs
(AIAA PAPER 87-1427)

Aerodynamic loads on a multibladed helicopter rotor in hover and forward flight are calculated by solving the three-dimensional Euler equations in a rotating coordinate system on body-conforming curvilinear grids around the blades. The Euler equations are recast in absolute flow variables so that the absolute flow in the far field is uniform but the relative flow is nonuniform. The equations are solved for the absolute flow variables employing Jameson's finite-volume explicit Runge-Kutta time-stepping scheme. Rotor-wake effects are modeled in the form of a correction applied to the geometric angle of attack along the blades. This correction is obtained by computing the local induced downwash with a free-wake analysis program. The calculations are performed on a Cray X/MP for a model helicopter rotor, the OLS rotor, and the 500E rotor in hover and forward flight at various collective pitch angles. The results are compared with experimental data. Author

A87-42455#

TURBULENCE MEASUREMENTS IN A RADIAL UPWASH

BARRY GILBERT (Grumman Corporate Research Center, Bethpage, NY) AIAA, Fluid Dynamics, Plasma Dynamics, and Lasers Conference, 19th, Honolulu, HI, June 8-10, 1987. 12 p. refs
(Contract F49620-85-C-0111)
(AIAA PAPER 87-1435)

Detailed measurements taken in the upwash flow created by the collision of radially flowing wall jets are reported. This configuration closely approximates actual V/STOL flow behavior. Detailed surveys of the three velocity components and several of their statistical moments are presented. Profiles through the flow domain of the upwash formed by equal strength wall jets are shown. These results are expected to significantly improve the computational empirical tools available for predicting V/STOL behavior near the ground. C.D.

A87-42458#

COMPUTATIONS OF AXISYMMETRIC TURBULENT FLOWS IN WAKES BEYOND BLUFF BODIES BY USING AN ALGEBRAIC-STRESS MODEL

R. S. AMANO (Wisconsin, University, Milwaukee) and V. S. KODALI AIAA, Fluid Dynamics, Plasma Dynamics, and Lasers Conference, 19th, Honolulu, HI, June 8-10, 1987. 10 p. refs
(AIAA PAPER 87-1440)

A numerical study is reported on an external flow over a disk and an internal flow past a cone in which there are regions of reverse currents created by these bluff bodies. For the computations of turbulent flows, an algebraic-stress model is developed for the axisymmetric wakes. The computed results are compared with experimental data in the literature. The results are also compared with the computations by the k-epsilon model. It is shown that the agreement is better than by using the k-epsilon model. The behavior of turbulent kinetic energy and coefficient of turbulent viscosity is investigated at different locations in the flow field beyond the bluff bodies. Furthermore, the profiles of the ratio of the generation to turbulent energy dissipation are examined in this flow region. Author

A87-42471*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

VISCOUS TRANSONIC AIRFOIL WORKSHOP COMPENDIUM OF RESULTS

TERRY L. HOLST (NASA, Ames Research Center, Moffett Field, CA) AIAA, Fluid Dynamics, Plasma Dynamics, and Lasers Conference, 19th, Honolulu, HI, June 8-10, 1987. 33 p. refs
(AIAA PAPER 87-1460)

Results from the Viscous Transonic Airfoil Workshop held at the AIAA 25th Aerospace Sciences Meeting at Reno, NV in January 1987, are compared with each other and with experimental data. Test cases used in this workshop include attached and separated transonic flows for three different airfoils: the NACA 0012 airfoil, the RAE 2822 airfoil, and the Jones airfoil. A total of 23 sets of numerical results from 15 different author groups are included. The numerical methods used vary widely and include 16 Navier-Stokes methods, 2 Euler/boundary-layer methods, and 5 full-potential/boundary-layer methods. The results indicate a high degree of sophistication among the numerical methods with generally good agreement between the various computed and experimental results for attached or moderately-separated cases. The agreement for cases with larger separation is only fair and suggests additional work is required in this area. Author

A87-42472*# Old Dominion Univ., Norfolk, Va.
FULL POTENTIAL INTEGRAL SOLUTION FOR TRANSONIC FLOWS WITH AND WITHOUT EMBEDDED EULER DOMAINS
OSAMA A. KANDIL and HONG HU (Old Dominion University, Norfolk, VA) AIAA, Fluid Dynamics, Plasma Dynamics, and Lasers Conference, 19th, Honolulu, HI, June 8-10, 1987. 10 p. refs
(Contract NAG1-648)
(AIAA PAPER 87-1461)

Two methods are presented to solve for the transonic airfoil flow problems. The first method is based on the integral equation solution of the full-potential equation in terms of the velocity field, and a Shock Capturing-Shock Fitting (SCSF) scheme has been developed. The SCSF-scheme consists of a shock-capturing part and a shock-fitting part in which shock panels are introduced at the shock location. The sock panels are fitted and crossed by using the Rankine-Hugoniot relations. The second method is based on coupling the integral equation of the full-potential equation with the pseudo time integration of Euler equations in a small embedded region around the shock. The integral solution provides the initial and boundary conditions for the Euler domain. This scheme is named as the Integral Equation-Embedded Euler (IEEE) scheme. The two methods are applied to NACA 0012 and NACA 64A010A over a wide range of Mach numbers, and the reults are in good agreement with the experimental data and other computational results. The schemes converge within a number of iterations which is one-order of magnitude less than the finite-difference schemes. Author

A87-42473*# Old Dominion Univ., Norfolk, Va.
COMPUTATION OF STEADY AND UNSTEADY VORTEX DOMINATED FLOWS
OSAMA A. KANDIL and ANDREW H. CHUANG (Old Dominion University, Norfolk, VA) AIAA, Fluid Dynamics, Plasma Dynamics, and Lasers Conference, 19th, Honolulu, HI, June 8-10, 1987. 15 p. refs
(Contract NAG1-648)
(AIAA PAPER 87-1462)

The unsteady Euler equations have been written in the conservation form for the relative motion in a rotating frame of reference. The resulting equations are solved by using a central-difference finite-volume scheme with four-stage Runge-Kutta time stepping. For steady flow problems, local time stepping is used and for unsteady flow problems, the minimum global time stepping is used. A three-dimensional tully vectorized computer program has been developed and applied to steady and unsteady maneuvering delta wing. The capability of the three-dimensional program has been demonstrated for a rigid sharp-edged delta wing undergoing uniform rolling in a conical flow and rolling oscillations in a locally conical flow. Author

A87-42480*# Amtec Engineering, Inc., Bellevue, Wash.
A ZONAL METHOD FOR MODELING 3-D AIRCRAFT FLOW FIELDS WITH JET PLUME EFFECTS
D. W. ROBERTS (Amtec Engineering, Inc., Bellevue, WA) AIAA, Fluid Dynamics, Plasma Dynamics, and Lasers Conference, 19th, Honolulu, HI, June 8-10, 1987. 13 p. refs
(Contract NAS2-11711)
(AIAA PAPER 87-1436)

A coupled zonal method has been developed for modeling flows about aircraft with highly integrated advanced nozzle installations in which the exhaust plume interacts with the aircraft flow field to enhance performance. A cost effective flow analysis is achieved by dividing the flow domain into zones and coupling the zonal solutions. PAN AIR is used to model the flow in the inviscid zone which surrounds the aircraft. The plume zone flow field is solved with a PNS code. The flow in the optional internal nozzle zone is modeled using a full Navier-Stokes code. An automated iterative procedure couples the inviscid and plume zones by passing updated boundary conditions between the zones. The coupled analysis provides converged solutions for the overall flow field. The method is demonstrated for a highly integrated nonaxisymmetric vectored nozzle installed on a swept-wing aircraft. Author

A87-42622#
NUMERICAL CALCULATION OF FLOW ABOUT WING-FUSELAGE COMBINATION ON THE BASIS OF EULER EQUATIONS
TOMIKO ISHIGURO and SATORU OGAWA (National Aerospace Laboratory, Chofu, Japan) Japan Society for Aeronautical and Space Sciences, Transactions (ISSN 0549-3811), vol. 29, Feb. 1987, p. 230-241. refs

A procedure to calculate a transonic flow about a wing-fuselage combination on the basis of the Euler equations is presented. The equations transformed to a computational coordinate system are solved in a three-dimensional rectangular domain by the finite volume method using a Runge-Kutta type scheme of second-order accuracy and local time-step technique. The artificial viscosity used takes account of the eigenvalues of amplification matrix of the scheme. It is proved that this procedure is efficient and applicable for numerical analysis of inviscid flow. Author

A87-42650*# Vigyan Research Associates, Inc., Hampton, Va.
HIGH RESOLUTION UPWIND SCHEMES FOR THE THREE-DIMENSIONAL INCOMPRESSIBLE NAVIER-STOKES EQUATIONS
PETER-M. HARTWICH (Vigyan Research Associates, Inc., Hampton, VA) and CHUNG-HAO HSU (Kansas, University, Lawrence) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 12 p. refs
(Contract NAS1-17919; NAG1-455)
(AIAA PAPER 87-0547)

Based on flux-difference splitting, implicit high resolution schemes are constructed for efficient computations of steady-state solutions to the three-dimensional, incompressible Navier-Stokes equations in curvilinear coordinates. These schemes use first-order accurate Euler backward-time differencing and second-order central differencing for the viscous shear fluxes. Up to third-order accurate upwind differencing is achieved through a reconstruction of the solution from its cell averages. The reconstruction is accomplished by linear interpolation, where the node stencils are selected such that in regions of smooth solution the flow is highly resolved while spurious oscillations in regions of rapid changes in gradient are still suppressed. Fairly rapid convergence to steady-state solutions is attained with a completely vectorizable hybrid time-marching method. Flows around a sharp-edged delta wing are computed with the maximum accuracy of the upwind-differencing restricted to first-, second-, and third-order, to illustrate the effect of accuracy on the global and on the local vortical flow fields. The results are validated with experimental data. Author

N87-23573# Joint Publications Research Service, Arlington, Va.
EXPERIMENTAL STUDY OF SUPERSONIC STREAM SLIDING AT ANGLE PAST ONE-STEP WEDGE WITH JAWS
V. V. DUGANOV, N. N. ZAKHAROV, and O. K. IVANOV *In its* USSR Report: Engineering and Equipment p 2-3 9 Mar. 1987 Transl. into ENGLISH from Izvestiya Vysshikh Uchebnykh Zavedeniy: Aviatsionnaya Tekhnika (Kazan, USSR), no. 1, Jan. - Mar. 1986 p 107-110 Original language document was announced in IAA as A86-43404
Avail: NTIS HC A06/MF A01

Experimental results are presented concerning flow around a single-stage wedge with side cheeks (a configuration typical for two-dimensional supersonic intakes) at sideslip angles of 0, 5, and 10 deg. Experiments were carried out in a wind tunnel at a Mach number of 2.1, a Reynolds number of 10 to the 8th (for a characteristic dimension of 1 m), and a stagnation temperature of 288 K. The pressure distributions are examined, and the shock wave configuration generated in the flow is discussed. IAA

N87-23574# Joint Publications Research Service, Arlington, Va.
STRUCTURAL ANALYSIS OF SUPERSONIC JET DISCHARGING FROM FREE-VORTEX NOZZLE BY METHOD OF HOLOGRAPHIC INTERFEROMETRY WITH PULSED LASER
V. I. PANCHENKO, A. A. GILERSON, and B. S. VINOGRADOV *In its* USSR Report: Engineering and Equipment p 3 9 Mar. 1987 Transl. into ENGLISH from Izvestiya Vysshikh Uchebnykh Zavedeniy: Aviatsionnaya Tekhnika (Kazan, USSR), no. 1, Jan. - Mar. 1986 p 3 Original language document was announced in IAA as A86-43403
Avail: NTIS HC A06/MF A01

Holographic interferometry was used to study the flow of a free-vortex jet beyond the nozzle in design conditions as well as when pressures on both boundaries of the jet differed from pressures on the nozzle section. The growth of the boundary layers on the jet boundaries is studied in both design and off-design conditions for different streamline curvatures of the ideal flow. IAA

N87-23584*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
EVALUATION OF NAVIER-STOKES AND EULER SOLUTIONS FOR LEADING-EDGE SEPARATION VORTICES
K. FUJII, S. GAVALI, and T. L. HOLST Jun. 1987 14 p Prepared for presentation at the 5th International Conference on Numerical Methods in Laminar and Turbulent Flow, Montreal, Quebec, 6-10 Jul. 1987
(NASA-TM-89458; A-87202; NAS 1.15:89458) Avail: NTIS HC A02/MF A01 CSCL 01A

Extensive study on the numerical simulation of the vortical flow over a double delta wing is carried out using the thin layer Navier-Stokes and Euler equations. Two important flow characteristics, vortex interaction and vortex breakdown, are successfully simulated. Grid resolution is one of the most important factors associated with the vortex problem. Computations were performed on a series of grids with various levels of refinement, coarse, medium, and fine. Computations using either the coarse or medium grids fail to capture the proper physical phenomena. The computed result using a fine grid shows flow unsteadiness once the vortex breakdown takes place. The C sub L - alpha characteristics are well predicted up to the breakdown angle of attack for all the grid distributions. The Euler solutions show fairly good agreement with the experiment on the C sub L - alpha characteristics. However, other aspects of the solution at each angle of attack, such as the locus of the leading edge separation vortex, are not consistent with the experiment. Even for the fine grid Navier-Stokes computations, further grid resolution is required to obtain good quantitative agreement with the experiment. Author

N87-23587*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
CROSSFLOW VORTICITY SENSOR Patent Application
BRUCE J. HOLMES, inventor (to NASA), DEBRA L. CARRAWAY, inventor (to NASA), HARLAN K. HOLMES, inventor (to NASA), and THOMAS C. MOORE, inventor (to NASA) 15 Jan. 1987 14 p
(NASA-CASE-LAR-13436-1-CU; US-PATENT-APPL-SN-003676) Avail: NTIS HC A02/MF A01 CSCL 01A

A crossflow vorticity sensor for the detection of crossflow vorticity characteristics is described. The sensor is comprised of crossflow sensors which are non-invasively adhered to a swept wing laminar surface either singularly, in multi-element strips, in polar patterns, or in orthogonal patterns. These crossflow sensors are comprised of hot-film sensor elements which operate as a constant temperature anemometer circuit to detect heat transfer rate changes. Accordingly, crossflow vorticity characteristics are determined via cross-correlation. In addition, the crossflow sensors have a thickness which does not exceed a maximum value h in order to avoid contamination of downstream crossflow sensors. NASA

N87-23589*# Ohio State Univ., Columbus. Aeronautical and Astronautical Research Lab.
TWO-DIMENSIONAL AERODYNAMIC CHARACTERISTICS OF THE AMES HI-120, HI-8, AND LOW-12 AIRFOILS Final Technical Report, Jun. - Sep. 1986
G. M. GREGOREK and M. J. BERCHAK Jun. 1987 51 p
(Contract NAG2-401)
(NASA-CR-181018; NAS 1.26:181018) Avail: NTIS HC A04/MF A01 CSCL 01A

During the period between June and September 1986, the Aeronautical and Astronautical Engineering Research Laboratory (AARL) at the Ohio State University (OSU) in Columbus, Ohio, conducted tests in the 6'X22' Transonic Blowdown Wind Tunnel to determine the two-dimensional lift, drag, and pitching moment coefficients for three airfoils designated AMES HI-120, AMES LOW-12, and AMES HI-8. These tests covered a Mach number range of 0.20 to 0.86, Reynolds numbers between 2 x 10 to the 6th and 6 x 10 to the 6th powers, and angles of attack between 0 and 13 degs as directed by the NASA Project Engineer; each model was not run at every condition. This work was performed under NASA Grant NAG-2-401, Analysis of Two Advanced Transonic Airfoils. Author

N87-23591*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
ICING OF FLOW CONDITIONERS IN A CLOSED-LOOP WIND TUNNEL M.S. Thesis
JAMES E. NEWTON Jun. 1987 13 p
(NASA-TM-89824; E-3474; NAS 1.15:89824) Avail: NTIS HC A02/MF A01 CSCL 01A

Described are the results of an experiment which determined whether flow conditioning screens and honeycombs would ice up in a closed-loop icing wind tunnel when placed downstream of the heat exchanger and upstream of the spray bars. The experiment was performed in the Icing Research Tunnel (IRT) at NASA Lewis Research Center. The investigation involved two separate tests: one to find the icing characteristics of flow conditioners in the IRT, and the second to find the icing characteristics of flow conditioners in the proposed rehabilitation of the Altitude Wind Tunnel (AWT). Both experiments showed that the heat exchanger removed nearly all of the icing cloud so that icing of the flow conditioners would cause no serious tunnel performance degradation during the course of a day's run. Only extremely cold conditions caused frost formation on the flow conditioners. The significance of this frost formation was minimized because frost buildup on the heat exchanger caused a much more severe pressure drop than did icing of the flow conditioners. Author

N87-23593*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
EFFECT OF A TRADE BETWEEN BOATTAIL ANGLE AND WEDGE SIZE ON THE PERFORMANCE OF A NONAXISYMMETRIC WEDGE NOZZLE
GEORGE T. CARSON, JR., E. ANN BARE, and JAMES R. BURLEY, II Jul. 1987 67 p
(NASA-TP-2717; L-16248; NAS 1.60:2717) Avail: NTIS HC A04/MF A01 CSCL 01A

An investigation was conducted in the Langley 16-Foot Transonic Tunnel to determine the effect of a boattail angle and wedge-size trade on the performance of nonaxisymmetric wedge nozzles installed on a generic twin-engine fighter aircraft model. Test data were obtained at static conditions and at Mach numbers from 0.60 to 1.25. Angle of attack was held constant at 0 deg. High-pressure air was used to simulate jet exhaust, and the nozzle pressure ratio was varied from 1.0 (jet off) to slightly over 15.0. For the configurations studied, the results indicate that wedge size can be reduced without affecting aeropropulsive performance. Author

N87-23594*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

HIGH REYNOLDS NUMBER TESTS OF THE NASA SC(2)-0012 AIRFOIL IN THE LANGLEY 0.3-METER TRANSONIC CRYOGENIC TUNNEL

RAYMOND E. MINECK and PIERCE L. LAWING Jul. 1987 58 p

(NASA-TM-89102; L-16259; NAS 1.15:89102) Avail: NTIS HC A04/MF A01 CSCL 01A

A wind-tunnel investigation of the NASA SC(2)-0012 airfoil has been conducted in the Langley 0.3-Meter Transonic Cryogenic Tunnel. This investigation supplements the two-dimensional airfoil studies of the Advanced Technology Airfoil Test Program. The Mach number was varied from 0.60 to 0.84. The stagnation temperature and pressure were varied to provide a Reynolds number range from 6 to 40 x 10 to the 6th power based on a 6.0-in. (15.24-cm) airfoil chord. No corrections for wind-tunnel wall interference have been made to the data. The aerodynamic results are presented as integrated force and moment coefficients and pressure distributions without any analysis. Author

N87-23595*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

SOME ASPECTS OF VORTEX FLOWS DETERMINED FROM THE THIN-LAYER NAVIER-STOKES EQUATIONS

UNMEEL MEHTA Sep. 1986 7 p Presented at the 3rd Asian Congres of Fluid Mechanics, Tokyo, Japan, Sep. 1986

(NASA-TM-88375; A86409; NAS 1.15:88375) Avail: NTIS HC A02/MF A01 CSCL 01A

Vortex flows caused by a swept wing are described in some detail. The thin-shear-layer Navier-Stokes equations with an algebraic eddy-viscosity turbulence model are solved. An implicit, factored numerical scheme is used. On the upper surface of the wing, flow is primarily along the free-stream and spanwise direction, respectively, at small and large angles of attack. Author

N87-23596*# McDonnell-Douglas Helicopter Co., Mesa, Ariz.

AEROELASTICITY AND MECHANICAL STABILITY REPORT, 0.27 MACH SCALE MODEL OF THE YAH-64 ADVANCED ATTACK HELICOPTER Final Report

F. K. STRAUB and R. A. JOHNSTON May 1987 67 p Prepared in cooperation with Hughes Helicopters, Culver City, Calif.

(Contract NAS1-16475)

(NASA-CR-178284; NAS 1.26:178284; MDHC-150-V-1003) Avail: NTIS HC A04/MF A01 CSCL 01A

A 27% dynamically scaled model of the YAH-64 Advanced Attack Helicopter main rotor and hub has been designed and fabricated. The model will be tested in the NASA Langley Research Center V/STOL wind tunnel using the General Rotor Model System (GRMS). This report documents the studies performed to ensure dynamic similarity of the model with its full scale parent. It also contains a preliminary aeroelastic and aeromechanical substantiation for the rotor installation in the wind tunnel. From the limited studies performed no aeroelastic stability or load problems are projected. To alleviate a projected ground resonance problem, a modification of the roll characteristics of the GRMS is recommended. Author

N87-23597*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

STUDY OF LEE-SIDE FLOWS OVER CONICALLY CAMBEHED DELTA WINGS AT SUPERSONIC SPEEDS, PART 1

RICHARD M. WOOD and CAROLYN B. WATSON Jul. 1987 212 p

(NASA-TP-2660-PT-1; L-16192; NAS 1.60:2660-PT-1) Avail: NTIS HC A10/MF A01 CSCL 01A

An experimental investigation was performed in which surface pressure data, flow visualization data, and force and moment data were obtained on four conical delta wing models which differed in leading-edge camber only. Wing leading-edge camber was achieved through a deflection of the outboard 30% of the local wind semispan of a reference 75 degrees swept flat delta wing. The four wing models have leading-edge deflection angles delta sub F of 0, 5, 10, and 15 degrees measured streamwise. Data for the wings with delta sub F = 10 and 15 degrees showed that hinge-line separation dominated the lee-side wing loading and prohibited the develpment of leading-edge separation on the deflected portion of wing leading edge. However, data for the wing with delta sub F = 5 degrees, a vortex was positioned on the deflected leading edge with reattachment at the hinge line. Flow visualization results were presented which detail the influence of Mach number, angle of attack, and camber on the lee-side flow characteristics of conically cambered delta wings. Analysis of photgraphic data identified the existence of 12 distinctive lee-side flow types. In general, the aerodynamic force and moment data correlated well with the pressure and flow visualization data. Author

N87-23598*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

COUPLED AERODYNAMIC AND ACOUSTICAL PREDICTIONS FOR TURBOPROPS

BRUCE J. CLARK and JAMES R. SCOTT Mar. 1986 13 p Presented at the 107th Meeting of the American Acoustical Society, Norfolk, Va., 7-10 May 1984

(NASA-TM-87094; E-2688; NAS 1.15:87094) Avail: NTIS HC A02/MF A01 CSCL 01A

To predict the noise fields for proposed turboprop airplanes, an existing turboprop noise code by Farassat has been modified to accept blade pressure inputs from a three-dimensional aerodynamic code. A Euler-type code can handle the nonlinear transonic flow of these high-speed, highly swept blades. This turbofan code was modified to allow the calculation mesh to extend to about twice the blade radius and to apply circumferential periodicity rather than solid-wall boundary conditions on the blade in the region between the blade tip and the outer shroud. Outputs were added for input to the noise prediction program and for color contour plots of various flow variables. The Farassat input subroutines were modified to read files of blade coordinates and predicted surface pressures. Aerodynamic and acoustic results are shown for the SR-3 model blade. Comparison of the acoustic predicted results with measured data show good agreement. Author

N87-24398# Advisory Group for Acrospace Research and Development, Neuilly-Sur-Seine (France). Propulsion and Energetics panel and Structures and Materials Panel.

AEROELASTICITY IN AXIAL-FLOW TURBOMACHINES. VOLUME 1: UNSTEADY TURBOMACHINERY AERODYNAMICS

MAX F. PLATZER, ed. and FRANKLIN O. CARTA, ed. (United Technologies Research Center, East Hartford, Conn.) Mar. 1987 276 p

(AGARD-AG-298-VOL-1; ISBN-92-835-1543-9) Avail: NTIS HC A13/MF A01

The field of unsteady turbomachinery aerodynamics is reviewed. Linearized unsteady aerodynamic theory, classical two-dimensional methods, three-dimensional flows, unsteady transonic flow, stall flutter, forced vibration, fan blade flutter, and unsteady aerodynamic measurements on rotors are among the topics discussed.

N87-24399 United Technologies Research Center, East Hartford, Conn.

LINEARIZED UNSTEADY AERODYNAMIC THEORY

JOSEPH M. VERDON *In* AGARD Aeroelasticity in Axial-Flow Turbomachines. Volume 1: Unsteady Turbomachinery Aerodynamics 31 p Mar. 1987 Sponsored by Naval Air Systems Command and Air Force Office of Scientific Research

Avail: NTIS HC A13/MF A01

The importance, complexity and variety of the unsteady flow phenomena occurring in axial flow turbomachines; the major assumptions used in theoretical aerodynamic formulations intended for aeroelastic investigations; and the requirements placed on such formulations were reviewed. Emphases was placed on the description of linearized two-dimensional unsteady aerodynamic theories and on the derivation of a rather general linearization that accounts for the effects of blade geometry, mean blade loading and shocks and their motions on aerodynamic response to prescribed structural and areodynamic excitations. R.J.F.

N87-24403 TopExpress Ltd., Cambridge (England).
NUMERICAL METHODS FOR UNSTEADY TRANSONIC FLOW
E. ACTON and S. G. NEWTON (Rolls-jRoyce Ltd., Derby, England) *In* AGARD Aeroelasticity in Axial-Flow Turbomachines. Volume 1: Unsteady Turbomachinery Aerodynamics 21 p Mar. 1987
Avail: NTIS HC A13/MF A01

Some of the numerical methods used in aeroelastic problems to calculate unsteady transonic flow are reviewed. Blade flutter and force response are studied. Author

N87-24405 Purdue Univ., West Lafayette, Ind. Thermal Sciences and Propulsion Center.
UNSTEADY AERODYNAMIC MEASUREMENTS IN FLUTTER RESEARCH
SANFORD FLEETER and ROBERT L. JAY (General Motors Corp., Indianapolis, Ind.) *In* AGARD Aeroelasticity in Axial-Flow Turbomachines. Volume 1: Unsteady Turbomachinery Aerodynamics 18 p Mar. 1987
Avail: NTIS HC A13/MF A01

Various aspects of unsteady aerodynamic flutter experiments were considered. Overall objectives included the validation of analysis, the development of a flutter boundary data bank, and concept investigations. Experimental modeling requirements and the applicability of high speed rotating rigs, stationary annular cascades, and two-dimensional linear cascade facilities were discussed in terms of the overall objectives. Author

N87-24407 Office National d'Etudes et de Recherches Aerospatiales, Paris (France).
UNDERSTANDING FAN BLADE FLUTTER THROUGH LINEAR CASCADE AEROELASTIC TESTING
EDMOND SZECHENYI *In* AGARD Aeroelasticity in Axial-Flow Turbomachines. Volume 1: Unsteady Turbomachinery Aerodynamics 16 p Mar. 1987
Avail: NTIS HC A13/MF A01

An attempt is made to give some insight into the causes and origins of different flutter regimes. The discussion is based on experimental data obtained in a linear cascade. For subtransonic flutter the validity of the cascade measurements is tested by comparison with actual compressor data. Author

N87-24409*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
PERFORMANCE AND LOADS DATA FROM A HOVER TEST OF A FULL-SCALE ADVANCED TECHNOLOGY XV-15 ROTOR
FORT F. FELKER, LARRY A. YOUNG, and DAVID B. SIGNOR Jan. 1986 359 p
(NASA-TM-86854; A-86023; NAS 1.15:86854) Avail: NTIS HC A16/MF A01 CSCL 01A

A hover test of a full-scale, composite, advanced technology XV-15 rotor was conducted at the Outdoor Aerodynamic Research Facility at Ames Research Center. The primary objective of the test was to obtain accurate measurements of the hover performance of this rotor system. Data were acquired for rotor tip Mach numbers ranging from 0.35 to 0.73. The rotor was tested with several alternate blade root and blade-tip configurations. Data are presented on rotor performance, rotor-wake downwash velocities, and rotor system loads. Author

N87-24412*# McDonnell-Douglas Research Labs., St. Louis, Mo.
LASER DOPPLER VELOCIMETER MEASUREMENTS IN A 3-D IMPINGING TWIN-JET FOUNTAIN FLOW
K. R. SARIPALLI *In* NASA. Ames Research Center Proceedings of the 1985 NASA Ames Research Center's Ground-Effects Workship p 147-159 Feb. 1987 Previously announced in IAA as A86-10965
Avail: NTIS HC A19/MF A01 CSCL 01A

Mean velocity and turbulence measurements were conducted on the three dimensional fountain flow field generated by the impingement of two axisymmetric jets on a ground plane with application to vertical takeoff and landing (VTOL) aircraft. The basic instantaneous velocity data were obtained using a two component laser Doppler velocimeter in a plane connecting the nozzle centerlines at different heights above the ground emphasizing the jet impingement region and the fountain upwash region formed by the collision of the wall jets. The distribution of mean velocity components and turbulence quantities, including the turbulence intensity and the Reynolds shear stress, were derived from the basic velocity data. Detailed studies of the characteristics of the fountain revealed self-similarity in the mean velocity and turbulence profiles across the fountain. The spread and mean velocity decay characteristics of the fountain were established. Turbulence intensities of the order of 50% were observed in the fountain. Author

N87-24413*# Flow Research, Inc., Kent, Wash.
NUMERICAL INVESTIGATION OF V/STOL JET INDUCED INTERACTIONS
MAGDI H. RIZK and SURESH MENON *In* NASA. Ames Research Center Proceedings of the 1985 NASA Ames Research Center's Ground-Effects Workship p 161-193 Feb. 1987
(Contract F49620-84-C-0027)
Avail: NTIS HC A19/MF A01 CSCL 01A

Direct numerical simulation using the full three dimensional, time dependent Navier-Stokes equations is used to investigate V/STOL jet induced interactions. The objective of this numerical simulation is to compute accurately the details of the flow field and to achieve a better understanding of the physics of the flow, including the role of initial turbulence in the jet, the influence of forward motion on hover aerodynamics, the collision zone and fountain characteristics. Preliminary results are presented. Author

N87-24414*# Nielsen Engineering and Research, Inc., Mountain View, Calif.
UNSTEADY THREE-DIMENSIONAL SIMULATION OF VTOL UPWASH FOUNTAIN TURBULENCE
ROBERT E. CHILDS and DAVID NIXON *In* NASA. Ames Research Center Proceedings of the 1985 NASA Ames Research center's Ground-Effects Workship p 195-206 Feb. 1987 Previously announced in IAA as A86-19753
Avail: NTIS HC A19/MF A01 CSCL 01A

Numerical simulations of a planar turbulent wall jet and a planar VTOL upwash fountain were performed. These are three dimensional simulations which resolve large scale unsteady motions in the flows. The wall jet simulation shows good agreement with experimental data and is presented to verify the simulation methodology. Simulation of the upwash fountain predicts elevated shear stress and a half velocity width spreading rate of 33% which agrees well with experiment. Turbulence mechanisms which contribute to the enhanced spreading rate are examined. Author

N87-24415*# Applied Research Lab., State College, Pa.
SUMMARY OF STOL GROUND VORTEX INVESTIGATION
MICHAEL L. BILLET and MARVIN M. WALTERS (Naval Air Development Center, Warminster, Pa.) *In* NASA. Ames Research Center Proceedings of the 1985 NASA Ames Research Center's Ground-Effects Workship p 207-238 Feb. 1987
Avail: NTIS HC A19/MF A01 CSCL 01A

An experimental facility was developed in the 1.23 (48 inch) wind tunnel of the Applied Research Lab. at the Pennsylvania

State Univ. to model the ground vortex. The purpose of the facility was to study the effect of various parameters on the location and characteristics of a ground vortex. An experimental investigation was conducted in the tunnel into the formation, stability and strength of the ground vortex for several flow parameters. The design of the facility, special instrumentation and results are summarized. E.R.

N87-24416*# Northrop Corp., Hawthorne, Calif. Aircraft Div.
EFFECTS OF THRUST REVERSING IN GROUND PROXIMITY
P. B. JOSHI and R. V. HUGHES *In* NASA. Ames Research Center Proceedings of the 1985 NASA Ames Research Center's Ground-Effects Workshop p 239-288 Feb. 1987
Avail: NTIS HC A19/MF A01 CSCL 01A

The changes in stability and control characteristics encountered by a thrust reversing aircraft during its final approach, landing, and ground roll are described. These changes include a strong pitch-up accompanied by the loss of horizontal tail and aileron control effectiveness. The magnitude of reverser induced changes in ground effect are much larger than corresponding changes in free air. Some unexpected unsteady motions exhibited in wind tunnel by an aircraft model with reversers operating in ground proximity are also described. The cause of this oscillatory behavior was determined to be an unsteady interaction between the wall jets formed by impingement of reverser jets on the ground and the on-coming free stream. Time histories of rolling moments measured by the wind tunnel balance or support system were removed and frequencies were scaled by Strouhal number to full scale. Corrected time series were used to simulate the motion of a fighter aircraft with thrust reversers in ground effect. The simulation predicted large roll angles and nose down attitude at touchdown. Some phenomena of jet attachment to solid surfaces are discussed and areas for future research are recommended. Author

N87-24417*# McDonnell Aircraft Co., St. Louis, Mo.
STOL LANDING THRUST: REVERSER JET FLOWFIELDS
D. R. KOTANSKY and L. W. GLAZE *In* NASA. Ames Research Center Prodeedings of the 1985 NASA Ames Research Center's Ground-Effects Workshop p 289-308 Feb. 1987
Avail: NTIS HC A19/MF A01 CSCL 01A

Analysis tools and modeling concepts for jet flow fields encountered upon use of thrust reversers for high performance military aircraft are described. A semi-empirical model of the reverser ground wall jet interaction with the uniform cross flow due to aircraft forward velocity is described. This ground interaction model is used to demonstrate exhaust gas ingestion conditions. The effects of control of exhaust jet vector angle, lateral splay, and moving versus fixed ground simulation are discussed. The Adler/Baron jet-in-cross flow model is used in conjunction with three dimensional panel methods to investigate the upper surface jet induced flow field. Author

N87-24420*# Kansas Univ., Lawrence.
INVESTIGATION OF DYNAMIC GROUND EFFECT
RAY CHUNG CHANG and VINCENT U. MUIRHEAD *In* NASA. Ames Research Center Proceedings of the 1985 NASA Ames Research Center's Ground-Effects Workshop p 363-393 Feb. 1987
Avail: NTIS HC A19/MF A01 CSCL 01A

An experimental investigation of dvnamic ground effect was conducted in the Univ. of Kansas wind tunnel using delta wings of 60, 70, 75 deg sweep; the XB-70 wing; and the F-104A wing. Both static and dynamic tests were made. Test data were compared to other test data, including dynamic flight test data of the XB-70 and F-104A. Limited flow visualization test were conducted. A significant dynamic effect was found for highly swept delta wings. Author

N87-24422*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
EFFECTS OF GROUND PROXIMITY ON A LOW ASPECT RATIO PROPULSIVE WING/CANARD CONFIGURATION
V. R. STEWART (Rockwell International Corp., Columbus, Ohio.) and G. T. KEMMERLY *In* NASA. Ames Research Center Proceedings of the 1985 NASA Ames Research Center's Ground-Effects Workshop p 415-444 Feb. 1987
Avail: NTIS HC A19/MF A01 CSCL 01A

The effect of near proximity to the ground are investigated on a low aspect ratio propulsive wing/canard concept at STOL conditions. Data were obtained on a wing/body and wing/body/canard configuration at various heights above the ground, ranging from free air to approximately 1/4 of the mean aerodynamic chord (MAC) above the ground. The data presented and discussed include force and moment coefficients, surface pressure distributions, and downwash angles measured one MAC behind the wing. The test technique, model requirements, and special considerations required for testing these configurations are also discussed. Special model requirements included evenly distributed exit nozzle pressures along four separate nozzles of lengths of one and two feet with only one air supply to the model. Test techniques must recognize and deal with the ground boundary layer as well as the air supply pressure measurement and management. Author

N87-24423*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
HELICOPTER BLADE DYNAMIC LOADS MEASURED DURING PERFORMANCE TESTING OF TWO SCALED ROTORS
JOHN D. BERRY Jul. 1987 49 p
(Contract DA PROJ. 1L1-62209-AH-76)
(NASA-TM-89053; L-16245; NAS 1.15:89053;
AVSCOM-TM-87-B-7) Avail: NTIS HC A03/MF A01 CSCL 01A

A test to determine the performance differences between the 27-percent-scale models of two rotors for the U.S. Army AH-64 helicopter was conducted in the Langley 14- by 22-Foot Subsonic Tunnel. One rotor, referred to as the baseline rotor, simulated the geometry and dynamic characteristics of the production baseline rotor, and the other rotor, referred to as the advanced rotor, was designed to have improved hover performance. During the performance test, the dynamic pitch-link forces and blade bending and torsion moments were also measured. Dynamic data from the forward flight investigation are reduced and presented. The advanced blade set was designed to have dynamic characteristics similar to those of the baseline rotor so that test conditions would not be limited by potential rotor instability and blade resonances, and so that the measured performance increments could be considered to be due purely to aerodynamic causes. Data show consistent trends with advance ratio for both blade sets with generally higher oscillatory loads occurring for the advanced blade set when compared with the baseline blade set. Author

N87-24424 Colorado Univ., Boulder.
NUMERICAL OPTIMIZATION DESIGN OF TRANSONIC AIRFOILS Ph.D. Thesis
MUH-SHENG CHEN 1986 209 p
Avail: Univ. Microfilms Order No. DA8706407

A computationally efficient and versatile procedure for the optimum design of transonic airfoils at given operating Mach number and lift coefficient was developed. The design tool is formed by coupling a reliable and efficient airfoil code, GRUMFOIL, with an unconstrained numerical optimization program. Only the two-dimensional transonic airfoil designs utilizing the computed drag minimization as design objectives are demonstrated, but this technique can also be applied to minimize or maximize any desired design objective which can be precisely calculated from the chosen objective code. A trade-off study was first made to examine a variety of airfoil shape perturbation methods, and an optimal shape perturbation technique was chosen after comparing the results. Four airfoil shapes, included RAE 2822, NACA 65(sub 1)012, NACA 0012, and a modified NACA 0012, were selected as the baseline airfoils to be optimized. Dissert. Abstr.

N87-24426 Princeton Univ., N. J.
COMPUTATION OF UNSTEADY TRANSONIC FLOWS OVER MOVING AIRFOILS Ph.D. Thesis
V. VENKATAKRISHNAN 1987 159 p
Avail: Univ. Microfilms Order No. DA8704598

Three numerical methods for the solution of the Euler equations for flows past a moving airfoil are developed and compared. The finite volume scheme is used to spatially discretize the integral form of the Euler equations for a moving domain. The first method uses dissipative terms constructed according to the theory of Total Variation Diminishing (or TVD) schemes. The second method utilizes dissipative terms constructed from second and fourth differences in the dependent variables. The third method uses an LU implicit scheme with dissipative terms constructed according to the TVD theory. Nonreflecting boundary conditions are derived in the farfield allowing for the use of a moving mesh. It is shown that the TVD schemes yield excellent results at the expense of more CPU time in comparison with the non-TVD scheme. The solutions are non-oscillatory, and the shocks are captured very well. The comparisons with experimental data for the unsteady airfoil calculations are uniformly good. It is anticipated that the finite volume scheme, with or without the TVD option, should make three dimensional unsteady flow simulations feasible.
Dissert. Abstr.

N87-24428# Office National d'Etudes et de Recherches Aerospatiales, Paris (France). Direction Scientifique de la Resistance des Structures.
COUPLING ITERATION METHOD LINKING AERODYNAMIC FIELDS WITH PERIODIC DYNAMIC FIELDS [METHODE DE COUPLAGE ITERATIF ENTRE LES CHAMPS AERODYNAMIQUE ET DYNAMIQUE PERIODIQUES]
C. T. TRAN Aug. 1986 25 p In FRENCH
(Contract STPA-85-91-015)
(ONERA-RT-19/3239-RY-054-R; ETN-87-99622) Avail: NTIS HC A02/MF A01

The aeromechanical coupling found in the motion of helicopter rotor blades is studied. The general aeroelasticity equations are solved by iteration. The introduction of a simplified aerodynamic model and of optimization procedures allow minimization of the perturbation terms to accelerate the convergence. Test cases are solved and the results are comparable to those obtained by other methods.
ESA

N87-24429# Aeronautical Research Inst. of Sweden, Stockholm. Aerodynamics Dept.
RUNGE-KUTTA FINITE-VOLUME SIMULATION OF LAMINAR TRANSONIC FLOW OVER A NACA 0012 AIRFOIL USING THE NAVIER-STOKES EQUATIONS
BERNHARD MUELLER and ARTHUR RIZZI 14 Nov. 1986 71 p Sponsored by the Swedish Board for Technical Development
(FFA-TN-1986-60; ETN-87-99782) Avail: NTIS HC A04/MF A01

For the solution of the compressible Navier-Stokes equations, a finite-volume space discretization of the viscous fluxes is presented. The gradients of the stress tensor are approximated in the cells by means of surface integrals along the cell boundaries. Similar to the inviscid fluxes, the viscous fluxes over the cell interfaces are evaluated by the arithmetic averages of their values in adjacent cells. A linear stability condition is derived for the local time steps of the three stage explicit Runge-Kutta method used for time discretization. Employing a 257x65 O-mesh generated by transfinite interpolation, the method is verified for laminar transonic flow at Reynolds numbers of 0(100) over a NACA0012 airfoil and compared with 193x65 C-mesh results of an implicit finite-difference scheme. The C-mesh is recommended for viscous flow near the trailing edge.
ESA

N87-24430# Air Force Wright Aeronautical Labs., Wright-Patterson AFB, Ohio.
VORTEX INTERACTION ON A CANARD-WING CONFIGURATION Final Report, Oct. 1982 - Mar. 1985
WLADIMIRO CALARESE Oct. 1986 265 p
(AD-A179718; AFWAL-TR-86-3100) Avail: NTIS HC A12/MF A01 CSCL 01A

This experiment studies the interaction of vortices shed by the canard and wing's leading edges, and their effect on the aircraft aerodynamic characteristics. A close-coupled canard-wing configuration was selected and tested in different wind tunnels and at different conditions. Tunnel and model size effects, Mach number, angle of attack, and spanwise blowing effects on the vortex interaction were analyzed. Intrusive (hot wires) and non-intrusive (laser doppler velocimeters) data acquisition techniques were used and compared to enhance the reliability of the results. Flow visualization by tufts, oil, and laser light sheets were employed. Mean velocities, vortex turbulence intensities, and Reynolds stresses obtained for different conditions were compared and found to be generally consistent. Mach number, wind tunnel, and model size effects were in general small. Turbulence intensities and stresses increased with angles of attack. Spanwise blowing produced a small favorable effect. The use of a coplanar canard produced a small favorable interaction between the leading edge vortices, while the off-set canard produced a considerable increase in the lift/drag ratio.
GRA

N87-24431# Tennessee Univ. Space Inst., Tullahoma.
INVESTIGATION OF NON-SYMMETRIC JETS IN CROSS FLOW (DISCRETE WING TIP JET EFFECTS) Final Report
J. M. WU, A. D. VAKILI, and F. M. YU Dec. 1986 98 p
(Contract AF-AFOSR-0114-84)
(AD-A179783; UTSI-86-13; AFOSR-87-0543TR) Avail: NTIS HC A05/MF A01 CSCL 20D

Asymmetric jets in cross flow provide complex interacting flow fields which contain many vortices. Four different cross section geometries were studied and compared with a circular cross section jet with the same exit area. Various flow visualization techniques were used and four major vortices were identified.
GRA

N87-24432*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
STATIC INTERNAL PERFORMANCE OF A TWO-DIMENSIONAL CONVERGENT-DIVERGENT NOZZLE WITH THRUST VECTORING
E. ANN BARE and DAVID E. REUBUSH Jul. 1987 115 p
(NASA-TP-2721; L-16240; NAS 1.60:2721) Avail: NTIS HC A06/MF A01 CSCL 01A

A parametric investigation of the static internal performance of multifunction two-dimensional convergent-divergent nozzles has been made in the static test facility of the Langley 16-Foot Transonic Tunnel. All nozzles had a constant throat area and aspect ratio. The effects of upper and lower flap angles, divergent flap length, throat approach angle, sidewall containment, and throat geometry were determined. All nozzles were tested at a thrust vector angle that varied from 5.60 tp 23.00 deg. The nozzle pressure ratio was varied up to 10 for all configurations.
Author

N87-24433*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
MULTIAXIS CONTROL POWER FROM THRUST VECTORING FOR A SUPERSONIC FIGHTER AIRCRAFT MODEL AT MACH 0.20 TO 2.47
FRANCIS J. CAPONE and E. ANN BARE Jul. 1987 264 p
(NASA-TP-2712; L-16213; NAS 1.60:2712) Avail: NTIS HC A12/MF A01 CSCL 01A

The aeropropulsive characteristics of an advanced twin-engine fighter aircraft designed for supersonic cruise have been studied in the Langley 16-Foot Tansonic Tunnel and the Lewis 10- by 10-Foot Supersonic Tunnel. The objective was to determine multiaxis control-power characteristics from thrust vectoring. A two-dimensional convergent-divergent nozzle was designed to provide yaw vector angles of 0, -10, and -20 deg combined with geometric pitch vector angles of 0 and 15 deg. Yaw thrust vectoring was provided by yaw flaps located in the nozzle sidewalls. Roll control was obtained from differential pitch vectoring. This investigation was conducted at Mach numbers from 0.20 to 2.47. Angle of attack was varied from 0 to about 19 deg, and nozzle pressure ratio was varied from about 1 (jet off) to 28, depending on Mach number. Increments in force or moment coefficient that result from pitch or yaw thrust vectoring remain essentially constant over the entire angle-of-attack range of all Mach numbers tested. There was no effect of pitch vectoring on the lateral aerodynamic forces and moments and only very small effects of yaw vectoring on the longitudinal aerodynamic forces and moments. This result indicates little cross-coupling of control forces and moments for combined pitch-yaw vectoring. Author

N87-24435*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
NUMERICAL SIMULATIONS OF UNSTEADY, VISCOUS, TRANSONIC FLOW OVER ISOLATED AND CASCADED AIRFOILS USING A DEFORMING GRID
DENNIS L. HUFF Jun. 1987 16 p Presented at the 19th Fluid Dynamics, Plasma Dynamics and Lasers Conference, Honolulu, Hawaii, 8-10 Jun. 1987; sponsored by AIAA
(NASA-TM-89890; E-3532; NAS 1.15:89890; AIAA-87-1316)
Avail: NTIS HC A02/MF A01 CSCL 01A

A compressible, unsteady, full Navier-Stokes, finite difference code was developed for modeling transonic flow through two-dimensional, oscillating cascades. The procedure introduces a deforming grid technique to capture the motion of the airfoils. Results using a deforming grid are presented for both isolated and cascaded airfoils. The load histories and unsteady pressure distributions are predicted for the NASA 64A010 isolated airfoil and compared with existing experimental data. Results show that the deforming grid technique can be used to successfully predict the unsteady flow properties around an oscillating airfoil. The deforming grid technique was extended for modeling unsteady flow in a cascade. The use of a deforming grid simplifies the specification of boundary conditions. Unsteady flow solutions similar to the isolated airfoil predictions are found for a NACA 0012 cascade with zero interblade phase angle and zero stagger. Experimental data for these cases are not available for code validation, but computational results are presented to show sample predictions from the code. Applications of the code to typical turbomachinery flow conditions will be presented in future work. Author

N87-24478# Rockwell International Corp., Los Angeles, Calif. Aircraft Operations.
UNSTEADY INLET DISTORTION CHARACTERISTICS WITH THE B-1B
C. J. MACMILLER and W. R. HAAGENSON *In* AGARD Engine Response to Distorted Inflow Conditions 17 p Mar. 1987
Avail: NTIS HC A14/MF A01

An extensive wind tunnel and flight test program was conducted to verify inlet performance and distortion characteristics on the B-1B aircraft. During the course of these investigations, several unsteady, total-pressure disturbances at various discrete frequencies were encountered: (1) inlet duct resonance at low power settings; (2) environmental control system (ECS) precooler duct resonance; and (3) nose gear wake ingestion. This resulted in the need to quantify these effects and assess the impact on engine stability characteristics. As a result, engine control features were modified, and aircraft configuration changes were implemented. Results and findings of these investigations are summarized. Author

03

AIR TRANSPORTATION AND SAFETY

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

A87-40095#
FORMATION AND ACCRETION OF SUPERCOOLED WATER DROPLETS AND THEIR EFFECT ON AIRCRAFT
RICHARD TOLIVER (SRI International, Menlo Park, CA) Journal of Environmental Sciences (ISSN 0022-0906), vol. 30, Mar.-Apr. 1987, p. 27-30. refs

MIL-STD-81D currently has no procedure to test equipment that will be exposed to supercooled fog and the resultant ice accretion. Supercooled fog icing is one of the most difficult conditions to simulate. The paper discusses several technical aspects of the icing process, including such topics as the supercooling process, nucleation and freezing of water droplets, ice type definition, types of problems to be expected during flight through icing conditions, and what icing parameters are important for an icing simulation. The paper can be used as an introduction to the icing phenomenon and will equip the reader with enough basic information to begin a discussion on icing test requirements. Author

A87-42135#
ANALYTICAL DESIGN OF A COMPLEX OF MULTIMODE DYNAMIC SYSTEMS [ANALITICHESKOE PROEKTIROVANIE KOMPLEKSA MNOGOREZHIMNYKH DINAMICHESKIKH SISTEM]
V. N. KURSHEV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 1, 1987, p. 49-53. In Russian.

A method is proposed for the numerical solution of the problem of the parametric synthesis of a complex of multiple-purpose multimode aircraft with allowance for certain random factors. The design problem is formulated as a fundamental control problem, which is then solved using the method of successive approximations based on a linearized mathematical model of the system. V.L.

A87-42682#
FIRE SAFETY ASPECTS FOR CONSTRUCTION OF CIVIL AIRCRAFT
EDITH MIKUS (Messerschmitt-Boelkow-Blohm GmbH, Bremen, West Germany) IN: New Technology to Reduce Fire Losses and Costs. London and New York, Elsevier Applied Science Publishers, 1986, p. 343-356.

Fire scenarios and risks are discussed with attention given to inflight and postcrash fires. Requirements and bench test methods such as the bunsen burner test, the Ohio State University heat release apparatus, and the kerosene burner are presented. The improvement of materials and composites via the introduction of the ATS 1000.001 (Airbus Technical Specification) is demonstrated and an approach is proposed for the fire containment of cargo holds. Composite materials are found to be superior to aluminum in terms of burn-through resistance. K.K.

N87-23599# Calspan Field Services, Inc., Arnold AFS, Tenn.
BIRD IMPACT QUALIFICATION TEST FOR A-10 WINDSHIELD Final Report, 9 Dec. 1986
T. L. BUCHANAN Apr. 1987 22 p Prepared in cooperation with AEDC, Arnold AFS, Tenn.
(AD-A179263; AEDC-TSR-86-V57) Avail: NTIS HC A02/MF A01 CSCL 01C

One shot was made on the A-10's left side windshield for this program. The objective of this shot was to qualify the windshield. The shot was at a nominal velocity of 360 knots using a 4-lb bird. Descriptions of the test facility, test articles, and test procedures are presented. GRA

N87-23602# Luftfahrt-Bundesamt, Brunswick (West Germany). Flugunfalluntersuchungsstelle.
RESULTS OF THE SPECIALIZED INVESTIGATION OF ACCIDENTS INVOLVING GERMAN AIRCRAFT AT HOME AND ABROAD, AND WITH FOREIGN AIRCRAFT AT HOME Annual Report, 1983 [ERGEBNISSE DER FACHLICHEN UNTERSUCHUNG VON UNFAELLEN BEI DEM BETRIEB DEUTSCHER LUFTFAHRZEUGE IM IN- UND AUSLAND SOWIE AUSLAENDISCHE LUFTFAHRZEUGE IM INLAND]
Jun. 1986 121 p In GERMAN
(ISSN-0178-8094; ETN-87-99668) Avail: NTIS HC A06/MF A01

Tables showing accidents of aircraft above 5.7 t, between 2 and 5.7 t, below 2 t, helicopters, sailplanes, powered gliders, parachutes, hang gliders and ultralight aircraft, balloons, and other aircraft, are given. For each type of aircraft, a short report is presented. ESA

N87-23603# National Transportation Safety Board, Washington, D. C. Bureau of Safety Programs.
AIRCRAFT ACCIDENT DATA: US AIR CARRIER OPERATIONS CALENDAR YEAR 1984 Annual Review
15 Apr. 1987 107 p
(PB87-183992; NTSB/ARC-87/02) Avail: NTIS HC A06/MF A01 CSCL 01C

This publication presents the record of aviation accidents involving revenue operations of U.S. Carriers including Commuter Air Carriers and on demand Air Taxis for calendar year 1984. The report is divided into three major sections according to the federal regulations under which the flight was conducted - 14 CFR 121, 125, 127, Scheduled 14 CFR 135, or Nonscheduled 14 CFR 135. In each section of the report tables are presented to describe the losses and characteristics of 1984 accidents to permit comparison with prior years. Author

N87-23604# National Transportation Safety Board, Washington, D. C. Bureau of Accident Investigation.
AIRCRAFT ACCIDENT REPORT: SOUTHERN AIR TRANSPORT LOGAIR FLIGHT 51, LOCKHEED L-382G, KELLY AIR FORCE BASE, TEXAS, OCTOBER 4, 1986
9 Apr. 1987 72 p
(PB87-910404; NTSB-AAR-87-04) Avail: NTIS HC A04/MF A01 CSCL 01C

Southern Air Transport's LOGAIR 15 flight, a Lockheed L-382G, was cleared for takeoff from Kelly Air Force Base, Texas, on an instrument flight plan to Warner Robbins Air Force Base, Georgia, at about 0405 on October 4, 1986. Visual meteorological conditions prevailed. There were three flightcrew members aboard the military contracted domestic cargo flight operating under 14 CFR Part 121. All communications with the air traffic control tower were routine. Radar recorded that the airplane reached an altitude of about 700 feet above ground level. Witnesses reported an abnormally steep climb attitude followed by a turn and/or bank to the left, after which the airplane continued to roll to the left and struck the ramp area at about a 90 deg angle to the departure runway in a near-inverted attitude between two hangars and exploded. A severe ground fire ensued. All three flight crew members were killed. The National Transportation Safety Board determines that the probable cause of this accident was the use by the carrier of a nonapproved device designed to raise the elevator during loading operations which was not properly stowed by the flightcrew and which lodged in the controls, preventing the flightcrew from controlling the aircraft during takeoff. Author

N87-23605# National Transportation Safety Board, Washington, D. C. Bureau of Safety Programs.
AIRCRAFT ACCIDENT DATA: US AIR CARRIER OPERATIONS CALENDAR YEAR 1983 Annual Review
13 Feb. 1987 111 p
(PB87-160028; NTSB/ARC-87/01) Avail: NTIS HC A06/MF A01 CSCL 01C

This publication presents the record of aviation accidents involving revenue operations of U.S. Air Carriers including Commuter Air Carriers and On demand Air Taxis for calendar year 1983. The report is divided into three major sections according to the federal regulations under which the flight was conducted - 14 CFR 121, 125, 127, Scheduled 14 CFR 135, or Nonscheduled 14 CFR 135. In each section of the report tables are presented to describe the losses and characteristics of 1983 accidents to permit comparison with prior years. Author

N87-23606# National Transportation Safety Board, Washington, D. C.
ANNUAL REVIEW OF AIRCRAFT ACCIDENT DATA, US GENERAL AVIATION: CALENDAR YEAR 1984
11 May 1987 235 p
(PB87-194791; NTSB/ARG-87/02) Avail: NTIS HC A11/MF A01

This report presents a statistical compilation and review of general aviation accidents which occurred in 1984 in the United States, its territories and possessions, and in international waters. The accidents reported are all those involving U.S. registered aircraft not conducting air carrier revenue operations under 14 CFR 121, 14 CFR 125, 14 CFR 127, or 14 CFR 135. This report is divided into sections, each of which (except for the All Operations section) presents a review of a subset of all general aviation accidents. Each subset represents aircraft of similar types or aircraft being operated for particular purposes. Several tables present accident parameters for 1984 only, and each section includes tabulations which present comparative statistics for 1984 and the five-year period 1979-1983. Author

N87-24437# Sandia National Labs., Albuquerque, N. Mex.
A NEW RECOVERY PARACHUTE SYSTEM FOR THE F111 AIRCRAFT CREW ESCAPE MODULE Status Report
D. W. JOHNSON 1986 8 p
(Contract DE-AC04-76DP-00789)
(DE87-000973; SAND-86-0685) Avail: NTIS HC A02/MF A01

A new recovery parachute system for the F-111 aircraft crew escape module has been designed. Six proof-of-design tests were conducted to determine if it is feasible to meet the requirements for a replacement recovery parachute system. The design of the proposed system is presented and the results of the tests discussed. DOE

N87-24438# National Transportation Safety Board, Washington, D. C. Bureau of Accident Investigation.
AIRCRAFT ACCIDENT REPORT: MIDWEST EXPRESS AIRLINES, INC., DC-9-14, N100ME, GENERAL BILLY MITCHELL FIELD, MILWAUKEE, WISCONSIN, SEPTEMBER 6, 1985
3 Feb. 1987 106 p
(PB87-910401; NTSB-AAR-87-01) Avail: NTIS HC A06/MF A01 CSCL 01C

At 1521 c.d.t. on 6 Sept. 1985, Midwest Express Airlines, Inc., Flight 105, a McDonnell-Douglas DC-9-14 airplane, crashed at the edge of a wooded area about 1,680 feet from the end of runway 19R shortly after takeoff from Mitchell Field, Milwaukee, Wisconsin. The weather was clear with visibility 10 miles. During the initial climb, about 450 feet above ground level (a.g.l.) there was a loud noise and a loss of power associated with an uncontained failure of the 9th and 10th stage high pressure compressor spacer of the right engine. Flight 105 continued to climb to about 700 feet a.g.l. and then rolled to the right, when the airplane entered an accelerated stall, control was lost, and the airplane crashed. The aircraft was destroyed by impact forces and postcrash fire. The pilot, the first officer, both flight attendants, and all 27 passengers were fatally injured. The National Transportation Safety Board determines that the probable cause of this accident was the flightcrew's improper use of flight controls in response to the catastrophic failure of the right engine during a critical phase of flight, leading to an accelerated stall and loss of control. Author

N87-24439# National Transportation Safety Board, Washington, D. C. Bureau of Accident Investigation.
AIRCRAFT ACCIDENT REPORT: MIDAIR COLLISION OF NABISCO BRANDS, INC., DASSAULT FALCON, DA50, N784B AND AIR PEGASUS CORPORATION, PIPER ARCHER, PA28-181, N1977H, FAIRVIEW, NEW JERSEY, NOVEMBER 10, 1985
4 May 1987 101 p
(PB87-910405; NTSB-AAR-87-05) Avail: NTIS HC A06/MF A01 CSCL 01C

On November 10, 1985 a Dassault Falcon, DA50 jet and a Piper Archer, PA28-181 collided about 1,500 feet over the towns of Fairview and Cliffside Park, New Jersey. The DA50 was cleared for a standard instrument approach procedure in visual meteorological conditions and was in a left turn to position itself on the downwind leg to runway 19 at the Teterboro Airport, and the PA28 was transiting the airport traffic area from west to east when they collided. Both planes had been in radio contact with the control tower. The National Transportation Safety Board determines that the probable cause of the accident was a breakdown in air traffic control coordination which resulted in an air traffic conflict and the inability of the DA50 flightcrew to see and avoid the other aircraft due to: (1) an erroneous and inadequate traffic advisory, and (2) the physiological limitations of human vision and reaction time at night. Air traffic control management contributed to the accident by failing to insure that controllers were following prescribed procedures and by failing to recognize and correct operational deficiencies. M.G.

N87-24440# Sandia National Labs., Albuquerque, N. Mex. Exploratory Batteries Div.
TRANSPORTATION CONTAINER FOR LI/SO2 BATTERIES ON PASSENGER AIRCRAFT
SAMUEL C. LEVY 1987 4 p Presented at Lithium '87, Niagara Falls, N.Y., 23 Jun. 1987
(Contract DE-AC04-76DP-00789)
(DE87-008653; SAND-87-1026C; CONF-870699-1) Avail: NTIS HC A02/MF A01

A surplus USN 40 mm ammunition can was subjected to a variety of tests. Pressure tests were carried out with nitrogen gas, followed by the venting of actual Li/SO2 cells and batteries inside the can. A fire test was also conducted on a can packed with 10 each 10-cell batteries surrounded by vermiculite. Test results indicate the US Navy (USN) 40-mm ammunition can is suitable as a shipping container for Li/SO2 batteries on passenger aircraft. To provide a further measure of safety, a sulfur dioxide getter was incorporated into the can. Studies indicated a commercial material, ASC carbon, is suitable for this purpose. The granular material was packaged in porous paper desiccant bags and placed in the can with the batteries and vermiculite. The batteries were vented inside the sealed can and the internal pressure monitored. Pressure returned to normal within several minutes, indicating that this arrangement should prevent sulfur dioxide (SO2) gas from leaking into the airplane in the event of multiple battery ventings during flight. DOE

N87-24441# Office National d'Etudes et de Recherches Aerospatiales, Paris (France). Direction de la Physique Generale.
ELECTROMAGNETIC PERTURBATIONS CREATED ONBOARD AIRCRAFT BY DIRECT OR CLOSE LIGHTNING *Final Report* [PERTURBATIONS ELECTROMAGNETIQUES CREEES SUR UN AERONEF PAR UN FOUDROIEMENT DIRECT OU DE PROXIMITE]
G. LABAUNE, J. P. MOREAU, V. GOBIN, and F. ISSAC Oct. 1986 112 p In FRENCH
(Contract DRET-85-001)
(ONERA-RF-15/7234-PY; ETN-87-99621) Avail: NTIS HC A06/MF A01

The effects of long (several meters) electric discharges simulating lightning were studied in laboratory to prepare an experiment that was carried out in flight. The electromagnetic fields generated by simulated or real lightning were measured. A large amount of information was obtained, and is presented. ESA

N87-24442# Naval Research Lab., Washington, D.C.
VECTOR ELECTRIC FIELDS MEASURED IN A LIGHTNING ENVIRONMENT
R. V. ANDERSON and J. C. BAILEY 7 Apr. 1987 104 p
(AD-A180012; NRL-MR-5899) Avail: NTIS HC A06/MF A01 CSCL 04A

The measurement of vector electric fields from an aircraft which is struck by lightning can provide information on lightning initiation and triggering processes. Calibration of the aircraft to determine geometric field enhancements and to separate the vector components, although difficult, has been accomplished. Data from 31 strikes in the summer of 1985 are presented in three formats. The raw fields measured at the four field meters are presented both to indicate proper operation and because strikes to the wing tips may be strongly related to the local field at the wing tips. The three cartesian vector components of field and the aircraft voltage (with respect to its immediate environment) are next shown followed finally by an azimuth-elevation-magnitude presentation which appears useful for triggering studies. Author (GRA)

N87-24443# National Transportation Safety Board, Washington, D. C. Bureau of Field Operations.
AIRCRAFT ACCIDENT REPORTS: BRIEF FORMAT, US CIVIL AND FOREIGN AVIATION, ISSUE NUMBER 15, 1985 ACCIDENTS
3 Feb. 1987 223 p
(PB87-916901; NTSB/AAB-87/01) Avail: NTIS HC A10/MF A01; also available on subscription, North American Continent HC $185.00/year; all others write for quote CSCL 01C

This publication contains selected aircraft accident reports in Brief Format occurring in U.S. civil and foreign aviation operations during Calendar Year 1985. Approximately 200 General Aviation and Air Carrier accidents are described, representing a random selection. The publication is issued irregularly, normally eighteen times each year. The brief Format presents the facts, conditions, circumstances and probable cause(s) for each accident. GRA

04

AIRCRAFT COMMUNICATIONS AND NAVIGATION

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

A87-39261#
AUTOMATION - A NECESSITY FOR HIGHER ATC EFFICIENCY
V. G. SHELKOVNIKOV (Central Department of Civil Aviation Air Traffic Control, USSR) and N. G. MISHCHENKO (International Scientific and Experimental Centre for ATC Automation, USSR) ICAO Bulletin, vol. 42, March 1987, p. 17, 18.

The application of automation to air traffic control (ATC) systems is examined. The automated ATC system at the Simferopol Area Control Centre, referred to as TRASSA, is described. The system was installed in order to improve service for congested over-water air routes. The operation of the system is discussed. TRASSA provides automatic extraction, transmission, consolidation, and display of radar data from several remote tracking stations, thereby allowing uninterrupted monitoring of flights and communication with aircraft throughout the ATC area from one control center. The system is capable of detecting a target with a probability of more than 0.9 with a false alarm probability of 10 to the -6th. I.F.

A87-39262#
MLS EVALUATION PROGRAMME UNDER WAY IN FRANCE
THIERRY ALLAIN (Service Technique de la Navigation Aerienne, Paris, France) ICAO Bulletin, vol. 42, March 1987, p. 19-21.

The development of the ground and airborne equipment for an MLS, and the evaluation of the system are discussed. The evaluation program consisted of developmental ground station and in-flight receiver testing and operational tests. Various MLSs were examined in terms of data display to the crew, the study of segmented approaches, and the link between the autopilot and the flight management system. The capabilities and advantages of the MLS are compared with those of the ILS. It is noted that the MLS is less sensitive to noise reflection from obstacles; more difficult to scramble; easier to install and maintain; has fewer critical area problems; and provides more complete ground measurements. I.F.

A87-39269#
THE OBSERVABILITY OF A DOPPLER-AIDED INERTIAL NAVIGATION SYSTEM
REN DA, JIXIANG YU, and SHENGWU LIU Northwestern Polytechnical University, Journal (ISSN 1000-2753), vol. 5, April 1987, p. 193-202. In Chinese, with abstract in English. refs

An intuitive method which directly investigates the relations between state variables and measurement values for Kalman filters is presented. This method can be used to study the observabilities of both a Doppler-aided strapdown inertial navigation systems (DSINS) and a Doppler-aided platform inertial navigation system (DPINS). The effects of different types of maneuvers on the system observability are discussed in detail, and major similarities and differences between the DSINS and DPINS characteristics in maneuvers are pointed out. Finally, a simple system with all numerical values included is shown. C.D.

A87-39411#
COMPLEMENTING INS WITH AIR DATA - AN IMPROVED NAVIGATION SYSTEM
E. ZHENG and YONGYUAN QIN (Northwestern Polytechnical University, Xian, People's Republic of China) Acta Aeronautica et Astronautica Sinica, vol. 8, March 1987, p. A211-A215. In Chinese, with abstract in English.

In this paper, the characteristics of the hybrid navigation system which is composed of an air data computer and an inertial navigation system and is integrated by a Kalman filter are analyzed. The result of the computer simulation shows that it is possible to obtain a medium accurate hybrid system with use of a low accurate inertial system. The hybrid system can detect and compensate drifts of gyros and perform platform realignment during flying. Author

A87-39428#
EMERGENCY LOCATOR TRANSMITTERS - A PROBLEM AND A CHALLENGE
R. E. MERRICK (Transport Canada, Ottawa) Canadian Aeronautics and Space Journal (ISSN 0008-2821), vol. 33, March 1987, p. 18, 19.

The advantages and disadvantages of emergency locator transmitters (ELTs) are analyzed. An ELT located on the Search and Rescue Satellite-aided Tracking system measures the Doppler shift in a received signal and then determines the transmitter's location. The difficulties encountered due to the inadverent activation and failure of ELTs to work for all types of crashes are discussed. It is proposed that changing the transmission frequency of the ELTs from 121.5/243.0 MHz to 406 MHz will improve the effectiveness of ELTs. The use of crash-position indicators instead of ELTs to detect crashes in uninhabited areas is examined. I.F.

A87-39736#
DECENTRALIZED FILTERING AND REDUNDANCY MANAGEMENT FOR MULTISENSOR NAVIGATION
THOMAS KERR (MIT, Lexington, MA) IEEE Transactions on Aerospace and Electronic Systems (ISSN 0018-9251), vol. AES-23, Jan. 1987, p. 83-119. refs

A failure detection/redundancy management approach is presented for avionics applications of integrated navigation involving coordinated use of multiple-simultaneous-sensor subsystems such as GPS, TACAN, inertial navigation, and Doppler AHRS. The technique is based on voter/monitoring at both the raw data and at the filtered level, in addition to using inputs from hardware built-in testing and from specialized tests for subsequent failure isolation (in the case of ambiguous detections). The probability of detecting both failed component subsystems and false alarms is evaluated to help select the thresholds used in the automated decision process. A structure to accommodate differing rates of subsystem assessment and tally is presented, and designs for navigation architectures are suggested based on likely subsystem utilization and emerging concepts in decentralized Kalman filtering. R.R.

A87-39950#
MANAGING THE CROWDED SKY - THE UK EXPERIENCE
KEITH R. MACK (Civil Aviation Authority, National Air Traffic Control System, London, England) (Civil Aviation Chief Executives Management Seminar, Singapore, June 1986) The Controller (ISSN 0010-8073), vol. 26, March 1987, p. 2, 4-6, 8-11.

The systems used for airspace management in the UK are examined. The National Air Traffic Services was created to meet the requirements of civil and military traffic; air traffic strategies for managing their needs are discussed. A mixture of controlled airspace and open FIR is utilized for managing air traffic in the UK area of responsibility; the operation of the ATC system employed in this area is described. The control of helicopter operations in the North Sea, and the North Atlantic traffic flow are considered. I.F.

A87-40360#
TOWARDS SATELLITE SERVICE FOR AIRCRAFT
K. HUNGERFORD and K. SMITH (International Maritime Satellite Organization, London, England) IN: EASCON '86; Proceedings of the Nineteenth Annual Electronics and Aerospace Systems Conference, Washington, DC, Sept. 8-10, 1986 . New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 80-82.

The development of a communications, navigation, and surveillance system (CNS), based on the use of satellite technology, for servicing aircraft is proposed. The aeronautical satellite service requirements for transmission of data at low speeds involves using an aircraft antenna gain of 0-3 dBi, and for voice transmission a higher gain antenna of 12 dBi is needed. A program for developing a CNS system with an antenna gain of 12 dBi, aircraft earth stations, and ground earth stations is discussed. I.F.

A87-41279#
A SECURE DATA LINK FOR RPV AND OTHER APPLICATIONS
A. J. LAMBELL and J. WELLS (Philips Electronics and Associated Industries, Ltd., MEL Div., Crawley, England) IN: Military microwaves '86; Proceedings of the Conference, Brighton, England, June 24-26, 1986 . Tunbridge Wells, England, Microwave Exhibitions and Publishers, Ltd., 1986, p. 49-54.

Direct sequence pseudonoise spread spectrum modulation provides a method of achieving covert and jam-resistant data communication. A microwave data link designed for use with military RPV surveillance systems is described in this paper. The link operates in the 5 GHz and provides simultaneous transmission of narrow band digital command and control data and wideband video from surveillance sensors. In addition the synchronization of the pseudonoise codes results in an accurate measurement of range between the two stations, which adds a navigation capability to the system. The basic modulation and acquisition circuitry can be common to a wide range of roles, with microwave frequency and antenna configuration optimized to the specific requirement. Author

A87-41281#
MULTIPLE OBJECT TRACKING RADAR
RALPH L. STEGALL (RCA Corp., Missile and Surface Radar Div., Moorestown, NJ) IN: Military microwaves '86; Proceedings of the Conference, Brighton, England, June 24-26, 1986 . Tunbridge Wells, England, Microwave Exhibitions and Publishers, Ltd., 1986, p. 69-74.

Multiple Object Tracking Radar (MOTR) is under development in response to increasingly complex range instrumentation mission requirements for present and 21st-century scenarios. A MOTR's pedestal-mounted phased array can simultaneously acquire and track ten targets with a precision comparable to that of an AN/FPS-16; the radar is mobile, and can be emplaced and calibrated in less than eight hours. Any of the available resources that are not actively engaged in tracking can be diverted to sophisticated search operations. Multiple drone control is possible, as is the acquisition of target-per-pulse phase and amplitude data. O.C.

A87-41351#

PLANS '86 - POSITION LOCATION AND NAVIGATION SYMPOSIUM, LAS VEGAS, NV, NOV. 4-7, 1986, RECORD

Symposium sponsored by IEEE. New York, Institute of Electrical and Electronics Engineers, 1986, 544 p. For individual items see A87-41352 to A87-41405.

The present conference considers state-of-the art technologies in the fields of space-based navigation, radio navigation, inertial systems and their component technologies, GPS/Position Location Reporting System (PLRS)-aided inertial land navigation system performance, the positioning and stabilization of space systems, and integrated communications/navigation systems. Additional sessions address the development status and performance of GPS equipment and its applications to date, geodetic surveying, marine navigation, digital map technology, aircraft navigation and traffic control, differential GPS, land vehicle navigation and position reporting, and integrated navigation/flight control systems. O.C.

A87-41358#

IMPLEMENTATION AND FUTURE OF LORAN-C FOR GENERAL AVIATION

ELIJAH JACKSON (FAA, Washington, DC) IN: PLANS '86 - Position Location and Navigation Symposium, Las Vegas, NV, Nov. 4-7, 1986, Record . New York, Institute of Electrical and Electronics Engineers, 1986, p. 38, 39.

The Long Range Navigation (LORAN-C) System will be an interim supplemental navigation system which the Federal Aviation Administration (FAA) will begin implementing in the National Airspace System (NAS) in fiscal year 1987. The purpose of the LORAN-C System will be to provide the aviation community with nonprecision instrument approaches at airports with and without existing navigational aids. The FAA plans to award a contract in September 1986 to purchase 112 LORAN-C monitor receivers. These aviation monitor receivers will be used to: (1) monitor the signal integrity of the United States Coast Guard (USCG) LORAN-C, (2) support nonprecision instrument approaches, (3) provide data to forecast changes in LORAN-C signal time differences, and (4) provide a data source for the Notice to Airmen (NOTAMS). Author

A87-41359#

SITING ANALYSIS FOR LORAN-C OPERATIONAL MONITOR DEPLOYMENT

FRANKLIN D. MACKENZIE (DOT, Transportation Systems Center, Cambridge, MA) and ELIJAH E. JACKSON (FAA, Navigation and Landing Div., Washington, DC) IN: PLANS '86 - Position Location and Navigation Symposium, Las Vegas, NV, Nov. 4-7, 1986, Record . New York, Institute of Electrical and Electronics Engineers, 1986, p. 40-45. refs

The Transportation Systems Center (TSC), under the auspices of the Federal Aviation Administration (FAA) has developed the deployment strategy for the LORAN-C monitoring system. The system, a network of 100 units, will span the existing signal coverage area in the contiguous U.S. Most units will be integrated into the VORTAC system, taking advantage of the Facility Central Processing Unit (FCPU) and the dedicated communication lines for automatic status checking, data collection, remote certification, trend analysis, control parameter insertion and maintenance alerting. Other units will be placed in Flight Service Centers, Air Route Traffic Control Centers or towers. The number of monitors needed for area coverage was determined in a range-of-validity study. The maximum number of monitors would be greater than 5000, one per airport; the minimum number would be one per triad. The range-of-validity (ROV) study determined that a circle of 80 to 90 mile radius would be sufficient. Author

A87-41360#

LORAN-C DATA ANALYSIS IN SUPPORT OF MID-CONTINENT EXPANSION

GARY L. NOSEWORTHY, JOHN H. FAGAN (Synetics Corp., Reading, MA), and ED BREGSTONE (U.S. Coast Guard, Washington, DC) IN: PLANS '86 - Position Location and Navigation Symposium, Las Vegas, NV, Nov. 4-7, 1986, Record . New York, Institute of Electrical and Electronics Engineers, 1986, p. 46-51. refs

(Contract DTCG23-86-A-20022)

During 1984 and 1985 the FAA conducted a series of LORAN-C Stability Test Program Flights throughout the contiguous United States (CONUS). The data recorded along each flight path provide indications of time difference (TD) variations with respect to geographic location as well as indications of LORAN-C converge, based on signal-to-noise ratio (SNR) and other signal parameters. This paper addresses the archiving of the FAA flight data in a tractable database format and the utilization of the database in deriving a signal strength attenuation model. Averaged signal strength parameters are used to develop a 60-cell conductivity map for LORAN-C coverage within CONUS. Author

A87-41364#

RING LASER GYRO INERTIAL AND GPS INTEGRATED NAVIGATION SYSTEM FOR COMMERCIAL AVIATION

SUDHAKAR P. DIVAKARUNI (Honeywell Systems and Research Center, Minneapolis, MN), RICHARD A. STENSLAND, and MATS B. BRENNER (Honeywell, Inc., Commercial Aviation Div., Minneapolis, MN) IN: PLANS '86 - Position Location and Navigation Symposium, Las Vegas, NV, Nov. 4-7, 1986, Record . New York, Institute of Electrical and Electronics Engineers, 1986, p. 73-80.

The ring laser gyro-based inertial reference and navigation systems presently discussed are integrated in order to take advantage of GPS in civil aviation use, in conjunction with the ARINC 700-series of avionics equipment. The basic feature of the system architecture employed is that it furnishes pure inertial, autonomous GPS and GPS-bounded inertial navigation outputs while preserving the inertial reference system's integrity. Attention is given to the navigation filter algorithms that derive the autonomous GPS solution, the GPS/inertial hybrid solution, and the inertial sensor calibration data. O.C.

A87-41365#

SITAN IMPLEMENTATION IN THE SAINT SYSTEM

J. R. FELLERHOFF (Sandia National Laboratories, Albuquerque, NM) IN: PLANS '86 - Position Location and Navigation Symposium, Las Vegas, NV, Nov. 4-7, 1986, Record . New York, Institute of Electrical and Electronics Engineers, 1986, p. 89-95. USAF-supported research.

The AFTI/F-16 Sandia Inertial Terrain-Aided Navigation (SITAN) system, which is a flight computer algorithm that yields accurate position corrections to an inertial navigation system, has been adapted for integration into the Sandia Aided-Inertial Navigation Testbed (SAINT) system and subsequently flight-tested. Attention is presently given to the AFTI/SITAN algorithm in the SAINT system, as well as to the flight test results obtained, which demonstrated reliable, accurate, and continuous estimation of aircraft position in the presence of large initial horizontal position errors. O.C.

A87-41371#

PLRS DEVELOPMENT TESTING - AN UPDATE

U. S. OKAWA and N. R. FINCHER (Hughes Aircraft Co., Communications Systems Div., Fullerton, CA) IN: PLANS '86 - Position Location and Navigation Symposium, Las Vegas, NV, Nov. 4-7, 1986, Record . New York, Institute of Electrical and Electronics Engineers, 1986, p. 147-153.

(Contract DAAB07-76-C-1750)

The Position Location Reporting System (PLRS) provides position location, tracking, and reporting for communities of hundreds of cooperating users in a tactical environment. PLRS uses time-of-arrival (TOA) measurements aided by barometric pressure measurements to establish position tracking of these large communities of user terminals. The system uses the positions of a few user terminals as grid references so that all positions are available both to the cooperating users and to command centers. All control, measurement reporting, and data exchange are cryptographically secured in a synchronous anti-jam communications network. Testing with live communities of 50 or more user terminals has been conducted at many sites throughout the U.S. and in West Germany, with consistently good results. In addition, testing has been accomplished with computer simulated communities of up to 380 user terminals. Recent live testing has successfully demonstrated an automated GPS interface for operation without fixed grid reference units. Results are presented, with an emphasis on position accuracy tests. Author

A87-41377#
FLIGHT TEST RESULTS OF AN INTEGRATED GPS AND STRAPDOWN INERTIAL SYSTEM
STEWART P. TEASLEY (Texas Instruments, Inc., Plano) IN: PLANS '86 - Position Location and Navigation Symposium, Las Vegas, NV, Nov. 4-7, 1986, Record . New York, Institute of Electrical and Electronics Engineers, 1986, p. 199-205.

A system known as Global Positioning System (GPS) Integrated Navigation (INAV) has progressed from laboratory test to a flight-test phase; the results of these flight tests, including accuracy evaluation of the INAV system, and the performance of the system under nap-of-the-earth tests, are presented. The tightly-coupled INAV approach supports the traditional alignment of an inertial set with GPS and, in addition, provides a real-time calibration of the basic inertial sensor errors, compensating for day-to-day drift of the instruments. Effective sensor drift rates are improved by a factor of 3. The performance of this single-channel multiplex GPS receiver against dynamics or jamming exceeds that achieved with many multichannel sets to date. Although the system is configured for use with low-cost inertial systems, it is readily adapted to higher quality instruments. Author

A87-41378#
EVALUATION OF GPS IONOSPHERIC TIME DELAY ALGORITHM FOR SINGLE-FREQUENCY USERS
W. A. FEESS and S. G. STEPHENS (Aerospace Corp., El Segundo, CA) IN: PLANS '86 - Position Location and Navigation Symposium, Las Vegas, NV, Nov. 4-7, 1986, Record . New York, Institute of Electrical and Electronics Engineers, 1986, p. 206-213.

For single-frequency Global Positioning System (GPS) users, uncompensated ionospheric GPS-signal time delay is the largest source of range-measurement error, contributing as much as 100 meters. To improve performance for these users, a numeric model of the ionospheric range error was incorporated into the GPS system. This paper presents an assessment of that model in which actual ionospheric time delay values as measured by GPS dual-frequency receivers were compared with model values computed at the same time points. Comparison was made over a broad range of conditions with dependency of model accuracy on several of the model parameters. It appears that the model leads to an overall reduction in RMS range measurement error at 60 percent. Author

A87-41385#
GEOLOC LONG RANGE SPREAD SPECTRUM ACCURATE RADIOLOCATION SYSTEM OPERATIONAL RESULTS
GEORGES NARD, LYNN WEEMS, and SERGE BOURASSEAU (Sercel, Inc., Houston, TX) IN: PLANS '86 - Position Location and Navigation Symposium, Las Vegas, NV, Nov. 4-7, 1986, Record . New York, Institute of Electrical and Electronics Engineers, 1986, p. 256-265. refs

The Geoloc HF Band Spread Spectrum radio-location system has been operational for two years in European waters, and new chains are soon expected to be operational in other continents. Thanks to the ultimate capabilities of coherent correlation techniques used, a tremendous process gain (10 to the 8th), is obtained, allowing unique field proven performances such as : (1) day and night, all weather, 1000-kilometer range; (2) accuracies of up to 15 meters at maximum ranges; (3) capability of proper operation in the presence of jammers or ionospheric waves 50 decibels stronger than the desired signals; (4) flexible set up of lightweight shore stations; and (5) full radio compatibility with other radio operation in the same frequency band. After a recall of the concept and characteristics of the Geoloc, some operational results related mainly to accuracy, range and reliability are given. Last recent technical developments of Geoloc are described, and its alternative and complementary capabilities of GPS are highlighted. Author

A87-41388#
INTEGRITY OF THE MICROWAVE LANDING SYSTEM (MLS) DATA FUNCTIONS
M. B. EL-ARINI and M. J. ZELTSER (Mitre Corp., McLean, VA) IN: PLANS '86 - Position Location and Navigation Symposium, Las Vegas, NV, Nov. 4-7, 1986, Record . New York, Institute of Electrical and Electronics Engineers, 1986, p. 330-342. refs

The Basic and Auxiliary Data Functions of the Microwave Landing System provide access to data such as ground system geometry, signal characteristics, and approach path definitions. In this paper, the performance of these functions is analyzed in terms of the probability of undetected errors remaining in the data. Results show that the performance requirements can be met using: (1) averaging the received data bits of several samples of the same word using a majority voting; (2) reducing the bit error rate at the output of the receiver's decoder; and (3) a combination of the above techniques. Author

A87-41389#
INDEPENDENT GROUND MONITOR COVERAGE OF GLOBAL POSITIONING SYSTEM (GPS) SATELLITES FOR USE BY CIVIL AVIATION
KAREN J. MILLER (Mitre Corp., McLean, VA) IN: PLANS '86 - Position Location and Navigation Symposium, Las Vegas, NV, Nov. 4-7, 1986, Record . New York, Institute of Electrical and Electronics Engineers, 1986, p. 343-348. refs
(Contract DOT-FA01-84-C-00001)

In connection with the proposed use of GPS in nonprecision approach guidance in the National Airspace System, the required number of ground monitoring stations and their locations must be determined so as to provide acceptable coverage of the geographical area of interest with a minimum number of stations. Here, a general algorithm is developed for determining the locations of GPS monitoring stations for a given area of GPS use. The algorithm is then applied to specific geographical areas (conterminous U.S., Canada, and Alaska), and it is shown that the ground monitoring stations placed on the outer edges of the defined area of GPS use provide the most complete coverage of the GPS satellites. V.L.

A87-41390#
ALTITUDE AIDED GPS
FRANK LORGE (FAA, Technical Center, Atlantic City, NJ) IN: PLANS '86 - Position Location and Navigation Symposium, Las Vegas, NV, Nov. 4-7, 1986, Record . New York, Institute of Electrical and Electronics Engineers, 1986, p. 349-353. refs

Flight tests have been conducted to investigate altitude aiding as a means of improving the navigational accuracy of a Global Positioning System (GPS) receiver during three-satellite coverage. It is found that altitude aiding does improve positional accuracy during three-satellite coverage as well as during some periods of poor satellite geometry. The type of geometry is shown to affect the extent of performance improvement that is possible with this method. A summary of test results is presented. V.L.

A87-41391#

PARTIAL INERTIAL AIDING FOR LOW COST AIRCRAFT GPS NAVIGATORS

IGNACIO J. DIAZ BOBILLO (Argentine Air Force, Buenos Aires, Argentina) and WILLIAM S. WIDNALL IN: PLANS '86 - Position Location and Navigation Symposium, Las Vegas, NV, Nov. 4-7, 1986, Record . New York, Institute of Electrical and Electronics Engineers, 1986, p. 354-361.

Significant position errors develop in an unaided GPS navigator if tracking of two of the four satellites is interrupted during aircraft maneuvers. Inertial aiding is known to overcome this performance problem, but utilizing a full three axis inertial measurement unit is not a low cost solution. This paper shows that partial inertial aiding, using only one rate gyro, also overcomes the performance problem and is of much lower cost. Another partial aiding design employs one rate gyro plus two accelerometers and gives somewhat better performance than the single gyro design. Both partial inertial aiding designs give performance comparable to a barometric altimeter aided GPS navigator during short interruptions. The performances of the various designs are compared using a simulation of an aircraft approach and landing. Author

A87-41392#

THE POTENTIAL FOR DIGITAL DATABASES

D. HALLIWELL (GEC Avionics, Ltd., Guidance Systems Div., Rochester, England) IN: PLANS '86 - Position Location and Navigation Symposium, Las Vegas, NV, Nov. 4-7, 1986, Record . New York, Institute of Electrical and Electronics Engineers, 1986, p. 362-367.

The architecture and performance of a digital color map unit (DCMU) that has recently been developed and successfully flight tested are discussed. The system architecture uses an all-electronic design, which enables the expected improvements in digital source data and the means for storing it in the aircraft to be fully exploited, while retaining the proven image generation subsystem. The potential broadening of the DCMU functions into terrain-referenced navigation, threat avoidance, terrain following/terrain avoidance, and target acquisition is discussed in the light of data-base developments. V.L.

A87-41393#

RELIABLE HIGH ACCURACY LONG RANGE REAL TIME DIFFERENTIAL G.P.S. USING A LIGHTWEIGHT HIGH FREQUENCIES DATA LINK

GEORGES NARD (Sercel SA, Carquefou, France) IN: PLANS '86 - Position Location and Navigation Symposium, Las Vegas, NV, Nov. 4-7, 1986, Record . New York, Institute of Electrical and Electronics Engineers, 1986, p. 377-388. refs

A Differential GPS (DGPS) system capable of providing metric accuracies in real time at distances of up to 1500 km is presented. The system's format, modulation method, and selection of carrier frequencies are detailed. The advantages of DGPS hybridization with other position sensors are demonstrated. K.K.

A87-41394#

HIGH PRECISION DIFFERENTIAL GPS NAVIGATION

ALFRED KLEUSBERG and DAVID E. WELLS (New Brunswick, University, Fredericton, Canada) IN: PLANS '86 - Position Location and Navigation Symposium, Las Vegas, NV, Nov. 4-7, 1986, Record . New York, Institute of Electrical and Electronics Engineers, 1986, p. 389-392. refs

GPS pseudo ranges and carrier signal Doppler measurements are integrated in a kinematic positioning and navigation algorithm. Range and range rate corrections observed with a monitor receiver at a known location are utilized to correct the observations of the remote receiver for satellite ephemerides and clock errors. Kinematic positioning results obtained with the position filter developed at the University of New Brunswick are presented. Measurement of dual freqency P-code tracking receivers are shown to give a relative positioning accuracy of the order of 1 to 2 meters. Author

A87-41395#

USE OF PHASE DATA FOR ACCURATE DIFFERENTIOAL GPS KINEMATIC POSITIONING

G. LACHAPELLE, W. FALKENBERG (Nortech Surveys /Canada/, Inc., Calgary, Canada), and M. CASEY (Department of Fisheries and Oceans, Canadian Hydrographic Service, Ottawa, Canada) IN: PLANS '86 - Position Location and Navigation Symposium, Las Vegas, NV, Nov. 4-7, 1986, Record . New York, Institute of Electrical and Electronics Engineers, 1986, p. 393-398. refs

Differential GPS land kinematic positioning tests conducted at velocities of 20 to 100 km/h over a baseline of 1000 km using a combination of pseudo-range and phase measurements are described. The algorithm utilized was designed to deal effectively with losses of phase lock on one or more satellites simultaneously. The relatively long baseline utilized provided valuable information on the effects of broadcast ephemeris errors on the differential results. The tests were conducted with two Texas Instruments TI4100 receivers using both the P and C/A codes to assess the effect of the ionosphere on accurate differential positioning over such a long baseline. The use of cesium clocks was also tested. Accuracies of the order of 1 to 2 m (rms) were obtained. Author

A87-41397#

SENSOR MANAGEMENT FOR A FAULT TOLERANT INTEGRATED INERTIAL FLIGHT CONTROL REFERENCE AND NAVIGATION SYSTEM

S. Y. WEI and J. R. HUDDLE (Litton Industries, Guidance and Control Systems Div., Woodland Hills, CA) IN: PLANS '86 - Position Location and Navigation Symposium, Las Vegas, NV, Nov. 4-7, 1986, Record . New York, Institute of Electrical and Electronics Engineers, 1986, p. 445-455.

The paper presents a mechanization for the realization of an FO-FO-FS (fail-operate, fail-operate, and fail-safe) integrated flight control reference and navigation system. Highly efficient algorithms for the rapid detection and isolation of failed or degraded instruments are considered in connection with a system of two identical inertial measurement units, each with redundant gyros and accelerometers. A second type of algorithm which utilizes the nondegraded sensor outputs to obtain the optimal permissible solutions for both the flight control system reference inputs and the navigation function is also presented. K.K.

A87-41399#

ADAPTIVE TACTICAL NAVIGATION

DOUGLAS P. GLASSON (Analytic Sciences Corp., Reading, MA) IN: PLANS '86 - Position Location and Navigation Symposium, Las Vegas, NV, Nov. 4-7, 1986, Record . New York, Institute of Electrical and Electronics Engineers, 1986, p. 461-467. refs (Contract F33615-83-C-1111)

Technical objectives and accomplishments of the Adaptive Tactical Navigation (ATN) Concept Development are summarized in this paper. Specifically, the Expert Navigator/Knowledge Base, Real-time Inferencing Techniques and Laboratory Demonstration System developed in this effort are described. Future research and development activities to expand the ATN concept and to transition to an onboard implementation are identified. Author

A87-41402#

REQUIREMENTS FOR SOLE MEANS NAVIGATION IN U.S. NAVY AIRCRAFT

GEORGE LOWENSTEIN, JOHN PHANOS (U.S. Navy, Naval Air Development Center, Warminster, PA), and EDWARD RISH (Synetics Corp., Washington, DC) IN: PLANS '86 - Position Location and Navigation Symposium, Las Vegas, NV, Nov. 4-7, 1986, Record . New York, Institute of Electrical and Electronics Engineers, 1986, p. 488-495. refs

The requirements for GPS certification as a sole means air navigation system in the U.S. National Aerospace System are investigated. The GPS must satisfy all the requirements of an airborne area navigation system as well as provide data as accurate, stable, and verifiable as those of the VOR/DME network GPS user-equipment (UE) implementation is described as well as approaches to UE integration with flight instruments on Navy aircraft. K.K.

A87-41403#
CIVIL ACCESS TO THE PRECISE POSITIONING SERVICE OF THE NAVSTAR GLOBAL POSITIONING SYSTEM
MICHAEL J. ELLETT (USAF, Systems Engineering Directorate, Los Angeles, Air Force Station, CA) IN: PLANS '86 - Position Location and Navigation Symposium, Las Vegas, NV, Nov. 4-7, 1986, Record . New York, Institute of Electrical and Electronics Engineers, 1986, p. 505-509.

A program to provide limited civil access to the Precise Positioning Service (PPS) of the GPS is being formulated. The basic characteristics and operation of the GPS are reviewed. The user charge and PPS approaches for civil access to GPS are described and compared; the benefits of the PPS approach are discussed. The approval of an application for use of the GPS is based on whether the applicant can provide a demonstrable need, if the granting of access will be in the U.S. national interest, and if the security of the GPS can be adequate. The information an applicant needs to include in the request, and methods for providing adequate security for the system are considered. I.F.

A87-41696#
ATS AND VTS - SOME OBSERVATIONS TOWARDS A SYNTHESIS
R. BOOTSMA and K. POLDERMAN (Journal of Navigation, Jan. 1987) Ortung und Navigation (ISSN 0474-7550), vol. 28, no. 1, 1987, p. 47-57.

Technical, legal, and organizational aspects of air-traffic and vessel-traffic services (ATS and VTS) are compared, with a focus on improving VTS. Consideration is given to the standardization and regional organization of ATS under the Chicago Convention of 1944 (establishing the ICAO); the flexible implementation of the standards via a legal structure of annexes, standards and recommended practices, and national regulations; typical ATC practices (using the Netherlands as an example); and the establishment of air-traffic flow-management services. The history and activities of the International Maritime Organization (the UN body corresponding to the ICAO) are summarized, and it is pointed out that about 150 different VTSs are presently in operation. Greater standardization of VTS under rules and procedures similar to those for ATS is recommended. T.K.

A87-42609#
TIME MODULATION. I - MODULATION SCHEME HELPS AIR-TRAFFIC SAFETY
EDMOND R. GUNNY Microwaves & RF (ISSN 0745-2993), vol. 26, May 1987, p. 245, 246, 248-250, 252, 254.

A digital modulation scheme reducing the probability of simultaneous signal reception is described with emphasis on applications for aircraft collision-avoidance systems. In the modulation format described here, one unit-time pulse is sent to indicate the start of a clock-counting interval, and a second time-unit pulse is sent to indicate the end of the message time interval. In the intervening period, the receiver counts the message number of clock pulses; the actual number counted is the code for the word being transmitted. The advantages of this scheme are discussed, and a sample circuit is presented. V.L.

N87-23607*# Mitre Corp., McLean, Va.
DEVELOPMENT OF AN AIR GROUND DATA EXCHANGE CONCEPT: FLIGHT DECK PERSPECTIVE Final Report
G. W. FLATHERS, II Jun. 1987 257 p
(Contract NAS1-17974)
(NASA-CR-4074; NAS 1.26:4074; MTR-87W21) Avail: NTIS HC A12/MF A01 CSCL 17B

The planned modernization of the U.S. National Airspace System (NAS) includes the development and use of a digital data link as a means to exchange information between aircraft and ground-based facilities. This report presents an operationally-oriented concept on how data link could be used for applications related directly to air traffic control. The specific goal is to establish the role that data link could play in the air-ground communications. Due regard is given to the unique characteristics of data link and voice communications, current principles of air traffic control, operational procedures, human factors/man-machine interfaces, and the integration of data link with other air and ground systems. Their resulting concept is illustrated in the form of a paper-and-pencil simulation in which data link and voice communications during the course of a hypothetical flight are described. Author

N87-23608# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France)
EFFICIENT CONDUCT OF INDIVIDUAL FLIGHTS AND AIR TRAFFIC OR OPTIMUM UTILIZATION OF MODERN TECHNOLOGY FOR THE OVERALL BENEFIT OF CIVIL AND MILITARY AIRSPACE USERS
BERNARDO FURCOLO 1987 16 p
(AGARD-AR-236) Avail: NTIS HC A02/MF A01

The AGARD Guidance and Control Panel 42nd Symposium was held in Brussels, Belgium, from 10 to 13 June 1986. The program presented at the symposium is appended to this report, and the Conference Proceedings are published separately. Author

05

AIRCRAFT DESIGN, TESTING AND PERFORMANCE

Includes aircraft simulation technology.

A87-39265#
A NEW CONCEPT OF SURFACE-AIRPLANE (POWER-AUGMENTED RAM WING)
SHIGENORI ANDO Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 35, no. 397, 1987, p. 91-101. In Japanese, with abstract in English. refs

The PAR (Power Augmented Ram) Wing concept is presented. It will be useful for over-water transport to carry passengers, cargos, and/or cars. It is much faster than ships, while it requires no runway, in contrast to airplanes. The PAR concept makes the fuselage-shape 'aero-configured' rather than 'hydro-configured', and so decreases the parasite-drag significantly. An empirical formula is found for the effective aspect ratio which is applicable to various kinds of ground effect wings. The present PAR concept has a variable geometry wing, in front of which tiltable turboprop engines are installed. Untill the take-off speed is exceeded, the wing is swept-forward with extended full span flaps (the outer ones are differential flaps). In cruising condition, the wing becomes unswept. If the sea-state is bad, the vehicle can fly off-ground effect with unswept wing. Special devices are proposed for the tip-floats, which improve aerodynamic efficiency and which alleviate loads due to wave-impacts. Author

A87-39272#
A SIMPLIFIED STATE-SPACE MODELING OF ELASTIC VEHICLE
SHUO TANG and SHILU CHEN Northwestern Polytechnical University, Journal (ISSN 1000-2753), vol 5, April 1987, p 229-236. In Chinese, with abstract in English. refs

A simplified state-space modeling of an elastic vehicle is presented in this paper. The model is based on approximate indicial lift and moment functions of unsteady aerodynamics derived from Theodorsen's incompressible, two-dimensional flow theory for simple harmonic motion. Important relations between the frequency-response function, impulse response function, and unit-step response function are shown. The state-space equation of the aeroelastic system consisting of longitudinal small perturbation equations and vibration equations is obtained. Digital calculations indicate that the effect of unsteady aerodynamic force on the aeroelastic system is negligible at a relatively high Mach number. C.D.

A87-39478#

ARE TANDEM, DIAMOND, JOINED AND WARREN WINGS RELATED?

DARROL STINTON Interavia (ISSN 0020-5168), vol. 42, April 1987, p. 349-352.

The possibility of a broad characterization of the diamond-, joined-, twin-, and Warren-wing geometries as variants of the canard and tandem-winged family of aircraft configurations is discussed with a view to common pitch axis stability and yaw/roll effect similarities. While significant structural economy and volumetric efficiency advantages are obtainable by these exotic configurations, aerodynamic excellence in cruise conditions is often offset by considerable nonlinearities in maneuvering behavior. The greatest benefits accrue to the diamond form of wing. O.C.

A87-39647*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

EFFECT OF HELICOPTER BLADE DYNAMICS ON BLADE AERODYNAMIC AND STRUCTURAL LOADS

RUTH M. HEFFERNAN (NASA, Ames Research Center, Moffett Field, CA) AIAA, Dynamics Specialists Conference, Monterey, CA, Apr. 9, 10, 1987. 21 p. refs

(AIAA PAPER 87-0919)

The effect of rotor blade dynamics on aerodynamic and structural loads is examined for a conventional, main-rotor helicopter using a comprehensive rotorcraft analysis (CAMRAD) and flight-test data. The impact of blade dynamics on blade section lift-coefficient time histories is studied by comparing predictions from a rigid-blade analysis and an elastic-blade analysis with helicopter flight test data. The elastic blade analysis better predicts high-frequency behavior of section lift. In addition, components of the blade angle of attack such as elastic blade twist, blade flap rate, blade slope velocity, and inflow are examined as a function of blade mode. Elastic blade motion changed blade angle of attack by a few tenths of a degree, and up to the sixth rotor harmonic. A similar study of the influence of blade dynamics on bending and torsion moments was also conducted. A correlation study comparing predictions from several elastic-blade analyses with flight-test data revealed that an elastic-blade model consisting of only three elastic bending modes (first and second flap and first lag), and two elastic torsion modes was sufficient for good correlation. Author

A87-39649*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

THE EFFECT OF NONLINEAR ELASTOMERIC LAG DAMPER CHARACTERISTICS ON HELICOPTER ROTOR DYNAMICS

FORT F. FELKER, BENTON H. LAU (NASA, Ames Research Center, Moffett Field, CA), STACEY MCLAUGHLIN (Bell Helicopter Textron, Fort Worth, TX), and WAYNE JOHNSON (Johnson Aeronautics, Palo Alto, CA) AIAA, Dynamics Specialists Conference, Monterey, CA, Apr. 9, 10, 1987. 12 p. refs

(AIAA PAPER 87-0955)

Many helicopters use elastomeric lag dampers to prevent ground resonance and aeromechanical instability in hover and forward flight. Recent experimental results have shown that when the damper motion occurs at two superimposed frequencies, which is characteristic of operation in forward flight, the damper properties are not well-predicted by a superposition of the damper properties at each of the motion frequencies. This paper presents experimental data obtained with an elastomeric damper while it was undergoing single- and dual-frequency motion. The effect of the nonlinear dual-frequency damper characteristics on predicted rotor aeromechanical stability in forward-flight operation in a wind tunnel was evaluated using the comprehensive rotorcraft analysis program called CAMRAD. Author

A87-39768#

ANALYSIS OF ASYMMETRIC NATURAL VIBRATIONS OF A DEFORMABLE AEROPLANE WITH SUSPENDED BODIES BY THE METHOD OF FINITE ELEMENTS

J. BLASZCZYK Journal of Technical Physics (ISSN 0324-8313), vol. 27, no. 3, 1986, p. 257-277. refs

A theoretical and numerical analysis of asymmetric natural vibrations of structures with concentration masses suspended below the wing and the fuselage of an aircraft is presented. The moving control surfaces are assumed to be rigidly connected to the structure. The equations of motion of the rigid parts of the fuselage are derived along with the kinematic and boundary conditions in the assembling sections of attachment. A complete set of equations is established, the solution of which gives the required spectrum of asymmetric vibrations of an aircraft with suspended masses. C.D.

A87-39774#

ANALYSIS OF LOCAL FLUTTER AND FORCED VIBRATIONS OF THE COVERING OF SUPERSONIC AEROPLANE

A. OLEJNIK Journal of Technical Physics (ISSN 0324-8313), vol. 27, no. 4, 1986, p. 417-427. refs

A numerical technique for analysis of the aeroelastic response of a rectangular plate in a supersonic flow is developed, adapting the approach of Olejnik (1972) to a recurrent FEM procedure. The general formulation is explained; the equilibrium equations for a plate element are derived; and the frequency equation and expressions for forced and self-excited vibrations are obtained. The method makes it possible to determine simultaneously the plate displacement, its derivative with respect to x, the bending moment, and the shear force; a further practical advantage is its suitability for minicomputer implementation. T.K.

A87-39775#

A DYNAMIC MODEL FOR STUDYING VIBRATIONS OF A HELICOPTER TAIL BOOM

Z. DZYGADLO and R. OMASTA Journal of Technical Physics (ISSN 0324-8313), vol. 27, no. 4, 1986, p. 429-439. refs

A dynamic model is developed analytically for use in the FEM analysis of the vibrational response of a helicopter tail-boom/rotor-shaft assembly attached to a rigid fuselage. Concentrated masses, elastic supports, and articulated shaft joints are accounted for in a model comprising both deformable and rigid elements. The equilibrium equations for the beam elements, fuselage, and shaft elements; the coupling conditions between the boom equations and the equations of flexural and torsional vibration; the support conditions; and the coupling conditions between the tail-boom and shaft equations of motion are derived and applied to obtain the matrix equation of system dynamic equilibrium and the frequency equation. T.K.

A87-39951#

BOEING 360 - HELICOPTER HI-TECH

GRAHAM WARWICK Flight International (ISSN 0015-3710), vol. 131, April 18, 1987, p. 22-25.

An evaluation is made of the composite primary structures and aerodynamic configuration features that are incorporated in the Model 360 tandem-rotor technology demonstrator aircraft, as well as the performance gains expected from their use. A potential maximum speed of 240 kt is anticipated; emphasis on the reduction of vibration in order to reach that speed has led to the use of four-blade rotors, and the delay of advancing blade drag rise has required the use of VR 12 and 15 transonic airfoil sections. Blade cruise efficiency is thereby improved by 23 percent. The influence of design practices developed for the V-22 Osprey tilt-rotor aircraft is prominent in the Model 360. O.C.

A87-40200#

THE CASE OF AIRBUS A320 - PRODUCT DEVELOPMENT WITHOUT THE DRAWING BOARD? [BEISPIEL AIRBUS A320 - PRODUKTENTWICKLUNG OHNE REISSBRETT?]

W. RIECKMANN VDI-Z (ISSN 0042-1766), vol. 129, no. 3, March 1987, p. 10-14. In German.

The application of CAD/CAM techniques in the development of the A320 at MBB is described and illustrated with diagrams and sample graphics, summarizing a talk presented at a joint meeting of the VDI working groups on manufacturing technology and design, development, and marketing held in Stuttgart on December 9, 1986. CAD/CAM was used exclusively for the MBB-designed and manufactured A320 components, including pressurized cabin, rudder, landing flaps, interior furnishings, climate-control system, hydraulic and water systems, and electrical system. The personnel and hardware prerequisites for 100 percent CAD/CAM development are outlined; the structure of the CAD/CAM network is explained; the problems encountered and improvements introduced are discussed; and productivity and cost factors are considered. T.K.

A87-40218#

ON DAMAGE TOLERANCE DESIGN OF FUSELAGE STRUCTURE - CIRCUMFERENTIAL CRACKS

PIR M. TOOR (Bettis Atomic Power Laboratory, West Mifflin, PA) Engineering Fracture Mechanics (ISSN 0013-7944), vol. 26, no. 5, 1987, p. 771-782. refs

The design of a fail-safe fuselage structure for aircraft is considered, and linear elastic fracture mechanics is used to evaluate the damage tolerance capability of the fuselage for circumferential cracks under stresses from vertical bending of the fuselage. A model which includes the effects of frames, straps, and curvature is presented and is applied to a problem having typical military cargo aircraft fuselage structural elements. Air Force damage tolerance requirements are also considered. R.R.

A87-40923#

THE SERVICE LIFE OF THE L200 AIRCRAFT ACCORDING TO MEASUREMENTS OF CONDITIONS OF OPERATION IN THE USSR [ZIVOTNOSTI LETOUNU L 200 NA ZAKLADE MERENI PROVOZNICH PODMINEK V SSSR]

VACLAV KAHANEK Zpravodaj VZLU (ISSN 0044-5355), no. 1, 1987, p. 23-29. In Czech.

The loading spectra and average flight parameters of the L200 aircraft during operation in the USSR were determined in an effort to evaluate the service life of the aircraft. An analysis of the data along with supplementary fatigue tests lead to conclusions about the service life of the aircraft and to recommendations on aircraft utilization. B.J.

A87-41026#

TAIL ROTORS - WHICH WAY SHOULD THEY ROTATE?

R. W. PROUTY (McDonnell-Douglas Helicopter Co., Culver City, CA) Rotor and Wing International (ISSN 0191-6408), vol. 21, June 1987, p. 20, 22.

Wind tunnel tests have indicated that the main rotor of a helicopter reduces the tail rotor's vortex ring-state effects. The benefit of main rotor proximity appears to apply only to tail rotors that rotate with the blade closest to the main rotor swinging up. In right-sideward flight, the main rotor's tip vortices may be sucked into the tail rotor; in this case, flight is made demonstrably easier when the rotor blade closest to the main rotor goes up. The formulation of equations correlating theory with test data remains a challenge to helicopter aerodynamicists. O.C.

A87-42152#

AN ALGORITHM FOR SPECIFYING THE DIRECTRIX IN THE DESIGN OF TRANSITION SURFACES [ALGORITM ZADANIIA NAPRAVLIAIUSHCHEI LINII PRI PROEKTIROVANII SOPRIAGAIUSHCHIKH POVERKHNOSTEI]

V. A. OSIPOV, F. K. CHISTIAKOV, and A. A. DUBANOV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 1, 1987, p. 114-116. In Russian.

An algorithm for calculating transition surfaces, such as fillets, is proposed which is based on the structural-kinematic approach to the generation of cyclic surfaces. The method, which is valid for any analytically specified mated surfaces, is demonstrated by calculating a transition surface between a wing and a fuselage. A flow diagram of the algorithm is presented. V.L.

A87-42674#

STRUCTURAL ANALYSIS ASPECTS OF COMPOSITE HELICOPTER COMPONENTS

H. BANSEMIR (Messerschmitt-Boelkow-Blohm GmbH, Munich, West Germany) CASI, Canadian Symposium on Aerospace Structures and Materials, 3rd, Ottawa, Canada, June 9-11, 1986, Paper. 27 p. refs
(MBB-UD-480-86-OE)

An account is given of analytical methods for optimization of the stress level and the geometry of tail and main rotor blades in helicopters. Attention is given to the structural analysis of composite blades for bearingless rotors and to the stresses generated by composite rotor hub thermal effects. An analysis is also undertaken for composite sandwich structures used in fuselages, with a view to the behavior of bonded structures. O.C.

N87-23571# Joint Publications Research Service, Arlington, Va.

EFFECT OF SURFACE ROUGHNESS ON DRAG OF AIRCRAFT

R. I. ZUKAKISHVILI, A. M. ILLARIONOV, and V. YA. BELYAYEV *In its* USSR Report: Engineering and Equipment p 1 9 Mar. 1987 Transl. into ENGLISH from Soobshcheniya Akademii Nauk Gruzinskoy SSR (Tbilisi, USSR), v. 122, no. 2, May 1986 p 358-360 Original language document was announced in IAA as A87-14717
Avail: NTIS HC A06/MF A01

The effect of the roughness of a painted surface on the head resistance of an aircraft is investigated by using a physical model of flow past such a surface. It is found that a surface roughness of 2 to 10 microns has a noticeable effect on the head resistance of the aircraft and that the density of the surface projections determines the friction coefficient increment. It is further shown that the use of polyurethane coatings, rather than paint coatings, makes it possible to reduce the head resistance of the aircraft and its fuel consumption by 2%. IAA

N87-23609# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). Structures and Materials Panel.

AIRCRAFT DYNAMIC RESPONSE TO DAMAGED AND REPAIRED RUNWAYS

Loughton, England Mar. 1987 45 p Meeting held in Oberammergau, West Germany, 8-13 Sep. 1985
(AGARD-R-739; ISBN-92-835-0409-7) Avail: NTIS HC A03/MF A01

The dynamic response of aircraft operating from damaged and repaired runways is examined. The response of a simplified representation of an aircraft to two discrete disturbances is analyzed to see how the second disturbance modifies system behavior caused by the first disturbance. A mathematical model is provided which can be used for calculation of the dynamic response of aircraft structures operating on rough surfaces; a comparison is made between theoretical predictions for a YF16 aircraft and typical measurements from frequency response tests.

N87-23610# Air Force Wright Aeronautical Labs., Wright-Patterson AFB, Ohio. Structures and Dynamics Div.
INTERPRETATION IN TERMS OF THE RESPONSE OF A ONE DEGREE-OF-FREEDOM OSCILLATOR TO TWO SUCCESSIVE DISTURBANCES
JAMES J. OLSEN *In* AGARD Aircraft Dynamic Response to Damaged andRepaired Runways 22 p Mar. 1987
Avail: NTIS HC A03/MF A01

The dynamic response of an aircraft that taxies over two arbitrary disturbances, under the assumption that the aircraft can be represented as a linear, one degree-of-freedom system is explained. That analysis produced the concept of the BUMP MULTIPLIER which explicitly and simply determines whether a second discrete disturbance will amplify or attenuate the response from a first disturbance. The BUMP MULTIPLIER also simplifies the understanding and presentation of the results. While the assumptions are very severe, the resulting formulas can be very useful to guide more elaborate nonlinear calculations or to plan test programs. Author

N87-23611# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Goettingen (West Germany). Inst. of Aeroelasticity.
AN EXPERIMENTAL-ANALYTICAL ROUTINE FOR THE DYNAMIC QUALIFICATION OF AIRCRAFT OPERATING ON ROUGH RUNWAY SURFACES
R. FREYMANN *In* AGARD Aircraft Dynamic Response to Damaged and Repaired Runways 14 p Mar. 1987
Avail: NTIS HC A03/MF A01

A mathematical model to be used as a basis for analytical investigations to predict the dynamic structural response of flexible aircraft operating on rough runway surfaces is presented. It is shown how the structural parameters included in the aircraft generalized equations of motion are determined in a ground vibration test on the real aircraft structure and in additional tests on components of the undercarriage. The validation of the developed mathematical model is achieved by a comparison of typical results from frequency response tests and calculations performed on a YF-16 prototype fighter aircraft. Finally, the way in which the developed mathematical model can be used in combination with various systematic test procedures for the dynamic qualification process of aircraft operation on damages/repaired runways is indicated. Author

N87-23612# Air Force Inst. of Tech., Wright-Patterson AFB, Ohio. School of Engineering.
EVALUATION OF THE ANGLE OF ATTACK LIMITER OF THE F-16 C/D AIRCRAFT M.S. Thesis
ZEKI DIKILITAS Dec. 1986 311 p
(AD-A177941; AFIT/GE/ENG/86D-9) Avail: NTIS HC A14/MF A01 CSCL 01C

The angle-of-attack (AOA) limiter used in the present fighter aircraft can provide safe, head-up maneuvering capability up to full aerodynamic potential of the fighter. However, the F-16 aircraft flight control system limits the effective normal acceleration (g) command with the AOA. The AOA limiter utilized in the F-16 aircraft adversely impacts air-to-air tracking tasks. Therefore, it should be modified to improve this tracking capability. Two aircraft models are developed to evaluate current AOA limiter effects on the aircraft dynamics. The first model is a linear model which is developed in state space form for the F-16 from linearized aerodynamic data. This is accomplished at four points in the flight enveloped. The second model is a non-linear model which is developed using non-linear equations of motion and flight control system equations and then coded using PTRAN simulation language employed on SIMSTAR hybrid computer system at the Air Force Institute of Technology. After validation, these models are used for the evaluation of the AOA limiter. GRA

N87-23613# Cranfield Inst. of Tech., Bedford (England). Coll. of Aeronautics.
AN EXPERIMENTAL INVESTIGATION INTO METHC)S FOR QUANTIFYING HANG GLIDER AIRWORITHNESS PARAMETERS Summary Report
M. V. COOK and E. A. KILKENNY May 1987 27 p
(Contract GR/B94953)
(CAR-8705; ISBN-0-947767-58-4) Avail: NTIS HC A03/MF A01

A three year program of research was completed in which the principle activity was an experimental investigation of those aerodynamic, stability and control parameters which influence the airworthiness of the hang glider. An experimental test rig was used which enabled aerodynamic measurements to be made on full scale hang glider wings. Early experiments were aimed at obtaining quantitative data for a number of wings, whereas later tests were concerned with flow visualization on the flexible wing surfaces. The principle objectives of the work were to provide a base of aerodynamic data for a representative selection of hang glider wings to improve the theoretical understanding of hang glider aerodynamics, stability and control and to assist in developing the test rig as a routine airworthiness test facility. M.G.

N87-23614*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
FLIGHT INVESTIGATION OF THE EFFECTS OF AN OUTBOARD WING-LEADING-EDGE MODIFICATION ON STALL/SPIN CHARACTERISTICS OF A LOW-WING, SINGLE-ENGINE, T-TAIL LIGHT AIRPLANE
H. PAUL STOUGH, III, DANIEL J. DICARLO, and JAMES M. PATTON, JR. Jul. 1987 117 p
(NASA-TP-2691; L-16243; NAS 1.60:2691) Avail: NTIS HC A06/MF A01 CSCL 01A

Flight tests were performed to investigate the change in stall/spin characteristics due to the addition of an outboard wing-leading-edge modification to a four-place, low-wing, single-engine, T-tail, general aviation research airplane. Stalls and attempted spins were performed for various weights, center of gravity positions, power settings, flap deflections, and landing-gear positions. Both stall behavior and wind resistance were improved compared with the baseline airplane. The latter would readily spin for all combinations of power settings, flap deflections, and aileron inputs, but the modified airplane did not spin at idle power or with flaps extended. With maximum power and flaps retracted, the modified airplane did enter spins with abused loadings or for certain combinations of maneuver and control input. The modified airplane tended to spin at a higher angle of attack than the baseline airplane. Author

N87-23615*# Hamilton Standard, Windsor Locks, Conn.
DYNAMIC RESPONSE OF TWO COMPOSITE PROP-FAN MODELS ON A NACELLE/WING/FUSELAGE HALF MODEL Final Report
ARTHUR F. SMITH and BENNETT M. BROOKS Oct. 1986 157 p
(Contract NAS3-24088)
(NASA-CR-179589; NAS 1.26:179589; HSER-11058) Avail: NTIS HC A08/MF A01 CSCL 01C

Results are presented for blade response wind tunnel tests of two 62.2 cm diameter Prop-Fan (advanced turboprop) models with swept and unswept graphite/epoxy composite blades. Measurements of dynamic response were made with the rotors mounted on a simulated nacelle/wing/fuselage model, with varying tilt, at flow speeds up to 0.85 Mach number. The presence of the wing, downstream of the rotor, induced 1-P responses that were about twice those previously measured for an isolated nacelle installation. The swept blade had less 1-P response than the unswept (straight) blade. The 2-P response was significant for both blades, and was closely correlated to wing lift. Higher order response was not important for the straight blade, but possibly important for the swept blade near critical speeds, due to the proximity of the blade tips to the wing leading edge. Measurements are compared with theoretically based prediction. Correlations between calculated and measured 1-P response were good for the straight blade, and fair for the swept blade. Improvements to the calculation method were identified and implemented. Author

N87-24411*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

V/STOL AND STOL GROUND EFFECTS AND TESTING TECHNIQUES

R. E. KUHN *In its* Proceedings of the 1985 NASA Ames Research Center's Ground-Effects Workshop p 1-145 Feb. 1987

Avail: NTIS HC A19/MF A01 CSCL 01C

The ground effects associated with V/STOL operation were examined and an effort was made to develop the equipment and testing techniques needed for that understanding. Primary emphasis was on future experimental programs in the 40 x 80 and the 80 x 120 foot test sections and in the outdoor static test stand associated with these facilities. The commonly used experimental techniques are reviewed and data obtained by various techniques are compared with each other and with available estimating methods. These reviews and comparisons provide insight into the limitations of past studies and the testing techniques used and identify areas where additional work is needed. The understanding of the flow mechanics involved in hovering and in transition in and out of ground effect is discussed. The basic flow fields associated with hovering, transition and STOL operation of jet powered V/STOL aircraft are depicted. E.R.

N87-24421*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

THE GROUND EFFECTS OF A POWERED-LIFT STOL AIRCRAFT DURING LANDING APPROACH

VICTOR C. STEVENS *In its* Proceedings of the 1985 NASA Ames Research Center's Ground-Effects Workshop p 395-413 Feb. 1987

Avail: NTIS HC A19/MF A01 CSCL 01C

The effects of ground proximity on a powered lift STOL aircraft are presented. The data are from NASA's Quiet Short Haul Research Aircraft (QSRA) flown at landing approach airspeeds of less than 60 knots with an 80 lb/sq ft wing loading. These results show that the ground effect change in lift is positive and does significantly reduce the touchdown sink rate. These results are compared to those of the YC-14 and YC-15. The change in drag and pitching moment caused by ground effects is also presented. Author

N87-24445# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). Flight Mechanics Panel.

INTEGRATED DESIGN OF ADVANCED FIGHTERS

Loughton, England May 1987 213 p Lectures held in London, England, 1-2 Jun. 1987; in Lisbon, Portugal; and in Los Angeles, Calif., 23-24 Jun. 1987

(AGARD-LS-153; ISBN-92-835-1552-8) Avail: NTIS HC A10/MF A01

A general overview of the state of the art in modern fighter design is presented, with an introduction to the innovations of computer aided design evaluation to both preliminary design and the final optimization of the various design compromises. After the introduction reviewing the evolution of the modern fighter aircraft, the various stages of the total design problem is developed. The integration of requirements into the preliminary configuration of the design is followed by discussions of modern design techniques that are currently used to assess and validate the evolving configuration. The overall integrations process as applied to various current design challenges are considered including multi-role aircraft, shipborne operators and VSTOL and STOVL concepts.

N87-24446# Dornier-Werke G.m.b.H., Friedrichshafen (West Germany).

INTEGRATION OF AERODYNAMIC, PERFORMANCE, STABILITY AND CONTROL REQUIREMENTS INTO THE DESIGN PROCESS OF MODERN UNSTABLE FIGHTER AIRCRAFT CONFIGURATIONS

G. WEDEKIND and P. MANGOLD *In* AGARD Integrated Design of Advanced Fighters (date) 20 p May 1987

Avail: NTIS HC A10/MF A01

Already in the early design stage of a modern fighter aircraft development with usually unstable basic characteristics in pitch, a well balanced compromise between optimum performance and excellent handling qualities has to be found. This compromise must be based on sufficient margins for stability and control, maneuverability in terms of agility and economic aspects which usually are in contradiction to pure performance requirements as for example sustained/instantaneous turn rates and high specific excess power. Reasonable criteria deducted from flight mechanical and control law design point of view are discussed, which lead straight ahead towards a set of desirable longitudinal and lateral characteristics for the basic unaugmented aircraft. These requirements impose remarkable constraints for the aerodynamic design of a fighter and its elements like wing planform, strakes, vertical fins and horizontal tail size and location. The problems and possibilities to stay within the reasonable flight mechanical limits are demonstrated. Author

N87-24450# Avions Marcel Dassault-Breguet Aviation, Saint-Cloud (France).

DESIGN OPTIMIZATION FOR A FAMILY OF MULTI-ROLE COMBAT AIRCRAFT

JEAN-CLAUDE HIRONDE *In* AGARD Integrated Design of Advanced Fighters 23 p May 1987

Avail: NTIS HC A10/MF A01

The future multi-role combat aircraft design process is used as an example. At the early stage of the design, requirements of the French Air Force and Navy and other potential customers are studied very closely. Then the main technological improvements, from the existing aircraft, that are needed to meet these requirements are clearly defined. The improvements are achieved by an optimization process carried throughout each and all aircraft design disciplines, involving an intensive use of the very large range of design and tests tools available from the aircraft company and state research establishments. Because of the numerous technical innovations which will be introduced in the future combat aircraft, an in-flight demonstration aircraft was judged necessary. The RAFALE demonstration aircraft, and the evolution into a future family of multi-role specific versions, is presented. Author

N87-24451# McDonnell Aircraft Co., St. Louis, Mo. Aircraft Engineering.

DESIGN OPTIMIZATION OF FIGHTER AIRCRAFT

D. D. SNYDER *In* AGARD Integrated Design of Advanced Fighters 20 p May 1987

Avail: NTIS HC A10/MF A01

The explosion of digital computation capability over the last 30 years has transformed the military aircraft design process, and provided unprecedented opportunity for true optimization of selected configurations prior to production commitment. To date, this revolution has worked primarily to reduce risk in aircraft development. Today's new aircraft flies as expected, without unforeseen handling quirks or instability, and exploration of most, if not all the flight envelope is possible on the first flight. Digital flight simulation, sophisticated wind tunnel test techniques, and performance, structural and thermal modeling all combine to elevate confidence in a new design to a very high level. Another, as yet unrealized benefit is an enormous potential improvement in productivity and efficiency, and therefore cost, of the aircraft design and manufacturing process. Insight is provided into the modern aircraft development process from the perspective of a designer and builder of high performance military fighter, McDonnell Aircraft Co. Author

N87-24452# British Aerospace Aircraft Group, Kingston-upon-Thames (England).

V/STOL AND STOVL FIGHTER DESIGN

CLIFFORD L. BORE *In* AGARD Integrated Design of Advanced Fighters 20 p May 1987

Avail: NTIS HC A10/MF A01

A wide range of basing concepts, including dispersed land bases, small and very small ships, ski jump and Skyhook, are reviewed. The design of STOVL fighter aircraft is examined, starting from consideration of the engine and nozzles system, which is the heart of jet powered STOVL fighters. This leads to consideration of the nature of the aerodynamics of vertical landing, such as hot gas ingestion, jet induced suck-down and the ground/jets fountain. Then the special features of air intakes design are considered, followed by the special considerations of lifting-surface design. Finally, the special features of thrust vectoring in forward flight (VIFF), are considered. Author

N87-24453# Societe pour l'Equipment des Vehicules, Gosselies (Belgium).

ADVANCED FIGHTER DESIGN: OPERATIONAL EXPERIENCE AND FUTURE REQUIREMENTS

D. AGNEESSENS *In* AGARD Integrated Design of Advanced Fighters 14 p May 1987

Avail: NTIS HC A10/MF A01

The possibilities of the F84F, Mirage 5, the F104G and the F-16 are compared. The deficencies that they show for the mission for which they are employed are examined. Before these aircraft are analyzed, it is necessary to state in what role each they are employed. To do this, the requirements have to be considered. These are mostly imposed by NATO, but national requirements could also be considered. Due to the large variety of missions to be performed, in the air-to-air (A/A) or in the air-to-ground (A/G) roles, it is evident that non specialized aircraft will be used and also low cost aircraft will be chosen more and more often. This analysis is limited to the different aircraft which were or are still in use in European airforces or more generally in the European theater of operations. This theater is very demanding due to different factors such as the threat and the weather. The concept of multi-role aircraft, being considered as the ideal choice by many, is discussed as a response to the variety of requirements in the European theater. Another point that is discussed is pilot training in peace time. The use of simulators is mentioned to show how it is possible to maintain a high level of proficiency for the pilots. Author

N87-24454# Air Force Systems Command, Andrews AFB, Md. Test and Evaluation.

THE INTEGRATION AND OPERATIONAL SUITABILITY OF EMERGING TECHNOLOGIES FOR FUTURE FIGHTER AIRCRAFT: A PILOT'S PERSPECTIVE

JOHN M. HOFFMAN *In* AGARD Integrated Design of Advanced Fighters 9 p May 1987

Avail: NTIS HC A10/MF A01

The tactical air mission has become extremely challenging and complex due to improvements in ground defenses and sophistication of opposing threat air forces. To fight, survive, and win in this demanding environment, the capabilities must be developed which are needed by the tactical pilots to successfully counter the threat. Technological developments have fostered a host of new capabilities for application to future aircraft. A pilot's perspective on the development, integration, and application of these emerging technologies for the air superiority mission is provided. Of real concern is determining which capabilities will be most useful to the pilot, yet not overload or exceed his capacity to perform. Assessments are based on personal experiences in combat, in flight testing applications in current fighter aircraft, and on plans for incorporation in future fighter aircraft. The pilot/vehicle interface and enhanced pilot performance is the central focus, conditioned by operational suitability. Key factors include information or task saturation, situational awareness, physiological limitations, and cockpit designs. The concept of Fighter Battle Management is introduced. Author

N87-24455*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

SYMBOLIC GENERATION OF ELASTIC ROTOR BLADE EQUATIONS USING A FORTRAN PROCESSOR AND NUMERICAL STUDY ON DYNAMIC INFLOW EFFECTS ON THE STABILITY OF HELICOPTER ROTORS

T. S. R. REDDY Jun. 1986 113 p

(NASA-TM-86750; A-85227; NAS 1.15:86750) Avail: NTIS HC A06/MF A01 CSCL 01C

The process of performing an automated stability analysis for an elastic-bladed helicopter rotor is discussed. A symbolic manipulation program, written in FORTRAN, is used to aid in the derivation of the governing equations of motion for the rotor. The blades undergo coupled bending and torsional deformations. Two-dimensional quasi-steady aerodynamics below stall are used. Although reversed flow effects are neglected, unsteady effects, modeled as dynamic inflow are included. Using a Lagrangian approach, the governing equations are derived in generalized coordinates using the symbolic program. The program generates the steady and perturbed equations and writes into subroutines to be called by numerical routines. The symbolic program can operate on both expressions and matrices. For the case of hovering flight, the blade and dynamic inflow equations are converted to equations in a multiblade coordinate system by rearranging the coefficients of the equations. For the case of forward flight, the multiblade equations are obtained through the symbolic program. The final multiblade equations are capable of accommodating any number of elastic blade modes. The computer implementation of this procedure consists of three stages: (1) the symbolic derivation of equations; (2) the coding of the equations into subroutines; and (3) the numerical study after identifying mass, damping, and stiffness coefficients. Damping results are presented in hover and in forward flight with and without dynamic inflow effects for various rotor blade models, including rigid blade lag-flap, elastic flap-lag, flap-lag-torsion, and quasi-static torsion. Results from dynamic inflow effects which are obtained from a lift deficiency function for a quasi-static inflow model in hover are also presented. Author

N87-24456 British Aerospace Public Ltd. Co., Weybridge (England). Aerodynamics Dept.

QUIET AIRCRAFT STUDY. AERODYNAMIC CONSIDERATIONS OF PROPOSED SWEPT SHIELDED AIRCRAFT CONFIGURATIONS

Jul. 1982 38 p

(BAE-AERO/PROJ/087; BR72788; ETN-87-99824) Avail: Issuing Activity

It is shown that there may be handling problems associated with the change of trim with power and that the increased trimming losses have significant performance penalties at the larger take-off flap angles of swept shielded aircraft. While it does not appear that the proximity of the nacelles to the wing results in any intake design problems, the induced effects of the nacelles on the wing must be allowed for in the wing design. Further work is required to evaluate the implications on wing root design. A specification for a low speed wind tunnel model to investigate the induced power effects on the tail surfaces is given. ESA

N87-24457*# Sikorsky Aircraft, Stratford, Conn.

A ROTORCRAFT FLIGHT/PROPULSION CONTROL INTEGRATION STUDY Report, Jun. 1984 - Jun. 1986

D. G. C. RUTTLEDGE Nov. 1986 211 p

(Contract NAS3-24343)

(NASA-CR-179574; NAS 1.26:179574; SER-760606) Avail: NTIS HC A10/MF A01 CSCL 01C

An eclectic approach was taken to a study of the integration of digital flight and propulsion controls for helicopters. The basis of the evaluation was the current Gen Hel simulation of the UH-60A Black Hawk helicopter with a model of the GE T700 engine. A list of flight maneuver segments to be used in evaluating the effectiveness of such an integrated control system was composed, based on past experience and an extensive survey of the U.S. Army Air-to-Air Combat Test data. A number of possible features of an integrated system were examined and screened. Those that survived the screening were combined into a design that replaced the T700 fuel control and part of the control system in the UH-60A Gen Hel simulation. This design included portions of an existing pragmatic adaptive fuel control designed by the Chandler-Evans Company and an linear quadratic regulator (LQR) based N(p) governor designed by the GE company, combined with changes in the basic Sikorsky Aircraft designed control system. The integrated system exhibited improved total performance in many areas of the flight envelope. Author

N87-24458*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

MEASUREMENTS OF FLOW RATE AND TRAJECTORY OF AIRCRAFT TIRE-GENERATED WATER SPRAY

ROBERT H. DAUGHERTY and SANDY M. STUBBS Jul. 1987 118 p

(NASA-TP-2718; L-16195; NAS 1.60:2718) Avail: NTIS HC A06/MF A01 CSCL 01C

An experimental investigation was conducted at the NASA Langley Research Center to measure the flow rate and trajectory of water spray generated by an aircraft tire operating on a flooded runway. Tests were conducted in the Hydrodynamics Research Facility and made use of a partial airframe and a nose tire from a general aviation aircraft. Nose tires from a commercial transport aircraft were also used. The effects of forward speed, tire load, and water depth on water spray patterns were evaluated by measuring the amount and location of water captured by an array of tubes mounted behind the test tire. Water ejected from the side of the tire footprint had the most significant potential for ingestion into engine inlets. A lateral wake created on the water surface by the rolling tire can dominate the shape of the spray pattern as the distance aft of the tire is increased. Forward speed increased flow rates and moved the spray pattern inboard. Increased tire load caused the spray to become less dense. Near the tire, increased water depths caused flow rates to increase. Tests using a fuselage and partial wing along with the nose gear showed that for certain configurations, wing aerodynamics can cause a concentration of spray above the wing. Author

N87-24459*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

STATIC CALIBRATION OF THE RSRA ACTIVE-ISOLATOR ROTOR BALANCE SYSTEM Final Report

C. W. ACREE, JR. Mar. 1987 40 p

(NASA-TM-88211; A-86115; NAS 1.15:88211) Avail: NTIS HC A01/MF A01 CSCL 01C

The Rotor Systems Research Aircraft (RSRA) active-isolator system is designed to reduce rotor vibrations transmitted to the airframe and to simultaneously measure all six forces and moments generated by the rotor. These loads are measured by using a combination of load cells, strain gages, and hydropneumatic active isolators with built-in pressure gages. The first static calibration of the complete active-isolator rotor balance system was performed in 1983 to verify its load-measurement capabilities. Analysis of the data included the use of multiple linear regressions to determine calibration matrices for different data sets and a hysteresis-removal algorithm to estimate in-flight measurement errors. Results showed that the active-isolator system can fulfill most performance predictions. The results also suggested several possible improvements to the system. Author

N87-24460*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

HELICOPTER HAVING A DISENGAGEABLE TAIL ROTOR Patent Application

HENRY L. KELLEY, inventor (to NASA) and JOHN C. WILSON, inventor (to NASA) 23 Apr. 1987 14 p

(NASA-CASE-LAR-13609-1; NAS 1.71:LAR-13609-1; US-PATENT-APPL-SN-041387) Avail: NTIS HC A02/MF A01 CSCL 01C

A helicopter is provided with a tail rotor which can be braked within a predetermined range of speeds, and stopped and locked at a predetermined speed. The helicopter includes a tail portion having a vertical fin extending therefrom. The vertical fin has a rudder movably attached thereto and the tail rotor is rotatably attached to one side of the vertical fin. The braking and stopping of the tail rotor can be performed automatically or manually from the cockpit. A brake and clutch system is provided in a main portion of the helicopter and controls the tail rotor. The rudder becomes operative when the tail rotor is slowed, stopped and locked so as to provide fine control of the helicopter especially at high speeds. Thus, the helicopter can fly at higher speeds without incurring aerodynamic loads thereon which occur at high speeds. In addition to the reduced noise from the helicopter with the tail rotor stopped, the safety of the helicopter, especially when boarding and deplaning passengers during emergency situations, is increased. NASA

N87-24461*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

IMPROVED CONTROL SURFACE ACTUATOR Patent Application

GERHARD E. SEIDEL, inventor (to NASA) (Boeing Co., Renton, Wash.) 23 Mar. 1987 10 p

(NASA-CASE-LAR-12852-1; NAS 1.71:12852-1; US-PATENT-APPL-SN-028832) Avail: NTIS HC A02/MF A01 CSCL 01C

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

06

AIRCRAFT INSTRUMENTATION

Includes cockpit and cabin display devices; and flight instruments.

A87-39462*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.

TWO-COLOR SHORT-PULSE LASER ALTIMETER MEASUREMENTS OF OCEAN SURFACE BACKSCATTER

JAMES B. ABSHIRE and JAN F. MCGARRY (NASA, Goddard Space Flight Center, Greenbelt, MD) Applied Optics (ISSN 0003-6935), vol. 26, April 1, 1987, p. 1304-1311. refs

The timing and correlation properties of pulsed laser backscatter from the ocean surface have been measured with a two-color short-pulse laser altimeter. The Nd:YAG laser transmitted 70- and 35-ps wide pulses simultaneously at 532 and 355 nm at nadir, and the time-resolved returns were recorded by a receiver with 800-ps response time. The time-resolved backscatter measured at both 330-m and 1291-m altitudes showed little pulse broadening due to the submeter laser spot size. The differential delay of the 355-nm and 532-nm backscattered waveforms were measured with a rms error of about 75 ps. The change in aircraft altitudes also permitted the change in atmospheric pressure to be estimated by using the two-color technique. Author

A87-41404#

INTEGRATED COMMUNICATIONS NAVIGATION IDENTIFICATION AVIONICS MOVES INTO THE NEXT GENERATION AVIONICS

PETER CAMANA (TRW, Inc., TRW Military Electronics and Avionics Div., San Diego, CA) IN: PLANS '86 - Position Location and Navigation Symposium, Las Vegas, NV, Nov. 4-7, 1986, Record . New York, Institute of Electrical and Electronics Engineers, 1986, p. 510-514.

The design of the Integrated Communications Navigation Identification Avionics (ICNIA) is described. The ICNIA architecture is flexible, and the flexibility is implemented with RF switches and common buses. The ICNIA terminal contains 28 different module types all interconnected to support rapid reconfiguration for high Communications Navigation Identification (CNI) availability. These module types can be classified as either RF standard modules or digital standard modules. The software used in the ICNIA is examined. The information an applicant needs to include in the request, and methods for providing adequate security for the system are considered. I.F.

A87-41405#
UNIVERSAL RECEIVER FOR ICNIA
FRANK W. SMEAD (ITT, ITT Avionics Div., Nutley, NJ) IN: PLANS '86 - Position Location and Navigation Symposium, Las Vegas, NV, Nov. 4-7, 1986, Record . New York, Institute of Electrical and Electronics Engineers, 1986, p. 515-519.

The universal receiver for the Integrated Communication Navigation Identification Avionics (ICNIA) is examined. The receiver is designed to allow a common type of receiver module to be used throughout the ICNIA terminal for all signal types. The univeral receiver has a broad programmable tuning range from 2 MHz to 2 GHz, handles waveforms ranging from narrow-band conventional voice to fast frequency hopping and spread spectrum antijam signals, provides a programmable bandwidth from 6 KHz to over 10 MHz, has a dynamic range of greater than 110 dB; and a high-resolution tuning down to 2 Hz. GaAs prescalers and SAW devices are used in the receiver; the functions of each of these components are discussed. The filter banks, which provide the flexibility for the receiver, and the fast and slow hopping frequency synthesizers are described. Block diagrams of the univeral receiver and the slow and fast hopping frequency synthesizers are presented. I.F.

A87-41599#
THE BIG PICTURE
STEVEN L. THOMPSON Air and Space (ISSN 0886-2257), vol. 2, Apr.-May 1987, p. 74-83.

The visually coupled airborne systems simulator (VCASS) which resembles a huge Darth Vader helmet is described. With the VCASS, the pilot observes symbols generated by a computer and projected directly into his/her field of vision inside the helmet. The first stage involves the development (by 1990) of a functional system that includes head-aimed weapons together with a display of flight situation and navigation data plus weapon delivery and sensor control. The next stage is the addition of three-dimensional sound cues and voice control of system functions. The final stage is called 'the pilot's associate'. Ground-based VCASS applications are discussed as well. K.K.

A87-42183*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
THE DEVELOPMENT OF AN AIR MOTION MEASUREMENT SYSTEM FOR NASA'S ELECTRA AIRCRAFT
J. RITTER, S. BECK, R. HEDGEPETH, J. BARRICK (NASA, Langley Research Center, Hampton, VA), C. BUTLER (Old Dominion University, Norfolk, VA) et al. IN: Symposium on Meteorological Observations and Instrumentation, 6th, New Orleans, LA, Jan. 12-16, 1987, Preprints. Boston, MA, American Meteorological Society, 1987, p. 140-143. refs

The development of the Turbulent Air Motion Measurement System (TAMMS), which is to measure dynamical and photochemical processes over a wide range of spatial and temporal scales, is examined. The composition and operation of the TAMMS subsystems, which include (1) fast-response meteorological sensors; (2) a boom/inertial navigation system; (3) baseline meteorological sensors; (4) an analog/digital interface; (5) control and data acquisition; and (6) data/reduction and spectral analysis software, are described. The planned flight testing and calibration of the TAMMS are discussed. The TAMMS platform wil be able to estimate the turbulent fluxes of heat, moisture, momentum, and any chemical species for which fast-response instrumentation is available. I.F.

A87-42184*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
THE USE OF A NUMERICAL FILTER TO CORRECT AIRBORNE TEMPERATURE MEASUREMENTS FOR THE EFFECTS OF SENSOR LAG
JOHN A. RITTER, G. LOUIS SMITH (NASA, Langley Research Center, Hampton, VA), and DONALD R. CAHOON (OAO Corp., Hampton, VA) IN: Symposium on Meteorological Observations and Instrumentation, 6th, New Orleans, LA, Jan. 12-16, 1987, Preprints. Boston, MA, American Meteorological Society, 1987, p. 261-264.

A numerical filter for transforming measured temperature signals into a close approximation of the actual temperature signal is described. The filter is derived by minimizing the mean-square error of the system, and assuming a knowledge of the characteristics of the sensing element and its housing. The equation representing the frequency-response function of the numerical filter is given. Input and output spectra for a filter applied to a case with negligible noise and a noise level of 1.5 percent of the total power in the input spectrum are analyzed, and the numerical weights for these two cases are calculated. Phase angle and gain for the entire system are examined. It is noted that the filter can enhance spectral components as high as 8 Hz with little phase and gain degradation over the bandwidth. I.F.

A87-42435#
AERO/OPTICS EFFECTS OF AIRBORNE LASER TURRETS
A. J. LADERMAN, W. D. MOTOOKA, and D. D. BARBER (Ford Aerospace and Communications Corp., Newport Beach, CA) AIAA, Fluid Dynamics, Plasma Dynamics, and Lasers Conference, 19th, Honolulu, HI, June 8-10, 1987. 12 p. refs
(Contract F29601-79-C-0010; F29601-82-C-0005)
(AIAA PAPER 87-1397)

Aerodynamically induced beam degradation in typical airborne laser turrets is analyzed with allowance for the influence of the local aerodynamic flow field. The analysis is restricted to forward look angles and to laser turrets with a material window; it assumed that the flow over the forward portion of the turret is attached. It is shown that the optical degradation arising from boundary layer turbulence is negligible and that aero/optic effects are dominated by the inviscid flow over the turret. It is noted that significant improvements can be made in the optical quality with modest adaptive optical elements. K.K.

A87-42629*# Tennessee Univ., Tullahoma.
A FLIGHT EXPERT SYSTEM (FLES) FOR ON-BOARD FAULT MONITORING AND DIAGNOSIS
M. ALI, D. A. SCHARNHORST, C. S. AI, and H. J. FERBER (Tennessee, University, Tullahoma) IN: Applications of artificial intelligence III, Proceedings of the Meeting, Orlando, FL, Apr. 1-3, 1986 . Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1986, p. 58-61. FAA-supported research. refs
(Contract NAG1-513)

The increasing complexity of modern aircraft creates a need for a larger number of caution and warning devices. But more alerts require more memorization and higher work loads for the pilot and tend to induce a higher probability of errors. Therefore, an architecture for a flight expert system (FLES) to assist pilots in monitoring, diagnosing and recovering from in-flight faults has been developed. A prototype of FLES has been implemented. A sensor simulation model was developed and employed to provide FLES with the airplane status information during the diagnostic process. The simulator is based partly on the Lockheed Advanced Concept System (ACS), a future generation airplane, and partly on the Boeing 737, an existing airplane. A distinction between two types of faults, maladjustments and malfunctions, has led us to take two approaches to fault diagnosis. These approaches are evident in two FLES subsystems: the flight phase monitor and the sensor interrupt handler. The specific problem addressed in these subsystems has been that of integrating information received from multiple sensors with domain knowledge in order to assess abnormal situations during airplane flight. This paper describes the reasons for handling malfunctions and maladjustments separately and the use of domain knowledge in the diagnosis of each. Author

N87-23572# Joint Publications Research Service, Arlington, Va.
PRINCIPLES OF DATA DISPLAY IN AVIATION INSTRUMENTS
P. A. KOVALENKO and V. M. KUZNETSOV *In its* USSR Report: Engineering and Equipment p 2 9 Mar. 1987 Transl. into ENGLISH from Tekhnicheskaya Estetika (Moscow, USSR), no. 4, Apr. 1986 p 4-6
Avail: NTIS HC A06/MF A01

Approaches to the ergonomical updating of aviation instrument displays are reviewed, and emphasis is given to the efficacious organization of data in composite instruments. The KI composite indicator which shows the positions of the elevators, rudder, stabilizer, ailerons, and spoilers is described. A redesign based on displaying the silhouette of the plane in foreshortened view (from behind) in such a way as to eliminate unnecessary explanatory text, with one optimum foreshortening of all control surfaces and one standard graphic language, has resulted in the modern MKI version of this instrument having faster readout, lower error rate, and ease of memorization. Author

N87-23616*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
HIGH-ANGLE-OF-ATTACK PNEUMATIC LAG AND UPWASH CORRECTIONS FOR A HEMISPHERICAL FLOW DIRECTION SENSOR
STEPHEN A. WHITMORE, JENNIFER HEEG, TERRY J. LARSON, L. J. EHERNBERGER, FLOYD W. HAGEN, and RICHARD V. DELEO May 1987 21 p
(NASA-TM-86790; H-1314; NAS 1.15:86790) Avail: NTIS HC A02/MF A01 CSCL 01D

As part of the NASA F-14 high angle of attack flight test program, a nose mounted hemispherical flow direction sensor was calibrated against a fuselage mounted movable vane flow angle sensor. Significant discrepancies were found to exist in the angle of attack measurements. A two fold approach taken to resolve these discrepancies during subsonic flight is described. First, the sensing integrity of the isolated hemispherical sensor is established by wind tunnel data extending to an angle of attack of 60 deg. Second, two probable causes for the discrepancies, pneumatic lag and upwash, are examined. Methods of identifying and compensating for lag and upwash are presented. The wind tunnel data verify that the isolated hemispherical sensor is sufficiently accurate for static conditions with angles of attack up to 60 deg and angles of sideslip up to 30 deg. Analysis of flight data for two high angle of attack maneuvers establishes that pneumatic lag and upwash are highly correlated with the discrepancies between the hemispherical and vane type sensor measurements. Author

N87-23617*# Charles River Analytics, Inc., Cambridge, Mass.
A DUAL-PROCESSOR MULTI-FREQUENCY IMPLEMENTATION OF THE FINDS ALGORITHM Final Report
PANKAJ M. GODIWALA and ALPER K. CAGLAYAN Apr. 1987 59 p
(Contract NAS1-17719)
(NASA-CR-178252; R-8610; NAS 1.26:178252; FR-2) Avail: NTIS HC A04/MF A01 CSCL 01D

This report presents a parallel processing implementation of the FINDS (Fault Inferring Nonlinear Detection System) algorithm on a dual processor configured target flight computer. First, a filter initialization scheme is presented which allows the no-fail filter (NFF) states to be initialized using the first iteration of the flight data. A modified failure isolation strategy, compatible with the new failure detection strategy reported earlier, is discussed and the performance of the new FDI algorithm is analyzed using flight recorded data from the NASA ATOPS B-737 aircraft in a Microwave Landing System (MLS) environment. The results show that low level MLS, IMU, and IAS sensor failures are detected and isolated instantaneously, while accelerometer and rate gyro failures continue to take comparatively longer to detect and isolate. The parallel implementation is accomplished by partitioning the FINDS algorithm into two parts: one based on the translational dynamics and the other based on the rotational kinematics. Finally, a multi-rate implementation of the algorithm is presented yielding significantly low execution times with acceptable estimation and FDI performance. Author

N87-24462# European Space Agency, Paris (France).
LABORATORY TESTS OF THE SENSORS OF THE STEINHEIL-LEAR SIEGLER STRAPDOWN MEASUREMENT UNIT MODEL 1903-SB FOR MODEL ATTITUDE MEASUREMENTS IN A WIND TUNNEL. VOLUME 2 OF THE DOCUMENTATION ON THE MODEL ATTITUDE MEASUREMENT SYSTEM (MAMS) FOR THE GERMAN/DUTCH WIND TUNNEL (DNW)
VOLKER WETZIG and EGMAR LUEBECK Dec. 1986 70 p
Transl. into ENGLISH of "Labortests der Sensoren des Strapdown-Systems Model 1903-SB der Firma Steinheil-Lear-Siegler zur Lagemessung von Modellen im Windkanal" DFVLR, Brunswick (West Germany), Apr. 1986 Original language document was previously announced as N87-14682
(ESA-TT-1017-VOL-2; DFVLR-MITT-86-15-VOL-2; ETN-87-99854)
Avail: NTIS HC A04/MF A01; orginal German version available from DFVLR, Cologne, West Germany DM 26

Laboratory tests of the sensors for the Model Attitude Measurement System (MAMS) were performed. The sensor units, the test equipment, and the data acquisition are discussed. The sensor tests included rate tests for the investigation of the gyroscope scale factors and measuring axis misalignments, multiposition tests to determine constant and g-dependent gyroscope drift and to calibrate accelerometers, as well as stability tests to evaluate gyroscope drift variations. The results are given in tables with coefficients for error compensation, and with indications concerning short and longterm variations of the coefficients and measured values. ESA

07

AIRCRAFT PROPULSION AND POWER

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

A87-39266#
BASIC ANALYSES FOR OPTIMUM PROPULSION EFFICIENCY OF A COUNTER ROTATING ATP
TOMOARI NAGASHIMA and TAKEICHIRYO HIROSE Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 35, no. 397, 1987, p. 102-107. In Japanese, with abstract in English. refs

To clarify the effects of wake contraction, swirl velocity and mutual interactions on the cruising performances of a counter rotating advanced turboprop fundamental analyses based on the generalized momentum theory were carried out. Assuming a linear interaction scheme, the optimum propulsion efficiency and the wake geometry which minimize the total induced losses for a given thrust were established as solutions of a calculus of variations problems. The optimum combinations of operating parameters such as the thrust sharing ratio, the power sharing ratio and the disk area ratio between fore and aft propellers were also specified, and their dependency upon the axial velocity, the total thrust level and the axial spacing were revealed. It was understood that, in addition to the counter-rotating effect of propellers, the upwash effect of the contracted top propeller wake on the outer part of the bottom propeller disk plays a fundamental role for improving the propulsion efficiency of a counter-rotating advanced turboprop. Author

A87-39274#

PORSCHE - THE WARM-UP LAP IS OVER

ROBIN BLECH Flight International (ISSN 0015-3710), vol. 131, April 4, 1987, p. 21-24.

The PFM.3200 is a six-cylinder reciprocating engine of 3.2-l displacement which is to become commercially available in avgas/mogas 210-hp and avgas 217-hp versions. A 245-hp turbocharged variant is also under development. Single power-level control is featured, together with an automatic fuel injection system that compensates for changes in altitude and a ducted fan cooling system whose throughflow is proportional to engine power in order to preclude thermal shock. Attention is given to the various changes undertaken simultaneously by the single-lever engine control. O.C.

A87-39814#

EFFECTS OF ALTERNATIVE FUELS ON IGNITION LIMITS OF THE J85 ANNULAR COMBUSTOR

T. A. JARYMOWYCZ (Pennsylvania State University, University Park) and A. M. MELLOR (Drexel University, Philadelphia, PA) Journal of Propulsion and Power (ISSN 0748-4658), vol. 3, May-June 1987, p. 283-288. refs

(Contract N00140-84-D-3704)

Recent studies on ignition limits in gas-turbine engines have focused on alternative fuels and their effects. New tests reported here at the Naval Air Propulsion Center (NAPC) utilized five fuels and systematic increments of combustor inlet conditions to establish data for the General Electric J85-21 gas-turbine combustor. A characteristic time model for ignition was used to scale inlet conditions to those used by GE and to reduce the data. The resulting correlation, including both NAPC and GE data, is rearranged to predict loss in engine altitude for relight with a fuel more viscous than JP-4. Author

A87-40847#

DEVELOPMENT OF THE F3-IHI-30 TURBOFAN ENGINE

Ishikawajima-Harima Engineering Review (ISSN 0578-7904), vol. 27, Jan. 1987, p. 36-41. In Japanese, with abstract in English.

The F3-IHI-30 turbofan engine developed for the XT-4 intermediate trainer is described. The engine is a two-spool, low-bypass-ratio turbofan engine with a thrust of 16.38 kN. The engine was designed and tested in accordance with the modified MIL-E-5007D so that requirements of the intermediate trainer and environmental conditions in Japan are reflected. Through both the preliminary flight rating and qualification tests, it has been demonstrated that the engine can withstand bird and ice ingestion, low-cycle-fatigue, endurance, inlet distortion tests, etc. The flight test of the XT-4 powered by two XF3-30 engines is being successfully conducted. The engine is qualified for series production. Author

A87-41901#

TIME OPTIMIZATION OF THE CYCLIC TESTING OF THE FULL-SCALE PARTS OF GAS TURBINE ENGINES [OPTIMIZATSIIA PO VREMENI TSIKLICHESKIKH ISPYTANII NATURNYKH DETALEI GTD]

V. I. TSEITLIN and D. G. FEDORCHENKO Problemy Prochnosti (ISSN 0556-171X), March 1987, p. 3-5. In Russian.

A method for the bench testing of the parts and components of gas turbine engines is described whereby the minimum cycle stresses are selected in such a way as to reduce the testing time, making the testing more cost effective. Testing of the compressor disk of a gas turbine engine is used as an example to demonstrate the method. The principal steps of the test procedure are described, and test results are presented. V.L.

A87-41911#

A MATHEMATICAL MODEL FOR ESTIMATING THE NATURAL VIBRATION FREQUENCY OF THE DISKS OF GAS TURBINE ENGINES IN THE CASE OF A SLIGHT CHANGE IN THE DISK THICKNESS [MATEMATICHESKAIA MODEL' DLIA OTSENKI CHASTOTY SOBSTVENNYKH KOLEBANII DISKOV GTD PRI MALOM IZMENENII TOLSHCHINY POLOTNA]

V. S. LUK'IANOV and G. A. KHODAKOV (Zaporozhskoe Proizvodstvennoe Ob'edinenie Motorostroitel', Zaporozhe, Ukrainian SSR) Problemy Prochnosti (ISSN 0556-171X), March 1987, p. 116-118. In Russian. refs

Experimental data and results of a correlation-regression analysis are used to develop a mathematical model which provides a convenient way of estimating changes in the frequency of the natural vibrations of a gas-turbine disk due to local changes in the disk thickness. The formulas presented here are applicable to the disks of most gas-turbine engines. V.L.

A87-42145#

EFFECT OF NONUNIFORM EXCESS AIR RATIO DISTRIBUTION IN THE AFTERBURNER ON THE SPECIFIC PULSE OF THE NOZZLE AND THE EFFECTIVE HEAT RELEASE COEFFICIENT [VLIIANIE NERAVNOMERNOSTI RASPREDELENIIA KOEFFITSIENTA IZBYTKA VOZDUKHA V FORSAZHNOI KAMERE NA UDEL'NYI IMPUL'S SOPLA I EFFEKTIVNYI KOEFFITSIENT TEPLOVYDELENIIA]

V. N. GRUZDEV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 1, 1987, p. 97-99. In Russian. refs

The effect of the nonuniform distribution of the excess air ratio in the afterburner of a jet engine on the specific pulse of the nozzle and on the effective heat-release coefficient is determined analytically for a known dependence of the chemical completeness of combustion on the local excess air ratio. With reference to a specific example, it is shown that the nonuniformity of excess-air-ratio distribution in the afterburner leads to a decrease in the nozzle pulse (up to 9.3 percent) and to large losses (up to 35 percent) in effective heat release even in the case of thermodynamically complete fuel combustion. V.L.

A87-42149#

CALCULATION OF THE RADIAL CLEARANCE CHRONOGRAM FOR THE COMPRESSORS OF AIRCRAFT GAS TURBINE ENGINES [METOD RASCHETA KHRONOGRAMMY RADIAL'NYKH ZAZOROV V KOMPRESSORAKH AVIATSIONNYKH GTD]

V. I. LOKAI, R. G. SAGADEEV, and V. I. PROKOP'EV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 1, 1987, p. 106-108. In Russian.

The calculation of the radial clearance chronogram for the compressor of a gas turbine engine at an early design stage is essential for the optimal control of the radial clearances during engine operation. A method for calculating the radial clearance chronogram is presented which includes the following three independent procedures: (1) determination of changes in the outer disk radius, (2) determination of changes in the blade height, and (3) determination of changes in the inner radius of the housing. The method has been implemented in a computer program written in FORTRAN-IV. V.L.

A87-42153#

CLASSIFICATION OF MATHEMATICAL MODELS OF GAS TURBINE ENGINES. II [KLASSIFIKATSIIA MATEMATICHESKIKH MODELEI GTD. II]

A. P. TUNAKOV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 1, 1987, p. 116, 117. In Russian. refs

A classification of mathematical models of gas turbine engines is proposed whereby such models are divided into six classes in accordance with the level of complexity of the description of thermodynamic processes taking place in the hot flow path. The classification proposed here also applies to other modules of the mathematical models that are not directly related to gas turbine components and processes, such the weight and dimensions module and the cost-effectiveness module. The classification has been incorporated into a set of computer programs for calculating gas turbine engines. V.L.

A87-42446#
APPLICATION OF COMPUTATIONAL DESIGN TECHNIQUES TO THE DEVELOPMENT OF SCRAMJET ENGINES
D. M. VAN WIE, M. E. WHITE, and P. J. WALTRUP (Johns Hopkins University, Laurel, MD) AIAA, Fluid Dynamics, Plasma Dynamics, and Lasers Conference, 19th, Honolulu, HI, June 8-10, 1987. 13 p. refs
(AIAA PAPER 87-1420)

A recent resurgence in the interest in hypersonic flight of missiles and aircraft has focused attention on the development of supersonic combustion ramjet (scramjet) engines. Maturing technologies in the area of computational fluid dynamics are proving to be powerful tools for the design and analysis of highly efficient scramjet engine flow paths. The application of CFD techniques to scramjet engine design is dicussed from the point of view of a design methodology for the complete engine flowfield including inlets, combustors and nozzles. CFD codes are integrated within numerical optimization schemes in a fully coupled procedure to design optimal inlet and nozzle contours. Methods for analysis of the highly complex, chemically reacting flow in the combustor are discussed. Example cases are presented for optimal inlets and nozzles designed using numerical optimization coupled with simple computational techniques, and the prospects for integration of higher order techniques are discussed. Author

N87-23577# Joint Publications Research Service, Arlington, Va.
DEVELOPMENT OF MODEL DESCRIBING UNSTABLE OPERATION OF TURBOCOMPRESSOR AND DESIGN OF ANTISURGING PROTECTION FOR GAS TURBINE ENGINE
M. M. SHAKIRYANOV *In its* USSR Report: Engineering and Equipment p 5 9 Mar. 1987 Transl. into ENGLISH from Izvestiya Vysshikh Uchebnykh Zavedeniy: Aviatsionnaya Tekhnika (Kazan, USSR), no. 1, Jan. - Mar. 1986 p 61-66
Avail: NTIS HC A06/MF A01

Unstable operation of an acoustical mechanical system which consists of a turbocompressor and a receiver with connecting pipes and a throttle is described by a mathematical model which includes four equations of state for air as an ideal gas in each of four locations within the system. On the basis of this model are established the surge characteristics of such a system, its stability region according to the Hurwitz criterion, and the conditions for gas dynamic stability. A pneumoelectronic system is then designed accordingly for protection of a gas turbine engine against surges. The system consists of three pressure transducers and one temperature transducer, two threshold devices, two computers and a function converter, and three final control elements between engine and guide vane array, engine and air bypass, and engine and fuel cutoff valve. Author

N87-23580# Joint Publications Research Service, Arlington, Va.
EFFECTIVENESS OF BALANCING FLEXIBLE ROTARY COMPRESSOR VANES ON LOW-SPEED BALANCING MACHINE
A. I. GLEYZER and V. A. BULYCHEV *In its* USSR Report: Engineering and Equipment p 7 9 Mar. 1987 Transl. into ENGLISH from Izvestiya Vysshikh Uchebnykh Zavedeniy: Aviatsionnaya Tekhnika (Kazan, USSR), no. 1, Jan. - Mar. 1986 p 15-19 Original language document was announced in IAA as A86-43379
Avail: NTIS HC A06/MF A01

A method for calculating the efficiency of the low-cycle balancing of flexible rotors on acceleration-type balancing machines is proposed. The method includes a probabilistic estimation of the residual unbalance and a calculation of the limiting level of support vibrations or rotor deflections. The data obtained are compared with norms of residual vibrations permitted under low-cycle balancing. IAA

N87-23582# Joint Publications Research Service, Arlington, Va.
FLOW OF GAS THROUGH TURBINE STAGE WITH SPHERICAL NOZZLE SEGMENT
A. I. ARKHIPOV, M. K. MAKSUTOVA, and YU. V. STRUNKIN *In its* USSR Report: Engineering and Equipment p 8 9 Mar. 1987 Transl. into ENGLISH from Izvestiya Vysshikh Uchebnykh Zavedeniy: Aviatsionnaya Tekhnika (Kazan, USSR), no. 1, Jan. - Mar. 1986 p 8-11 Original language document was announced in IAA as A86-43377
Avail: NTIS HC A06/MF A01

The characteristics of the structure behind the nozzle box are investigated. It is shown that the spherical flow-through part leads to a deflection of the flow from the periphery to the root, resulting in a greater energy loss in the peripheral zone. This flow deflection can lead to separation in this region, particularly for a large axial gap. Experimental results indicate that energy losses in the peripheral zone of a nozzle cascade are significantly greater than those in the root zone. IAA

N87-23618# Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.
ACTA AERONAUTICA ET ASTRONAUTICA SINICA
7 Apr. 1987 232 p Transl. into ENGLISH from Hang Kong Xuebao (China), v. 6, no. 3, 1985 p 201-300
(AD-A179673; FTD-ID(RS)T-1246-85) Avail: NTIS HC A11/MF A01 CSCL 13H

This paper reviews the current situation and the history of development of cast turbine blades of Chinese aircraft engines for nearly three decades since 1956 and sums up the cast high-temperature alloys and casting methods which were provided by the materials and casting scientific and technical personnel during this period which have met the demands of aircraft engines. Remarkable successes have been made in many fields such as cast rotor blades, ceramic cores for hollow blades, research into dispersion-strengthened alloys, and computer-based quality control, etc. With a view to future development of high performance engines this paper proposes research on ceramic and refractory materials to meet the following requirements: (1) increased operating temperature; (2) enhanced surface stability; and (3) superior mechanical properties. GRA

N87-23619*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
HIGHLY INTEGRATED DIGITAL ELECTRONIC CONTROL: DIGITAL FLIGHT CONTROL, AIRCRAFT MODEL IDENTIFICATION, AND ADAPTIVE ENGINE CONTROL
JENNIFER L. BAER-RIEDHART and ROBERT J. LANDY (McDonnell Aircraft Co., St. Louis, Mo.) Mar. 1987 16 p Presented at the AIAA Guidance and Control Conference, Snowmass, Colo., 19-21 Aug. 1985
(NASA-TM-86793; H-1318; NAS 1.15:86793; AIAA-PAPER-85-1877) Avail: NTIS HC A02/MF A01 CSCL 21E

The highly integrated digital electronic control (HIDEC) program at NASA Ames Research Center, Dryden Flight Research Facility is a multiphase flight research program to quantify the benefits of promising integrated control systems. McDonnell Aircraft Company is the prime contractor, with United Technologies Pratt and Whitney Aircraft, and Lear Siegler Incorporated as major subcontractors. The NASA F-15A testbed aircraft was modified by the HIDEC program by installing a digital electronic flight control system (DEFCS) and replacing the standard F100 (Arab 3) engines with F100 engine model derivative (EMD) engines equipped with digital electronic engine controls (DEEC), and integrating the DEEC's and DEFCS. The modified aircraft provides the capability for testing many integrated control modes involving the flight controls, engine controls, and inlet controls. This paper focuses on the first two phases of the HIDEC program, which are the digital flight control system/aircraft model identification (DEFCS/AMI) phase and the adaptive engine control system (ADECS) phase. Author

N87-23621# Indian Inst. of Tech., New Delhi.
TURBOMACHINE BLADE VIBRATION
J. S. RAO *In* Vibration Inst. The Shock and Vibration Digest, Vol. 19, No. 5 p 3-10 May 1987
Avail: NTIS HC A04/MF A01

Literature since 1983 is reviewed for free vibrations, excitation forces of blades, and blade response. Author

N87-23622*# Pratt and Whitney Aircraft Group, East Hartford, Conn. Engineering Div.
LIFE PREDICTION AND CONSTITUTIVE MODELS FOR ENGINE HOT SECTION ANISOTROPIC MATERIALS Annual Status Report
G. A. SWANSON, I. LINASK, D. M. NISSLEY, P. P. NORRIS, T. G. MEYER, and K. P. WALKER Apr. 1987 166 p
(Contract NAS3-23939)
(NASA-CR-179594; NAS 1.26:179594; PWA-5968-47; ASR-2)
Avail: NTIS HC A08/MF A01 CSCL 21E

The results are presented of a program designed to develop life prediction and constitutive models for two coated single crystal alloys used in gas turbine airfoils. The two alloys are PWA 1480 and Alloy 185. The two oxidation resistant coatings are PWA 273, an aluminide coating, and PWA 286, an overlay NiCoCrAlY coating. To obtain constitutive and fatigue data, tests were conducted on uncoated and coated specimens loaded in the <100>, <110>, <111> and <123> crystallographic directions. Two constitutive models are being developed and evaluated for the single crystal materials: a micromechanic model based on crystallographic slip systems, and a macroscopic model which employs anisotropic tensors to model inelastic deformation anisotropy. Based on tests conducted on the overlay coating material, constitutive models for coatings also appear feasible and two initial models were selected. A life prediction approach was proposed for coated single crystal materials, including crack initiation either in the coating or in the substrate. The coating initiated failures dominated in the tests at load levels typical of gas turbine operation. Coating life was related to coating stress/strain history which was determined from specimen data using the constitutive models. Author

N87-23626*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
THE SUPERSONIC THROUGH-FLOW TURBOFAN FOR HIGH MACH PROPULSION
LEO C. FRANCISCUS Jul. 1987 14 p Presented at the 23rd Joint Propulsion Conference, San Diego, Calif., 29 Jun. - 2 Jul. 1987
(NASA-TM-100114; E-3659; NAS 1.15:100114; AIAA-87-2050)
Avail: NTIS HC A02/MF A01 CSCL 21E

A study was done to evaluate the potential improvements in aircraft turbine engine performance by incorporating unique supersonic through-flow fans. Engine performance, weight, and mission studies were carried out for conventional turbofan engines using supersonic through-flow fans. A Mach 3 commercial transport mission was considered. The advantages of the supersonic fan engines were evaluated in terms of mission range comparisons between the supersonic fan engines and conventional engines. The installed specific fuel consumption of the supersonic fan engines was 12 percent better than the conventional engines and the installed weight was projected to be 25 percent lighter. For a takeoff gross weight of 550,000 lbs, the aircraft powered by supersonic fan engines had a range capability of 6600 nm compared to 5300 nm (a 25% improvement) for conventional engines. Author

N87-24418*# Rolls-Royce Ltd., Bristol (England). Military Installation.
THE SCALING OF MODEL TEST RESULTS TO PREDICT INTAKE HOT GAS REINGESTION FOR STOVL AIRCRAFT WITH AUGMENTED VECTORED THRUST ENGINES
C. J. PENROSE *In* NASA. Ames Research Center Proceedings of the 1985 NASA Ames Research Center's Ground-Effects Workshop p 309-339 Feb. 1987
Avail: NTIS HC A19/MF A01 CSCL 01A

The difficulties of modeling the complex recirculating flow fields produced by multiple jet STOVL aircraft close to the ground have led to extensive use of experimental model tests to predict intake Hot Gas Reingestion (HGR). Model test results reliability is dependent on a satisfactory set of scaling rules which must be validated by fully comparable full scale tests. Scaling rules devised in the U.K. in the mid 60's gave good model/full scale agreement for the BAe P1127 aircraft. Until recently no opportunity has occurred to check the applicability of the rules to the high energy exhaust of current ASTOVL aircraft projects. Such an opportunity has arisen following tests on a Tethered Harrier. Comparison of this full scale data and results from tests on a model configuration approximating to the full scale aircraft geometry has shown discrepancies between HGR levels. These discrepancies although probably due to geometry and other model/scale differences indicate some reexamination of the scaling rules is needed. Therefore the scaling rules are reviewed, further scaling studies planned are described and potential areas for further work are suggested. Author

N87-24419*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
HOT GAS INGESTION: FROM MODEL RESULTS TO FULL SCALE ENGINE TESTING
ALBERT L. JOHNS, THOMAS J. BIESIADNY, and L. L. PAGEL (McDonnell Aircraft Co., St. Louis, Mo.) *In* NASA. Ames Research Center Proceedings of the 1985 NASA Ames Research Center's Ground-Effects Workshop p 341-361 Feb. 1987
Avail: NTIS HC A19/MF A01 CSCL 21E

An overview is presented of a joint NASA Lewis McDonnell Aircraft Co. Hot Gas Ingestion (HGI) test program in NASA Lewis' 9 x 15 foot Low Speed Wind Tunnel (LSWT). Advanced short takeoff vertical landing (ASTOVL) aircraft capable of operating from remote sites, damaged runways, aircraft carriers and small air-capable ships are being pursued for deployment around the turn of the century. To achieve this goal, it is important that technologies critical to this unique class of aircraft be developed. One of the ASTOVL concepts, the vectored thrust, has as its critical technology item, the potential of hot gas ingestion (which occurs during vertical flight operation while in ground effect) as a key development issue. Recognizing this need, NASA Lewis Powered Lift Section and McAir have defined a cooperative program for testing in the Lewis 9 x 15 foot LSWT. This program is described in detail. Author

N87-24467# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (West Germany). Helicopter and Military Aircraft Group.
NEW TRENDS IN INTAKE/ENGINE COMPATIBILITY ASSESSMENT
F. AULEHLA and D. M. SCHMITZ *In* AGARD Engine Response to Distorted Inflow Conditions 24 p Mar. 1987
Avail: NTIS HC A14/MF A01

The measurement of dynamic distortion requires considerable effort in instrumentation and data processing. Distortion measurement methods which are time and cost efficient are described. Experience gained from the Tornado aircraft indicates that the relevance of dynamic distortion on intake/engine compatibility has been overestimated and, in fact, swirl emerged as the decisive compatibility parameter. Also, during the Airbus A-300 APU intake development swirl turned out to be an important criterion. In conclusion, it is argued whether in many cases dynamic distortion measurements can be avoided in favor of swirl measurements in combination with simplified methods for dynamic distortion predictions based on steady state measurements and, in some cases, on statistical models. Author

N87-24473# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Cologne (West Germany). Inst. fuer Antriebstechnik.

IMPROVEMENT OF THE PARALLEL COMPRESSOR MODEL BY CONSIDERATION OF UNSTEADY BLADE AERODYNAMICS

M. LECHT *In* AGARD Engine Response to Distorted Inflow Conditions 13 p Mar. 1987

Avail: NTIS HC A14/MF A01

The parallel compressor model has been applied to predict compressor performance with cicumferential total inlet distortion. In comparison with experiment data, however, this model gives pessimistic results for the predicted stall line shift considering sector angles of distortion up to 120 deg. Detailed experimental evaluation of a compressor stage leads to unsteady performance effects obviously being responsible for this discrepancy. In order to improve the original model the performance characteristic of the compressor was extended to account for a short time overload capability analogous to an airfoil in an unsteady flow. The governing factor of this modification is the time-to-stall versus the time for a blade channel to pass the distorted sector. The model improvement was demonstrated for a DFVLR and a NASA single stage transonic compressor subjected to a screen induced total pressure distortion. Author

N87-24475# Royal Aircraft Establishment, Farnborough (England).

TRANSMISSION OF INLET DISTORTION THROUGH A FAN

J. E. FLITCROFT, J. DUNHAM, and W. A. ABBOTT *In* AGARD Engine Response to Distorted Inflow Conditions 11 p Mar. 1987

Avail: NTIS HC A14/MF A01

The effect of inlet swirl on the propagation of total pressure distortion through a three-stage fan without inlet guide vanes was investigated on a compressor rig. The tests gave the unexpected finding that the presence of a swirl counter to the rotation of the fan generally reduced the level of steady state distortion transmitted to the core compressor. Dynamic pressure measurements made at the exit from the fan, however, revealed that the swirl also caused a sudden early breakdown of the flow in a sector of the hub region, resulting in high time-invariant distortion levels in the core flow. This observation is compatible with the destabilizing effect of a swirl counter to fan rotation on engines. A theoretical analysis confirmed that a swirl, concentrated at the fan tip at entry, could drive some of the hub blade rows strongly towards stall. Author

N87-24476# Alfa Romeo S.p.A., Naples (Italy). Direzione R and D.

EXPERIMENTAL INVESTIGATION ON SMALL TURBOPROP BEHAVIOUR UNDER COMPRESSOR ROTATING STALL FOR DIFFERENT INLET FLOW CONDITIONS

S. COLANTUONI and G. LIOTTI *In* AGARD Engine Response to Distorted Inflow Conditions 16 p Mar. 1987

Avail: NTIS HC A14/MF A01

An experimental investigation on compressor rotating stall and acoustic noise in a small turboprop is discussed. The intent of the study, undertaken in Alfa Romeo Avio using the engine test bed during the initial phase of the AR 318 turboprop development program, was to clarify the noisy and unstable behavior of some engines at part-speeds. The overall performances of the centrifugal compressor, the time-dependent wall static pressure measurements used to visualize impeller rotating stall regions on the compressor map, and the acoustic noise signals detected at the engine-intake inlet are presented. Finally, the engine performances in stalled compressor conditions are analyzed and main results are discussed. Author

N87-24481*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

LOW-COST FM OSCILLATOR FOR CAPACITANCE TYPE OF BLADE TIP CLEARANCE MEASUREMENT SYSTEM

JOHN P. BARRANGER Jul. 1987 16 p

(NASA-TP-2746; E-3455; NAS 1.60:2746) Avail: NTIS HC A02/MF A01 CSCL 21E

The frequency-modulated (FM) oscillator described is part of a blade tip clearance measurement system that meets the needs of a wide class of fans, compressors, and turbines. As a result of advancements in the technology of ultra-high-frequency operational amplifiers, the FM oscillator requires only a single low-cost integrated circuit. Its carrier frequency is 42.8 MHz when it is used with an integrated probe and connecting cable assembly consisting of a 0.81 cm diameter engine-mounted capacitance probe and a 61 cm long hermetically sealed coaxial cable. A complete circuit analysis is given, including amplifier negative resistance characteristics. An error analysis of environmentally induced effects is also derived, and an error-correcting technique is proposed. The oscillator can be calibrated in the static mode and has a negative peak frequency deviation of 400 kHz for a rotor blade thickness of 1.2 mm. High-temperature performance tests of the probe and 13 cm of the adjacent cable show good accuracy up to 600 C, the maximum permissible seal temperature. The major source of error is the residual FM oscillator noise, which produces a clearance error of + or - 10 microns at a clearance of 0.5 mm. The oscillator electronics accommodates the high rotor speeds associated with small engines, the signals from which may have frequency components as high as 1 MHz. Author

08

AIRCRAFT STABILITY AND CONTROL

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

A87-39410#

AIRCRAFT SERVO-AEROELASTICITY STABILITY

CONGQING ZOU and GUIBING CHEN (Beijing Institute of Aeronautics and Astronautics, People's Republic of China) Acta Aeronautica et Astronautica Sinica, vol. 8, March 1987, p. A200-A205. In Chinese, with abstract in English.

A dynamic stability analysis approach to an airplane equipped with automatic control systems is demonstrated, and two technical approaches to solving stability problems are introduced. The numerical calculation of a complete system, including unsteady aerodynamic forces, is presented. The influence of the control systems on the airplane flutter are shown by illustrating the results of both open and closed-loop calculations with Nyquist and V-G diagrams. The results indicate that servoaeroelasticity problems should be stressed in the process of airplane design and that a suitable notch filter must be selected for the control systems. C.D.

A87-39419#

DESIGN OF FLIGHT CONTROL SYSTEM WITH MANEUVER ENHANCEMENT AND GUST ALLEVIATION

YIDONG YANG and JIANPING WANG (Nanjing Aeronautical Institute, People's Republic of China) Acta Aeronautica et Astronautica Sinica, vol. 8, April 1987, p. B171-B178. In Chinese, with abstract in English. refs

This paper, based on the CCU-YH-16 fighter aircraft, investigates the design philosophy and configuration of a flight-control system with maneuver enhancement and gust alleviation. Comparison between a basic flight-control system and the maneuver-enhancement/gust-alleviation system is shown by simulation results. The maneuver-enhancement/gust-alleviation functions are examined and evaluated. A parameter optimization method is used, with the C-asterisk flight-performance criterion as the objective function. Author

A87-39420#

A COMPUTATIONAL METHOD FOR STABILITY AND MANEUVERABILITY OF HELICOPTER

ZHIMING XIN, YONGCHENG TIAN, and ZHONGXIAO YOU Acta Aeronautica et Astronautica Sinica, vol. 8, April 1987, p. B179-B185. In Chinese, with abstract in English.

In this paper, approximation techniques for handling the original data used in helicopter stability and maneuverability calculations are given in accordance to the needs of failure study and obtaining the characteristics of import helicopters. Then the stability and maneuverability derivatives are corrected using a method of flight-test contrast correction, and satisfactory results are obtained. This procedure is used in calculations and analyses of the stability and maneuverability of a typical helicopter. Author

A87-39422#

EFFECTS OF REDUNDANCY CONFIGURATION AND ITS MANAGEMENT MODE ON THE RELIABILITY OF FLIGHT CONTROL SYSTEM

LICHUN LI (Institute of Automatic Flight Control System, People's Republic of China) Acta Aeronautica et Astronautica Sinica, vol. 8, April 1987, p. B198-B203. In Chinese, with abstract in English.

Simplified formulas for estimating the probability of failure of flight-control systems (FCSs) are derived and applied to the comparative evaluation of FCSs with nine different redundancy configurations of the actuators, sensors, and computers. It is found that a pure triplex configuration with self-monitoring does not satisfy present reliability requirements, considering the failure rates of typical manufactured components. The best reliability results were obtained when an integrated triplex-quadruplex configuration (with quadruplex computers and triplex actuators, sensors, and I/O devices) was combined with a reconfigurable redundancy strategy for the sensors. The cross-loss probability for the integrated configuration is shown to be negligible. T.K.

A87-39773#

A DYNAMIC MODEL OF AN AEROPLANE WITH WINGS OF HIGH ASPECT RATIO FOR FLUTTER ANALYSIS BY THE METHOD OF FINITE ELEMENTS

A. OLEJNIK Journal of Technical Physics (ISSN 0324-8313), vol. 27, no. 4, 1986, p. 405-415. refs

A dynamic model applicable to the FEM flutter analysis of aircraft with high-aspect-ratio wings is developed on the basis of nonstationary strip theory. The one-dimensional discretization of deformable structural elements is explained; a model adequately representing the aircraft mass and rigidity is constructed; the elements of the aerodynamic matrix are determined; and the frequency equation and self-excited vibrations are discussed. The model is to be used in estimating the critical flutter speeds of a military trainer. T.K.

A87-40272*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

MULTIAXIS AIRCRAFT CONTROL POWER FROM THRUST VECTORING AT HIGH ANGLES OF ATTACK

FRANCIS J. CAPONE and MARY L. MASON (NASA, Langley Research Center, Hampton, VA) AIAA, Applied Aerodynamics Conference, 4th, San Diego, CA, June 9-11, 1986. 50 p. Previously announced in STAR as N86-28054. refs
(AIAA PAPER 86-1779)

Extensive research programs conducted at the Langley Research Center have shown that thrust vectoring can be provided by multifunction (nonaxisymmetric) nozzles. Most of this research has been conducted on pitch vectoring at both static and forward flight conditions. Recent efforts have been aimed at evaluating yaw vectoring concepts at static (wind off) conditions. This paper summarizes results for three different twin-engine fighter configurations tested over a Mach number range of 0.15 to 2.47 at angles of attack up to 35 deg. The objective of these investigations was to determine the multiaxis control power characteristics provided by thrust vectoring. All three configurations employed two-dimensional convergent-divergent nozzles which provided pitch vectoring by differential deflection of the upper and lower nozzle divergent flaps. Three different means of yaw vectoring were tested: (1) a translating nozzle sidewall; (2) yaw flaps located in the nozzle sidewalls; and (3) canted nozzles. These investigations were conducted in the Langley 16-Foot Transonic Tunnel and the Lewis 10 x 10-Foot Supersonic Tunnel. Longitudinal and direction control power from thrust vectoring was greater than that provided by aerodynamic control effectors at low speed or at high angles of attack. Author

A87-40274*# National Aeronautics and Space Administration. Flight Research Center, Edwards, Calif.

EXPERIENCE WITH SYNCHRONOUS AND ASYNCHRONOUS DIGITAL CONTROL SYSTEMS

VICTORIA A. REGENIE, CLAUDE V. CHACON, and WILTON P. LOCK (NASA, Flight Research Center, Edwards, CA) AIAA, Guidance, Navigation, and Control Conference, Williamsburg, VA, Aug. 18-20, 1986. 18 p. Previously announced in STAR as N86-29866.
(AIAA PAPER 86-2239)

Flight control systems have undergone a revolution since the days of simple mechanical linkages; presently the most advanced systems are full-authority, full-time digital systems controlling unstable aircraft. With the use of advanced control systems, the aerodynamic design can incorporate features that allow greater performance and fuel savings, as can be seen on the new Airbus design and advanced tactical fighter concepts. These advanced aircraft will be and are relying on the flight control system to provide the stability and handling qualities required for safe flight and to allow the pilot to control the aircraft. Various design philosophies have been proposed and followed to investigate system architectures for these advanced flight control systems. One major area of discussion is whether a multichannel digital control system should be synchronous or asynchronous. This paper addressed the flight experience at the Dryden Flight Research Facility of NASA's Ames Research Center with both synchronous and asynchronous digital flight control systems. Four different flight control systems are evaluated against criteria such as software reliability, cost increases, and schedule delays. Author

A87-40521#

COMPARISON OF ANALYTIC AND PRAGMATIC MODEL REDUCTION METHODS USING AS AN EXAMPLE THE DYNAMICS OF AIRCRAFT LATERAL MOTION [POROWNANIE ANALITYCZNYCH I PRAGMATYCZNYCH METOD REDUKCJI MODELU NA PRZYKLADZIE DYNAMIKI RUCHU BOCZNEGO SAMOLOTU]

JANUSZ JANUSZEWSKI Instytut Lotnictwa, Prace (ISSN 0509-6669), no. 104-105, 1986, p. 41-76. In Polish. refs

Two simplified models of the dynamics of aircraft lateral motion are described. They have been constructed by two different simplification methods. The first, which is a conventional method, consists in a more or less formalized analysis of the importance of particular components of differential equations and the rejection of the less important. As a result a simplified model with a reduced number of elements of the matrix of state is obtained. The other method of simplification is referred to as a pragmatic simulation technique and consists in separating the solution into rapidly and slowly varying fractions of the solution, then mixing both fractions in a filter alignment circuit. The rapid fraction may be calculated in a slower rhythm of the computing procedure. The complexity of the models thus obtained has been evaluated in terms of the computation time necessary for a single step. Author

A87-40522#

AN OPTIMIZED METHOD FOR COMPUTING THE COEFFICIENTS OF THE SIMPLIFIED MODEL OF THE LATERAL MOTION OF AN AIRPLANE [ZOPTYMALIZOWANY SPOSOB WYLICZANIA WSPOLCZYNNIKOW UPROSZCZONEGO MODELU DYNAMIKI SAMOLOTU W RUCHU BOCZNYM]

JERZY GRAFFSTEIN Instytut Lotnictwa, Prace (ISSN 0509-6669), no. 104-105, 1986, p. 77-91. In Polish. refs

The mode in which the coefficients are calculated usually determines the overall speed of computation. The real-time simulation requires special procedures. A two-rhythm idea of the computation of the coefficients of a simplified model of aircraft dynamics is presented. Although the lateral motion has been selected as an example, the method used is general. The coefficients have been divided into two separate sets: rapidly and slowly varying. The two sets require different sampling frequencies, i.e., different rhythms of computation. The coefficients are generally multivariable nonlinear functions of the flight parameters. The most suitable approximation procedures have been analyzed and chosen. Author

A87-40860#

DESIGN METHODOLOGY FOR ROBUST STABILIZING CONTROLLERS

WILLIAM E. SCHMITENDORF (Northwestern University, Evanston, IL) (Guidance, Navigation and Control Conference, Williamsburg, VA, Aug. 18-20, 1986, Technical Papers, p. 657-662) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 10, May-June 1987, p. 250-254. Previously cited in issue 23, p. 3409, Accession no. A86-47475. refs
(Contract NSF ECS-84-15591; AF-AFOSR-ISSA-85-00051)

A87-40862#

ON-LINE AIRCRAFT STATE AND STABILITY DERIVATIVE ESTIMATION USING THE MODIFIED-GAIN EXTENDED KALMAN FILTER

JASON L. SPEYER and EDWIN Z. CRUES (Texas, University, Austin) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 10, May-June 1987, p. 262-268. Research sponsored by General Dynamics Corp. Previously cited in issue 21, p. 3051, Accession no. A85-43827. refs
(Contract AF-AFOSR-84-0371)

A87-40863*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

AIRCRAFT AUTOMATIC FLIGHT CONTROL SYSTEM WITH MODEL INVERSION

G. ALLAN SMITH and GEORGE MEYER (NASA, Ames Research Center, Moffett Field, CA) (Digital Avionics Systems Conference, 6th, Baltimore, MD, Dec. 3-6, 1984, Proceedings, p. 140-150) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 10, May-June 1987, p. 269-275. Previously cited in issue 06, p. 693, Accession no. A85-17823. refs

A87-40921#

CALCULATION OF THE MINIMUM-TIME TURN OF AN AIRCRAFT WITHOUT SIDESLIP [VYPOCET CASOVE NEJKRATSI SPRAVNE ZATACKY LETOUNU VE VODOROVNE ROVINE]

JOSEF KUDRNA Zpravodaj VZLU (ISSN 0044-5355), no. 1, 1987, p. 7-15. In Czech. refs

Optimal bank and thrust characteristics are determined which permit the achievement of minimum-time turn without sideslip and a specified flight velocity at the end of the turn. This velocity may be greater or less than the initial velocity; attention is also given to the case when the flight velocity or the heading angle at the end of the turn is not specified. Three different optimal subarcs of the trajectory are determined; the optimal control variables are functions of the Mach number and Lagrange multipliers. B.J.

A87-41628#

ACCURATE ESTIMATION OF AIRCRAFT INERTIA CHARACTERISTICS FROM A SINGLE SUSPENSION EXPERIMENT

R. C. DE JONG and J. A. MULDER (Delft, Technische Hogeschool, Netherlands) Journal of Aircraft (ISSN 0021-8669), vol 24, June 1987, p. 362-370. refs

A novel method for the experimental determination of the aircraft center of gravity and the moments and products of inertia is presented and evaluated. The method is based on the application of statistical parameter estimation techniques to the analysis of multi-degree-of-freedom oscillations using a high-accuracy instrumentation system. An existing suspension rig, in which the aircraft can simultaneously rotate about the Y and Z axes (pitch and yaw axes) and translate along the X (roll) and Y axes, is used to demonstrate the validity of the method. The inertia moments Iy and Iz, the inertia product Iyz, and the three coordinates of the center of gravity are simultaneously estimated from measurements of only one oscillation. The experiment is much less time-consuming compared to earlier methods, since no separate center-of-gravity measurements nor rig reconfigurations are needed. It is suggested that the remaining inertia characteristics (Ix, Ixz, and Ixy) can be simultaneously estimated after a slight modification in the suspension construction. Author

A87-42127#

A MATHEMATICAL MODEL OF PROCESSES IN A MULTIPLE DISCRETE AIRCRAFT STABILIZATION SYSTEM [MATEMATICHESKAIA MODEL' PROTSESSOV V MNOGOKRATNOI DISKRETNOI SISTEME STABILIZATSII LETATEL'NOGO APPARATA]

A. I. BOGOMOLOV and S. A. TERENT'EV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 1, 1987, p. 9-13. In Russian.

A mathematical model is derived which describes the processes occurring in the state space of a linear discrete aircraft stabilization system of the multiple type. The model can be used in developing computer algorithms for the analysis and synthesis of aircraft stabilization systems. A diagram of a discrete stabilization system is presented. V.L.

A87-42139#

ANALYTICAL DETERMINATION OF THE OPTIMAL PARAMETERS OF AUTOMATIC PILOTS [OB ANALITICHESKOM OPREDELENII OPTIMAL'NYKH PARAMETROV AVTOPILOTOV]

L. G. ROMANENKO and G. L. ROMANENKO Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 1, 1987, p. 69-73. In Russian. refs

An algorithm is developed for the analytical determination of the optimal parameters of automatic pilots. The algorithm is demonstrated by applying it to two typical flight control problems: control of the flight altitude and control of the angular position of the aircraft. V.L.

A87-42140#

EFFECT OF THE LONGITUDINAL STATIC STABILITY MARGIN ON THE TAKE-OFF MASS OF AIRCRAFT [VLIIANIE ZAPASA PRODOL'NOI STATICHESKOI USTOICHIVOSTI NA VZLETNUIU MASSU SAMOLETA]

V. P. SURIN Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 1, 1987, p. 74-78. In Russian.

Changes in the take-off mass of aircraft with the static stability margin are analyzed using the gradient method. Expressions are obtained for determining the coefficient of the increase in the take-off mass for two versions of initial data specification. It is noted that, by reducing the margin of longitudinal static stability and adopting a statically unstable scheme, it is possible to significantly improve the flight performance characteristics of maneuverable aircraft. V.L.

A87-42623#

A SIMPLE THEORY ON HOVERING STABILITY OF ONE-DUCTED-FAN VTOL

SHIGENORI ANDO (Nagoya University, Japan) Japan Society for Aeronautical and Space Sciences, Transactions (ISSN 0549-3811), vol. 29, Feb. 1987, p. 242-250. refs

Flying Platforms supported by ducted fan(s), such as the Hiller VZ-1, are the safest and simplest aircraft. The height of vehicle CG (center-of-gravity) from the ducted-fan aerodynamic-center should be selected quite carefully, from stability and control viewpoints. A simple theory is presented for the longitudinal motion. It is found that the vehicle is stable only in a small range of CG. The stable CG range is located above the duct, the height of which depends on the duct lip radius. A simple philosophy is presented to make the vehicle safe against horizontal gusts.
Author

A87-42649#

ROBUST NONLINEAR CONTROL FOR HIGH ANGLE OF ATTACK FLIGHT

HAROLD L. STALFORD (Virginia Polytechnic Institute and State University, Blacksburg) and FREDERICK E. GARRETT, JR. AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 25 p. refs
(AIAA PAPER 87-0346)

A robust nonlinear controller is developed for head-on-pass-engagement vertical target tracking by an aircraft in high-angle-of-attack flight. The dynamics of the aircraft is based on a wind-tunnel model of the U.S. Navy T2-C aircraft (Fortenbaugh, 1976), and the controller is designed with respect to a switching manifold in state space. A model with zero sideslip is modified to include uncertain sideslip up to 5 deg, and the performance of the controllers is evaluated by means of numerical simulations. The results are presented graphically and briefly characterized. It is shown that a robust control exists for all equilibrium-state values at sideslip 2 deg or less, but that at 5 deg there is a narrow band of states for which the open-loop system cannnot be stabilized against all uncertainties.
T.K.

N87-23627*# Stanford Univ., Calif. Joint Inst. for Aeronautics and Acoustics.

TWO BLOWING CONCEPTS FOR ROLL AND LATERAL CONTROL OF AIRCRAFT

D. A. TAVELLA, N. J. WOOD, C. S. LEE, and L. ROBERTS Oct. 1986 107 p
(Contract NCC2-271)
(NASA-CR-180478; NAS 1.26:180478; JIAA-TR-75) Avail: NTIS HC A06/MF A01 CSCL 01C

Two schemes to modulate aerodynamic forces for roll and lateral control of aircraft have been investigated. The first scheme, called the lateral blowing concept, consists of thin jets of air exiting spanwise, or at small angle with the spanwise direction, from slots at the tips of straight wings. For this scheme, in addition to experimental measurements, a theory was developed showing the analytical relationship between aerodynamic forces and jet and wing parameters. Experimental results confirmed the theoretically derived scaling laws. The second scheme, which was studied experimentally, is called the jet spoiler concept and consists of thin jets exiting normally to the wing surface from slots aligned with the spanwise direction.
Author

N87-23628# Air Force Inst. of Tech., Wright-Patterson AFB, Ohio. School of Engineering.

FAILURE DETECTION AND ISOLATION FOR AN ASYCHRONOUS DIGITAL FLIGHT CONTROL SYSTEM M.S. Thesis

GURSEL SERPEN Mar. 1987 192 p
(AD-A179210; AFIT/GE/ENG/87M-6) Avail: NTIS HC A09/MF A01 CSCL 01C

The purpose of this study was to design and test a failure detection and isolation subsystem for a triply redundant asychronous digital flight control system. The focus of the research was to analyze the time skew effect in an asychronous environment. A model to estimate the time skew and the time skew related interchannel difference was developed. The design was tested in a simulation environment where the YF-16 longitudinal dynamics and the AFTI/F-16 digital flight control system were modelled.
GRA

N87-23629# Air Force Inst. of Tech., Wright-Patterson AFB, Ohio. School of Engineering.

FLIGHT TEST EVALUATION OF TECHNIQUES TO PREDICT LONGITUDINAL PILOT INDUCED OSCILLATIONS M.S. Thesis

EILEEN A. BJORKMAN Dec. 1986 186 p
(AD-A179229; AFIT/GAE/AA/86J-1) Avail: NTIS HC A09/MF A01 CSCL 05H

The purpose of this study was to determine if pilot induced oscillations (PIOs) can be predicted prior to flight using existing PIO prediction techniques. Two techniques to predict longitudinal PIO tendencies were studied analytically using an existing PIO data base. The two techniques were then applied to 18 aircraft/flight control system landing configurations. The 18 configurations were flight tested using a flared landing task with the USAF/Calspan variable stability NT-33A. The PIO tendencies and frequencies were correctly predicted provided the configuration was not sensitive to the pilot model used. A suggested modification of theory correctly predicted PIO ratings within an average of 0.5 rating. A suggested modification to the bandwidth method predicted PIO ratings within an average of 0.5 rating. The limited data base was too small to draw any definite conclusions. Recommendations for further study included collecting more PIO data and using existing data bases and simulator studies to better define the two techniques and to gain physical insights into PIO mechanization.
GRA

N87-23630*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

HELICOPTER ANTI-TORQUE SYSTEM USING FUSELAGE STRAKES Patent Application

HENRY L. KELLEY, inventor (to NASA) and JOHN C. WILSON, inventor (to NASA) 30 Jan. 1987 14 p
(NASA-CASE-LAR-13630-1; US-PATENT-APPL-SN-008895)
Avail: NTIS HC A02/MF A01 CSCL 01C

This invention relates to helicopters, and particularly to the improvement of the helicopter torque control system. At low to medium forward speeds helicopter performance is limited by the effectiveness of the means for counter-acting main rotor torque and controlling sideslip airloads. These problems may be overcome by mounting strakes on the aft fuselage section. For single rotor helicopters whose main rotor rotates counter-clockwise as viewed from above, one of the strakes would be mounted in the upper left hand quadrant and the second in the lower left hand quadrant. The strakes alter the air flow around the fuselage by separating the flow so as to produce lateral air loads on the tail boom which oppose main-rotor torque. The upper strake operates in a right crosswind to oppose main rotor torque, and the lower strake has effect in left crosswinds. The novelty of this invention resides in the simple and economical manner in which the helicopter tail boom may be modified by the addition of strakes in order to increase torque control, and reduce the need for supplemental mechanical means of torque control.
NASA

N87-23631* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

SWASHPLATE CONTROL SYSTEM Patent

RICHARD J. PEYRAN, GEORGENE H. LAUB, and H. ANDREW MORSE 2 Jun. 1987 9 p Filed 31 Mar. 1986 Supersedes N86-24700 (24 - 15, p 2417)
(NASA-CASE-ARC-11633-1; US-PATENT-4,669,958; US-PATENT-APPL-SN-846439; US-PATENT-CLASS-416-114; US-PATENT-CLASS-416-158) Avail: US Patent and Trademark Office CSCL 01C

A mechanical system to control the position of a rotating swashplate is developed. This system provides independent lateral cyclic, longitudinal cyclic and collective pitch control of a helicopter rotor attached to the swashplate, without use of a mixer box. The system also provide direct, linear readout of cyclic and collective swashplate positions. NASA

N87-23632*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

DEMONSTRATION OF FREQUENCY-SWEEP TESTING TECHNIQUE USING A BELL 214-ST HELICOPTER

MARK B. TISCHLER, JAY W. FLETCHER, VERNON L. DIFKMANN, ROBERT A. WILLIAMS, and RANDALL W. CASON (Army Aviation Engineering Flight Activity, Edwards AFB, Calif.) Apr. 1987 83 p

(NASA-TM-89422; A-87073; AVSCOM-TM-87-A-1; NAS 1.15:89422) Avail: NTIS HC A05/MF A01 CSCL 01C

A demonstration of frequency-sweep testing using a Bell-214ST single-rotor helicopter was completed in support of the Army's development of an updated MIL-H-8501A, and an LHX (ADS-33) handling-qualities specification. Hover and level-flight (V sub a = 0 knots and V sub a = 90 knots) tests were conducted in 3 flight hours by Army test pilots at the Army Aviation Engineering Flight Activity (AEFA) at Edwards AFB, Calif. Bandwidth and phase-delay parameters were determined from the flight-extracted frequency responses as required by the proposed specifications. Transfer function modeling and verification demonstrates the validity of the frequency-response concept for characterizing closed-loop flight dynamics of single-rotor helicopters -- even in hover. This report documents the frequency-sweep flight-testing technique and data-analysis procedures. Special emphasis is given to piloting and analysis considerations which are important for demonstrating frequency-domain specification compliance. Author

N87-24404 Stevens Inst. of Tech., Hoboken, N. J. Dept. of Mechanical Engineering.

STALL FLUTTER

F. SISTO *In* AGARD Aeroelasticity in Axial-Flow Turbomachines. Volume 1: Unsteady Turbomachinery Aerodynamics 11 p Mar. 1987

Avail: NTIS HC A13/MF A01

A qualitative exposition of stall flutter and the closely related phenomena of choke flutter and supersonic bending stall flutter in axial flow turbomachines is given. R.J.F.

N87-24482*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

INFLUENCE OF DYNAMIC INFLOW ON THE HELICOPTER VERTICAL RESPONSE

ROBERT T. N. CHEN and WILLIAM S. HINDSON (Stanford Univ., Calif.) Jun. 1986 49 p

(NASA-TM-88327; A-86262; NAS 1.15:88327) Avail: NTIS HC A03/MF A01 CSCL 01C

A study was conducted to investigate the effects of dynamic inflow on rotor-blade flapping and vertical motion of the helicopter in hover. Linearized versions of two dynamic inflow models, one developed by Carpenter and Fridovich and the other by Pitt and Peters, were incorporated in simplified rotor-body models and were compared for variations in thrust coefficient and the blade Lock number. In addition, a comparison was made between the results of the linear analysis, and the transient and frequency responses measured in flight on the CH-47B variable-stability helicopter. Results indicate that the correlations are good, considering the simplified model used. The linear analysis also shows that dynamic inflow plays a key role in destabilizing the flapping mode. The destabilized flapping mode, along with the inflow mode that the dynamic inflow introduces, results in a large initial overshoot in the vertical acceleration response to an abrupt input in the collective pitch. This overshoot becomes more pronounced as either the thrust coefficient or the blade Lock number is reduced. Compared with Carpenter's inflow model, Pitt's model tends to produce more oscillatory responses because of the less stable flapping mode predicted by it. Author

N87-24483*# Dayton Univ., Ohio.

IMPROVEMENTS TO THE FASTEX FLUTTER ANALYSIS COMPUTER CODE Final Report

RONALD F. TAYLOR Jul. 1987 80 p

(Contract NAG2-377)

(NASA-CR-181072; NAS 1.26:181072; UDR-TR-87-14) Avail: NTIS HC A05/MF A01 CSCL 01C

Modifications to the FASTEX flutter analysis computer code (UDFASTEX) are described. The objectives were to increase the problem size capacity of FASTEX, reduce run times by modification of the modal interpolation procedure, and to add new user features. All modifications to the program are operable on the VAX 11/700 series computers under the VAX operating system. Interfaces were provided to aid in the inclusion of alternate aerodynamic and flutter eigenvalue calculations. Plots can be made of the flutter velocity, display and frequency data. A preliminary capability was also developed to plot contours of unsteady pressure amplitude and phase. The relevant equations of motion, modal interpolation procedures, and control system considerations are described and software developments are summarized. Additional information documenting input instructions, procedures, and details of the plate spline algorithm is found in the appendices. M.G.

09

RESEARCH AND SUPPORT FACILITIES (AIR)

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

A87-39417#

DEVELOPMENT OF FUEL PUMP-MOTOR ROTATIONAL SPEED CONTROL SYSTEM

ZHENG CHEN, RONGCHU ZHU, and JUNYING ZENG (Nanjing Aeronautical Institute, People's Republic of China) Acta Aeronautica et Astronautica Sinica, vol. 8, April 1987, p. B157-B164. In Chinese, with abstract in English.

The importance of the dynamic experimental stand of a power-device control system and of semiphysical simulating tests is discussed. Stress has been laid on the development of an electrohydraulic servo fuel-pump-motor rotational-speed control system, including design method, static and dynamic calculation, mathematic modeling, time- and frequency-domain analysis, correction, and experiment-result analysis. The control system has rapid dynamic response, easy operation, smooth control, good static accuracy, and so on. It also has larger power, higher speed, a double-pump-control fuel motor, and reasonable energy consumption, and thus has wide application. Successful development of the system not only provides the equipment for semiphysical simulating tests of aviation-power-device control systems but also a dynamic test stand for high-quality ground rotational-speed control systems. Author

A87-39893#

DOUBLET-PANEL METHOD FOR HALF-MODEL WIND-TUNNEL CORRECTIONS

M. MOKRY, J. R. DIGNEY (National Research Council of Canada, Ottawa), and R. J. D. POOLE (De Havilland Aircraft of Canada, Ltd., Downsview) (ICAS, Congress, 15th, London, England, Sept. 7-12, 1986, Proceedings. Volume 2, p. 779-785) Journal of Aircraft (ISSN 0021-8669), vol. 24, May 1987, p. 322-327. Research supported by the de Havilland Aircraft of Canada, Ltd. and National Research Council of Canada. Previously cited in issue 24, p. 3550, Accession no. A86-49060. refs

A87-40306#

AIRCRAFT POWER REQUIREMENT IN THE PRODUCTION PROCESS [LEISTUNGSBEDARF DER LUFTFAHRZEUGE BEIM ABFERTIGUNGSPROZESS]

WOLF-DIETER KROHS (Interflug Gesellschaft fuer Internationalen Flugverkehr mbH, Berlin, East Germany) Technisch-oekonomische Information der zivilen Luftfahrt (ISSN 0232-5012), vol. 23, no. 1, 1987, p. 15-17. In German. refs

The temporal flow of energy usage requirements of aircraft in the production process was determined using a specially designed measurement configuration. The results showed that the power requirement is characterized by a constant basic load on which are superposed a number of load peaks which attain a maximum of 10 times the basic load. As a result, it is possible to equip two aircraft with a stationary installed alternating current supply with appropriate safety precautions and a time grading. The current peaks can be measured using correction factors which take into account the lag of the measurement systems during transition processes and the narrowed power requirements of aircraft. C.D.

A87-41625#

COLD WEATHER TRIALS FOR MILITARY AIRCRAFT

H. D. JUDKINS (Aeroplane and Armament Experimental Establishment, Salisbury, England) Aerospace (UK) (ISSN 0305-0831), vol. 14, May 1987, p. 10-17. refs

The design requirements for military aircraft and the objectives and procedures for cold-weather testing of aircraft are described. The problems encountered with APU/engine starting of aircraft and with the main-rotor gearbox lubrication and rotor engagement of helicopters due to cold weather are discussed. The selection of test sites is examined in terms of arctic topography and the climate and wind-chill factor, and examples of applicable test sites are presented. I.F.

A87-41629#

EXPERIMENTS WITH AN ADAPTABLE-WALL WIND TUNNEL FOR LARGE LIFT

DANIEL C. L. LEE and WILLIAM R. SEARS (Arizona, University, Tucson) Journal of Aircraft (ISSN 0021-8669), vol. 24, June 1987, p. 371-376. refs

(Contract AF-AFOSR-82-0185)

Experiments have been carried out in a demonstration wind tunnel of the adaptable-wall type designed for the testing of high-lift configurations, such as powered-lift V/STOL aircraft. The simulated flight vector makes a large angle (30-40 deg) relative to the tunnel axis, so that the model's wake lies in a benign position. Simulation of flight at the desired speed and angle is accomplished by iteratively matching conditions at an interface within the tunnel to the calculated, updated outer flowfield. Measurements were made with a traversing LDA system. The test model in these experiments was a V/STOL transport aircraft model with lower-surface blown wing flaps. Under test conditions, the powered wing-wake made a large angle with the flight direction, and wake positions were measured and are shown. Results show that the iterative procedure successfully reduced matching discrepancies at the interface. Typically, the best match was reached after about six or eight iterations, and this match represents precise simulation at the model to within 1 percent of stream speed. Author

N87-23633# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). Flight Mechanics Panel.

FLIGHT SIMULATION

Loughton, England Sep. 1986 360 p In ENGLISH and FRENCH Symposium held in Cambridge, England, 30 Sep. - 3 Oct. 1985

(AGARD-CP-408; ISBN-92-835-0394-5) Avail: NTIS HC A16/MF A01

The objectives of the conference were to provide an up-to-date description of state-of-the-art technology and engineering for both ground-based and in-flight simulators, together with an indication of future possibilities; and to place the roles of ground-based and in-flight simulators into context with one another and within the aerospace industry.

N87-23634*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

VISUAL AND MOTION CUEING IN HELICOPTER SIMULATION

RICHARD S. BRAY *In* AGARD Flight Simulation 16 p Sep. 1986 Previously announced as N86-11208

Avail: NTIS HC A16/MF A01

The visual cues presented in the simulator are compared with those of flight in an attempt to identify deficiencies. For the low-amplitude maneuvering tasks normally associated with the hover mode, the unique motion capabilities of the Vertical Motion Simulator (VMS) at Ames Research Center permit nearly a full representation of vehicle motion. Especially appreciated in these tasks are the vertical-acceleration responses to collective control. For larger-amplitude maneuvering, motion fidelity must suffer diminution through direct attenuation through high-pass filtering washout of the computer cockpit accelerations or both. Experiments were conducted in an attempt to determine the effects of these distortions on pilot performance of height-control tasks. Author

N87-23635# Rediffusion Simulation Ltd., Crawley (England).

VISUAL DISPLAY RESEARCH TOOL

P. M. MURRAY and B. BARBER *In* AGARD Flight Simulation 8 p Sep. 1986

Avail: NTIS HC A16/MF A01

The Visual Display Research Tool (VDRT) is a new concept in visual displays which utilizes area of interest approach by matching its display parameters to those of the human eye. Two fields of view are employed, a wide-angle field corresponding to the peripheral area and an area of interest field inset at its center. The combined field is coupled to head and eye movements such that the direction of gaze is followed and a detailed scene is apparent over the whole field of regard at all times. The specific design chosen for VDRT is based on helmet mounted projection of two full color rasters onto the interior surface of a spherical dome surrounding the cockpit. The VDRT has been designed to meet the specified performance in a manner which allows a great deal of flexibility in system performance under software control. It should enable a lot of experimental results to be obtained on the performance and suitability of a head mounted eye tracker area of interest system as a training device. Author

N87-23636# Singer-Link-Miles Ltd., Lancing (England). Visual Applications Group.

ADVANCED VISUALS IN MISSION SIMULATORS

D. A. COWDREY *In* AGARD Flight Simulation 10 p Sep. 1986

Avail: NTIS HC A16/MF A01

Modern, sophisticated full mission flight systems trainers are capable of accurate representation of the actual aircraft in many areas including handling, controls, systems, etc. The major area of inadequacy to date has been the inability to produce a satisfactory visual representation of the outside world. To produce an image to match that of the pilot's field-of-view at the required resolution is beyond the capabilities of conventional visual system technology. Various alternative techniques of satisfying this demanding field-of-view/resolution requirement including the technique developed at the Link Flight Simulation Division of the Singer Company, based on an eye-slaved area-of-interest (AOI) concept are discussed. Author

N87-23637# Toronto Univ., Downsview (Ontario). Inst. for Aerospace Studies.

THE APPLICATION OF OPTIMAL CONTROL TECHNIQUES TO THE UTIAS RESEARCH SIMULATOR

L. D. REID *In* AGARD Flight Simualation 13 p Sep. 1986 Sponsored by the Natural Sciences and Engineering Research Council and the Transportation Development Centre

Avail: NTIS HC A16/MF A01

Optimal control has been useful in many aerospace applications in recent years. Two such applications to flight simulators are described. The first involves the generation of wind shear effects for use in training exercises. This work included simulator trails and an assessment of the process by a number of pilots. The second application is to the generation of simulator motion-base drive signals in a six degrees-of-freedom facility. In this case the optimal controller is composed of a series of filters that act much like a classical washout algorithm. Vestibular models which predict the sensation of motion by the pilot are incorporated within the optimal controller and are also used to evaluate its overall performance. Author

N87-23638# Avions Marcel Dassault-Breguet Aviation, Istres (France).
OASIS: A MODERN TOOL FOR REAL-TIME SIMULATION
J. BENOIT *In* AGARD Flight Simulation 13 p Sep. 1986
Avail: NTIS HC A16/MF A01

The hardware and software of the OASIS real-time flight simulation system are discussed. Symbol generation, the performance of elementary graphic functions, the validation of system concepts, and training are briefly discussed. R.J.F.

N87-23639# Royal Aircraft Establishment, Bedford (England). FS(B)3 Div.
SIMULATOR MOTION CHARACTERISTICS AND PERCEPTUAL FIDELITY Progress Report
B. N. TOMLINSON *In* AGARD Flight Simulation 12 p Sep. 1986 Previously announced as X87-70218
Avail: NTIS HC A16/MF A01

Information is given on a study, commissioned by the AGARD Flight Mechanics Panel, to review existing data and try to describe a relationship between certain motion system parameters, identified in an earlier AGARD Report (AR-144), and the fidelity of the pilot's perception of flight. Motion system characteristics as a whole are discussed, thus extending AR-144's treatment of motion mechanisms to include motion drive software and other features. Some of the key parameters of AR-144 are then examined in relation to total motion system fidelity. Finally, some proposals are made for a common format data structure with which to summarise research results on motion cues. Author

N87-23640# British Aerospace Public Ltd. Co., Preston (England).
SIMULATION OF AIRCRAFT BEHAVIOUR ON AND CLOSE TO THE GROUND: SUMMARY OF AGARD
A. G. BARNES *In* AGARD Flight Simulation 4 p Sep. 1986
Avail: NTIS HC A16/MF A01

A summary of a report on the simulation of aircraft characteristics on and near the ground is given. The benefits of good handling are noted. The components needed to put together a simulation - the data set, the computer, the visual system, the motion system, and other cueing devices - are considered. Modeling of the vehicle on the ground is discussed, as are visual system requirements. R.J.F.

N87-23643# National Aerospace Lab., Amsterdam (Netherlands).
FLEXIBLE AND HIGH QUALITY SOFTWARE ON A MULTIPROCESSOR COMPUTER SYSTEM CONTROLLING A RESEARCH FLIGHT SIMULATOR
A. P. L. A. MARSMAN *In* AGARD Flight Simulation 11 p Sep. 1986 Previously announced as N87-18578
Avail: NTIS HC A16/MF A01

The research environment and the multiprocessor computer system required for flexible software for flight simulation programs are described. The program incorporates all hardware options with different calibration tables as the most simple solution, since for example the drive laws trimming the primary control systems are different for each system. Modularity of the simulation program allows the usage of subsets of the hardware. Even the primary controls can be replaced by inputs from a file. This enables the flexibility of parallel maintenance of hardware, while testing modified modules in the software. It reduces the costs for projects which do not need all systems. Author

N87-23645# Air Force Wright Aeronautical Labs., Wright-Patterson AFB, Ohio. Flight Control Div.
TRENDS IN GROUND-BASED AND IN-FLIGHT SIMULATORS FOR DEVELOPMENT APPLICATIONS
PAUL E. BLATT and DON R. GUM *In* AGARD Flight Simulation 13 p Sep. 1986
Avail: NTIS HC A16/MF A01

Current capabilities and future trends for research and development simulators - both ground-based and in-flight are described. Engineering simulators are applied as design tools for synthesis and assessment of advanced aircraft, flight control systems, avionic system design, and cockpit man-machine integration. Real-time, piloted flight simulation for dynamic applications is discussed. No training simulation implications are intended. Author

N87-23646# Textron Bell Helicopter, Fort Worth, Tex.
PILOTED SIMULATION IN THE DEVELOPMENT OF THE XV-15 TILT ROTOR RESEARCH AIRCRAFT
ROGER L. MARR and GARY B. CHURCHILL (Army Aeromechanics Lab., Moffett Field, Calif.) *In* AGARD Flight Simulation 15 p Sep. 1986
Avail: NTIS HC A16/MF A01

The effective use of simulation in the XV-15 preliminary design was demonstrated. All primary program objectives were met. The initial simulation evaluation during the source evaluation board proceedings contributed significantly to performance and stability and control evaluations. Subsequent simulation periods provided major contributions in the areas of control concepts, cockpit configuraiton, handling qualities, pilot workload, failure effects and recovery procedures. The fidelity of the simulation also provided a valuable pilot training aid as well as a means of evaluating the tilt rotor concept for various military and civil missions. Simulation continues to provide valuable design data for refinement of automatic flight control systems and design support for future tilt rotor applications. Throughout, fidelity has been a prime issue and has resulted in unique data and methods to validate and update the tilt rotor math model. Researchers participation from contractor and government agencies in the development of this simulation effort has led to a generic tilt rotor simulation capability on numerous facilities.

N87-23647# Centre d'Essais en Vol, Istres (France).
SIMULATION OF FLY-BY-WIRE CONTROL FOR CIVIL TRANSPORT AIRCRAFT AT THE FRENCH CENTRE D'ESSAIS EN VOL [SIMULATION DES COMMANDES DE VOL ELECTRIQUES AU CENTRE D'ESSAIS EN VOL FRANCAIS (CEV) POUR LES AVIONS DE TRANSPORT CIVIL]
R. VADROT *In* AGARD Flight Simulation 13 p Sept. 1986 In FRENCH
Avail: NTIS HC A16/MF A01

A review of the facilities and projects of the flight simulation center at Istres is presented. In particular, a joint program of the Centre d'Essais en Vol and Aerospatiale to develop simulation capabilities and conduct studies in civil aviation fly-by-wire control is discussed. The two phase project covered real-time image generation, cabin motion simulation, and control law development for the Airbus A-300 and A320 aircraft. M.G.

N87-23649# Grumman Aerospace Corp., Bethpage, N.Y. Flight Test Dept.
UTILIZATION OF SIMULATION TO SUPPORT F-14A LOW ALTITUDE HIGH ANGLE OF ATTACK FLIGHT TESTING
P. CONIGLIARO and R. GOODMAN *In* AGARD Flight Simulation 15 p Sept. 1986
Avail: NTIS HC A16/MF A01

Ground-based flight simulation has been used successfully to support low altitude, asymmetric thrust, high angle of attack flight testing of the Grumman/Navy F-14A. The high risk nature of this flight testing, while representing a prime example of the application of simulation in the flight test environment, nonetheless generated particular problems regarding simulation fidelity and utilization requirements. As a result, new simulation capabilities were developed specifically for flight test support applications and were fully integrated into existing flight test computing/data analysis facilities. Results from the F-14 high angle of attack flight testing are used to illustrate how simulation can significantly enhance overall flight test safety and productivity. Using simulation support, an efficient test program was completed on time and allowed the F-14's departure characteristics to be safely demonstrated at angles of attack greater than 60 degrees with full engine thrust asymmetry at altitudes below 10,000 ft (3030 m). Author

N87-23650# Aeritalia S.p.A., Torino (Italy). Combat Aircraft Group.
THE USE OF AERITALIA FLIGHT SIMULATOR FOR THE DEVELOPMENT OF THE AM-X WEAPON SYSTEM
ARMANDO ARMANDO and MAURIZIO SPINONI *In* AGARD Flight Simulation 12 p Sep. 1986
Avail: NTIS HC A16/MF A01

The use of the Aeritalia flight simulator in the development of the AM-X weapon system is discussed. A brief discription of simulator components is given. Flight mechanics, flight controls simulation, cockpit development, head-up display symbology, air-to-air gun attack simulation, in-flight refueling simulation, and aircraft formation lights positioning are among the topics covered. R.J.F.

N87-23651# Thomson-CSF, Trappes (France).
RADAR SIMULATORS
J. C. PIETREMENT *In* AGARD Flight Simulation 5 p Sep. 1986
Avail: NTIS HC A16/MF A01

The diversity of on-board radars, the required training in their use and the need for preliminary testing prior to their definition led to the development of a multifunction radar simulator architecture offering maximum flexibility. This modular architecture makes possible a wide variety of products from simple training equipment to the most sophisticated research simulators. In addition, it can be adapted as radar techniques develop. Author

N87-23652# Air Force Flight Test Center, Edwards AFB, Calif. 6520 Test Group.
THE DEVELOPMENT OF THE T-46 NEXT GENERATION TRAINER MANNED ENGINEERING SIMULATOR AT THE US AIR FORCE FLIGHT TEST CENTER
JONATHAN C. PICK *In* AGARD Flight Simulation 12 p Sep. 1986
Avail: NTIS HC A16/MF A01

The development and structure of the T-46A flight test simulation at the U.S. Air Force Flight Test Center is described. Two interesting aspects of the simulation are emphasized: (1) An electrohydraulic force-feel system is driven by a digital computer to model a reversible flight control system. This led to some force-feel system instabilities that had to be eliminated. (2) Data for extremely high angles-of-attack are incorporated into the simulation in order to simulate aircraft stall, departure, spin, and recovery. As a tool for supporting flight test operations, the T-46 simulation will be used for planning, practice flying of flight tests, and to facilitate the development and evaluation of aircraft modifications (especially those involving the flight control system). This necessitates the use of very versatile software which can be changed daily to support daily flight operations. In addition, a simulation that can accurately model flight conditions on the edges of the flight envelope greatly enhances the safety and efficiency of flight tests. Since handling qualities is the primary area of interest in this simulation, certain elements of the simulation are of key importance. One of these is control stick feel. The use of an electrohydraulic force-feel system with digital control caused a number of challenges related to force-feel system stability, which are described along with the solutions implemented. Author

N87-23653# Dornier-Werke G.m.b.H., Friedrichshafen (West Germany).
OPERATIONAL TRAINING: APPLICATION AND EXPERIENCE
HEINZ FRIEDRICH *In* AGARD Flight Simulation 8 p Sep. 1986
Avail: NTIS HC A16/MF A01

Possible applications and experience gained in the simulation of missions are described. At first, activities involving operational flight simulation are presented which are performed in the Dornier simulation laboratory and on the Alpha Jet simulator. Following a brief description of the simulator, typical examples are explained. Then a specific task on the simulator is detailed - the development of an air-to-air mode for the Heads Up Display (HUD). In the final section some aspects of operational training on flight simulators in the German air force are discussed. Author

N87-23654# Air Force Flight Test Center, Edwards AFB, Calif. 6520 Test Group.
A METHOD FOR AIRCRAFT SIMULATION VERIFICATION AND VALIDATION DEVELOPED AT THE UNITED STATES AIR FORCE FLIGHT SIMULATION FACILITY
G. R. ANDERSON *In* AGARD Flight Simulation 7 p Sep. 1986
Avail: NTIS HC A16/MF A01

The flight simulators at the United States Air Force Flight Test Center (AFFTC), Aircraft Flight Simulation Facility (AFSF) are primarily used for performance and flying qualities studies. These high-fidelity, real-time simulators are used as an engineering tool during the flight development of new or modified aircraft. Emphasis is placed on fully developing, verifying and validating a simulation before the actual aircraft begins flight testing. The flexibility, accuracy and ease with which the facility's method of verification and validation can be learned and implemented are a few of its advantages. This is demonstrated by the number of simulations which have been developed using it. The F-16 A/B, B-1B, Shuttle, F-15 C/D, AFTI (Advanced Fighter Technology Integration) F-16, F-16 C/D, and the T-46 are examples of simulations presently operational at the facility which were developed using the AFSF's method. The philosophy of developing a simulation before flight test allows the most to be learned about the aircraft before testing begins. The test smarter approach taken at the AFFTC requires that aircraft simulations be built quickly and be used to make flight testing more efficient and safer. The method for verifying and validating simulations used at the AFSF assures that these requirements are fulfilled. Author

N87-23655# National Aerospace Lab., Amsterdam (Netherlands).
CORRELATION BETWEEN FLIGHT SIMULATION AND PROCESSING OF FLIGHT TESTS BASED ON INERTIAL MEASUREMENTS
A. M. H. NIEUWPOORT, J. H. BREEMAN, L. J. J. ERKELENS, and P. J. J. VANDERGEEST *In* AGARD Flight Simulation 18 p Sep. 1986 Previously announced as N87-10863
Avail: NTIS HC A16/MF A01

Flight tests and simulations were performed using conventional and dynamic techniques based on inertial measurements. The use of inertial sensors in flight testing implies that specific forces and body rates are determined which are directly employed in the flight path reconstruction procedure. This procedure uses the equations of motion governing flight. After this step, aerodynamics model identification can take place. In flight simulation, the opposite process occurs. From the available aerodynamic and engine model, specific forces and angular accelerations can be computed. Then the equations of motion can be integrated in order to determine the flight path. Consequently there is a strong similarity in the way flight test results are processed and reduced in order to obtain aerodynamic information and the way simulations are executed using a given model. Author

N87-23656# Calspan Advanced Technology Center, Buffalo, N.Y.
UNUSUAL AIRBORNE SIMULATOR APPLICATIONS
PHILIP A. REYNOLDS *In* AGARD Flight Simulation 14 p Sep. 1986
Avail: NTIS HC A16/MF A01

Airborne simulation was conceived as a general purpose flying qualities research technique. Many diverse uses, forecast for the Total In-Flight Simulator (TIFS) while it was being developed, have come to pass, but diversity of application has exceeded even the most imaginative predictions. Some of the most unusual TIFS projects since it became active in 1971 are described. The objective is to help define and illustrate the role of airborne simulation in aerospace research and development as it interfaces with analysis, ground simulation, and flight test. Author

N87-23657# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick (West Germany). Inst. fuer Flugmechanik.
DFVLR IN-FLIGHT SIMULATORS ATTAS AND ATTHES FOR FLYING QUALITIES AND FLIGHT CONTROL RESEARCH
DIETRICH HANKE and GERD BOUWER *In* AGARD Flight Simulation 13 p Sep. 1986
Avail: NTIS HC A16/MF A01

Two new in-flight simulators have been developed by DFVLR in recent years. These are the advanced airborne simulator Advanced Technologies Testing Aircraft System (ATTAS) based on a modified VFW-614 jet transport aircraft which will be operational in 1986, and the helicopter silulator ATTHeS (Advanced Technologies Testing Helicopter System) based on a BO 105 helicopter, which has operated since 1984. The application potential, the design requirements, the vehicle modifications, the overall system performance and the simulation capabilities as well as the used model-following-control methods, showing that good simulation fidelity could be achieved are among the types discussed. Author

N87-23658# Royal Aircraft Establishment, Bedford (England). FS(B)1 Div.
DEVELOPMENT OF IN-FLIGHT SIMULATION AIRCRAFT FOR RESEARCH AND TRAINING APPLICATIONS IN UK
O. P. NICHOLAS, J. A. GILES, and D. A. WILLIAMS (Cranfield Inst. of Tech., Bedford, England) *In* AGARD Flight Simulation 13 p Sep. 1986
Avail: NTIS HC A16/MF A01

The objectives and the aircraft experimental system for the Vectored thrust Aircraft Advanced Flight Control (VAAC) research program are discussed. The VAAC program studies control laws, displays and cockpit controls for advanced STOL aircraft. The objective is to develop concepts and design and assessment techniques through ground based piloted simulation, mathematical studies, and flight in a two-seat fly-by-wire research Harrier aircraft. This work seeks to free the designer from some of the traditioned stability and control constraints and to maximise operational effectiveness throughout the flight envelope VSTOL aircraft. Author

N87-23659# National Aeronautical Establishment, Ottawa (Ontario). Airborne Simulation Facility.
AIRBORNE SIMULATION AT THE NATIONAL AERONAUTICAL ESTABLISHMENT OF CANADA
J. M. MORGAN *In* AGARD Flight Simulation 16 p Sep. 1986
Sponsored in part by the Canadian Department of National Defence
Avail: NTIS HC A16/MF A01

The present Airborne Simulator operated by the Flight Research Laboratory (FRL) of the National Aeronautical Establishment (NAE), is based on a Bell 205A-1 host vehicle, and is the third generation of such simulators at the laboratory, the previous two being based on Bell 47 models. This aircraft was acquired by the NAE in 1969, first saw service in the simulation of variable stability role in 1971, and since then has undergone and is still undergoing a process of evolutionary development. This paper will concentrate on the operational aspects of airborne simulation using this aircraft, specifically addressing its limitations and the flight safety implications of operating in a single channel fly-by-wire mode in close proximity to the surface and obstacles. The implications of such operations, encompassing such flight phases as landing and Nap of the Earth (NOE) flight on future generations of airborne simualtion are also mentioned. Recent trends in flight mechanics research at the FRL have tended to remove emphasis from classical handling qualities experiments to a more system oriented field, and following this the Airborne Simuator has, of late, been used for investigations of the inherent aspects of fly-by-wire systems and as a general research tool in the investigation of various aspects of the glass cockpit and high technology pilot/machine interfacing. Author

N87-23660# Systems Technology, Inc., Hawthorne, Calif.
COLLECTED FLIGHT AND SIMULATION COMPARISONS AND CONSIDERATIONS
IRVING L. ASHKENAS *In* AGARD Flight Simulation 34 p Sep. 1986
Avail: NTIS HC A16/MF A01

Government-sponsored research at Systems Technology, Inc. dealing with simulation fidelity and utility is reviewed, starting with some generic effects of motion and vision system characteristics and computational artifacts. Diagnostic methods and tools useful in discovering and delineating significant qualitative and quantitative differences between simulation and flight are then exposed and illustrated. Finally, examples of both fixed and moving simulation successes and shortcomings are reviewed and examined as to root causes of either. The research-simulator equipment involved in the above comparisons ranges from modern large-scale motion systems and computer-generated imagery to fixed-base with simple CRT-generated displays.

N87-23661# Army Construction Engineering Research Lab., Champaign, Ill.
CONSEQUENCE OF LAYER SEPARATION ON PAVEMENT PERFORMANCE Final Report
MOHAMED Y. SHAHIN, ELEANOR W. BLACKMON, THOMAS VANDAM, and KEITH KIRCHNER Apr. 1987 59 p
(DOT/FAA/PM-86/48) Avail: NTIS HC A04/MF A01

Asphalt concrete (AC) and portland cement concrete (PCC) pavements were investigated to determine the consequence of overlay separation on pavement behavior. Available methods of detection and rehabilitation of layer separation were addressed. Stresses and strains resulting from aircraft loading in an AC pavement section were computed by layered elastic theory. Layer slippage and consequent separation generates large tensile strains at the bottom of the slipped layer, resulting in reduced fatigue life. Horizontal tangential loads due to braking or turning generate high tensile strains at the top of the overlay just outside the wheel imprint which are likely to be critical even when layer separation is not present. A finite element model was used to evaluate PCC pavement response to load, and Westergaard/Bradbury equations were used to determine curling stresses. It was found that loss of bond adversely affects maximum pavement tensile stress and maximum pavement deflections. Detection of bond loss may be possible using corner deflections determined by nondestructive testing. Author

N87-23662*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
EXPERIMENTAL EVALUATION OF HONEYCOMB/SCREEN CONFIGURATIONS AND SHORT CONTRACTION SECTION FOR NASA LEWIS RESEARCH CENTER'S ALTITUDE WIND TUNNEL
RICHARD R. BURLEY and DOUGLAS E. HARRINGTON May 1987 30 p
(NASA-TP-2692; E-3142; NAS 1.60:2692) Avail: NTIS HC A03/MF A01 CSCL 14B

An experimental investigation was conducted in the high speed leg of the 0.1 scale model of the proposed Altitude Wind Tunnel to evaluate flow conditioner configurations in the settling chamber and their effect on the flow through the short contraction section. The lowest longitudinal turbulence intensity measured at the contraction-section entrance, 1.2%, was achieved with a honeycomb plus three fine-mesh screens. Turbulence intensity in the test section was estimated to be between 0.1 and 0.2% with the honeycomb plus three fine mesh screens in the settling chamber. Adding screens, however, adversely affected the total pressure profile, causing a small defect near the centerline at the contraction section entrance. No significant boundary layer separation was evident in the short contraction section. Author

N87-23664*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
REACTIVATION STUDY FOR NASA LEWIS RESEARCH CENTER'S HYPERSONIC TUNNEL FACILITY
JEFFREY E. HAAS Jul. 1987 14 p Presented at the 23rd Joint Propulsion Conference, San Diego, Calif., 29 Jun. - 2 Jul. 1987; cosponsored by AIAA, SAE, ASME, and ASEE
(NASA-TM-89918; E-3614; NAS 1.15:89918; AIAA-87-1886)
Avail: NTIS HC A02/MF A01 CSCL 14B

The Hypersonic Tunnel Facility (HTF) at NASA Lewis Research Center's Plum Brook Station is a blowdown, free-jet, nonvitiated propulsion facility capable of Mach 5, 6, and 7 with true temperature, altitude, and air composition simulation. The facility has been in a deactivated status for 13 years. Discussed are the capabilities of HTF, and the results of a deactivation study recently conducted to determine the cost, schedule, and technical effort required to restore HTF to its original design operating capabilities are summarized. Author

N87-23665# Duits-Nederlandse Windtunnel, North East Polder (Netherlands).
ACTIVITIES REPORT OF THE GERMAN-DUTCH WIND TUNNEL Annual Report, 1984
1985 12 p Original document contains color illustrations
(B8677593; JE535; ETN-87-99590) Avail: NTIS HC A02/MF A01

Wind tunnel tests on aircraft and automobiles are described. Support interference and ground proximity effects; blockage correction for automotive testing; and helicopter rotor noise were studied. ESA

N87-23666# Duits-Nederlandse Windtunnel, North East Polder (Netherlands).
ACTIVITIES REPORT OF THE GERMAN-DUTCH WIND TUNNEL Annual Report, 1985
7 Jan. 1987 18 p Original document contains color illustrations
(B8677594; JE535; ETN-87-99591) Avail: NTIS HC A02/MF A01

Wind tunnel tests on aircraft and automobiles are described. Correction of thermal effects on an internal gage balance; flow visualization with a sweeping laser beam; and acoustical calibration are summarized. ESA

N87-24480# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (West Germany). Helicopter and Military Aircraft Div.
DEVELOPMENT OF INTAKE SWIRL GENERATORS FOR TURBO JET ENGINE TESTING
H. P. GENSSLER, W. MEYER, and L. FOTTNER (Technische Univ., Munich, West Germany) *In* AGARD Engine Response to Distorted Inflow Conditions 21 p Mar. 1987 Sponsored in part by the German Bundesministerium der Verteidigung
Avail: NTIS HC A14/MF A01

The main objective of this investigation is to assess the influence of different types and magnitudes of swirl on the performance and compatibility of turbojet engines. The generation of intake swirl, typical for many supersonic combat aircraft, is described. Essentially two basic types, i.e., twin swirl and bulk swirl of varying strength and also combinations thereof, were selected in order to simulate these swirl patterns by subscale generators in a model wind tunnel. The swirl patterns measured behind these generators show good agreement with the target patterns selected at the beginning. The small scale swirl generators are being rebuilt at full scale for subsequent testing in front of the Larzac engine under static conditions with a bellmouth inlet at the engine test facility of the Jet Propulsion Institute at the Universitaet der Bundeswehr Muenchen. Author

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ASTRONAUTICS

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

A87-42477*# Grumman Aerospace Corp., Bethpage, N.Y.
DESIGN AND TEST OF A PROTOTYPE THERMAL BUS EVAPORATOR RESERVOIR ABOARD THE KC-135 0-G AIRCRAFT
RICHARD F. BROWN, ERIC GUSTAFSON (Grumman Aerospace Corp., Bethpage, NY), and W. RUSS LONG (NASA, Johnson Space Center, Houston, TX) AIAA, Thermophysics Conference, 22nd, Honolulu, HI, June 8-10, 1987. 11 p.
(AIAA PAPER 87-1503)

The Thermal Bus Zero-G Reservoir Demonstration Experiment (RDE) has currently undergone two flights on the NASA-JSC KC-135 Reduced Gravity Aircraft. The objective of the experiment, which uses a smaller version of the evaporator reservoirs being designed for the Prototype Thermal Bus for Space Station, is to demonstrate proper 0-g operation of the reservoir in terms of fluid positioning, draining, and filling. The KC-135 was chosen to provide a cost-effective and timely evaluation of 0-g design issues that would be difficult to predict analytically. A total of fifty 0-g parabolas have been flown, each providing approximately 25-30 seconds of 0-g time. While problems have been encountered, the experiment has provided valuable design data on the 0-g operation of the reservoir. This paper documents the design of the experiment; the results of both flights, based on the high-speed movies taken during the flight and the visual observations of the experimenters; and the design modifications made as a result of the first flight and planned as a result of the second flight. Author

N87-23795# California Inst. of Tech., Pasadena.
LINEAR COUPLING OF ACOUSTICS AND ENTROPY AND ACOUSTIC STABILITY IN RAMJET COMBUSTION CHAMBERS CONTAINING A PLANE FLAME
JOSEPH W. HUMPHREY and F. E. C. CULICK *In* Johns Hopkins Univ., The 23rd JANNAF Combustion Meeting, Volume 1 p 435-448 Oct. 1986
(Contract N00014-84-K-0434)
Avail: CPIA, Laurel, Md. 20707 HC $70.00

A one-dimensional analytical model is presented for calculating the longitudinal acoustic modes of idealized dump-type ramjet engines. The model contains the matching required to place an oscillating flame sheet in the interior of a combustion chamber with mean flow. The linear coupling of the acoustic and entropy waves at the inlet shock, flame sheet, and exit nozzle along with acoustic admittances at the inlet and exit are combined to determine the stability of the system as well as the acoustic modes. Since the acoustic and entroy waves travel at different velocities, the geometry is a critical factor in determining stability. Typical values of the admittances will produce damped solutions when the entropy is neglected, but, as the ratio of the entropy to acoustic fluctuations is increased, the coupling can either feed acoustic energy into or out of different modes independently. This transfer of energy has a destabilizing or stabilizing effect on the acoustic modes of the system depending upon the phase of the energy transfer. Author

N87-23796# California Inst. of Tech., Pasadena.
ANALYSIS OF PRESSURE OSCILLATIONS IN RAMJETS. REVIEW OF RESEARCH: 1985-1986
F. E. C. CULICK *In* Johns Hopkins Univ., The 23rd JANNAF Combustion Meeting, Volume 1 p 449-457 Oct. 1986
(Contract N00014-84-K-0434)
Avail: CPIA, Laurel, Md. 20707 HC $70.00

Unsteady motions in ramjet engines are studied. The program comprises analytical work devoted generally to the question: what causes unsteady motions in ramjet engines to grow and reach the limiting amplitudes observed in practice? The effort therefore encompasses both the causes or mechanisms of instabilities; and the linear and nonlinear processes influencing the time evolution of the motions. The application of approximate analysis, in contrast to numerical analysis carried out, to produce solution of complete equations of motion was of primary concern. Subjects covered here include progress in the linear and nonlinear analysis of acoustics with entropy waves; application of the method of averaging to problems having arbitrary distributions of modal frequencies; and the excitation of nonlinear acoustic waves by random sources. Author

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CHEMISTRY AND MATERIALS

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

A87-40230#
EFFECT OF COLD-WORKING BY HOLE EXPANSION ON FATIGUE LIFE OF 7075-T7351 AND 7475-T761 ALUMINUM LUGS WITH AND WITHOUT INITIAL FLAWS UNDER MANEUVER LOADING SPECTRUM
A. BUCH (Technion - Israel Institute of Technology, Haifa, Israel) Zeitschrift fuer Werkstofftechnik (ISSN 0049-8688), vol. 18, March 1987, p. 74-78. refs

The effect of cold working by hole expansion on fatigue life of aircraft lugs under maneuver and constant amplitude loading was investigated. Of the two nominal expansion levels used, 2 percent expansion resulted in greater life improvement than the larger expansion of 3.3 percent. The reason for this was the relatively small w/d ratio and lug head shape distortion caused by the larger expansion. The hole expansion had a more beneficial effect in the case of lugs with 1 mm deep initial flaws than lugs without flaws. Hole expansion considerably improved the damage tolerance of the lugs investigated. Author

A87-40384#
MOISTURE DIFFUSION IN GRAPHITE/BISMALIMIDE-MODIFIED-EPOXY COMPOSITE IM6/5245C
JERZY P. KOMOROWSKI (National Aeronautical Establishment, Ottawa, Canada) and SYLVIE BELAND Canadian Aeronautics and Space Journal (ISSN 0008-2821), vol. 32, Sept. 1986, p. 218-226. refs

The diffusion properties of, and the effect of long-term environmental exposure on IM6/5254C are investigated. The relationship between relative humidity and moisture saturation, and temperature and diffusivity were examined. The moisture weight gain under long-term service conditions for transport and fighter aircraft are estimated and compared with predictions for the graphite/epoxy AS/3501-5. The data reveal that IM6/5245C is highly diffusive and is expected to absorb up to 0.7 percent moisture by weight in the worst environmental conditions regardless of the aircraft type; however, for AS/3501-5 the fighter aircraft had lower moisture weight gain (0.6 percent) than the transport aircraft (1.5 percent). I.F.

A87-40925#
BLACKENING OF PETROLEUM-BASED AVIATION OILS - CAUSES AND CONSEQUENCES [PRISPEVEK K CERNANI LETECKYCH ROPNYCH OLEJU - PRICINY A DUSLEDKY]
JAROSLAV CERNY Zpravodaj VZLU (ISSN 0044-5355), no. 2, 1987, p. 69-71. In Czech. refs

The problem of the blackening of aviation oils is examined theoretically. In particular, it is suggested that oil blackening results primarily from rapid oxidation by hot air leaking through defective or damaged oil seals. The oxidation process, which results in the formation of nonsoluble polymeric sediments, is briefly described. The effect of oxidation products on the lubrication characteristics of oils is discussed. V.L.

A87-41305#
REVIEW OF THE ROLE OF THERMOPLASTICS IN AIRBORNE RADOMES FOR THE 1990S
M. C. CRAY (British Aerospace, PLC, Reinforced and Microwave Plastics Group, Stevenage, England) IN: Military microwaves '86; Proceedings of the Conference, Brighton, England, June 24-26, 1986 . Tunbridge Wells, England, Microwave Exhibitions and Publishers, Ltd., 1986, p. 249-254. refs

High performance engineering thermoplastics, particularly polyarylates, show promise as tough matrices in advanced aerospace composites. The future potential of these and thermoset resin matrix systems has been assessed during development and manufacture of radomes for advanced aircraft and missile systems. The advantages and possible penalties of the major resins are reviewed in seeking a realistic prediction of their role in airborne radomes in the 1990s. Author

A87-41913#
DEFORMATION AND FRACTURE OF THE TITANIUM DISKS OF GAS-TURBINE ENGINES DUE TO CHANGES IN THE FREQUENCY AND SHAPE OF THE LOADING CYCLE [DEFORMIROVANIE I RAZRUSHENIE TITANOVYKH DISKOV GTD PRI IZMENENII CHASTOTY I FORMY TSIKLA NAGRUZHENIIA]
V. V. OMEL'CHENKO, N. S. MOZHAROVSKII, N. V. STEPANOV, and A. A. ZAKHOVAIKO (Zaporozhskoe Proizvodstvennoe Ob'edinenie Motorostroitel', Zaporozhe; Kievskii Politekhnicheskii In Problemy Prochnosti (ISSN 0556-171X), April 1987, p. 15-19. In Russian. refs

The low-cycle fatigue of test specimens and compressor disks of VT3-1 titanium alloy is investigated experimentally as a function of the loading conditions. It is found that a decrease in loading frequency and an increase in the hold time at maximum cycle stress lead to a significant decrease in the fatigue life of VT3-1 test specimens and disks. In real structural elements, the effect of the loading conditions on the fatigue life is more pronounced than in test specimens. V.L.

N87-23729*# Sverdrup Technology, Inc., Cleveland, Ohio.
THE T55-L-712 TURBINE ENGINE COMPRESSOR HOUSING REFURBISHMENT PROJECT Final Report
GEORGE W. LEISSLER, CLIFF DARLING, and GEORGE GILCHRIST (Corpus Christi Army Depot, Tex.) May 1987 23 p
Prepared in cooperation with Army Aviation Research and Development Command, Cleveland, Ohio
(Contract NAS3-24105; DA PROJ. 1L1-61102-AH-45)
(NASA-CR-179624; E-3571; NAS 1.26:179624; AVSCOM-TR-87-C-20) Avail: NTIS HC A02/MF A01 CSCL 11F

A study was conducted to access the feasibility of reclaiming T55-L-712 turbine engine compressor housings with an 88 wt % aluminum -- 12 wt % silicon alloy applied by the plasma spray processes. Tensile strength testing was conducted on as-sprayed and thermally cycled test specimens which were plasma sprayed from 0.020 to 0.100 in. Satisfactory tensile strength valves were observed in the as-sprayed tensile specimens. There was essentially no decrease in tensile strength after thermally cycling the tensile specimens. Author

N87-23737*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
CERAMIC HONEYCOMB STRUCTURES AND THE METHOD THEREOF Patent Application
SALVATORE R. RICCITIELLO, inventor (to NASA) and DOMENICK E. CAGLIOSTRO, inventor (to NASA) 29 Jan. 1987 17 p
(NASA-CASE-ARC-11652-1; NAS 1.71:ARC-11652-1; US-PATENT-APPL-SN-008242) Avail: NTIS HC A02/MF A01 CSCL 11B

The subject invention pertains to a method of producing an improved composite-composite honeycomb structure for aircraft or aerospace use. Specifically, the subject invention relates to a method for the production of a lightweight ceramic-ceramic composite honeycomb structure, which method comprises: (1) pyrolyzing a loosely woven fabric/binder having a honeycomb shape and having a high char yield and geometric integrity after pyrolysis at between about 700 and 1,100 C; (2) substantially evenly depositing at least one layer of ceramic material on the pyrolyzed fabric/binder of step (1); (3) recovering the coated ceramic honeycomb structure; (4) removing the pyrolyzed fabric/binder of the structure of step (3) by slow pyrolysis at between 700 and 1000 C in between about a 2 to 5% by volume oxygen atmosphere for between about 0.5 and 5 hr.; and (5) substantially evenly depositing on and within the rigid hollow honeycomb structure at least one additional layer of the same or a different ceramic material by chemical vapor deposition and chemical vapor infiltration. The honeycomb shaped ceramic articles have enhanced physical properties and are useful in aircraft and aerospace uses. NASA

N87-23789* National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
PLASMA TORCH IGNITER FOR SCRAMJETS
TIMOTHY C. WAGNER, WALTER F. OBRIEN, G. BURTON NORTHAM, and JAMES M. EGGERS *In* Johns Hopkins Univ., The 23rd JANNAF Combustion Meeting, volume 1 p 365-376 Oct. 1986 Prepared in cooperation with Virginia Polytechnic Inst. and State Univ., Blacksburg
Avail: CPIA, Laurel, Md. 20707 HC $70.00 CSCL 21I

A small, uncooled plasma torch was developed and used in combination with an injector designed to study ignition and flameholding in hydrogen-fueled supersonic flows. The plasma torch was operated on mixtures of hydrogen and argon with total flows of 10 to 70 scfh. The fuel injector design consisted of five small upstream pilot fuel injectors, a rearward facing step for recirculation, and three main fuel injectors downstream of the step. The plasma torch was located in the recirculation region, and all injection was perpendicular to the Mach 2 stream. Both semi-freejet and ducted tests were conducted. The experimental results indicate that a low power plasma torch operating on a 1:1 volumetric mixture of hygrogen and argon and located in the recirculation zone fueled by the upstream pilot fuel injectors is a good igniter for flow conditions simulating a flight Mach number of 3.7. The total temperature required to autoignite the hydrogen fuel for this injector geometry was 2640 R. The injector configuration was shown to be a good flameholder over a wide range of total temperature. Spectroscopic measurements were used to verify the presence of air total temperatures below 1610 R. Author

N87-23791* National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
OPPOSED JET BURNER STUDIES OF SILANE-METHANE, SILANE-HYDROGEN AND HYDROGEN DIFFUSION FLAMES WITH AIR
G. L. PELLETT, ROSEMARY GUERRA, L. G. WILSON, and G. B. NORTHAM *In* Johns Hopkins Univ., The 23rd JANNAF Combustion Meeting, Volume 1 p 391-404 Oct. 1986 Previously announced in IAA as A87-23259
Avail: CPIA, Laurel, Md. 20707 HC $70.00 CSCL 21I

An atmospheric pressure tubular opposed jet burner technique was used to characterize certain diffusion-flame transitions and associated burning rates for N2-diluted mixtures of highly-reactive fuels. Presented are: (1) details of the technique, with emphasis on features permitting the study of flames involving pyrophoric gases and particle-forming combustion reactions: (2) discoveries on the properties of these flames which correspond to physically and chemically distinct stages of silane and hydrogen combustion; and (3) unburnt gas velocity data obtained from flames based on SiH4-CH4-N2, SiH4-H2-N2, and H2-N2 fuel mixtures, and plotted as functions of combustible-fuel mole fraction and fuel/oxygen molar input flow ratios. In addition, these burning velocity results are analyzed and interpreted. IAA

N87-23792 United Technologies Research Center, East Hartford, Conn.
CARS APPROACHES TO SIMULTANEOUS MEASUREMENTS OF H2 AND H2O CONCENTRATION AND TEMPERATURE IN H2-AIR COMBUSTION SYSTEMS
ALAN C. ECKBRETH, TORGER J. ANDERSON, and GREGORY M. DOBBS *In* Johns Hopkins Univ., The 23rd JANNAF Combustion Meeting, Volume 1 p 405-415 Oct. 1986
Avail: CPIA, Laurel, Md. 20707 HC $70.00

An approach to Coherent Anti-Stokes Raman Spectroscopy (CARS) capable of providing simultaneous measurements of major H2/air combustion constituents with potential as a diagnostic for advanced air-breathing propulsion concepts, is described and demonstrated. The technique employs both a broadband and a narrowband Stokes beam to generate CARS via two, two-color and two, three-color wave mixing processes. Temperature and concentration information are simultaneously available from N2, H2, and H2O. This permits the disappearance of fuel and appearance of product to be monitored. An analysis of the technique's capabilities and future improvements are discussed. Author

N87-23798# Naval Weapons Center, China Lake, Calif.
PASSIVE SHEAR-FLOW CONTROL TO MINIMIZE RAMJET COMBUSTION INSTABILITIES
K. C. SCHADOW, E. GUTMARK, T. P. PARR, D. M. PARR, and K. J. WILSON *In* Johns Hopkins Univ., The 23rd JANNAF Combustion Meeting, Volume 1 p 469-484 Oct. 1986
Avail: CPIA, Laurel, Md. 20707 HC $70.00

Passive shear-flow control methods to avoid combustion instabilites in a ramjet dump combustor were developed in cold nonreacting flows and verified in combustion processes. All control methods, which are based on the detailed understanding of flow instability mechanisms in shear layers, were used to change the initial conditions of the air flow issued from the inlet duct into dump combustor, in an attempt to decouple combustion from the large-scale structures in the flow. Four different jet nozzles located at the dump plane are discussed to augment fine-scale mixing and, at the same time, reduce large-scale mixing: jet nozzles having sharp corners, tapered-elliptical nozzles with a special inner transition section which induces axial vorticity into the flow, multiple-step nozzle with numerous sources for turbulence production yielding highly turbulent homogeneous incoherent flow fields, and secondary high speed axial and radial injection which simulates fuel injection and is aimed to use rationally the fuel injection for a desired flow management. All methods were shown to be able to modify the flow field mixing patterns and inner eddy structure and to provide the potential for minimizing combustion instabilites. Author

N87-23803# Georgia Inst. of Tech., Atlanta.
COMBUSTION INSTABILITIES IN DUMP TYPE RAMJET COMBUSTORS
U. G. HEGDE, D. REUTER, B. T. ZINN, and B. R. DANIEL *In* Johns Hopkins Univ., The 23rd JANNAF Combustion Meeting, Volume 1 p 533-544 Oct. 1986
(Contract N00014-84-K-0470)
Avail: CPIA, Laurel, Md. 20707 HC $70.00

Combustion instability problems often occur in coaxial dump type ramjet combustors. A potentially severe type of instability is characterized by low frequency pressure and velocity oscillations. The coupling between cone shaped flames, often encountered in dump type ramjet combustors and the longitudinal acoustic fields associated with the low frequency instability are investigated. Specifically the unsteady behavior of a V-shaped flame, stabilized in a rectangular combustor, in various longitudinal acoustic fileds is studied. A variety of experimental techniques were employed. It is found that the shear layer formed by the flame exhibits a marked fluid dynamical instability at low frequencies resulting in the formation of burning vortical structures that are convected along the flame front. The resulting unsteady combustion process acts as a strong acoustic source resulting in longitudinal pressure oscillations. This problem, therefore, presents an intricate coupling among the three basic modes of fluid motion. A simple model developed to predict flame generated acoustic spectra from measurements of the unsteady heat release rate yields the coupling between the thermal and acoustic modes. The unsteady vortical behavior of the flame is extremely complicated and exhibits many nonlinear features, in particular the presence of subharmonics and harmonics of the main repsonse frequency. Author

N87-23805# California Univ., Irvine.
SPRAY COMBUSTION: A DRIVING MECHANISM FOR RAMJET COMBUSTION INSTABILITY
W. A. SIRIGNANO, G. RIVA, A. TONG, B. ABRAMZON, and K. MOLAVI *In* Johns Hopkins Univ., The 23rd JANNAF Combustion Meeting, Volume 1 p 551-559 Oct. 1986
(Contract N00014-85-K-0658)
Avail: CPIA, Laurel, Md. 20707 HC $70.00

Analytical and computational studies of liquid-fueled ramjet combustion instability are made. The vaporization rate of droplets in an oscillatory gaseous environment are determined; heat conduction and convection within the droplet interior are considered and shown to have very significant effects compared to the infinite-conductivity or rapid-mixing models of the past. The gain or response function associated with the oscillatory vaporization rate component in phase with the pressure is shown to be sufficiently large to sustain instability. A one-dimensional analysis of longitudinal mode instability indicates that limit cycle oscillations do result after a perturbation is applied. An axisymmetric analysis is concerned on improved numerical methods to reduce numerical diffusion and dispersion. Author

N87-23806# California Univ., Davis. Dept. of Mechanical Engineering.
COMBUSTION, VAPORIZATION, AND MICROEXPLOSION OF DROPLETS OF ORGANIC AZIDES
C. K. LAW, A. LEE, S. DEEVI, A. GANJI, and A. MAKINO *In* Johns Hopkins Univ., The 23rd JANNAF Combustion Meeting, Volume 1 p 561-572 Oct. 1986
(Contract N00014-84-K-0700)
Avail: CPIA, Laurel, Md. 20707 HC $70.00

An experimental investigation was conducted on the vaporization, combustion, and microexplosion characteristics of freely-falling droplets of organic azides and their mixtures with conventional hydrocarbon fuels in hot oxidizing or inert environments. The droplet burning rate and the state of microexplosion were measured. Results show that, compared with the conventional hydrocarbon fuels, droplets of azido fuels gasify faster and microexplode earlier in the droplet lifetime. The effect is especially strong for n-alkyl diazides whose gasification rates can exceed those of the corresponding n-alkanes by several hundred percent. Such strong responses are believed to be caused by the exothermic decomposition of the azides either in the liquid phase or upon gasification. Effects of OH-substitution, molecular branching, and the proximity and number of the azide groups on the gasification behavior were studied while the potential of inducing droplet microexplosion by doping JP-10 with various diazides was also explored. A theoretical model was formulated; the predictions qualitatively agree with the experimental observations. Author

N87-23807# Illinois Univ., Chicago.
FUNCTIONALIZATION OF CUBANE USING HYPERVALENT IODINE
ROBERT M. MORIARTY and JAFFAR S. KHOSROWSHANI *In* Johns Hopkins Univ., The 23rd JANNAF Combustion Meeting, Volume 1 p 573-575 Oct. 1986
(Contract ONR-2-538403-SDI-1986)
Avail: CPIA, Laurel, Md. 20707 HC $70.00

The hypervalent iodine oxidative decarboxlyation reaction upon homocubyl and cubyl mono and dicarboxylic acids is examined. Specifically the appropriate carboxylic acid is treated with C6H5I(OCOCH3)2/CCl4/I2 under irradiation conditions and 80 to 90% of the derived iodo compound is obtained. These derivatives are of key importance because they serve as starting materials for subsequent displacement reactions using hypervalent iodine methodology. Thus azido analogs are synthetically accessible. The cubylaryliodonium salt is also accessible using these methods. Author

N87-23815# Federal Aviation Agency, Atlantic City, N.J.
AUTOGAS IN GENERAL AVIATION AIRCRAFT Final Report
H. STEWART BYRNES, WILLIAM C. CAVAGE, and AUGUSTO M. FERRARA Mar. 1987 58 p
(DOT/FAA/CT-87/05) Avail: NTIS HC A04/MF A01

A series of aircraft engine tests was conducted on a dynamometer which compared the vapor lock tendency of selected automobile gasolines against aviation gasolines. The effects of fuel temperature, the technique for heating the fuel used in vapor lock studies, the engine cooling air temperature, the fill level in the tanks, and fuel system configuration were investigated. The tendency for automobile gasoline to detonate in and aircraft engine was investigated, and the results show a strong correlation with the Motor Octane Number. Flight data is presented which shows the effect of the mode of operation on fuel system temperatures in two typical general aviation aircraft. Select results from a fuel aging study demonstrate the effects of long-range storage of automobile gasoline in typical general aviation wing tanks. Based on these results, a number of considerations pertaining to certification of general aviation aircraft fuel systems with automobile gasoline are identified. Author

N87-23816# General Electric Co., Cincinnati. Ohio. Aircraft Engine Business Group.
ANTIMISTING FUEL (AMK) FLIGHT DEGRADER DEVELOPMENT AND AIRCRAFT FUEL SYSTEM INVESTIGATION Final Report, Mar. 1983 - Dec. 1985
GEORGE A. COFFINBERRY and THOMAS M. TUCKER Feb. 1987 209 p
(Contract DTFA03-83-C-00018)
(DOT/FAA/CT-86/6; R86AEB565) Avail: NTIS HC A10/MF A01

Results from an effort involving the design, fabrication and evaluation of an Antimisting Kerosene (AMK) degrader are summarized. The principal objective was to demonstrate the feasibility of employing a high speed centrifugal pump to condition AMK fuel for use in an aircraft turbine engine. The effects of AMK fuel on the engine/airframe fuel system as well as any effect the flight environment might have had on the fire preventive characteristics of the AMK were also investigated. Five functionally identical degrader systems were produced. The first system was installed on the No. 3 engine of a CV880 aircraft with a dedicated AMK fuel tank. The remaining four degrader systems were installed on a B720 aircraft that was used in the Full Scale Transport Controlled Impact Demonstration (CID). The degrader system performed well and met the objectives of both the CV880 and the CID programs. Aside from the intermittent occurrence of gel, little difference in performance could be distinguished between the No. 3 engine, operating on AMK, and the No. 2 reference engine, operating on Jet A. Author

N87-24553# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). *Corrosion Subcommittee of the Structures and Materials Panel.*
AGARD CORROSION HANDBOOK. VOLUME 2: AIRCRAFT CORROSION CONTROL DOCUMENTS: A DESCRIPTIVE CATALOGUE
J. J. DELUCCIA, R. D. GERGAR, and E. J. JANKOWSKY (Jaylords, Inc., Philadelphia, Pa.) Mar. 1987 48 p
(AGARD-AG-278-VOL-2; AGARDOGRAPH-278;
ISBN-92-835-1545-5) Avail: NTIS HC A03/MF A01
This is the second part of a handbook of Aircraft Corrosion produced by the AGARD Structures and Materials Panel. This volume catalogs sources of information and requirements for corrosion control obtained from documents issued by NATO, France, UK, and US authorities. IATA (International Air Transport Association) documents are also cited as a commercial reference. Author

N87-24577*# Pratt and Whitney Aircraft, East Hartford, Conn.
ANTIMISTING KEROSENE JT3 ENGINE FUEL SYSTEM INTEGRATION STUDY Final Report
A. FIORENTINO Washington NASA Jan. 1987 48 p
(Contract NAS3-24217; NAS3-24353; DTFA03-81-A-00154)
(NASA-CR-4033; NAS 1.26:4033) Avail: NTIS HC A03/MF A01 CSCL 21D
An analytical study and laboratory tests were conducted to assist NASA in determining the safety and mission suitability of the modified fuel system and flight tests for the Full-Scale Transport Controlled Impact Demonstration (CID) program. This twelve-month study reviewed and analyzed both the use of antimisting kerosene (AMK) fuel and the incorporation of a fuel degrader on the operational and performance characteristics of the engines tested. Potential deficiencies and/or failures were identified and approaches to accommodate these deficiencies were recommended to NASA Ames -Dryden Flight Research Facility. The result of flow characterization tests on degraded AMK fuel samples indicated levels of degradation satisfactory for the planned missions of the B-720 aircraft. The operability and performance with the AMK in a ground test engine and in the aircraft engines during the test flights were comparable to those with unmodified Jet A. For the final CID test, the JT-3C-7 engines performed satisfactorily while operating on AMK right up to impact. Author

N87-24578*# General Electric Co., Cincinnati, Ohio.
AVIATION FUEL PROPERTY EFFECTS ON ALTITUDE RELIGHT Final Report, Jan. 1984 - Jun. 1986
K. VENKATARAMANI May 1987 67 p
(Contract NAS3-24215)
(NASA-CR-179582; NAS 1.26:179582; R87AEB111) Avail: NTIS HC A01/MF A01 CSCL 21D
The major objective of this experimental program was to investigate the effects of fuel property variation on altitude relight characteristics. Four fuels with widely varying volatility properties (JP-4, Jet A, a blend of Jet A and 2040 Solvent, and Diesel 2) were tested in a five-swirl-cup-sector combustor at inlet temperatures and flows representative of windmilling conditions of turbofan engines. The effects of fuel physical properties on atomization were eliminated by using four sets of pressure-atomizing nozzles designed to give the same spray Sauter mean diameter (50 + or - 10 micron) for each fuel at the same design fuel flow. A second series of tests was run with a set of air-blast nozzles. With comparable atomization levels, fuel volatility assumes only a secondary role for first-swirl-cup lightoff and complete blowout. Full propagation first-cup blowout were independent of fuel volatility and depended only on the combustor operating conditions. Author

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ENGINEERING

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

A87-39415#
CLOSE FORM SOLUTION FOR PREDICTION OF CRACK PROPAGATION LIFE OF STRUCTURE MEMBER AND ITS APPLICATION TO LANDING GEARS
XING ZHANG (Beijing Institute of Aeronautics and Astronautics, People's Republic of China), BAOXIN WU, and HUEIZHU WEI (People's Liberation Army, Air Force Research Institute, People's Republic of China) Acta Aeronautica et Astronautica Sinica, vol. 8, April 1987, p. B140-B146. In Chinese, with abstract in English. refs
A formula for determining the crack-propagation life of structural elements is derived and applied. The approach is based on the retardation model of Matsuoka and Tanaka (1976) and the effective-strain concept of Walker (1970). The derivation is briefly explained, and numerical results for a fighter nose landing gear are presented in extensive tables and graphs. The residual life about the failure position predicted by the formula is found to be about 18 percent lower than the experimental mean value. T.K.

A87-39484#
PURIFYING HYDRAULIC SYSTEMS
JAMES H. BRAHNEY Aerospace Engineering (ISSN 0736-2536), vol. 7, April 1987, p. 31-36.
Filtration systems for 8000-psi operating pressure and nonflammable CTFE fluid-using aircraft hydraulics are discussed. Research results indicate that, as a dynamic component operates in a hydraulic system, it is the film thickness of the operating fluid which determines the clearances between opposing moving component surfaces. The combination of high pressure and temperature in the operating environment plays an important role in determining both fluid film thickness and the shape of the contact zone. Manufacturers have minimized the complexities of filtering requirements by integrating main system filter elements into a single unit. O.C.

A87-39539*# North Carolina State Univ., Raleigh.
EFFICIENT CALCULATION OF CHEMICALLY REACTING FLOW
DEAN R. EKLUND, H. A. HASSAN (North Carolina State University, Raleigh), and J. PHILIP DRUMMOND (NASA, Langley Research Center, Hampton, VA) AIAA Journal (ISSN 0001-1452), vol. 25, June 1987, p. 855, 856. Abridged. Previously cited in issue 07, p. 894, Accession no. A86-19952. refs
(Contract NAG1-244)

A87-39641#
EVALUATION OF ALUMINUM-LITHIUM ALLOYS IN COMPRESSION STIFFENED AIRCRAFT STRUCTURES
J. C. EKVALL and D. J. CHELLMAN (Lockheed-California Co., Burbank) AIAA, ASME, ASCE, and AHS, Structures, Structural Dynamics and Materials Conference, 28th, Monterey, CA, Apr. 6-8, 1987. 9 p. refs
(AIAA PAPER 87-0758)
Aluminum-lithium (Al-Li) alloys represent an area of considerable interest to the aircraft industry because of the potential for high structural efficiencies compared to conventional aluminum alloy products. The reported work addresses the identification and characterization of a candidate Al-Li alloy that demonstrates promise for use in 7075 aluminum structural applications. Heat treatment studies were conducted initially to select a suitable combination of strength, ductility, and toughness. Mechanical property evaluations comprising static and cyclic testing were

subsequently performed on extruded bar materials, and compared to baseline 7075 aluminum extrusions. The structural behavior was established by compression testing of stiffened panels, typical of those used in airframe construction. Experimental findings and predictions are discussed in terms of the properties of materials. A structural weight savings of between 8 and 13 percent was shown for Al-Li alloy materials in compression critical components. Author

A87-39804#

APPLICATION OF SPATIALLY PRECISE LASER DIAGNOSTICS TO FUNDAMENTAL AND APPLIED COMBUSTION RESEARCH

ALAN C. ECKBRETH (United Technologies Research Center, East Hartford, CT) Journal of Propulsion and Power (ISSN 0748-4658), vol. 3, May-June 1987, p. 210-218. Previously cited in issue 07, p. 901, Accession no. A86-19714. refs

A87-39805*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

EFFECTS OF MULTIPLE ROWS AND NONCIRCULAR ORIFICES ON DILUTION JET MIXING

J. D. HOLDEMAN (NASA, Lewis Research Center, Cleveland, OH), R. SRINIVASAN, E. B. COLEMAN, G. D. MEYERS, and C. D. WHITE (Garrett Turbine Engine Co., Phoenix, AZ) Journal of Propulsion and Power (ISSN 0748-4658), vol. 3, May-June 1987, p. 219-226. Previously cited in issue 18, p. 2620, Accession no. A85-39606. refs

A87-39839#

SOME RESULTS FROM PARABOLIC FLIGHTS

J. C. LEGROS, M. C. LIMBOURG (Bruxelles, Universite Libre, Brussels, Belgium), D. SCHWABE (Giessen, Universitaet, West Germany), J. H. LICHTENBELT (Groningen, Rijksuniversiteit, Netherlands), and D. FRIMOUT (ESA, European Space Research and Technology Centre, Noordwijk, Netherlands) (COSPAR, Plenary Meeting, 26th, Topical Meeting on Material Sciences in Space - IV, Toulouse, France, June 30-July 11, 1986) Advances in Space Research (ISSN 0273-1177), vol. 6, no. 5, 1986, p. 93-95. FNRS-SPPS-FRFC-supported research. refs

(Contract NATO-916, 83)

Parabolic flight experiments were performed aboard a KC 135 aircraft to investigate the possibility of creating a flat liquid/gas interface (by filling a cuvette under microgravity conditions), the stability of these interfaces, and the behavior of such systems when heated from below. Two cells were tested: (1) a Pyrex tube glued on a stainless steel plate and (2) a cylindrical quartz cuvette, using anticreeping barriers and different methods to inject fluids of varying surface tension values (water, water + LAC, and paraffin oil). The interfaces created were stable with respect to shaking. On the hand, it was demonstrated that inertia was a dominant force. By rapid longitudinal displacements it was possible to extract large drops from the center of the interface, but this interface remained attached at the limit of the anticreeping barrier. I.S.

A87-39840#

IMPROVEMENT OF FLIGHT HARDWARE AND ISOTHERMAL MARANGONI CONVECTION UNDER MICRO-GRAVITY CONDITIONS

J. H. LICHTENBELT (Groningen, Rijksuniversiteit, Netherlands) (COSPAR, Plenary Meeting, 26th, Topical Meeting on Material Sciences in Space - IV, Toulouse, France, June 30-July 11, 1986) Advances in Space Research (ISSN 0273-1177), vol. 6, no. 5, 1986, p. 97-100. ESA-supported research. refs

Parabolic flight experiments were performed to investigate Marangoni convection due to concentration gradients along the gas-liquid interface under isothermal conditions, using gas bubbles as tracer particles. In one experiment, Marangoni convection was introduced by a horizontal concentration gradient; in another, the convection was due to evaporation of a component from a solution under steady state conditions. It was found that the problems encountered in the control of the concentration gradients are more complicated than those associated with the temperature-gradient control. The parabolic flights were found to yield qualitative rather than quantitative results and are considered to be useful as a preliminary stage of space experiments. I.S.

A87-39895*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

EXPERIMENTAL FLOWFIELD VISUALIZATION OF A HIGH ALPHA WING AT MACH 1.62

JAMES L. PITTMAN (NASA, Langley Research Center, Hampton, VA) Journal of Aircraft (ISSN 0021-8669), vol. 24, May 1987, p. 335-341. refs

Experimental oil-flow and tuft patterns and vapor-screen flow-visualization data were obtained on a cambered wing model at Mach = 1.62 for an angle-of attack range of 0-14 deg. These data were used as flow diagnostic tools along with surface-pressure and force data and full-potential theory calculations. A large separation bubble was found on the lower wing surface at low angle of attack. The high-angle-of-attack flowfield was characterized by a large attached-flow leading-edge expansion followed by a crossflow shock. At alpha = 14 deg the crossflow shock apparently induced discrete regions of streamwise separated flow, which were clearly indicated in the vapor-screen and oil-flow photographs. Author

A87-39935#

ASSESSMENT OF ROTOR CRITICAL SPEEDS - A NOTE

RAHUL BASU (Gas Turbine Research Establishment, Bangalore, India) Defence Science Journal (ISSN 0011-748X), vol. 36, Oct. 1986, p. 421-424. refs

The evaluation of aircraft engine rotor critical speeds is examined. The use of computer programs and the transfer matrix method to estimate critical speeds is discussed. An example in which a computer program and the transfer matrix method are applied to a rotor in order to determine critical speeds is presented. I.F.

A87-40060#

NONLINEAR AEROELASTICITY - AN OVERVIEW

E. H. DOWELL (Duke University, Durham, NC) IN: U.S. National Congress of Applied Mechanics, 10th, Austin, TX, June 16-20, 1986, Proceedings . New York, American Society of Mechanical Engineers, 1987, p. 171-173. refs

Theoretical and experimental investigations of nonlinear aeroelastic systems are briefly reviewed. The main characteristics of fully linear, dynamically linear, and fully nonlinear models are listed, and specific problems such as the oscillations of bluff bodies in a flowing stream, large oscillations of streamlined bodies with intermittent flow separation, and hydraulic and dry-friction structural damping mechanisms are indicated. T.K.

A87-40096#

DETERMINISTIC FAILURE PREDICTION

ALAN H. BURKHARD (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) (IEEE, Annual Reliability and Maintainability Symposium, Philadelphia, PA, Jan. 27-29, 1987) Journal of Environmental Sciences (ISSN 0022-0906), vol. 30, Mar.-Apr. 1987, p. 34-36. refs

This paper presents an approach to equipment reliability prediction based on the concept that failures of electronic equipment are ultimately due to chemical, mechanical and/or metallurgical processes. These processes follow physical laws which can be modeled and the amount of life available for exposure to a given stress condition can be calculated. Using this approach, a failure-free operational period can be calculated during which, for all practical purposes, the probability of failure is essentially zero. Such an approach is used to design structural systems such as airframes, bridges, etc. But to implement such an approach will require a change in mindset and philosophy in terms of how avionics reliability and failures are considered. This paper presents concepts and ideas of how this can be and is beginning to be implemented. Author

A87-40329#
LOW-POWER ELECTRIC MECHANISMS OF AIRCRAFT [AVIATSIONNYE ELEKTROMEKHANIZMY MALOI MOSHCHNOSTI]
ISSAK IOSIFOVICH CHERNITSKII and IOSIF LAZAREVICH POTUPIKOV Moscow, Izdatel'stvo Mashinostroenie, 1986, 264 p. In Russian.
The functions, principle of operation, and the main components of the low-power electric equipment of aircraft are examined, with attention given to electric motors, reducers, transmission mechanisms, safety mechanisms, and control and switching devices. The discussion covers the assembly, maintenance, and repair of low-power electric mechanisms, as well as testing and storage of electric hardware. Repair procedures for several types of electric motors and mechanisms are presented as an example.
V.L.

A87-40496*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
ANALYTICAL AND EXPERIMENTAL INVESTIGATION OF MISTUNING IN PROPFAN FLUTTER
KRISHNA RAO V. KAZA, ORAL MEHMED (NASA, Lewis Research Center, Cleveland, OH), MARC WILLIAMS (Purdue University, West Lafayette, IN), and LARRY A. MOSS (Sverdrup Technology, Inc., Cleveland, OH) IN: 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 2A. New York, American Institute of Aeronautics and Astronautics, 1987, p. 98-110. Previously announced in STAR as N87-18116. refs
(AIAA PAPER 87-0739)
An analytical and experimental investigation of the effects of mistuning on propfan subsonic flutter was performed. The analytical model is based on the normal modes of a rotating composite blade and a three-dimensional subsonic unsteady lifting surface aerodynamic theory. Theoretical and experimental results are compared for selected cases at different blade pitch angles, rotational speeds, and free-stream Mach numbers. The comparison shows a reasonably good agreement between theory and experiment. Both theory and experiment showed that combined mode shape, frequency, and aerodynamic mistuning can have a beneficial or adverse effect on blade damping depending on Mach number. Additional parametric results showed that alternative blade frequency mistuning does not have enough potential for it to be used as a passive flutter control in propfans similar to the one studied. It can be inferred from the results that a laminated composite propfan blade can be tailored to optimize its flutter speed by selecting the proper ply angles. Author

A87-40497*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
ANALYTICAL FLUTTER INVESTIGATION OF A COMPOSITE PROPFAN MODEL
K. R. V. KAZA, O. MEHMED (NASA, Lewis Research Center, Cleveland, OH), G. V. NARAYANAN (Sverdrup Technology, Inc., Cleveland, OH), and D. V. MURTHY (Toledo, University, OH) IN: 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 2A. New York, American Institute of Aeronautics and Astronautics, 1987, p. 84-97. Previously announced in STAR as N87-18115. refs
(AIAA PAPER 87-0738)
A theoretical model and an associated computer program for predicting subsonic bending-torsion flutter in propfans are presented. The model is based on two-dimensional unsteady cascade strip theory and three-dimensional steady and unsteady lifting surface aerodynamic theory in conjunction with a finite element structural model for the blade. The analytical results compare well with published experimental data. Additional parametric studies are also presented illustrating the effects on flutter speed of steady aeroelastic deformations, blade setting angle, rotational speed, number of blades, structural damping, and number of modes. Author

A87-40511#
EVOLUTION OF THE NOTION OF QUALITY IN ADHESIVELY BONDED STRUCTURES FOR AERONAUTICAL AND SPACE APPLICATIONS [EVOLUTION DE LA NOTION QUALITE DANS LES STRUCTURES COLLEES A VOCATION AERONAUTIQUE ET SPATIALE]
G. BRIENS (Aerospatiale, Paris, France) Materiaux et Techniques (ISSN 0032-6895), vol. 75, Mar.-Apr. 1987, p. 107-116. In French.
The fabrication and analysis of adhesively bonded structures for aeronautical and space applications is considered in addition to surface treatments, qualification tests, and the evolution of quality assurance for adhesively bonded structures. Techniques for the study of the morphology, corrosion resistance, crystallographic structure, and energy of surfaces, in order to investigate surface adhesivity properties, are considered. The development of organic-product analysis methods, and the evolution of the fabrication and dimensioning of adhesively bonded structures, are then discussed. Qualification tests are performed to determine the behavior of materials in humid and corrosive environments, and in aging under loading. Ultrasound, thermographic, radiographic, and holographic nondestructive testing techniques are also considered. R.R.

A87-41237*# Tennessee Univ., Knoxville.
ON RECENT ADVANCES AND FUTURE RESEARCH DIRECTIONS FOR COMPUTATIONAL FLUID DYNAMICS
A. J. BAKER, M. O. SOLIMAN (Tennessee, University, Knoxville), and P. D. MANHARDT (Tennessee, University; Computational Mechanics Corp., Knoxville) IN: Computational mechanics - Advances and trends; Proceedings of the Session - Future Directions of Computational Mechanics of the ASME Winter Annual Meeting, Anaheim, CA, Dec. 7-12, 1986 . New York, American Society of Mechanical Engineers, 1986, p. 299-328. Research supported by the University of Tennessee. refs
(Contract NAS2-12347; N62669-84-C-0264; NAG1-319)
This paper highlights some recent accomplishments regarding CFD numerical algorithm constructions for generation of discrete approximate solutions to classes of Reynolds-averaged Navier-Stokes equations. Following an overview of turbulent closure modeling, and development of appropriate conservation law systems, a Taylor weak-statement semi-discrete approximate solution algorithm is developed. Various forms for completion to the final linear algebra statement are cited, as are a range of candidate numerical linear algebra solution procedures. This development sequence emphasizes the key building blocks of a CFD RNS algorithm, including solution trial and test spaces, integration procedure and added numerical stability mechanisms. A range of numerical results are discussed focusing on key topics guiding future research directions. Author

A87-41269#
3D AND AXISYMMETRIC THERMO-ELASTIC STRESS ANALYSIS BY BEASY
M. HONGOH (Pratt and Whitney Canada, Longueuil) IN: Boundary elements VII; Proceedings of the Seventh International Conference, Como, Italy, Sept. 24-27, 1985. Volume 2 . Berlin and New York, Springer-Verlag, 1985, p. 14-73 to 14-82. refs
Experience using BEASY-LINEAR, a subset of the Boundary Element Analysis System called BEASY, in the analysis of thermoelastic stresses of axisymmetric and three-dimensional problems is described and compared to results using the finite element method. Good accuracy was obtained for both potential and thermoelastic stresses by a simple discretization in the axisymmetric problem. This makes BEASY-LINEAR an attractive design tool for problems in which efficiency in handling frequent changes in geometry and fast turnaround are essential. For the three-dimensional problem, modeling was easier with BEASY-LINEAR than with the finite element method, since no internal discretization was required. C.D.

A87-41322#

DUAL-MODE COUPLED CAVITY TWT

F. PAYEN and B. VILLETTE IN: Military microwaves '86; Proceedings of the Conference, Brighton, England, June 24-26, 1986 . Tunbridge Wells, England, Microwave Exhibitions and Publishers, Ltd., 1986, p. 372-376. Research supported by the Ministere de la Defense.

A high-performance dual-mode power TWT has been developed whose characteristics are optimized for the next generation of airborne radars operating in the X-band. The liquid-cooled coupled-cavity TWT has two peak output power levels, 38 and 6 kW (typical), with a mean output power level of 1000 W. In both operating modes, approximately 4 percent of the beam is collected at the fourth collector stage at cathode voltage. The mean power consumption is lower than 2.8 kW in the high-peak-power mode and lower than 3.8 kW in the low-peak-power mode. V.L.

A87-41647#

FINITE AND BOUNDARY ELEMENT MODELING OF CRACK PROPAGATION IN TWO AND THREE DIMENSIONS

WALTER H. GERSTLE (New Mexico, University, Albuquerque), LUIZ F. MARTHA, and ANTHONY R. INGRAFFEA (Cornell University, Ithaca, NY) Engineering with Computers (ISSN 0177-0667), vol. 2, no. 3, 1987, p. 167-183. Research supported by the Grumman Aerospace Corp. refs

(Contract NSF CEE-83-51914; NSF CEE-83-16730)

The development of two interactive graphical fracture-propagation systems is described. The Finite Element Fracture Analysis Program - Graphical (FEFAP-G) is a two-dimensional fracture-propagation system. The BEM3D is a three-dimensional boundary-element fracture-propagation system. In addition, the implementation of BEM3D on an FPS-264 processor attached to a VAX-11/750 is described. The results show that a realistic analysis is not only feasible with the aid of attached processors, but it can have its total time reduced by factors of the order of hundreds when compared to VAX-alone statistics. In an example problem concerning fatigue-crack propagation in a stiffened wing skin, both FEFAP-G and the BEM3D are employed to illustrate the utility of the fracture propagation systems.

Author

A87-41689#

CHARACTERISATION OF PURE AND MIXED MODE FRACTURE IN COMPOSITE LAMINATES

T. E. TAY, J. F. WILLIAMS (Melbourne, University, Australia), and R. JONES (Department of Defence, Structures Div., Melbourne, Australia) Theoretical and Applied Fracture Mechanics (ISSN 0167-8442), vol. 7, April 1987, p. 115-123. refs

The problem of the characterization of the complex failure modes of fiber composites, including the effect of temperature, moisture, and manufacturing or service-related defects, is examined in the context of the development of a damage tolerant methodology for aircraft components. In particular, the effect of delamination-type defects on the structural behavior of fiber composites is examined with emphasis on mode II and mixed mode behavior. Some general failure criteria based on the principles of linear elastic fracture mechanics and the concept of energy release rate are discussed and compared. V.L.

A87-41690#

INFLUENCE OF DEBONDING ON THE EFFICIENCY OF CRACK PATCHING

L. R. F. ROSE (Department of Defence, Aeronautical Research Laboratories, Melbourne, Australia) Theoretical and Applied Fracture Mechanics (ISSN 0167-8442), vol. 7, April 1987, p. 125-132. refs

A simplified analysis of crack patching is presented in which the restraining effect of the external bonded reinforcement on the crack opening is simulated by distributed springs acting between the crack faces. It is suggested that elastic/perfectly-plastic springs provide an adequate idealization for the case where debonding can occur. The analysis is thereby reduced to the solution of a one-dimensional integral equation involving only two material parameters: a spring constant k and a limit stress sigma(L), both of which can be determined from the behavior of a suitable overlap joint. The efficiency of the reinforcement is shown to be determined by the normalized crack length ka and the normalized stress sigma/sigma(L), so that a comprehensive characterization can be obtained from relatively little computation or experimental study.

Author

A87-41914#

DETERMINATION OF THE LIFE OF A TYPICAL FILAMENT-WOUND SECTION OF A HELICOPTER ROTOR USING A CONTINUITY CRITERION [OPREDELENIE DOLGOVECHNOSTI TIPOVOI CHASTI NAMOTANNOI LOPASTI VINTA VERTOLETA PO KRITERIIU MONOLITNOSTI]

G. P. ZAITSEV (Moskovskii Aviatsionnyi Tekhnologicheskii Institut, Moscow, USSR) Problemy Prochnosti (ISSN 0556-171X), April 1987, p. 19-23. In Russian. refs

A method is proposed whereby the fatigue life of a filament-wound helicopter rotor section is determined as a function of the winding angle using a continuity criterion characterizing the presence of defects, such as delamination or cracks, in the composite. A method is also presented for plotting a fatigue diagram for a material with a given winding angle. The diagram is plotted on the basis of a given number of cycles to fracture with allowance for the linearity criterion under short-term loading and the continuity criterion under cyclic loading. V.L.

A87-42128#

PREDICTION OF THE RELIABILITY OF AIRCRAFT PART MANUFACTURING PROCESSES [DIAGNOSTIKA NADEZHNOSTI TEKHNOLOGICHESKIKH PROTSESSOV IZGOTOVLENIIA AVIATSIONNYKH DETALEI]

S. M. BOROVSKII and V. S. MUKHIN Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 1, 1987, p. 13-16. In Russian. refs

The problem of predicting the reliability of aircraft part manufacturing processes is reduced to that of determining the probability that a manufactured part will satisfy the corresponding specifications with respect to a single generalized or differential parameter characterizing the quality of the surface layer. It is shown that the approach proposed here makes it possible to continuously refine the quality control of the surface layer using the accumulated experience of quality assurance. V.L.

A87-42136#

INTERFERENCE OF ROTOR HARMONICS IN TWO-SHAFT COAXIAL ROTOR SYSTEMS WITH NONLINEARLY ELASTIC SHAFT SUPPORTS [VZAIMNOE VLIIANIE ROTORNYKH GARMONIK V DVUKHVAL'NYKH SOOSNYKH ROTORNYKH SISTEMAKH S NELINEINO-UPRUGIMI OPORAMI VALOV]

L. E. LASTOVETSKII and D. V. KHRONIN Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 1, 1987, p. 53-58. In Russian. refs

A generalized complex differential equation is derived which describes the vibrations of two characteristic models of two-shaft coaxial rotor systems exposed to two harmonics of a perturbing force. A system of transcendental equations is then obtained for calculating the amplitude-frequency and skeleton characteristics. Computer-generated results are presented. V.L.

A87-42137#

FULL-STRENGTH AND MINIMUM-WEIGHT CONICAL AND COMPOSITE SHELLS OF REVOLUTION [RAVNOPROCHNYE I OPTIMAL'NYE PO MASSE KONICHESKIE I SOSTAVNYE OBOLOCHKI VRASHCHENIIA]

IU. V. NEMIROVSKII and A. V. SHUL'GIN Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 1, 1987, p. 58-63. In Russian. refs

The problem of the minimum-weight design of plastic sandwich shells is solved using the criterion of a constant energy dissipation rate. A unified procedure is developed for the optimum and full-strength design of conical and composite shells of revolution subjected to axisymmetric loading. It is shown that absolute-minimum-volume designs provide significant savings in materials in comparison with full-strength designs. V.L.

A87-42155#
A STUDY OF THE PERFORMANCE OF REINFORCING COVER PLATES [ISSLEDOVANIE RABOTY USILIVAIUSHCHIKH NAKLADOK]
B. A. IUDKEVICH Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 1, 1987, p. 122-125. In Russian.
Stress distribution in reinforcing cover plates is investigated as a function of the arrangement of fasteners (bolts or rivets), with allowance made for the shear forces acting at the fasteners. An expression is obtained which makes it possible to evaluate the performance of a cover plate and provides a way to optimize the position of fasteners with respect to the plate edge. A duralumin sheet reinforced by a cover plate fastened by five steel bolts is considered as an example. V.L.

A87-42171#
CAUSES OF THE FORMATION OF FATIGUE CRACKS WITH A COMPRESSED CAVITY [PRICHINY OBRAZOVANIIA USTALOSTNYKH TRESHCHIN SO SZHATOI POLOST'IU]
IU. A. GLAZKOV Defektoskopiia (ISSN 0130-3082), no. 4, 1987, p. 70-78. In Russian. refs
A characterization of fatigue cracks with a compressed cavity is presented which reflects the requirements for the capillary method of fault detection. The physical phenomena responsible for the failure to detect such cracks by the capillary method are examined. Particular attention is given to the factors leading to the formation of cracks with a compressed cavity. The results of the study are relevant to the development of specific fault detection procedures based on the capillary method. V.L.

A87-42185*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
IN SITU OZONE INSTRUMENTATION FOR 10-HZ MEASUREMENTS - DEVELOPMENT AND EVALUATION
G. L. GREGORY, C. H. HUDGINS, J. A. RITTER (NASA, Langley Research Center, Hampton, VA), and M. LAWRENCE (Wyle Laboratories, Inc., Hampton, VA) IN: Symposium on Meteorological Observations and Instrumentation, 6th, New Orleans LA, Jan. 12-16, 1987, Preprints. Boston, MA, American Meteorological Society, 1987, p. 136-139. refs
The development of the fast-response ozone detector for the Electra aircraft is described. The selection of a technique to meet the design goal of 10-Hz detection is examined in terms of detection principles, instrument sampling parameters, signal conditioning, and aircraft and sampling environment. An instrument which employs a NO technique for detection of ozone with a reaction chamber volume of 16 cu cm, a pressure of 60 torr, and a sample flow of 1000 standard cu cm/min was developed. Laboratory and flight testings of the detector were conducted in order to evaluate its performance. The data reveal that the fast-response ozone detector is highly reliable with a response of 0.1 sec to 90 percent of reading, has a lower detection limit of 1 ppbv, and an S/N of 20 at 20 ppbv ozone. I.F.

A87-42345#
TRANSVERSE CURVATURE EFFECTS IN TURBULENT BOUNDARY LAYERS
P. M. SFORZA, M. J. SMORTO, and M. GRENIER (New York, Polytechnic University, Farmingdale) AIAA, Fluid Dynamics, Plasma Dynamics, and Lasers Conference, 19th, Honolulu, HI, June 8-10, 1987. 11 p. refs
(Contract N00014-80-C-0223; NR PROJECT 062-688)
(AIAA PAPER 87-1252)
Low-speed turbulent boundary layer flow over constant cross-section bodies possessing varying degrees and distributions of transverse curvature has been investigated experimentally and theoretically. Mean flow measurements showed that the effect of increased transverse curvature is to increase the skin friction coefficient and decrease the integral thicknesses in the vicinity of large curvature if the local boundary layer thickness is on the order of or larger than the lcoal radius of curvature of the body. When the boundary layer thickness is small compared to a characteristic transverse dimension of the body, the local skin friction is increased and the displacement thickness is reduced. This effect occurs with no perceptible alteration of the pressure field, but is instead a mainly diffusive effect. C.D.

A87-42385*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
INFLOW VELOCITY MEASUREMENTS MADE ON A HELICOPTER ROTOR USING A TWO-COMPONENT LASER VELOCIMETER
JOE W. ELLIOTT, SUSAN L. ALTHOFF (NASA, Langley Research Center; U.S. Army, Aerostructures Directorate, Hampton, VA), WILLIAM L. SELLERS, III, and CECIL E. NICHOLS, JR. (NASA, Langley Research Center, Hampton, VA) AIAA, Fluid Dynamics, Plasma Dynamics, and Lasers Conference, 19th, Honolulu, HI, June 8-10, 1987. 9 p. refs
(AIAA PAPER 87-1321)
An experimental investigation was conducted in the 14- by 22-Foot Subsonic Tunnel at NASA Langley Research Center to measure the inflow into a scale model helicopter rotor in forward flight. The measurements were made with a two component Laser Velocimeter (LV) one chord above the plane formed by the path of the rotor tips (tips path plane). A conditional sampling technique was employed to determine the position of the rotor at the time that each velocity measurement was made so that the azimuthal fluctuations in velocity could be determined. The results of these tests were compared with inflow velocities predicted by a current technology rotor wake analysis program. Author

N87-23793# McDonnell-Douglas Corp., St. Louis, Mo.
RESPONSE OF TRANSONIC DIFFUSER FLOWS TO ABRUPT INCREASES OF BACK PRESSURE: WALL PRESSURE MEASUREMENTS
T. J. BOGAR and M. SAJBEN *In* Johns Hopkins Univ., The 23rd JANNAF Combustion Meeting, Volume 1 p 417-424 Oct. 1986
(Contract N60530-83-C-0186)
Avail: CPIA, Laurel, Md. 20707 HC $70.00
The propagation of compression pulses in a supercritically operated transonic diffuser was investigated by use of pressure measurements along the top wall of the model. The pulses were generated at the downstream end of the diffuser by the abrupt injection of a secondary flow of air. Two types of waves were observed: (1) an upstream-traveling acoustic wave and (2) a downstream-traveling convective wave which resulted from the impingement of the acoustic wave on the shock. Wave speeds were determined for a range of diffuser pressure ratios including separated, strong-shock flows and fully attached, weak-shock flows. Streamwise distributions of initial and reflected pulse amplitudes were determined for one weak and one strong-shock case over a 3-to-1 range of initial pulse strengths. Author

N87-23794# Naval Surface Weapons Center, Silver Spring, Md.
DOWNSTREAM BOUNDARY EFFECTS ON THE FREQUENCY OF SELF-EXCITED OSCILLATIONS IN TRANSONIC DIFFUSER FLOWS
T. HSIEH *In* Johns Hopkins Univ., The 23rd JANNAF Combustion Meeting, Volume 1 p 425-434 Oct. 1986
Avail: CPIA, Laurel, Md. 20707 HC $70.00
Investigation of downstream boundary effects on the frequency of self-excited oscillations in two-dimensional, separated transonic diffuser flows were conducted numerically by solving the compressible, Reynolds-averaged, thin-layer Navier-Stokes equation with two equation turbulence models. It was found that the flow fields are very sensitive to the location of the downstream boundary. Extension of the diffuser downstream boundary significantly reduces the frequency and amplitude of oscillations for pressure, velocity, and shock. The existence of a suction slot in the experimental setpup obscures the physical downstream boundary and therefore presents a difficulty for quantitative comparisons between computation and experiment. Author

N87-23800# California Univ., Berkeley. Dept. of Mechanical Engineering.

VORTEX-NOZZLE INTERACTIONS IN RAMJET COMBUSTORS

K. YU, S. LEE, H. E. STEWART, and J. W. DAILY *In* Johns Hopkins Univ., The 23rd JANNAF Combustion Meeting, Volume 1 p 499-508 Oct. 1986

(Contract N00014-84-K-0372)

Avail: CPIA, Laurel, Md. 20707 HC $70.00

A facility designed to study the role of vortex-nozzle interactions in promoting low frequency instabilities in ramjet combustors is described. The design issues are outlined, as are potential instabilities. Preliminary data are reported which indicate the possibility of a recirculation vortex instability being an important mode. Author

N87-23801# Naval Research Lab., Washington, D.C. Lab. for Computational Physics.

COMPUTATIONAL STUDIES OF THE EFFECTS OF ACOUSTICS AND CHEMISTRY ON THE FLOW FIELD IN AN AXISYMMETRIC RAMJET COMBUSTOR

K. KAILASANATH, J. H. GARDNER, E. S. ORAN, and J. P. BORIS *In* Johns Hopkins Univ., The 23rd JANNAF Combustion Meeting, Volume 1 p 509-520 Oct. 1986

Avail: CPIA, Laurel, Md. 20707 HC $70.00

A potentially important source of large pressure oscillations in compact ramjets is a combustion instability induced by the interaction of large-scale vortex structures with acoustic modes in the combustion chamber. To study these interactions numerical simulations were performed using the Flux Corrected Transport technique. The highlights are presented of the work to date on the chemical-acoustic-vortex interactions in an idealized axisymmetric ramjet combustor. The results of a number of cold flow calculations are presented in which the length of the combustion chamber and the acoustic forcing function were systematically varied. These simulations indicate a strong coupling between the acoustic modes and the frequency of formation of large vortical structures near the entrance to the combustion chamber. They also show the presence of a low frequency oscillation which does not directly depend on the acoustics of the combustor but depends on the acoustics of the inlet. The effects of energy release from chemical reactions on the flow field in the combustor and the low frequecy oscillations are discussed. Author

N87-23802# Flow Research, Inc., Kent, Wash.

NUMERICAL SIMULATIONS OF COLD FLOW IN A RAMJET DUMP COMBUSTOR WITH A CHOKED EXIT NOZZLE

S. MENON and W.-H. JOU *In* Johns Hopkins Univ., The 23rd JANNAF Combustion Meeting, Volume 1 p 521-531 Oct. 1986

(Contract N00014-84-C-0359)

Avail: CPIA, Laurel, Md. 20707 HC $70.00

Simulations of the flow field were performed in a ramjet dump combustor equipped with an exit nozzle. The flow through the nozzle is choked numerically to simulate a realistic ramjet configuration. This also removes any ambiguities associated with the imposed outflow boundary conditions. The method of numerical choking is described. Large-scale motions similar to those in unchoked flow simulations are observed. The interaction between these large vortices and the choked throat is studied. Two simulations at Mach numbers 0.32 and 0.44 are discussed. Spectral analysis of the pressure and vorticity fluctuations in the combustor indicate a much richer spectral content when compared to unchoked flow results. Both convective-wave-dominated oscillations and acoustic oscillations appear to be present in the flow. Some preliminary results are presented. Author

N87-23804# Stanford Univ., Calif. Dept. of Mechanical Engineering.

EFFECTS ON FUEL SPRAY CHARACTERISTICS AND VAPORIZATION ON ENERGY RELEASE RATES AND FLOW FIELD STRUCTURE IN A DUMP COMBUSTOR

C. T. BOWMAN, R. K. HANSON, U. VANDSBURGER, M. G. ALLEN, and K. R. MCMANUS *In* Johns Hopkins Univ. 23rd JANNAF Combustion Meeting, Volume 1 p 545-550 Oct. 1986

(Contract N00014-84-K-0383)

Avail: CPIA, Laurel, Md. 20707 HC $70.00

An experimental investigation of the effects of fuel spray characteristics, specifically droplet size and extent of prevaporization, on energy release rate and flow field structure in a liquid-fueled dump combustor is in progress. Visualization and measurment of the spray characteristics and of the reacting flow field are carried out using high-speed schlieren photography and planar imaging techniques. An important element of the research is development of these imaging techniques for two-phase reacting flows. Progress to date is described in the development of several imaging techniques and initial results from experiments in the dump combustor. Author

N87-23818# Vibration Inst., Clarendon Hills, Ill.

THE SHOCK AND VIBRATION DIGEST, VOLUME 19, NO. 4 Monthly Report

JUDITH NAGLE-ESHLEMAN, ed. Apr. 1987 72 p

Avail: NTIS HC A04/MF A01

Recent advances in the nonlinear analysis of laminated composite plates and shells and various aspects of automobile suspension and steering systems are discussed in detail. Abstracts of articles dealing with machine tools, fans, electric motors, turbine blades, building foundations, ships, helicopters, and bearings are given.

N87-23850# Michigan Univ., Ann Arbor. Radiation Lab.

MAGNETOSTATIC SURFACE FIELD MEASUREMENT FACILITY Final Report, Oct. 1982 - Jun. 1984

V. V. LIEPA, D. L. SENGUPTA, and T. B. SENIOR Dec. 1986 137 p

(Contract F29601-82-K-0024)

(AD-A178258; AFWL-TN-86-29) Avail: NTIS HC A07/MF A01 CSCL 14B

This report presents the analysis, design, and performance characteristics of a Radio Frequency Helmholtz coil facility. The facility was developed to measure the magnetic response of models up to two feet in size. Test measurements were made on metallic spheres and cylinders, and on a model F 106 aircraft over a 1-25 MHz frequency range corresponding to 20-520 kHz full scale. A large portion of the report is devoted to the relevant theoretical studies that include studies of the magnetostatic response of canonical shapes, both perfectly and imperfectly conducting. GRA

N87-23851# Massachusetts Inst. of Tech., Cambridge. Lincoln Lab.

ADAPTIVE NOISE REDUCTION IN AIRCRAFT COMMUNICATION SYSTEMS

JEFFREY J. RODRIGUEZ 20 Jan. 1987 56 p

(Contract F19628-85-C-0002)

(AD-A178267; TR-756; ESD-T-86-096) Avail: NTIS HC A04/MF A01 CSCL 01C

In many military environments, such as fighter jet cockpits, the increasing use of digital communication systems has created a need for robust vocoders and speech recognition systems. However, the high level of ambient noise in such environments makes vocoders less intelligible and makes reliable speech recognition more difficult. One method of enhancing the noise-corrupted speech is adaptive noise cancellation. In previous research, this method was tested in a simulated cockpit environment, yielding impressive results. However, in new simulations, reflecting more realistic conditions, adaptive noise cancellation has been less successful. Spectral analysis of the data shows that the spectral concentration of the ambient noise, along with the microphone characteristics, has a significant effect on the performance of adaptive noise cancellation. GRA

N87-23856*# Boeing Commercial Airplane Co., Seattle, Wash.
AIRCRAFT ELECTROMAGNETIC COMPATIBILITY Final Report, Sep. 1985 - Jun. 1987
CLIFTON A. CLARKE and WILLIAM E. LARSEN (Federal Aviation Administration, Moffett Field, Calif.) Jun. 1987 146 p
(Contract NAS2-12261)
(NASA-CR-181051; NAS 1.26:181051; DOT/FAA/CT-86/40; D6-53840) Avail: NTIS HC A07/MF A01 CSCL 20N

Illustrated are aircraft architecture, electromagnetic interference environments, electromagnetic compatibility protection techniques, program specifications, tasks, and verification and validation procedures. The environment of 400 Hz power, electrical transients, and radio frequency fields are portrayed and related to thresholds of avionics electronics. Five layers of protection for avionics are defined. Recognition is given to some present day electromagnetic compatibility weaknesses and issues which serve to reemphasize the importance of EMC verification of equipment and parts, and their ultimate EMC validation on the aircraft. Proven standards of grounding, bonding, shielding, wiring, and packaging are laid out to help provide a foundation for a comprehensive approach to successful future aircraft design and an understanding of cost effective EMC in an aircraft setting. Author

N87-23859# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). Avionics Panel.
MICROWAVE ANTENNAS FOR AVIONICS
Apr. 1987 161 p Lectures held in Rome, Italy, 7-8 May 1987; in Guenzburg, West Germany, 11-12 May 1987; and in Ankara, Turkey, 14-15 May 1987
(AGARD-LS-151; ISBN-92-835-1547-1) Avail: NTIS HC A08/MF A01

Even though considerable advances have been made in digital technology and signal processing, antennas continue to play a key role and their performance is often a dominating factor in defining the overall effectiveness of a system. New system requirements, and the need to provide electronic scanning cababilities have presented major challenges to the technology that require substantial improvements over what is currently available. Over the last decade there have been notable advances in antenna and radome design, particularly in sidelobe reduction, electronic scanning, conformal arrays, printed circuit arrays, adaptive control and millimeter wave antennas. Many of these issues are addressed. Future trends and new directions for technological innovation are subjects for round table discussions.

N87-23860# Rome Air Development Center, Hanscom AFB, Mass. Electromagnetics Directorate.
BASIC PARAMETERS OF ANTENNAS FOR AIRCRAFT, SATELLITES AND MISSILES
ROBERT J. MAILLOUX *In* AGARD Microwave Antennas for Avionics 17 p Apr. 1987
Avail: NTIS HC A08/MF A01

System requirements for airborne, satellite and missile antennas continue to place increasingly severe demands upon antenna technology. In general these requirements push toward the increased capability to control and modify antenna patterns, and away from the use of small antennas with broad radiation patterns. Increased control can imply several levels of added sophistication. At the lowest level it implies mechanical or electronic scanning of an antenna directive pattern, at the next level there are needs to produce precise low sidelobe radiation patterns, and at the highest level of complexity there is the need to actively suppress jammer interference through the use of adaptive control of a full array or an antenna with sidelobe cancellers. In addition to increased control, there is also a trend toward higher frequencies, even to EHF frequencies where arrays of several thousand elements are necessary for some applications. These needs and applications of antenna technology are examined. Author

N87-23861# Westinghouse Electric Corp., Baltimore, Md. Advisory Engineer-Antenna Development.
AIRCRAFT RADAR ANTENNAS
HELMUT E. SCHRANK *In* AGARD Microwave Antennas for Avionics 7 p Apr. 1987
Avail: NTIS HC A08/MF A01

Many changes have taken place in airborne radar antennas since their beginnings over forty years ago. A brief historical review of the advances in technology is presented, from mechanically scanned reflectors to modern multiple function phased arrays. However, emphasis is not on history but on the state-of-the-art technology and trends for future airborne radar systems. The status of rotating surveillance antennas is illustrated by the AN/APY-1 Airborne Warning and Control System (AWACS) slotted waveguide array, which achieved a significant breakthrough in sidelobe suppression. Gimballed flat plate arrays in nose radomes are typified by the AN/APG-66 (F-16) antenna. Multifunction phased arrays are presented by the Electronically Agile Radar (EAR) antenna, which has achieved significant advances in performance versatility and reliability. Trends toward active aperture, adaptive, and digital beamforming arrays are briefly discussed. Antennas for future aircraft radar systems must provide multiple functions in less aperture space, and must perform more reliably. Author

N87-23862# AEG-Telefunken, Ulm (West Germany). Radar Subdivision.
AIRCRAFT ANTENNAS/CONFORMAL ANTENNAS MISSILE ANTENNAS
KLAUS SOLBACH *In* AGARD Microwave Antennas for Avionics 16 p Apr. 1987
Avail: NTIS HC A08/MF A01

Three major areas of airborne microwave antennas are examined. The basic system environment for missile telemetry/telecommand and fuze functions is sketched and the basic antenna design together with practical examples are discussed. The principle requirements of modern nose radar flat plate antennas are shown to result from missile/aircraft system requirements. Basic principles of slotted waveguide antenna arrays are sketched and practical antenna designs are discussed. The present early warning system designs are sketched to point out requirements and performance of practical radar warning and jamming antennas (broadband spiral antennas and horn radiators). With respect to newer developments in the ECM scenario, some demonstrated and proposed antenna systems (lens fed arrays, phased array, active array) are discussed. Author

N87-23864# Army Communications-Electronics Command, Fort Monmouth, N.J.
MILLIMETER WAVE ANTENNAS FOR AVIONICS
FELIX K. SCHWERING *In* AGARD Microwave Antennas for Avionics 8 p Apr. 1987
Avail: NTIS HC A08/MF A01

An overview of the area of mm-wave antennas is presented with emphasis on possible avionics applications. For the purpose of the review, mm-wave radiating structures are grouped into two classes: antennas of conventional configuration and antennas based on new design concepts. The first class is composed of well known antennas such as reflector, lens, horn and slotted waveguide antennas. The second class includes radiating structures such as printed circuit mm-wave antennas, antennas derived from open mm-waveguides, and integrated antennas. Some of these antennas have microwave counterparts, others are new with no microwave heritage. Millimeter wave antennas are usually of very reasonable size and weight, and some of these antennas are suitable for rapid mechanical scanning. They should be sufficiently versatile to satisfy most avionics requirements. Atmospheric propagation conditions vary strongly throughout the mm-wave band and have to be taken into account in the design of mm-wave systems and their antennas. A brief summary of these effects is included. Author

N87-23912# Colorado Univ., Boulder. Dept. of Aerospace Engineering Sciences.
UNSTEADY SEPARATED FLOWS: VORTICITY AND TURBULENCE Final Report
M. LUTTGES 6 Apr. 1987 36 p
(Contract F49620-83-K-0009)
(AD-A179500; AFOSR-87-0384TR) Avail: NTIS HC A03/MF A01 CSCL 20D

Throughout a wide combination of initial pitch angles, pitch amplitudes and pitch rates for a NACA 0015 airfoil section, several unsteady flow initiation and development trends have been documented. The effects of mean angle of attack and reduced frequency, and the interactions between them, are generally linear (for the ranges studied). Incremental changes in reduced frequency and mean pitch angle resulted in later or earlier vortex initiation, respectively, within the pitch cycle. Other notable features of the flowfield development include the initiation of a prominent trailing edge vortex as the leading edge vortex sheds, and the convection velocity of the leading edge vortex. Similar tests employing a flat plate produced somewhat different results. The vortices were more coherent and convected at higher velocities. In general, however, the developmental trends across the parameters tested followed those of the airfoil model. GRA

N87-24599# Ohio State Univ., Columbus. Electroscience Lab.
RADAR TARGET IDENTIFICATION TECHNIQUES APPLIED TO A POLARIZATION DIVERSE AIRCRAFT DATA BASE
ALEX J. KAMIS, E. K. WALTON, and F. D. GARBER Mar. 1987 145 p
(Contract N00014-85-K-0321)
(AD-A180044; ESL-717220-2) Avail: NTIS HC A07/MF A01 CSCL 17I

The report investigates the performance of several types of multi-frequency radar systems employing a data base of measured monostatic radar signatures as descriptors for Radar Target Identification (RTI). The approach, a Monte-Carlo computer simulation, enables the evaluation of radar systems exploiting various aspects of RTI techniques. These aspects, examined by misclassification percentage curves, are: the number of interrogation frequencies, operating bandwidths, classification algorithm types, larger target aspect zones, and target descriptors called feature vectors. The data base of radar signatures was obtained at The Ohio State University ElectroScience Laboratory Compact Range facility, and consisted of scale model monostatic calibrated radar measurements from five commercial aircraft. It is shown that the fully-coherent radar feature vectors HH, VV, RR, LL, and RL perform very effectively for target identification with signal to noise ratios of O dB. It is also shown that the low-frequency sector of the data base provides good classification performance versus noise power, and that the number of frequencies within a given bandwidth is optimized by Shannon's sampling theorem. GRA

N87-24672*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
MULTISCALE TURBULENCE EFFECTS IN SUPERSONIC JETS EXHAUSTING INTO STILL AIR
KHALED S. ABDOL-HAMID (Analytical Services and Materials, Inc., Hampton, Va.) and RICHARD G. WILMOTH Jul. 1987 38 p
(NASA-TP-2707; L-16258; NAS 1.60:2707) Avail: NTIS HC A03/MF A01 CSCL 20D

A modified version of the multiscale turbulence model of Hanjalic has been applied to the problem of supersonic jets exhausting into still air. In particular, the problem of shock-cell decay through turbulent interaction with the mixing layer has been studied for both mildly interacting and strongly resonant jet conditions. The modified Hanjalic model takes into account the nonequilibrium energy transfer between two different turbulent spectral scales. The turbulence model was incorporated into an existing shock-capturing, parabolized Navier-Stokes computational model in order to perform numerical experiments. The results show that the two-scale turbulence model provides significant improvement over one-scale models in the prediction of plume shock structure for underexpanded supersonic (Mach 2) and sonic (Mach 1) jets. For the supersonic jet, excellent agreement with experiment was obtained for the centerline shock-cell pressure decay up to 40 jet radii. For the sonic jet, the agreement with experiment was not so good, but the two-scale model still showed significant improvement over the one-scale model. It is shown that by relating some of the coefficients in the turbulent-transport equations to the relative time scale for transfer of energy between scales the two-scale model can provide predictions that bound the measured shock-cell decay rate for the sonic jet. Author

N87-24675# European Space Agency, Paris (France).
DIGITAL DATA RECORDING ON FLOPPY DISKS APPLIED FOR ONBOARD USE IN HELICOPTERS
RAINER HOLLAND, HORST MEYER, and PETER PFLEGING Dec. 1986 38 p Transl. into ENGLISH of "Diskettenregistrieung als Beispiel Digitaler Messdatenaufzeichnung an Bord von Hubschraubern" DFVLR, Brunswick (West Germany), May 1986 Original language document was previously announced as N87-11149
(ESA-TT-1011; DFVLR-MITT-86-10; ETN-87-99853) Avail: NTIS HC A03/MF A01; original German version available from DFVLR, Cologne, West Germany DM 16.50

A direct data recording system for helicopter flight tests was developed. The system stores the flight test data in an onboard mass memory. It fulfills the requirements imposed by the high vibration level of helicopters, and by the limted space and weight possibilities. Hardware configuration, software, and terminal are described. The system can be easily built and used. Comparisons with analog data recording show an improvement of data quality. ESA

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GEOSCIENCES

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

A87-39891#
OKLAHOMA WEATHER PHENOMENA THAT MAY AFFECT AVIATION
D. S. ZRNIC, R. J. DOVIAK, J. T. LEE, and M. D. EILTS (NOAA, National Severe Storms Laboratory, Norman, OK) Journal of Aircraft (ISSN 0021-8669), vol. 24, May 1987, p. 310-316. refs
(Contract DOT-FA01-80-Y-10524)

Studies by the National Severe Storms Laboratory of interest to the aviation community are presented which involve turbulence produced by storms, low-altitude wind shear in storms outflows, and downdrafts and gust fronts. Storm turbulence has been studied extensively with the help of Doppler radar. Comparison of spatial spectra of longitudinal and transverse velocities has revealed that in severe storms the outer scale of turbulence is at least 2 km. Because of this and because measurements of spectrum widths at two different viewing angles agree, the width could prove a good indicator of storm turbulence that may affect aircraft. The asymmetry of low-altitude divergent outflows produced by downbursts in Oklahoma are reported. Gust front shears estimated by Doppler radar (at heights between 50-600 m) average 1.6 times the shear measured a few meters above the surface. Tall tower data show that both wind speed and wind shear increase in the lowest 90 m of the atmosphere. Thus, surface-based anemometers considerably underestimate wind shear just 100 m or so above the surface. Doppler radars located near airports may allow measurements at such low altitudes and resolve significant wind shears. Automatic methods to detect, track, and extrapolate shear produced by waves and gravity currents (downburst) are being developed, and some results are shown. Author

A87-40245#

OKLAHOMA DOWNBURSTS AND THEIR ASYMMETRY

MICHAEL D. EILTS and RICHARD J. DOVIAK (NOAA, National Severe Storms Laboratory, Norman, OK) Journal of Climate and Applied Meteorology (ISSN 0733-3021), vol. 26, Jan. 1987, p. 69-78. refs

(Contract DOT-FA01-80-4-10524)

Doppler radar data collected each spring in 1979-1984 with the two Doppler radars operated by the National Severe Storms Laboratory are used to investigate the asymmetry of low-altitude divergent outflows of convective storm downbursts in central Oklahoma. The downbursts observed in central Oklahoma, all large-scale (4-10 km) events, were superposed with the maximum reflectivity core of the storms; however, scanning strategies may have precluded detection of smaller scale (less than 4 km) microbursts. Typical downbursts observed during the Joint Airport Weather Studies (JAWS) Project were of small scale (less than 4 km) and were often associated with little or no rain at the surface. The mechanism for the initiation of the majority of JAWS microbursts was evaporative cooling, which occurred when precipitation fell into a dry, deep, and nearly adiabatic boundary layer; it appears that other mechanisms are responsible for the initiation of the observed Oklahoma downbursts because of a lower cloud base and a moister and slightly more stable boundary layer. Author

A87-40247#

LOW ALTITUDE WIND SHEAR DETECTION WITH DOPPLER RADAR

MICHAEL D. EILTS (NOAA, National Severe Storms Laboratory, Norman, OK) Journal of Climate and Applied Meteorology (ISSN 0733-3021), vol. 26, Jan. 1987, p. 96-106. refs

(Contract DOT-FA01-80-Y-10524)

The feasibility of using the next generation weather radar system to detect low-altitude wind shear near airports is investigated. Surface-measured horizontal shear is compared with that observed aloft with Doppler radar to determine how the radar-estimated shear above the surface relates to the surface-measured shear. For five Oklahoma gust fronts, the Doppler radar estimate of shear (at heights between 50-600 m) averaged 1.6 times the shear measured at the surface. For none of the 43 comparisons was the surface radial velocity difference across the gust front stronger than the radial velocity difference measured by Doppler radar aloft. In all cases, the wind speed and wind shear increased in the lowest 90 m of the atmosphere. In one case, the 90-m height had the peak wind shear; in all other cases the peak wind shear was at a much higher altitude. Due to surface friction, it is expected that wind speeds and shears in downbursts will also be stronger aloft than at the surface. It is suggested that a combination of Doppler radar data and information gleaned from a low-level wind shear alert system would allow more accurate wind shear estimates in the terminal area of airports than would be possible with either system by itself. Author

A87-42483#

ADVANCES IN NUMERICAL WEATHER PREDICTION FOR AVIATION FORECASTING

P. W. WHITE, M. J. P. CULLEN, A. J. GADD, C. R. FLOOD, T. N. PALMER (Meteorological Office, Bracknell, England) et al. Royal Society (London), Proceedings, Series A - Mathematical and Physical Sciences (ISSN 0080-4630), vol. 410, no. 1839, April 8, 1987, p. 255-268. refs

Improvements in numerical weather prediction, which is based on Newton's laws of motion, laws of thermodynamics, and principles of mass conservation, are discussed. The numerical model currently being utilized by the Meteorological Office of the UK is described. Consideration is given to the interaction between the atmosphere and the earth's surface; the vertical transfer of heat, moisture, and momentum through the atmosphere; and radiative transfer within the atmosphere. The collection of atmospheric observations, the assimilation of observations, and observational errors are examined. The meteorological requirements for civil aviation include: data on route winds, temperature, and weather; warnings of adverse weather for both in-flight and ground operations; landing forecasts; information for controlling authorities; and historical data. It is observed that advances in numerical weather prediction have improved the accuracy of the models and provided economic benefits to the airlines. I.F.

N87-24045# Transportation Systems Center, Cambridge, Mass.

OTIS ANGB (AIR NATIONAL GUARD BASE) VISIBILITY SENSOR FIELD TEST STUDY Final Report, Dec. 1983 - Jan. 1986

D. SCHWARTZ and D. BURNHAM Feb. 1987 186 p

(Contract AF PROJ. 2688)

(AD-A179176; AFGL-TR-86-0011; ESD-5-606) Avail: NTIS HC A09/MF A01 CSCL 04B

Forward scatter meters (FSMs) are evaluated for use as visibility sensors in Automatic Observing Systems (AOS) and as possible replacements for transmissometers to measure Runway Visual Range (RVR) at airports. Data collected from three FSMs at the Otis Air National Guard Base during a 17-month period starting in 1983 is analyzed. Two of the FSMs use chopped incandescent light sources and have a large scatter volume. The other uses a modulated light emitting diode (LED) light source and has a small scatter volume. Two analysis procedures are included: (1) a statistical analysis of the entire data set disaggregated according to the obstruction to vision (fog, rain, snow, etc.) and the magnitude of the extinction coefficient; and (2) detailed analysis of selected reduced visibility events. Most of the time extinction coefficients measured by the FSMs and the transmissometers agreed to within 16.5 percent for RVR values between 400 and 6000 feet and within one reporting increment for AOS visibility. Most of the cases of large disagreement were traced to problems such as sensors being clogged by snow, which affected both FSMs and the transmissometers. The large volume FSMs gave more stable readings, but those with LED were more reliable. Author (GRA)

N87-?4802*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.

PHASE NOISE FROM AIRCRAFT MOTION: COMPENSATION AND EFFECT ON SYNTHETIC APERTURE RADAR IMAGES

ANDREW K. GABRIEL and RICHARD M. GOLDSTEIN *In* ESA Proceedings of the International Symposium on Progress in Imaging Sensors p 535-538 Nov. 1986 Sponsored by NASA

Avail: NTIS HC A99/MF A01 CSCL 20N

Image degradation of airborne SAR imagery caused by phase errors introduced in the received signal by aircraft motion is discussed. Mechanical motion has a small bandwidth and does not affect the range signal, where the total echo time is typically 60 microsec. However, since the aperture length can be several seconds, the synthesized azimuth signal can have significant errors of which phase noise is the most important. An inertial navigation system can be used to compensate for these errors when processing the images. Calculations to evaluate how much improvement results from compensation are outlined. ESA

N87-24866*# National Aeronautics and Space Administration, Washington, D.C.

THE CLASSIFICATION OF WIND SHEARS FROM THE POINT OF VIEW OF AERODYNAMICS AND FLIGHT MECHANICS

FRITZ SEIDLER and GUNTER HENSEL May 1987 23 p

Transl. into ENGLISH from Technisch-Oekonomische Information der Zivilen Luftfahrt (East Germany), v. 22, no. 3-4, 1986 p 107-112 Original language document was previously announced in IAA as A87-11898 Transl. by Kanner (Leo) Associates, Redwood City, Calif.

(Contract NASW-4005)

(NASA-TT-20020; NAS 1.77:20020; ISSN-0232-5012) Avail: NTIS HC A02/MF A01 CSCL 04B

A study of international statistical data shows that in about three quarters of all serious accidents which occurred with jet propelled airliners wind shear was either one of the main causes of the accident or represented a major contributory cause. Wind shear related problems are examined. The necessity of a use of different concepts, definitions, and divisions is explained, and the concepts and definitions required for the division of wind and wind shear into different categories is discussed. A description of the context between meteorological and aerodynamics-flight mechanics concepts, definitions, and divisions is also provided. Attention is given to wind and wind components, general characteristics of wind shear and the meteorological terms, the basic types of wind shear for aerodynamics-flight mechanics investigations, special types of wind shear for aerodynamics-flight mechanics investigations, and possibilities regarding a change of the wind component. Author

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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.

A87-39912#

THE GENERATION OF AIRFRAME FINITE ELEMENT MODELS USING AN EXPERT SYSTEM

BRENT L. GREGORY and MARK S. SHEPHARD (Rensselaer Polytechnic Institute, Troy, NY) Engineering with Computers (ISSN 0177-0667), vol. 2, no. 2, 1987, p. 65-77. Research supported by Rensselaer Polytechnic Institute. refs

(Contract DAAG29-82-K-0093)

This paper presents an expert system-based procedure for the creation of airframe finite element models from the geometric model available in a computer-aided design system. The objectives of the approach presented is the computerization of a process that is currently carried out in a semimanual manner, include previous modeling knowledge into the system, and provide a clear path for an ever-increasing level of automation in the process of creating analysis models for this class of structure. A main feature of the system developed is the combined use of algorithmic procedures and expert knowledge operating on data provided by previously run design software to produce an entirely different form of model to be used as input to a numerical analysis. Author

A87-40305#

DEVELOPMENT OF A MICROCOMPUTER-SUPPORTED AIRPORT WEATHER INFORMATION SYSTEM [ENTWICKLUNG EINES MIKRORECHNERGESTUETZTEN FLUGPLATZWETTER-INFORMATIONSSYSTEMS]

UWE NIEMZ (Interflug Gesellschaft fuer Internationalen Flugverkehr mbH, Berlin, East Germany) Technisch-oekonomische Information der zivilen Luftfahrt (ISSN 0232-5012), vol. 23, no. 1, 1987, p. 5-8. In German.

Progress made in the development of a computer-supported weather support system for the Berlin-Schoenefeld airport is discussed. The present technical status of airport weather information and the need for a new system are reviewed along with the present international state of the art in this area. The system structure, data sources, information processing, data transmission under near-actual conditions, application of light wave conduction technology, presentation of weather information, and organization of the user dialog are examined. C.D.

A87-40520#

THE TECHNIQUE OF PRAGMATIC SIMULATION [TECHNIKA SYMULACJI PRAGMATYCZNEJ]

JANUSZ M. MORAWSKI and LONGINA KREZLEWICZ Instytut Lotnictwa, Prace (ISSN 0509-6669), no. 104-105, 1986, p. 29-39. In Polish. refs

The paper presents some details on pragmatic simulation which may be defined as a man-oriented real-time version of simulation. The technique makes use of particular perception characteristics of man and provides new means for model reduction. Within each simulated variable, short-term and long-term fractions are detached, each of them calculated in a separate way, and eventually combined by use of a simple filter-alignment circuit. The overall time of calculation is conditioned by the short-term model complexity. The savings due to the use of the technique expressed in terms of necessary computer capacity and time of calculations have been evaluated. The considerations are illustrated by flight simulation applications. Author

A87-41151#

AI APPLICATIONS AND TRENDS IN THE AERONAUTICAL SYSTEMS DIVISION

JESSE RYLES, LAWRENCE PORTER, and DAVID KAISER (USAF, Avionics Laboratory, Wright-Patterson AFB, OH) AIAA, NASA, and USAF, Symposium on Automation, Robotics and Advanced Computing for the National Space Program, 2nd, Arlington, VA, Mar. 9-11, 1987. 3 p.

(AIAA PAPER 87-1659)

The paper will present background, status and planning of Artificial Intelligence (AI) activities at the Aeronautical Systems Division (ASD) at Wright-Patterson AFB. The major emphasis is application of AI technology in the area of air crew aiding, maintenance and diagnostics, tactical mission planning and manufacturing technology. Additionally, the paper will discuss the recent creation of an ASD AI applications center. The Center has a broad mandate to expand the level of understanding of AI, to expand the local area involvement in AI, and to expand the AI application areas. Although no attempt is made to address the entire AF program, the topics covered are representative of and consistent with current AF plans. Author

A87-41227*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

STATUS AND PROJECTIONS OF THE NAS PROGRAM

F. R. BAILEY (NASA, Ames Research Center, Moffett Field, CA) IN: Computational mechanics - Advances and trends; Proceedings of the Session - Future Directions of Computational Mechanics of the ASME Winter Annual Meeting, Anaheim, CA, Dec. 7-12, 1986 . New York, American Society of Mechanical Engineers, 1986, p. 7-21.

NASA's Numerical Aerodynamic Simulation (NAS) Program has completed development of the initial operating configuration of the NAS Processing System Network (NPSN). This is the first milestone in the continuing and pathfinding effort to provide state-of-the-art supercomputing for aeronautics research and development. The NPSN, available to a nation-wide community of remote users, provides a uniform UNIX environment over a network of host computers ranging from the new Cray-2 supercomputer to advanced scientific workstations. This system, coupled with a vendor-independent base of common user interface and network software, presents a new paradigm for supercomputing environments. Presented here is the background leading to the NAS Program, its programmatic goals and strategies, technical goals and objectives, and the development activities leading to the current NPSN configuration. Program status, near-term plans and plans for the next major milestone, the extended operating configuration, are also discussed. Author

A87-41230*# Boeing Military Airplane Development, Seattle, Wash.

A NEW APPROACH TO THE SOLUTION OF BOUNDARY VALUE PROBLEMS INVOLVING COMPLEX CONFIGURATIONS

P. E. RUBBERT, J. E. BUSSOLETTI, F. T. JOHNSON, K. W. SIDWELL (Boeing Military Airplane Co., Seattle, WA), W. S. ROWE, S. S. SAMANT, G. SENGUPTA, W. H. WEATHERILL (Boeing Commercial Airplane Co., Seattle, WA), R. H. BURKHART (Boeing Computer Services Co., Seattle, WA), A. C. WOO (NASA, Ames Research Center, Moffett Field, CA) et al. IN: Computational mechanics - Advances and trends; Proceedings of the Session - Future Directions of Computational Mechanics of the ASME Winter Annual Meeting, Anaheim, CA, Dec. 7-12, 1986 . New York, American Society of Mechanical Engineers, 1986, p. 49-84. refs
(Contract NAS2-11851)

A new approach for solving certain types of boundary value problems about complex configurations is presented. Numerical algorithms from such diverse fields as finite elements, preconditioned Krylov subspace methods, discrete Fourier analysis, and integral equations are combined to take advantage of the memory, speed and architecture of current and emerging supercomputers. Although the approach has application to many branches of computational physics, the present effort is concentrated in areas of Computational Fluid Dynamics (CFD) such as steady nonlinear aerodynamics, time harmonic unsteady aerodynamics, and aeroacoustics. The most significant attribute of the approach is that it can handle truly arbitrary boundary geometries and eliminates the difficult task of generating surface fitted grids. Author

A87-42066*# Virginia Polytechnic Inst. and State Univ., Blacksburg.

AN ANALYSIS OF FLUX-SPLIT ALGORITHMS FOR EULER'S EQUATIONS WITH REAL GASES

B. GROSSMAN and R. W. WALTERS (Virginia Polytechnic Institute and State University, Blacksburgh) IN: Computational Fluid Dynamics Conference, 8th, Honolulu, HI, June 9-11, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 177-186. refs
(Contract NAG1-684)
(AIAA PAPER 87-1117)

An analysis of flux-splitting procedures for the solution of Euler's equations with real gas effects is presented. An alternative real-gas flux-splitting is derived which can easily be implemented into existing codes. This approach, which takes the form of an 'equivalent' gamma representation is not an ad hoc model, but is based on theoretical considerations. Details of this method with the Steger-Warming and Van Leer flux vector splittings and the Roe flux-difference splitting are given. Applications of the method to several high Mach number, high temperature flows are presented for one and two space dimensions. Author

A87-42072#

NUMERICAL SOLUTIONS OF COMPRESSIBLE FLOW WITH COMPACT SCHEME

YANWEN MA and DEXUN FU (Beijing Institute of Aerodynamics, People's Republic of China) IN: Computational Fluid Dynamics Conference, 8th, Honolulu, HI, June 9-11, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 248-254. refs
(AIAA PAPER 87-1123)

A class of difference schemes for aerodynamic equations is given using Taylor series expansion. Many commonly used schemes can be obtained from it. No special linearization is needed for solving the obtained implicit schemes. A compact scheme from this class is used to solve the Navier-Stokes equations simplified by dropping the streamwise derivatives in the viscous part of the equations. Using special chosen Jacobian matrix splitting the obtained implicit scheme with compact difference can be solved easily without any matrix inversions and matrix operations. The developed scheme is used to solve the viscous supersonic flow past a sphere cone body. Numerical experiment shows certain efficiency of the method. Author

A87-42073*# Princeton Univ., N. J.

THREE DIMENSIONAL MESH GENERATION BY TRIANGULATION OF ARBITRARY POINT SETS

TIMOTHY J. BAKER (Princeton University, NJ) IN: Computational Fluid Dynamics Conference, 8th, Honolulu, HI, June 9-11, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 255-271. Research supported by IBM Corp., U.S. Navy, and NASA. refs
(AIAA PAPER 87-1124)

A method for generating an unstructured mesh is described. The approach is quite general and joins an arbitrary set of points to produce a covering of three dimensional space by tetrahedra. After removing the tetrahedra that connect surface points, a mesh suitable for a finite element based flow solver is obtained. Details of the triangulation algorithm are provided together with an analysis of the algorithm efficiency and validity. Author

A87-42077#

VISCOUS FLOW COMPUTATIONS USING A COMPOSITE GRID

KAZUHIRO NAKAHASHI (National Aerospace Laboratory, Chofu, Japan) and SHIGERU OBAYASHI IN: Computational Fluid Dynamics Conference, 8th, Honolulu, HI, June 9-11, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 303-312. refs
(AIAA PAPER 87-1128)

A composite grid method for viscous flow computations that consists of structured grids for a finite-different method (FDM) and unstructured grids for a finite-element method (FEM) is presented. FDM grids are used for the viscous flow regions near bodies, and FEM grids are applied to the remaining regions. The computational efficiency of the FDM and geometrical flexibility of the FEM can be obtained. The most important advantage of this composite grid method is its grid flexibility. In order to strengthen this advantage, a practical grid generation procedure for FEM is presented. The capability of the method is demonstrated by computing the Navier-Stokes equations for a double airfoil flowfield in two dimensions, and wing/nacelle simulator flowfield for three dimensions. Author

A87-42079#

COMPUTATIONAL FLUID DYNAMICS IN WEST GERMANY

WOLFGANG SCHMIDT (Dornier GmbH, Friedrichshafen, West Germany) IN: Computational Fluid Dynamics Conference, 8th, Honolulu, HI, June 9-11, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 322-335. refs
(AIAA PAPER 87-1130)

The present evaluation of the development status of CFD methods in West Germany gives attention to the past decade's advancements in analysis and design tools for engineering applications in industry, and notes the features of such numerical simulation elements as physical models, mathematical models, numerical algorithms, geometric discretization, and postprocessing. Such test cases as those of advanced fighter and automobile configurations, and of delta wing, diesel cylinder and turbofan flows, are discussed. Direct, fully time-dependent simulations are noted to yield insight into the remaining major problems associated with turbulence. O.C.

A87-42080#

COMPUTATIONAL FLUID DYNAMICS IN FRANCE

H. VIVIAND, C. LECOMTE, and PH. MORICE (ONERA, Chatillon-soux-Bagneux, France) IN: Computational Fluid Dynamics Conference, 8th, Honolulu, HI, June 9-11, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 336-351. refs
(AIAA PAPER 87-1131)

An evaluation is made of the status of aerodynamics-related CFD techniques' development in France. The theoretical developments noted encompass incompressible Euler or potential equations, compressible potential flow, structured and unstructured grids, incompressible Navier-Stokes equations, boundary layer equations, and viscous-inviscid coupling. The applications of these methodologies have extended to advanced fighters, helicopters, and missiles, turbomachine flow, propellers, and combustion systems. Attention is given to the computer systems on which these CFD researches have been conducted. O.C.

A87-42081#

COMPUTATIONAL FLUID DYNAMICS IN THE UNITED KINGDOM

M. G. HALL and S. P. FIDDES (Royal Aircraft Establishment, Farnborough, England) IN: Computational Fluid Dynamics Conference, 8th, Honolulu, HI, June 9-11, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 352-364. refs

(AIAA PAPER 87-1132)

A review is presented of computational methods in aerodynamic research and design, with application of the methods and associated computing facilities included. The review begins with a brief survey of the field, to give an overall view and to identify what seem to be notable features. These are then described in turn. The first is a development by Hall and his colleagues of accurate and fast schemes for solving the Euler equations, based on the finite-volume cell-vertex methods introduced by Denton and Ni. Next is a development of a block-structured ('multiblock') grid generation technique by the Aircraft Research Association. There follows an application of this grid generation scheme, in conjunction with an Euler solver, to the calculation of the transonic flow past a wing-body-canard configuration. Finally, an application of viscous-inviscid interaction techniques to the design of a fan rotor is described. Author

A87-42083*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

STATUS OF COMPUTATIONAL FLUID DYNAMICS IN THE UNITED STATES

PAUL KUTLER, JOSEPH L. STEGER, and F. R. BAILEY (NASA, Ames Research Center, Moffett Field, CA) IN: Computational Fluid Dynamics Conference, 8th, Honolulu, HI, June 9-11, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 375-396. refs

(AIAA PAPER 87-1135)

CFD-related progress in U.S. aerospace industries and research institutions is evaluated with respect to methods employed, their applications, and the computer technologies employed in their implementation. Goals for subsonic CFD are primarily aimed at greater fuel efficiency; those of supersonic CFD involve the achievement of high sustained cruise efficiency. Transatmospheric/hypersonic vehicles are noted to have recently become important concerns for CFD efforts. Attention is given to aspects of discretization, Euler and Navier-Stokes general purpose codes, zonal equation methods, internal and external flows, and the impact of supercomputers and their networks in advancing the state-of-the-art. O.C.

A87-42088#

APPLICATION OF MACSYMA AND SPARSE MATRIX TECHNOLOGY TO MULTIELEMENT AIRFOIL CALCULATIONS

LAURENCE B. WIGTON (Boeing Commercial Airplane Co., Seattle, WA) IN: Computational Fluid Dynamics Conference, 8th, Honolulu, HI, June 9-11, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 444-457. refs

(AIAA PAPER 87-1142)

An automated technique for implementing a full Newton method in computational fluid dynamics codes is discussed. Specially constructed MACSYMA programs write efficient error-free FORTRAN codes for computing the entries of the Jacobian matrix associated with Newton's method. Sparse matrix technology, which is both faster and easier to use than conventional banded matrix solvers, is invoked to directly solve the resulting system of equations. This technique for implementing a full Newton method is illustrated by extending the inviscid portion of the successful airfoil code recently developed by Giles and Drela at MIT to handle the multielement case. Author

A87-42090#

A LOCALLY IMPLICIT SCHEME FOR THE EULER EQUATIONS

K. C. REDDY and J. L. JACOCKS (Calspan Corp., Arnold Air Force Station, TN) IN: Computational Fluid Dynamics Conference, 8th, Honolulu, HI, June 9-11, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 470-477. refs

(AIAA PAPER 87-1144)

A locally implicit method for solving the Euler equations is described. The method uses finite volume spatial discretization, locally implicit time integration, and Jameson-type artificial dissipation terms. The convergence rate is significantly enhanced with a multigrid iteration and an extrapolation in time. The method is demonstrated with transonic and supersonic flows over an NACA 0012 airfoil. Author

A87-42097#

ON THE RECENT DIFFERENCE SCHEMES FOR THE THREE-DIMENSIONAL EULER EQUATIONS

YOKO TAKAKURA (Fujitsu, Ltd., Scientific Systems Dept., Tokyo, Japan), TOMIKO ISHIGURO, and SATORU OGAWA (National Aerospace Laboratory, Tokyo, Japan) IN: Computational Fluid Dynamics Conference, 8th, Honolulu, HI, June 9-11, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 537-545. refs

(AIAA PAPER 87-1151)

Numerical estimations of TVD schemes (Yee-Harten's TVD and Chakravarthy-Osher's TVD) in three-dimensional general coordinate system are performed by solving the Euler equations around the ONERA M6 wing. It is known their TVD schemes do not give good solutions in curvilinear coordinate system, and several modifications with regard to treatment of metrics are carried out. Comparing with the solution of Beam-Warming scheme, the modified TVD schemes yield excellent solutions with very few numerical oscillations for strong shock waves and high ability of capturing the leading edge expansion. Further, it is shown the solutions of both the TVD schemes almost perfectly coincide with each other in case of the computations using an adaptive grid. Author

A87-42123*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

FLOW VISUALIZATION OF CFD USING GRAPHICS WORKSTATIONS

THOMAS LASINSKI, PIETER BUNING, DIANA CHOI (NASA, Ames Research Center, Moffett Field, CA), STUART ROGERS, GORDON BANCROFT (Sterling Software, Moffett Field, CA) et al. IN: Computational Fluid Dynamics Conference, 8th, Honolulu, HI, June 9-11, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 814-824. refs

(AIAA PAPER 87-1180)

High performance graphics workstations are used to visualize the fluid flow dynamics obtained from supercomputer solutions of computational fluid dynamic programs. The visualizations can be done independently on the workstation or while the workstation is connected to the supercomputer in a distributed computing mode. In the distributed mode, the supercomputer interactively performs the computationally intensive graphics rendering tasks while the workstation performs the viewing tasks. A major advantage of the workstations is that the viewers can interactively change their viewing position while watching the dynamics of the flow fields. An overview of the computer hardware and software required to create these displays is presented. For complex scenes the workstation cannot create the displays fast enough for good motion analysis. For these cases, the animation sequences are recorded on video tape or 16 mm film a frame at a time and played back at the desired speed. The additional software and hardware required to create these video tapes or 16 mm movies are also described. Photographs illustrating current visualization techniques are discussed. Examples of the use of the workstations for flow visualization through animation are available on video tape. Author

A87-42125*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
COLOR GRAPHICS TECHNIQUES FOR SHADED SURFACE DISPLAYS OF AERODYNAMIC FLOWFIELD PARAMETERS
ROBERT P. WESTON (NASA, Langley Research Center, Hampton, VA) IN: Computational Fluid Dynamics Conference, 8th, Honolulu, HI, June 9-11, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 832-837.
(AIAA PAPER 87-1182)

A variety of algorithms are presented that are useful in the color graphics displays of large sets of three-dimensional aerodynamic data. These methods augment established techniques for rapidly and interactively reviewing an assortment of smooth-shaded, color-coded illustrations for experimental and computational distributions of both scalar and vector quantities. Author

A87-42126#
SUBOPTIMAL CONTROL OF DISTRIBUTED SYSTEMS IN THE CASE OF INCOMPLETE MEASUREMENTS [SUBOPTIMAL'NOE UPRAVLENIE RASPREDELENNYMI SISTEMAMI PRI NEPOLNOM IZMERENII]
A. A. BALOEV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 1, 1987, p. 3-9. In Russian. refs

An algorithm is proposed for formulating a control law on the basis of information on the state of a distributed system at a finite number of its points. The problem of the damping of the torsional vibration of a wing is examined as an example. V.L.

A87-42138#
AN APPROXIMATE ANALYSIS OF THE ACCURACY OF THE OPTIMAL DISCRETE CONTROL OF NONLINEAR STOCHASTIC SYSTEMS USING THE METHOD OF SEMIINVARIANTS [PRIBLIZHENNYI ANALIZ TOCHNOSTI DISKRETNOGO OPTIMAL'NOGO UPRAVLENIIA NELINEINYKH STOKHASTICHESKIKH SISTEM METODOM SEMIINVARIANTOV]
N. E. RODNISHCHEV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 1, 1987, p. 63-68. In Russian. refs

An approximate method for optimizing the discrete control of nonlinear stochastic systems is proposed which is based on the expansion of the state vector probability density into a functional series in terms of random process semiinvariants. In accordance with this method, the initial stochastic problem is reduced to that of solving a deterministic functional minimization problem in the presence of certain constraints. The approach proposed here is illustrated by an example. V.L.

N87-24911*# Columbia Univ., New York. Psychophysics Lab.
MULTIPLE PATHS IN COMPLEX TASKS
EUGENE GALANTER, THOMAS WIEGAND, and GLORIA MARK 15 Jul. 1987 39 p
(Contract NAGW-860)
(NASA-CR-180392; NAS 1.26:180392; PPL-87/4) Avail: NTIS HC A03/MF A01 CSCL 09B

The relationship between utility judgments of subtask paths and the utility of the task as a whole was examined. The convergent validation procedure is based on the assumption that measurements of the same quantity done with different methods should covary. The utility measures of the subtasks were obtained during the performance of an aircraft flight controller navigation task. Analyses helped decide among various models of subtask utility combination, whether the utility ratings of subtask paths predict the whole tasks utility rating, and indirectly, whether judgmental models need to include the equivalent of cognitive noise. B.G.

N87-24934# Aeronautical Research Labs., Melbourne (Australia).
AN IMPROVED COMPUTATIONAL PROCEDURE FOR THE UNSTEADY DOUBLET LATTICE METHOD
W. WALDMAN Aug. 1986 61 p
(ARL-STRUC-R-423; AR-004-497) Avail: NTIS HC A04/MF A01

A further modification and enhancement of the doublet lattice computational procedure in use at Aeronautical Research Laboratory (ARL) is described. The theoretical basis for the procedures used to integrate the unsteady Kernel function is covered in detail. A number of cases involving nonplanar and nonparallel lifting surface combinations are studied, and the results are compared with those of other workers. These show generally good agreement, although the predictions of the magnitudes of the forces acting on a tipstore and an underwing store do not compare as favorably. The present method was implemented at ARL into the FORTRAN 77 program called DOULAT. 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.

A87-39537#
SIGNIFICANCE OF UNSTEADY THICKNESS NOISE SOURCES
STEWART A. L. GLEGG (Florida Atlantic University, Boca Raton) AIAA Journal (ISSN 0001-1452), vol. 25, June 1986, p. 839-844. Previously cited in issue 22, p. 3337, Accession no. A86-45448. refs

A87-40307#
FLIGHT NOISE CONTROL - TASKS AND METHODS [FLUGLAERMUEBERWACHUNG - AUFGABEN UND METHODEN]
KLAUS WENZEL (Interflug Gesellschaft fuer Internationalen Flugverkehr mbH, Berlin, East Germany) Technisch-oekonomische Information der zivilen Luftfahrt (ISSN 0232-5012), vol. 23, no. 1, 1987, p. 24-27. In German. refs

The variables which must be measured in flight noise control are discussed along with the related technical measurement problems. The conversion of sound pressure to sound level is explained, and the ordering of the measurement results into standard protocols is described. The interpretation of acoustic data in terms of flight conditions is addressed. C.D.

A87-41560#
NON-LINEAR PROPAGATION OF BROADBAND NOISE SIGNALS
G. P. HOWELL and C. L. MORFEY (Southampton, University, England) Journal of Sound and Vibration (ISSN 0022-460X), vol. 114, April 22, 1987, p. 189-201. SERC-supported research. refs

The theoretical backround to the prediction of aircraft flyover noise is considered, and Taylor's series solutions to a generalized Burger's equation are generated for stationary noise signals. The expansions are in powers of the range variable, and the method allows any frequency dependence of attenuation and dispersion. The limitations of the approach are discussed, and it is found that the number of terms increases rapidly with range. For propagation over a long range, when nonlinear effects are important, it is suggested that a second-order differential equation for the power spectrum be used along with a closure hypothesis. It is noted that individual terms in the series may be treated separately as local spectrum evolution equations, valid at all points along the propagation path. R.R.

A87-41631#
IMPORTANCE OF BROADBAND NOISE FOR ADVANCED TURBOPROPS
K. KNOWLES (Royal Military College of Science, Shrivenham, England) Journal of Aircraft (ISSN 0021-8669), vol. 24, June 1987, p. 386-391. Previously cited in issue 22, p. 3337, Accession no. A86-45447. refs

N87-23797# San Diego State Univ., Calif.
TONES GENERATED DUE TO THE IMPINGEMENT OF TWO JETS ON EACH OTHER
NAGY NOSSEIR, URI PELED, and GREGORY HILDEBRAND *In* Johns Hopkins Univ., The 23rd JANNAF Combustion Meeting, Volume 1 p 459-467 Oct. 1986
Avail: CPIA, Laurel, Md. 20707 HC $70.00

The impingement of two, axisymmetric turbulent jets on each other is investigated experimentally. The angle of impingement is equal to 180 degrees, and the jets are issued from large flat plates. Characteristics of the flow field, and pressure disturbances generated in the impinging region and amplified by feedback mechanisms are discussed. Author

N87-23799# Georgia Inst. of Tech., Atlanta.
ACOUSTIC RESPONSE OF TURBULENT REACTING RECIRCULATORY FLOWS
J. A. DAVIS, N. L. SANKAR, and W. C. STRAHLE *In* Johns Hopkins Univ., The 23rd JANNAF Combustion Meeting, Volume 1 p 485-497 Oct. 1986
(Contract N00014-83-G-0047)
Avail: CPIA, Laurel, Md. 20707 HC $70.00

Experiment and analysis are reported upon concerning two dimensional plane turbulent cold flow behind a backward facing step which is acoustically forced. Numerically, the axisymmetric configuration was also examined. At issue is the interaction between vorticity and acoustics. It is shown experimentally that a lock-in between the shear layer behind the step and the acoustic potential field can occur at distinct frequencies. Furthermore, there is a significant alteration of the potential field when this occurs. In addition, the lock-in is removed when the recirculation zone is removed by a wind tunnel insert. Full numerical Navier-Stokes solution of the problem has shown that this phenomena is heavily dependent upon the boundary conditions of the problem and shows that inviscid treatments of the problem are likely to give misleading results. Author

N87-24160*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
EXTENSION OF KIRCHHOFF'S FORMULA TO RADIATION FROM MOVING SURFACES
F. FARASSAT and M. K. MYERS (Joint Inst. for Advancement of Flight Sciences, Hampton, Va.) May 1987 24 p Submitted for publication
(NASA-TM-89149; NAS 1.15:89149) Avail: NTIS HC A02/MF A01 CSCL 20A

Kirchhoff's formula for radiation from a closed surface has been used recently for prediction of the noise of high speed rotors and propellers. Because the closed surface on which the boundary data are prescribed in these cases is in motion, an extension of Kirchhoff's formula to this condition is required. In this paper such a formula, obtained originally by Morgans for the interior problem, is derived for regions exterior to surfaces moving at speeds below the wave propagation speed by making use of some results of generalized function theory. It is shown that the usual Kirchhoff formula is a special case of the main result of the paper. The general result applies to a deformable surface. However, the special form it assumes for a rigid surface in motion is also noted. In addition, Morgans' result is further extended by showing that edge line integrals appear in the formula when applied to a surface that is piecewise smooth. Some possible areas of application of the formula to problems of current interest in aeroacoustics are discussed. Author

N87-24161*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
ANNOYANCE RESPONSE TO SIMULATED ADVANCED TURBOPROP AIRCRAFT INTERIOR NOISE CONTAINING TONAL BEATS
JACK D. LEATHERWOOD Jul. 1987 28 p
(NASA-TP-2689; L-16184; NAS 1.60:2689) Avail: NTIS HC A03/MF A01 CSCL 20A

A study is done to investigate the effects on subjective annoyance of simulated advanced turboprop (ATP) interior noise environments containing tonal beats. The simulated environments consisted of low-frequency tones superimposed on a turbulent-boundary-layer noise spectrum. The variables used in the study included propeller tone frequency (100 to 250 Hz), propeller tone levels (84 to 105 dB), and tonal beat frequency (0 to 1.0 Hz). Results indicated that propeller tones within the simulated ATP environment resulted in increased annoyance response that was fully predictable in terms of the increase in overall sound pressure level due to the tones. Implications for ATP aircraft include the following: (1) the interior noise environment with propeller tones is more annoying than an environment without tones if the tone is present at a level sufficient to increase the overall sound pressure level; (2) the increased annoyance due to the fundamental propeller tone frequency without harmonics is predictable from the overall sound pressure level; and (3) no additional noise penalty due to the perception of single discrete-frequency tones and/or beats was observed. Author

N87-24965*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
ACOUSTIC FATIGUE: OVERVIEW OF ACTIVITIES AT NASA LANGLEY
JOHN S. MIXSON and LOUIS A. ROUSSOS Apr. 1987 40 p
Presented at the AIAA Dynamics Specialists Conference, Monterey, Calif., 9-10 Apr. 1987
(NASA-TM-89143; NAS 1.15:89143) Avail: NTIS HC A03/MF A01 CSCL 20A

A number of aircraft and spacecraft configurations are being considered for future development. These include high-speed turboprop aircraft, advanced vertical take-off and landing fighter aircraft, and aerospace planes for hypersonic intercontinental cruise or flight to orbit and return. Review of the acoustic environment expected for these vehicles indicates levels high enough that acoustic fatigue must be considered. Unfortunately, the sonic fatigue design technology used for current aircraft may not be adequate for these future vehicles. This has resulted in renewed emphasis on acoustic fatigue research at the NASA Langley Research Center. The overall objective of the Langley program is to develop methods and information for design of aerospace vehicles that will resist acoustic fatigue. The program includes definition of the acoustic loads acting on structures due to exhaust jets of boundary layers, and subsequent determination of the stresses within the structure due to these acoustic loads. Material fatigue associated with the high frequency structural stress reversal patterns resulting from acoustic loadings is considered to be an area requiring study, but no activity is currently underway. Author

N87-24966*# Cambridge Acoustical Associates, Inc., Mass.
PREDICTIONS OF WING AND PYLON FORCES CAUSED BY PROPELLER INSTALLATION
RUDOLPH MARTINEZ May 1987 82 p
(Contract NAS1-18020)
(NASA-CR-178298; NAS 1.26:178298; U-1411-349.10) Avail: NTIS HC A05/MF A01 CSCL 20A

Replacement of current turbojets by high-efficiency unducted propfans could have the unfortunate side effect of increasing cabin noise, essentially because unsteady-aerodynamic mechanisms are likely to be introduced whereby some of the energy saved may be lost again, to the production of propeller noise and to wing/pylon vibrations coupling to the cabin as a sounding board. The present study estimates theoretically associated harmonic aerodynamic forces for two candidate configurations: a pusher propeller which chops through the mean wake of the pylon supporting it, and in the process generates a blade-rate force driving the structure, and a tractor wing-mounted propeller, whose trailing rotating wake induces an unsteady downwash field generating unsteady wing airloads. Reported predictions of such propfan aerodynamic sources of structure-borne sound, or vibration, could be the basis for devising means for their mechanical isolation, and thus for the effective interruption of the structural noise path into the cabin. Both mechanisms are analyzed taking advantage of the high subsonic Mach number and high reduced frequency of the interaction between the impinging flow and the affected aerodynamic element. Author

N87-24984*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
OPTICAL DATA TRANSFER SYSTEM FOR CROSSING A ROTARY JOINT Patent Application
RICHARD J. WANGLER, inventor (to NASA) 23 Apr. 1987 19 p
(NASA-CASE-LAR-13613-1-SB; NAS 1.71:LAR-13613-1-SB; US-PATENT-APPL-SN-041388) Avail: NTIS HC A02/MF A01 CSCL 20F

A data transfer system for crossing a rotary joint is described which uses optical transmitters and receivers which require no physical contact therebetween. The optical transmitter is preferably formed from an optical fiber looped around the rotation axis of the rotary joint. The optical fiber preferably has a core which produces Rayleigh scattering encased by cladding which produces MIE scattering. The light which exits the cladding of the optical fiber is detected on the opposite side of the rotary joint by a photodetector. The photodetector may receive the transmitted light via a second optical fiber having a core encased by cladding and looped around the rotation axis in a manner similar to the optical fiber in the optical transmitter. The optical transmitter preferably uses a laser as a light generating means and two-way communication is made possible by using lasers and detectors tuned to two different wavelengths and connected to opposite ends of the optical fibers in the optical transmitter and receiver. NASA

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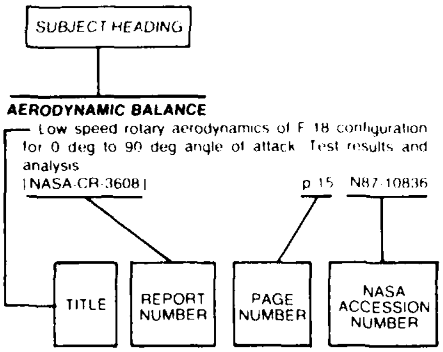
GENERAL

N87-24390*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
ENGINEER IN CHARGE: A HISTORY OF THE LANGLEY AERONAUTICAL LABORATORY, 1917-1958
JAMES R. HANSEN (Maine Univ., Orono.) Washington, D.C. 1986 643 p NASA History Series
(Contract NASW-3502)
(NASA-SP-4305; NAS 1.21:4305) Avail: SOD HC $30.00 as 033-000-00999-2; NTIS MF A01 CSCL 05B

A history is presented by using the most technologically significant research programs associated with the Langley Aeronautical Laboratory from 1917 to 1958 and those programs that, after preliminary research, seemed best to illustrate how the laboratory was organized, how it works, and how it cooperated with industry and the military. B.G.

Typical Subject Index Listing



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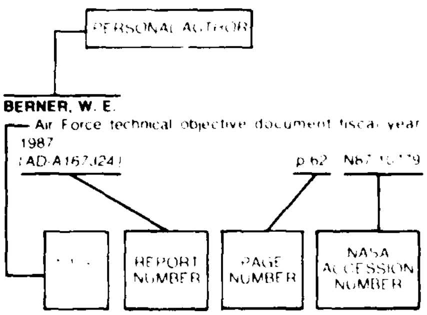
Typical Personal Author Index Listing



Listings in this index are arranged alphabetically by personal author. The title of the document provides the user with a brief description of the subject matter. The report number helps to indicate the type of document listed (e.g., NASA report, translation, NASA contractor report). The page and accession numbers are located beneath and to the right of the title. Under any one author's name the accession numbers are arranged in sequence with the AIAA accession numbers appearing first.

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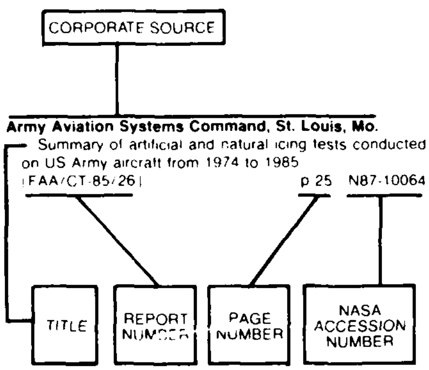
CORPORATE SOURCE INDEX

Typical Corporate Source Index Listing



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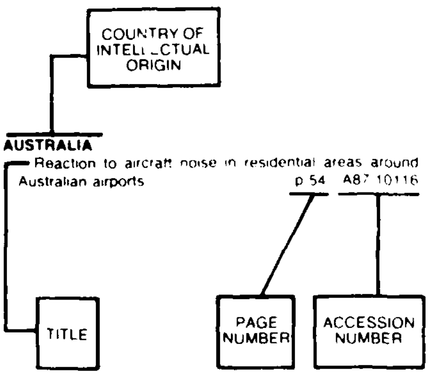
SOURCE

Typical Foreign Technology Index Listing



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FOREIGN

CONTRACT NUMBER INDEX

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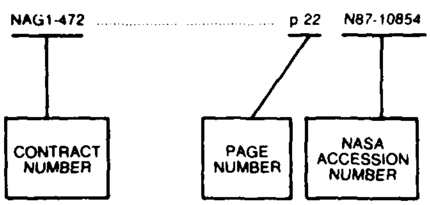
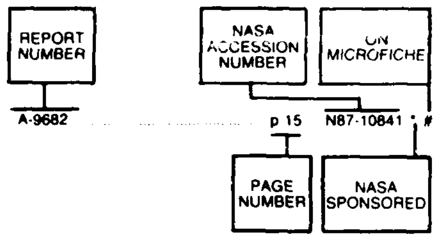


Listings in this index are arranged alphanumerically by contract number. Under each contract number, the accession numbers denoting documents that have been produced as a result of research done under that contract are arranged in ascending order with the AIAA accession numbers appearing first. The accession number denotes the number by which the citation is identified in the abstract section. Preceding the accession number is the page number on which the citation may be found.

CONTRACT

Typical Report Number Index Listing



Listings in this index are arranged alphanumerically by report number. The page number indicates the page on which the citation is located. The accession number denotes the number by which the citation is identified. An asterisk (*) indicates that the item is a NASA report. A pound sign (#) indicates that the item is available on microfiche.

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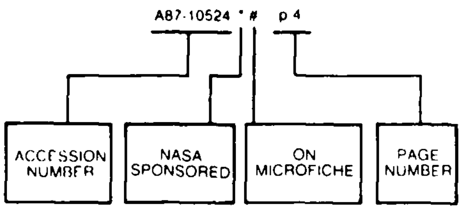

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