NASA

Aeronautical Engineering
A Continuing Bibliography with Indexes

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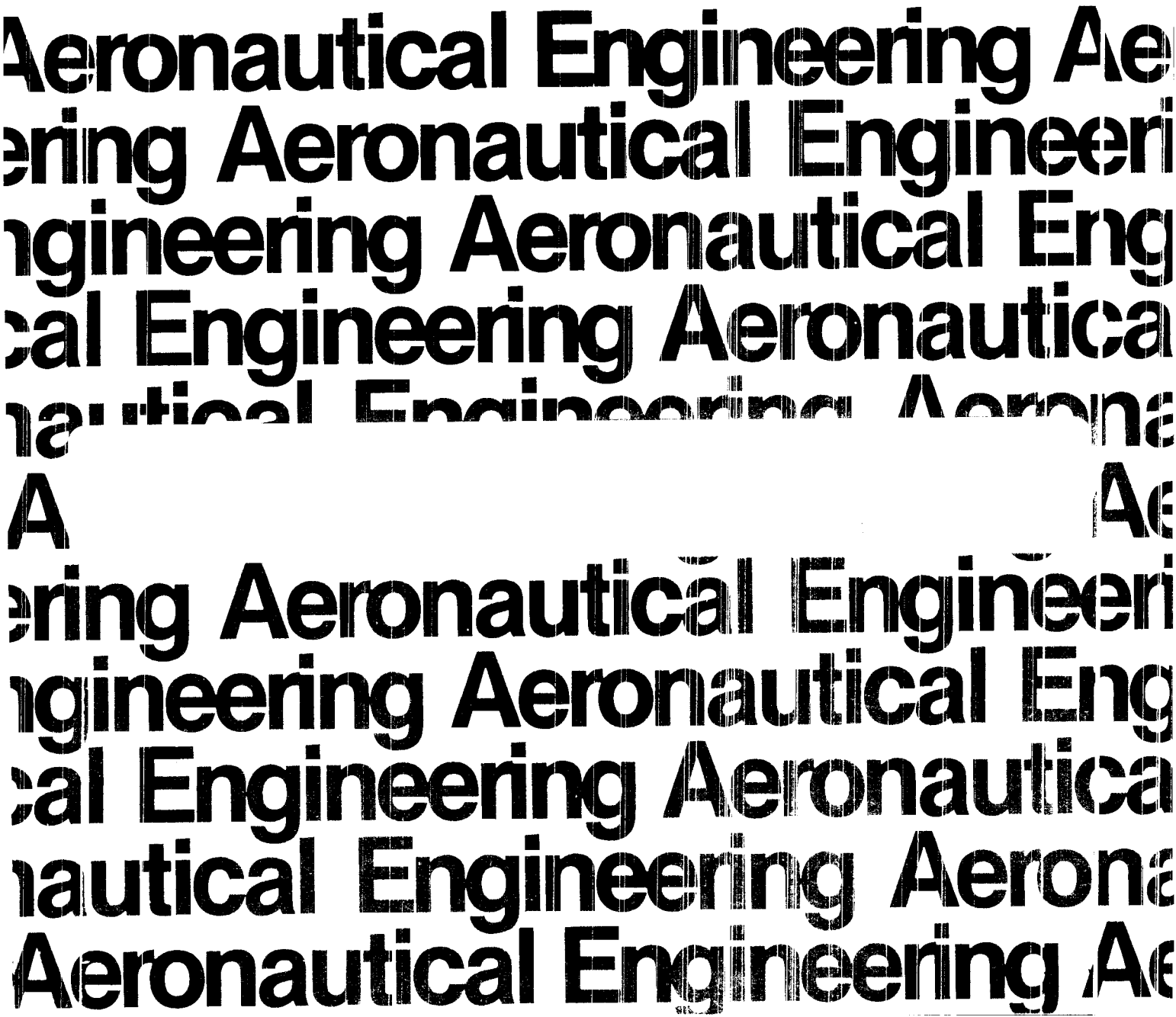

NASA SP-7037(232)

AERONAUTICAL ENGINEERING

A CONTINUING BIBLIOGRAPHY WITH INDEXES

(Supplement 232)

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 October 1988 in

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

NASA Scientific and Technical Information Division 1988
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INTRODUCTION

This issue of *Aeronautical Engineering -- A Continuing Bibliography* (NASA SP-7037) lists 422 reports, journal articles and other documents originally announced in October 1988 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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Category 10	**Astronautics** Includes astronautics (general); astrodynamics; ground support systems and facilities (space); launch vehicles and space vehicles; space transportation; space communications, spacecraft communications, command and tracking; spacecraft design, testing and performance; spacecraft instrumentation; and spacecraft propulsion and power.	**N.A.**
Category 11	**Chemistry and Materials** Includes chemistry and materials (general); composite materials; inorganic and physical chemistry; metallic materials; nonmetallic materials; propellants and fuels; and materials processing.	**673**

Category 12 Engineering 675
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Category 13 Geosciences 685
Includes geosciences (general); earth resources and remote sensing; energy production and conversion; environment pollution; geophysics; meteorology and climatology; and oceanography.

Category 14 Life Sciences N.A.
Includes life sciences (general); aerospace medicine; behavioral sciences; man/system technology and life support; and space biology.

Category 15 Mathematical and Computer Sciences 685
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.

Category 16 Physics 687
Includes physics (general); acoustics; atomic and molecular physics; nuclear and high-energy physics; optics; plasma physics; solid-state physics; and thermodynamics and statistical physics.

Category 17 Social Sciences 689
Includes social sciences (general); administration and management; documentation and information science; economics and cost analysis; law, political science, and space policy; and urban technology and transportation.

Category 18 Space Sciences N.A.
Includes space sciences (general); astronomy; astrophysics; lunar and planetary exploration; solar physics; and space radiation.

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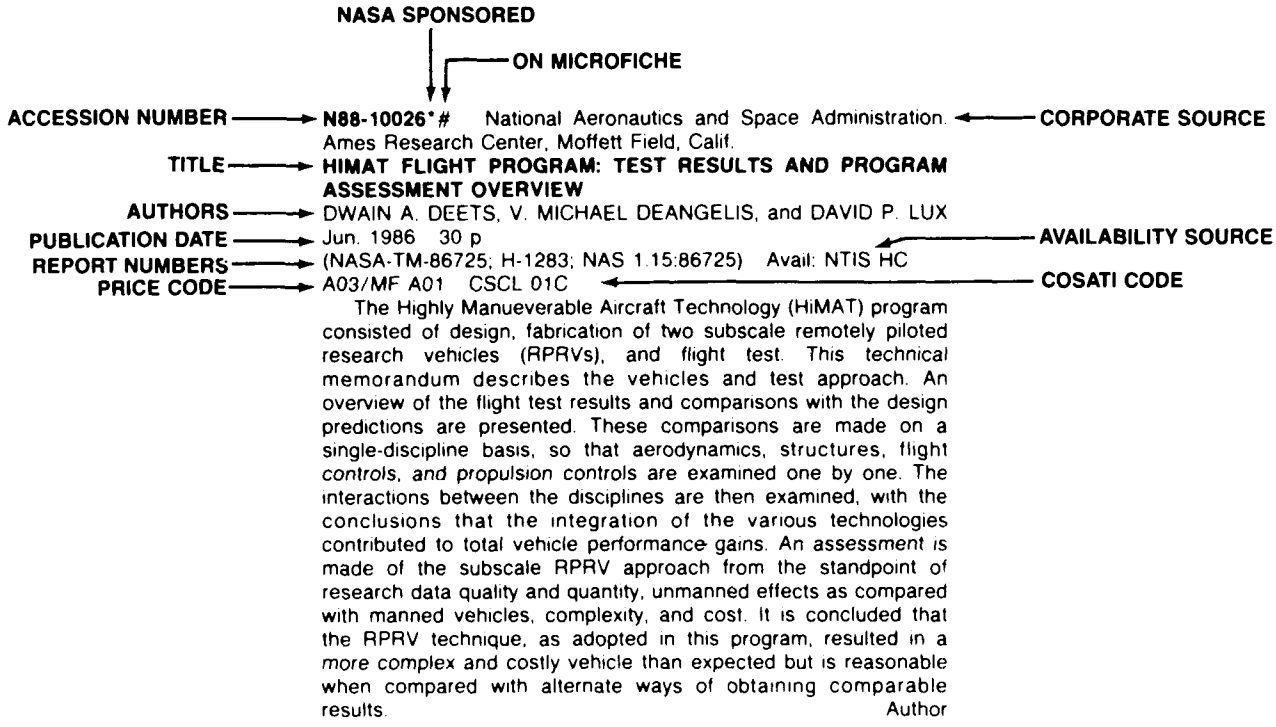
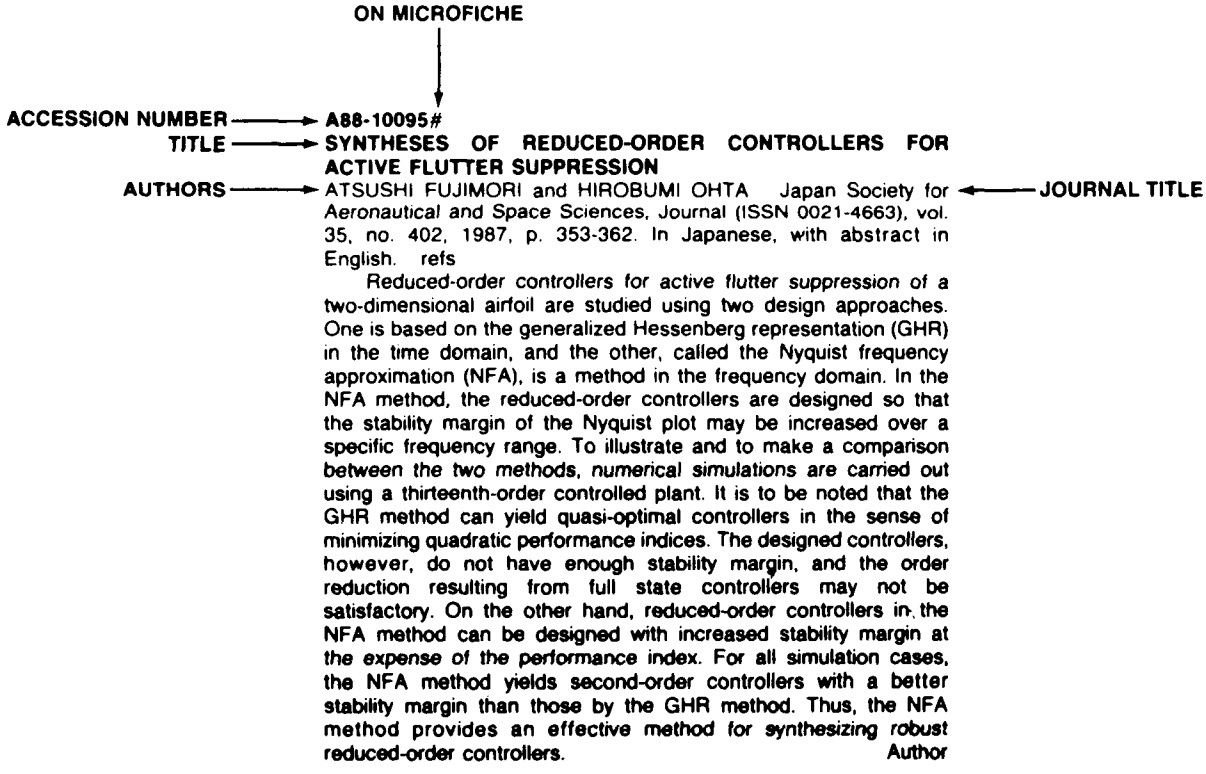
TYPICAL REPORT CITATION AND ABSTRACT



TYPICAL JOURNAL ARTICLE CITATION AND ABSTRACT



AERONAUTICAL ENGINEERING

A Continuing Bibliography (Suppl. 232)

NOVEMBER 1988

01

AERONAUTICS (GENERAL)

A88-46051 Yale Univ., New Haven, Conn.
THE DAEDALUS PROJECT - PHYSIOLOGICAL PROBLEMS AND SOLUTIONS
ETHAN R. NADEL (Yale University, New Haven, CT) and STEVEN R. BUSSOLARI (MIT, Cambridge, MA) American Scientist (ISSN 0003-0996), vol. 76, July-Aug. 1988, p. 350-360. Research supported by United Technologies Corp., Shaklee Corp., Smithsonian Institution, MIT, and NASA. refs

The physiological research for the Daedalus project which led to a man-powered flight of 119 km for about 4 hrs from Crete to the Greek island of Santorini in April 1988 is discussed. The ways in which candidate pilots were screened for aerobic power and ability to maintain oxygen delivery and the development of an energy-electrolyte drink for the flight are presented. The problems of heat dissipation, hydration, and maintaining fuel delivery are examined and endurance tests, including heart rate, change in plasma volume, oxygen uptake, plasma sodium and glucose levels, and mechanical power output are given in tables. From simulations, it was estimated that the pilot would lose on the order of 900 ml of water per hour during the flight. During the flight, the pilots heart rate did not exceed 142 beats per minute, confirming assessments made during simulation. R.B.

A88-46202
HIGH G AND HIGH G PROTECTION - THE OPERATIONAL SCENARIO
A. D. MOIR and J. WALMSLEY (RAF, London, England) IN: High G and high G protection - Aeromedical and operational aspects; Proceedings of the Symposium, London, England, Oct. 21, 1987. London, Royal Aeronautical Society, 1987, p. 1-8.

An account is given of the ways in which the RAF conducts its fighter aircraft pilot training to acclimatize crewmembers to the accelerations of various phases of air combat. The perceptual, physical, and psychological stresses exerted by high-Gs in combat are discussed in the context of such tasks as visual identification of target aircraft, weapon-limited engagement maneuvers, multiple engagement scenarios, evasive maneuvers, ground attack, interception, and nuclear-bacteriological-chemical scenarios. The levels of pilot G-loading that can be expected in the next-generation EFA fighter are noted. O.C.

A88-46267
DIAGNOSTICS - AN EFFICIENT METHODOLOGY FOR 'ROTOR TRACK AND BALANCE'
P. GADD (Royal Navy, Naval Aircraft Materials Laboratory, Gosport, England) IN: Helicopter vibration and its reduction; Proceedings of the Symposium, London, England, Nov. 16, 1987. London, Royal Aeronautical Society, 1987, p. 93-97.

An account is given of a novel methodology for the translation of helicopter main-rotor-blade track and lag measurements, in conjunction with the 1/rev vibration vectors, into a diagnosis of faults from which recommendations of maintenance actions for the rotor system can in turn be based. The performance levels achieved by these diagnostic procedures in an illustrative in-service trial are discussed; future UK Royal Navy adoption of the methodology appears justified in light of the results obtained. O.C.

A88-48323
A METHOD FOR DETERMINING DESIGN CONTACT PRESSURES FOR MOVING CHASSIS COMPONENTS ON THE BASIS OF THE SPECIFIC FRICTION FORCE [METOD OPREDELENIIA RASCHETNYKH KONTAKTNYKH DAVLENII DLIA PODVIZHNYKH UZLOV SHASSI PO PREDEL'NOMU ZNACHENIIU UDEL'NOI SILY TRENIIA]
V. I. RIABKOV, I. N. VOLOKH, and N. G. TOLMACHEV Samoletostroenie - Tekhnika Vozdushnogo Flota (ISSN 0581-4634), no. 54, 1987, p. 94-98. In Russian. refs

A new approach to the calculation of contact pressures for the moving components of chassis and other aircraft mechanisms is developed on the basis of the experimental finding that the limiting value of the specific friction force is the determining factor in the failure of the moving surfaces of friction pairs in aircraft components. The method proposed here makes it possible to obtain, early in the design process, reliable estimates of the contact pressures that would guarantee the required load-bearing capacity of the moving components and minimize their mass. V.L.

A88-48499#
COST-OF-A-CASSETTE AIR SAFETY
MASAYASU KAWAI (Kyowa Dengyo (Europe), Hoofdrorp, Netherlands) Aerospace America (ISSN 0740-722X), vol. 26, Aug. 1988, p. 32-34.

By the end of this century, powerful and compact computers directly integrated with aircraft instruments and programmed to analyze the complex interactions occuring over the entirety of the primary structure will make automated inspection part of routine maintenance; such checkups would then be conducted on site by mechanics, rather than in computer rooms by engineers. A single, properly equipped portable recorder can accept data from up to 224 sources simultaneously, recording them in separate channels of a video cassette for subsequent analysis. Installed recording equipment prompts more frequent monitoring, leading to more dependable and accurate advance warning of system defects, component deterioration, and metal fatigue. O.C.

A88-48704
AIRCRAFT SERVICING AND MAINTENANCE (2ND REVISED AND ENLARGED EDITION) [OBSLUZHIVANIE I REMONT AVIATSIONNOI TEKHNIKI PO SOSTOIANIIU /2ND REVISED AND ENLARGED EDITION/]
NIKOLAI NIKOLAEVICH SMIRNOV and ALEKSANDR ABRAMOVICH ITSKOVICH Moscow, Izdatel'stvo Transport, 1987, 272 p. In Russian. refs

Methodological aspects of aircraft maintenance are examined. Consideration is also given to aircraft servicing with reliability monitoring; general questions concerning the development of servicing and maintenance programs; airframe maintenance features; evaluation of maintenance efficiency; and the organizational aspects of servicing and maintenance. B.J.

N88-25431*# California Polytechnic State Univ., San Luis Obispo.
TAKEOFF PREDICTIONS FOR POWERED-LIFT AIRCRAFT Thesis
DOUGLAS A. WARDWELL and DORAL R. SANDLIN Jul. 1988 60 p
(Contract NCC2-236)
(NASA-CR-177491; NAS 1.26:177491) Avail: NTIS HC A04/MF A01 CSCL 01A

Takeoff predictions for powered-lift short takeoff (STO) and conventional takeoff (CTO) aircraft have been added to NASA Ames Research Center's Aircraft Synthesis (ACSYNT) code. The new computer code predicts the aircraft engine and nozzle settings required to achieve the minimum takeoff roll. As a test case, the code predicted takeoff ground rolls and nozzle settings for the YAV-8B Harrier that compared well with measured values. Brief analysis of takeoff performance for an Ejector, Remote Augmented Lift, Hybrid-Tandem Fan, and Vectored Thrust STO aircraft using the new routine will be presented. Author

N88-26289*# Puerto Rico Univ., Mayaguez.
THE ROLE OF AVIATION TECHNOLOGY IN THE CARIBBEAN BASIN Final Report, Sep. 1987 - Jul. 1988
ROBERT W. SMITH 1988 99 p
(Contract NCC2-496)
(NASA-CR-183069; NAS 1.26:183069) Avail: NTIS HC A05/MF A01 CSCL 01A

Aviation technology can play a significant role in the development of the countries of the Caribbean Basin. A variety of applications of rotorcraft in the region, the benefits, both economic and political which can result from utilization of rotorcraft in both a public service and commercial role are presented. A computer simulation of rotorcraft used as emergency medical vehicles is applied to compare and evaluate the advantages of using rotorcraft technology such as civil derivatives of the new tiltrotor. It is concluded that by using a civil derivative of the tiltrotor, significant improvements can be obtained in the level of health service in the region. The potential for cargo and passenger transport applications are currently being investigated and a second computer simulation is being developed to be used to evaluate the potential benefits to be derived from such applications. Author

N88-26328*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
FIBER OPTICS FOR ADVANCED AIRCRAFT
ROBERT J. BAUMBICK 1988 13 p Presented at the Fiber Optics, Optoelectronics and Laser Applications International Symposium and Exhibition, Boston, Mass., 6-9 Sep. 1988; sponsored by the Society of Photo-Optical Instrumentation Engineers
(NASA-TM-101294; E-4276; NAS 1.15:101294) Avail: NTIS HC A03/MF A01 CSCL 01B

The increased use of composites makes the digital control more susceptible to electromagnetic effects. In order to provide the protection to the digital control additional shielding will be required as well as protective circuitry for the electronics. This results in increased weight and reduced reliability. The advantages that fiber optic technology provides for advanced aircraft applications is recognized. The use of optical signals to carry information between the aircraft and the control module provides immunity from contamination by electromagnetic sources as well as other important benefits such as reduced weight and volume resulting from the elimination of the shielding and the replacement of metal conductors with low weight glass fibers. In 1975 NASA began work to develop passive optical sensors for use with fiber optics in aircraft control systems. The problem now is to choose the best optical sensor concepts and evaluate them for use. In 1985 NASA and DOD entered into a joint program, Fiber Optic Control System Integration (FOCSI), to look at optical technology specifically for use in advanced aircraft systems. The results of this program are discussed. The conclusion of the study indicated that the use of fiber optic technology in advanced aircraft systems is feasible and desirable. The study pointed to a lack of available sensors from vendors capable of operating in the adverse environments of advanced aircraft. Author

02

AERODYNAMICS

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

A88-45930#
NUMERICAL STUDY OF INCOMPRESSIBLE VISCOUS FLOW OVER AN ISOLATED AIRFOIL
CHUANGANG GU, XI CHEN, and YONGMIAO MIAO (Xian Jiaotong University, People's Republic of China) Acta Aerodynamica Sinica (ISSN 0258-1825), vol. 6, June 1988, p. 190-196. In Chinese, with abstract in English. refs

A finite difference method based on differential-integral equations is presented for the solution of Navier-Stokes equations for incompressible viscous flow. This method is applied to solve the turbulent flows past an isolated airfoil at large angles of attack with separations. The k-epsilon turbulence model, in conjunction with adverse pressure gradient, is utilized to describe and analyze turbulent flow processes. A modified hybrid scheme and a modified pressure correction formula suitable to nonorthogonal coordinates are developed to make the calculation rapidly convergent and simple. Comparison of predications and experiments shows that the agreements of calculated results with experimental data are fairly satisfactory with respect to the pressure distribution of airfoil surface, to the average velocity field, as well as to the point of separation and Reynolds shear stresses. Author

A88-45934#
A PRELIMINARY INVESTIGATION OF UNSTEADY PRESSURE MEASUREMENT ON A TWO-DIMENSIONAL WING MODEL
WEIXUN LIN (China Aerodynamics Research and Development Centre, Sichuan, People's Republic of China) Acta Aerodynamica Sinica (ISSN 0258-1825), vol. 6, June 1988, p. 226-231. In Chinese, with abstract in English. refs

A preliminary experimental investigation of unsteady pressure measurement technique is presented on two-dimensional wing model with flap oscillating in pitch. The model, equipment and test method are described and some typical results are given. The regularity of the data agrees with results previously obtained, indicating the technique and data processing methods used are feasible. Author

A88-45936#
THE INTERACTION BETWEEN NORMAL SHOCK AND TURBULENT BOUNDARY LAYER IN TRANSONIC FLOW OVER A CURVED WALL
XIAOCHUN LIAN (Northwestern Polytechnical University, Xian, People's Republic of China) and PEIZHENG JIANG (Xian Jiaotong University, People's Republic of China) Acta Aerodynamica Sinica (ISSN 0258-1825), vol. 6, June 1988, p. 237-240. In Chinese, with abstract in English. refs

Some calculation results on the interaction between a normal shock and turbulent boundary layer in transonic flow over a curved wall are presented. These results show that the pressure ratio across the shock is lower than the theoretical value, in which the wall curvature plays an important role. All the thickness of boundary layer displacement, moment and energy increase considerably in the interactive region. These increasements principally depend on the pressure ratio across the normal shock. Author

A88-45937#
NUMERICAL CALCULATION FOR THE FLOW FIELD OF TRANSONIC CASCADE WITH INVISCID-VISCOUS INTERACTION METHOD

MANLU LUO and BAINIAN ZHANG (Jiaotong University, Shanghai, People's Republic of China) Acta Aerodynamica Sinica (ISSN 0258-1825), vol. 6, June 1988, p. 241-245. In Chinese, with abstract in English. refs

An inviscid-viscous interaction method based on the inviscid time-marching computer code has been employed to calculate the transonic flow field of a two-dimensional cascade. Good agreement with the experimental data has been achieved for several numerical test cases for which the Mach number ranged from subsonic up to supersonic. The computer code works exceedingly well with the transonic flow when there is no strong boundary separation. Author

A88-46047#
STEADY NEWTONIAN FLOW OVER TWO-DIMENSIONAL AIRFOILS
HAMDI T. HEMDAN (King Saud University, Riyadh, Saudi Arabia) Japan Society for Aeronautical and Space Sciences, Transactions (ISSN 0549-3811), vol. 31, May 1988, p. 18-28. Research supported by King Saud University. refs

Closed-form solutions for Newtonian flow past two-dimensional thin airfoils with attached shock waves are found in this paper. The work relies on a previous formulation of the hypersonic small disturbance theory and the Newtonian flow theory. Simple results for the shock wave and the surface pressure are given. The analysis extends Cole's (1970) zero-order theory to the effects of nonzero (gamma-1) and finite values of freestream Mach number, where gamma is the ratio of the specific heats of the gas. It also improves over a recent work by the present author by getting the shock wave exactly. The results are compared with other approximate methods and the agreement is found to be generally good. Author

A88-46214#
NUMERICAL NAVIER-STOKES SOLUTIONS OF HIGH-SPEED PROPELLER FLOWS
S. J. YOON and J. A. SCHETZ (Virginia Polytechnic Institute and State University, Blacksburg) Journal of Propulsion and Power (ISSN 0748-4658), vol. 4, July-Aug. 1988, p. 291, 292. Abridged. Research supported by the Virginia Center for Coal and Energy Research. Previously cited in issue 20, p. 2916, Accession no. A86-42700.

A88-46221#
EXPERIMENTAL AND NUMERICAL INVESTIGATION OF A PROPELLER WITH THREE-DIMENSIONAL INFLOW
JOSEPH A. SCHETZ, DAVID A. MALLORY (Virginia Polytechnic Institute and State University, Blacksburg), and DOMINIQUE PELLETIER (Montreal, Universite, Montreal, Canada) Journal of Propulsion and Power (ISSN 0748-4658), vol. 4, July-Aug. 1988, p. 341-349. Navy-supported research. Previously cited in issue 08, p. 1044, Accession no. A87-22735. refs

A88-46223#
CALCULATION OF UNSTEADY WAKE/ROTOR INTERACTION
MICHAEL B. GILES (MIT, Cambridge, MA) Journal of Propulsion and Power (ISSN 0748-4658), vol. 4, July-Aug. 1988, p. 356-362. Research supported by Rolls-Royce, Inc. Previously cited in issue 08, p. 1032, Accession no. A87-22354. refs
(Contract N00014-81-K-0024)

A88-46227
TURBULENT DRAG REDUCTION BY PASSIVE MEANS; PROCEEDINGS OF THE INTERNATIONAL CONFERENCE, LONDON, ENGLAND, SEPT. 15-17, 1987. VOLUMES 1 & 2
Conference sponsored by British Aerospace, PLC, USAF, and U.S. Navy. London, Royal Aeronautical Society, 1987, p. Vol. 1, 252 p.; vol. 2, 352 p. For individual items see A88-46228 to A88-46249.

The present conference discusses turbulent drag reduction research at NASA Langley, direct total-force measurements of large eddy breakup (LEBU) device performance, the passive temperature contamination study of LEBU-modified turbulent boundary layers, the modeling of turbulent boundary layers manipulated with thin outer layer devices, and the boundary layer integral parameters and net drag reduction results of a novel method of calculating the boundary layer characteristics downstream of flow manipulators. Also discussed are the mechanism of viscous drag reduction by streamwise-aligned riblets, transonic speed results for riblet aerodynamic effects, organized flow features in boundary layer turbulence, turbulence-reduction on swept leading edges, and off-design condition performance penalties for riblets. O.C.

A88-46228* National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
TURBULENT DRAG REDUCTION RESEARCH AT NASA LANGLEY - PROGRESS AND PLANS
S. P. WILKINSON, J. B. ANDERS, B. S. LAZOS, and D. M. BUSHNELL (NASA, Langley Research Center, Hampton, VA) IN: Turbulent drag reduction by passive means; Proceedings of the International Conference, London, England, Sept. 15-17, 1987. Volume 1. London, Royal Aeronautical Society, 1987, p. 1-32. refs

Prospective research efforts planned at NASA-Langley in view of results obtained to date in passive turbulent drag reduction experiments are discussed. It has been established that conventional flow-aligned riblets are effective even in the presence of a degree of flow inclination and pressure gradients, and at transonic speeds. No increase in net drag reduction is expected from nonconventional riblet geometries. Large eddy breakup devices promise drag reductions in the 8-15 percent range. Heat transfer-augmentation, noise-reduction, turboprop/fuselage interaction noise reduction, are other advantages expected from this line of research. O.C.

A88-46229
A STUDY OF LEBU PERFORMANCE BY DIRECT TOTAL-FORCE MEASUREMENTS
D. I. A. POLL (Manchester, Victoria University, England) and P. G. WESTLAND (Cranfield Institute of Technology, England) IN: Turbulent drag reduction by passive means; Proceedings of the International Conference, London, England, Sept. 15-17, 1987. Volume 1. London, Royal Aeronautical Society, 1987, p. 33-44. refs

The performance of tandem ribbon boundary layer manipulators has been investigated experimentally. Tests have been conducted on a large thin plate with fully turbulent boundary layers on both sides. The aerodynamic loads on the plate have been measured with a sensitive force balance. By noting force differences it has been possible to deduce the basic drag of the manipulating ribbons, the effect of the ribbons on the skin friction drag of the plate, and the net drag change of the total system when manipulators are introduced into the boundary layers. Distributions of local wall shear have been estimated by the Preston-tube method. A parametric study has been performed to determine the effect of ribbon height and ribbon separation on net drag. The momentum thickness Reynolds number for the undisturbed boundary layer was varied from 1500 to 2100 at the location of the upstream ribbon. Although the ribbons had a significant effect on the distribution of skin friction over the test plate, no net drag reduction was observed. Author

A88-46235* High Technology Corp., Hampton, Va.
USE OF LEBU-DEVICES FOR DRAG REDUCTION AT FLIGHT CONDITIONS
A. BERTELRUD (High Technology Corp., Hampton, VA; Flygtekniska Forsoksanstalten, Bromma, Sweden) and R. D. WATSON (NASA, Langley Research Center, Hampton, VA) IN: Turbulent drag reduction by passive means; Proceedings of the International Conference, London, England, Sept. 15-17, 1987. Volume 1. London, Royal Aeronautical Society, 1987, p. 213-249. refs

The practical aspects of drag reduction using LEBU (large-eddy break-up) devices, turbulence manipulators, etc. in flight are discussed with the help of experience from previous flight tests.

These tests have shown that appreciable reductions in local skin friction exist under flight conditions, and that the turbulence-manipulating effects can be found for swept tandem devices in transonic as well as supersonic flows. The unsteady loads experienced with the devices are discussed in connection with the frequencies occurring in this type of real flight conditions. Author

A88-46236
DRAG REDUCTION PERFORMANCE ON RIBLET SURFACES AND THROUGH OUTER LAYER MANIPULATORS
E. COUSTOLS, J. COUSTEIX, and J. BELANGER (ONERA, Centre d'Etudes et de Recherches de Toulouse, France) IN: Turbulent drag reduction by passive means; Proceedings of the International Conference, London, England, Sept. 15-17, 1987. Volume 2. London, Royal Aeronautical Society, 1987, p. 250A-289. refs

Hot wire measurements behind a tandem-type outer flow manipulator configuration employing either thin plate or airfoil profiles have revealed the importance of the manipulator wake in the skin friction drag reduction process. The wake interacts with the large-scale motion of the preexisting turbulence and modifies it; the effect of this process on the mean characteristics of the turbulence boundary layer is to yield a lower momentum thickness curve slope. Attention is given to the compromise that must be negotiated between low flow manipulator drag penalty and the magnitude of the desired skin friction reduction. O.C.

A88-46237
ON THE MECHANISM OF VISCOUS DRAG REDUCTION USING STREAMWISE ALIGNED RIBLETS - A REVIEW WITH NET RESULTS
P. VUKOSLAVCEVIC, J. M. WALLACE, and J.-L. BALINT (Maryland, University, College Park) IN: Turbulent drag reduction by passive means; Proceedings of the International Conference, London, England, Sept. 15-17, 1987. Volume 2. London, Royal Aeronautical Society, 1987, p. 290-309. refs

The aerodynamic effects of riblet surfaces on the mean and fluctuating streamwise velocity field are confined to within about 4 percent of the boundary layer above the bounding surface. The local wall shear stress varies substantially in the spanwise direction, from about 80 percent greater than the smooth plate value at the riblet peak for flow with the same freestream velocity, to nil at the riblet valley. The turbulence intensities and the skewness and flatness factors of the streamwise velocity fluctuation all indicate that the turbulence is nearly suppressed below the grooves' midpoint. O.C.

A88-46240
AN ASSESSMENT OF THE DRAG REDUCTION PROPERTIES OF RIBLETS AND THE PENALTIES OF OFF-DESIGN CONDITIONS
L. GAUDET (Royal Aircraft Establishment, Bedford, England) IN: Turbulent drag reduction by passive means; Proceedings of the International Conference, London, England, Sept. 15-17, 1987. Volume 2. London, Royal Aeronautical Society, 1987, p. 363-376. refs

An assessment is given of the performance of riblets in reducing skin friction in turbulent flow. The data of Sawyer and Winter (1988) are used to develop skin-friction relationships derived from the velocity profile for a turbulent boundary layer as modified by a riblet surface. The maximum percentage drag reduction is shown to vary with Reynolds number. At large values of the nondimensional riblet height, the riblet surface acts as a uniform roughness and a value for the equivalent sand-grain roughness height is given. Examples of the estimated drag reductions which might be achieved for two current aircraft by incorporating riblet surfaces are presented. Author

A88-46241
SOME EXPERIENCES OF RIBLETS AT TRANSONIC SPEEDS
L. C. SQUIRE and A. M. SAVILL (Cambridge University, England) IN: Turbulent drag reduction by passive means; Proceedings of the International Conference, London, England, Sept. 15-17, 1987. Volume 2. London, Royal Aeronautical Society, 1987, p. 392-407. Research supported by Rolls-Royce, PLC and SERC. refs

The present investigation of the skin friction drag effects of riblets at high subsonic speeds, for Reynolds numbers (based on the momentum thickness of the undisturbed boundary layer) of about 20,000, gave attention to six different riblet sizes with height h (equal to spacing s) ranging from 0.0009 inches to 0.006 inches. For maximum reduction in skin friction, the optimum riblet scaling, in wall units, is of the order of 40, while for maximum overall drag reduction, riblet size is of the order of 20 wall units; an analysis of the results suggests that this apparent contradiction is associated with a drag force at the leading edge of the riblet surface. O.C.

A88-46243
EXPERIMENTS ON THREE-DIMENSIONAL RIBLETS
D. W. BECHERT (DFVLR, Berlin, Federal Republic of Germany) IN: Turbulent drag reduction by passive means; Proceedings of the International Conference, London, England, Sept. 15-17, 1987. Volume 2. London, Royal Aeronautical Society, 1987, p. 425-431. refs

The drag reduction by three-dimensional riblet surfaces is investigated experimentally. The turbulent wall shear stress is measured directly using a large floating element. This floating element is inserted into a flat plate with zero pressure gradient of the mean flow. Thje riblet surface consists of aboaut 600,000 tiny sharp-edged fin-like elements in a staggered array on a smooth flat plate. It was hoped that these elements would 'cut' the streamwise vortices in the viscous sublayer which produce the low speed streaks. However, the shear stress measurements do not support conclusively this latter idea. The data look almost exactly like previous data from conventional straight riblets. Drag reduction does occur (6 percent), and it is comparable to that of straight riblets. Finally, the manufacturing technique for these three-dimensional riblet surfaces is described in brief. Author

A88-46244* Notre Dame Univ., Ind.
MODIFICATION OF TURBULENT BOUNDARY LAYER STRUCTURE BY LARGE-EDDY BREAKUP DEVICES
H. M. ATASSI and G. A. GEBERT (Notre Dame, University, IN) IN: Turbulent drag reduction by passive means; Proceedings of the International Conference, London, England, Sept. 15-17, 1987. Volume 2. London, Royal Aeronautical Society, 1987, p. 432-456. refs
(Contract NAG1-662)

The modification of the turbulent boundary layer large-eddy structure by streamlined devices is analyzed using the rapid distortion approximation and unsteady aerodynamic theory. The fluctuating velocity downstream of thin plate and airfoil-shaped devices is calculated throughout the boundary layer for two-dimensional and three-dimensional upstream harmonic disturbances. It is shown that such devices suppress most effectively the fluctuating vertical velocity for a range of reduced frequencies k(1) based on the device chord length. This effect depends on the device geometry and loading, its distance to the wall, and on the upstream disturbance condition. Effective devices suppressing most of the large-scale turbulent energy are such that k(1) varies over the 0.5 to 3.0 range. For airfoil-shaped devices, the device thickness has minimal effect on its performance. On the other hand, lifting devices are more effective than thin plates particularly for two-dimensional disturbances. Author

A88-46249
TURBULENCE REDUCTION ON SWEPT LEADING EDGES
G. R. SEYFANG (British Aerospace, PLC, Preston, England) IN: Turbulent drag reduction by passive means; Proceedings of the International Conference, London, England, Sept. 15-17, 1987. Volume 2. London, Royal Aeronautical Society, 1987, p. 568-601. refs

Small, robust, and simple passive devices have been developed which can relaminarize swept leading edges that have been contaminated by either the wing root/fuselage junction flow or local roughness particles. A tentative explanation is given for the

flow mechanism permitting these devices to yield this effect. By retrofitting these passive leading-edge devices to winds, empennages and pylons, current aircraft may achieve a 5-percent total aircraft drag reduction; new laminar-flow aircraft could employ greater wing sweep if the devices were incorporated, to yield higher design speeds. It is also suggested that gliding reentry vehicles may undergo less aerodynamic heating, thereby saving on thermal protection system mass. O.C.

A88-46320
LARGE-EDDY SIMULATIONS OF AXISYMMETRIC EXCITATION EFFECTS ON A ROW OF IMPINGING JETS
MAGDI H. RIZK and SURESH MENON (Flow Research Co., Kent, WA) Physics of Fluids (ISSN 0031-9171), vol. 31, July 1988, p. 1892-1903. refs
(Contract F49620-85-C-0084)

Numerical simulations of a row of impinging jets are performed. Both the impinging jets and the fountains caused by the collision of the wall jets are modeled in the simulation. The problem considered contains the essential features of twin jets impinging on the ground, simulating the hovering configuration of a vertical takeoff and landing (VTOL) aircraft. The flow is assumed to be governed by the time-dependent, incompressible Navier-Stokes equations. The large-eddy simulation approach is followed. The present study focuses on the motion and dynamics of large-scale structures that have been experimentally observed in jet flows. The behavior of the jets and the fountain caused by the introduction of axisymmetric disturbances at the jet exits are investigated. Author

A88-46326
INTRODUCTION TO HYPERSONIC AERODYNAMICS - MODELING PROBLEMS [INTRODUCTION A L'AERODYNAMIQUE HYPERSONIQUE - PROBLEMES DE MODELISATION]
J. P. GUIRAUD (ONERA, Chatillon-sous-Bagneux; Paris VI, Universite, France) Colloque d'Aerodynamique Appliquee, 24th, Poitiers, France, Oct. 26-28, 1987. 28 p. In French. refs
(AAAF PAPER NT-87-02)

Problems in the modeling of hypersonic flow are discussed for the case of the modeling of gas mixtures using the diffusion approximation. In this approximation, only the barycentric movement of the mixture is considered, and the discussion is limited to the internal energy of the mixture. Following a review of the general principles of hypersonic aerodynamics, global models for the prediction of hypersonic flow which are based on partial differential equations are presented. The present models describe the kinetic theory of gases using the Boltzmann equation. Boundary conditions, particularly at the walls, are specified. R.R.

A88-46327
DEVELOPMENT OF CALCULATION METHODS FOR INVISCID HYPERSONIC FLOWS [DEVELOPPEMENT DE METHODES DE CALCUL POUR LES ECOULEMENTS HYPERSONIQUES NONVISQUEUX]
J. L. MONTAGNE (ONERA, Chatillon-sous-Bagneux, France) Colloque d'Aerodynamique Appliquee, 24th, Poitiers, France, Oct. 26-28, 1987. 29 p. In French. refs
(AAAF PAPER NT-87-03)

The second-order shock-capture methods of van Leer (1979), Harten (1984), and Yee (1987) for hypersonic equilibrium real gas flows are investigated, along with generalizations of Roe's (1981) approximate Riemann solver and the flux-vector splitting techniques of Steger and Warming (1981) and van Leer (1982) for a real gas. A one-dimensional Riemann solver can be used to validate the explicit schemes for capturing strong discontinuities in air at equilibrium. Two-dimensional calculations of detached shocks are used to evaluate the efficiency of these schemes. For the implicit algorithm considered, certain parameters which have no effect for low-Mach-number cases are shown to affect convergence in the hypersonic regime. R.R.

A88-46329
PHYSICOCHEMICAL NONEQUILIBRIUM EFFECTS IN HYPERSONIC FLOWS [LES EFFETS DE NON-EQUILIBRE PHYSICO-CHIMIQUE DANS LES ECOULEMENTS HYPERSONIQUES]
RAYMOND BRUN (Aix-Marseille I, Universite, Marseille, France) Colloque d'Aerodynamique Appliquee, 24th, Poitiers, France, Oct. 26-28, 1987. 21 p. In French. refs
(AAAF PAPER NT-87-05)

Nonequilibrium effects in hypersonic rarefied-gas flows, characteristic of orbital flight, in which the nonequilibrium parameter is of the same order as the Knudsen number are discussed. Nonequilibrium Eulerian flows are first considered, with special attention given to the classical example of the expanding flow inside supersonic and hypersonic nozzles at elevated enthalpies. Nonequilibrium dissipative flows are then studied, and it is noted for the catalytic case that the state of the boundary layer has little influence upon the heat flux. A chemical-laser example is presented in which two parallel reactant nozzles ducting into the laser cavity produce the necessary chemical reactions. R.R.

A88-46334
FLOW AROUND AND DOWNSTREAM OF POINTED OR BLUNT YAWED CONES IN A MACH 7 OR 5 STREAM [ECOULEMENT AUTOUR ET EN AVAL DE CONES A POINTE VIVE OU EMOUSSEE PLACES EN INCIDENCE DANS UN COURANT A M = 7 ET 5]
J. MARCILLAT and L. SALLES (Aix-Marseille II, Universite, Marseille, France) Colloque d'Aerodynamique Appliquee, 24th, Poitiers, France, Oct. 26-28, 1987. 32 p. In French. refs
(AAAF PAPER NT-87-10)

Wind tunnel experiments have been performed in order to study the viscous flow induced by pointed or blunt yawed cones in a Mach 7 or 5 stream. The models are placed at an incidence of 0-20 deg with respect to the stream, and the structures of the resulting three-dimensional boundary layer and near wake are characterized. The case where the boundary layer remains laminar is considered. Particular attention is given to the three-dimensional transition to turbulence. Results are presented for the effect of Reynolds number on the recirculation zone downstream of a pointed cone at zero incidence, along with the effect of incidence variations on the static pressure. R.R.

A88-46337
PREDICTION OF THE AERODYNAMIC COEFFICIENTS OF HYPERSONIC VEHICLES USING THE HABP AND SHABP CODES - COMPARISON WITH EXPERIMENTAL RESULTS [PREVISION DES COEFFICIENTS AERODYNAMIQUES DE VEHICULES HYPERSONIQUES PAR LES CODES HABP ET SHABP - COMPARAISONS AVEC L'EXPERIENCE]
M. LECUYER (ONERA, Chatillon-sous-Bagneux, France) Colloque d'Aerodynamique Appliquee, 24th, Poitiers, France, Oct. 26-28, 1987. 42 p. In French. refs
(AAAF PAPER NT-87-13)

The HABP (hypersonic arbitrary body program) and SHABP (supersonic-hypersonic arbitrary body program) codes are used to demonstrate the usefulness of approximate and empirical methods for predicting the global aerodynamic coefficients of hypersonic vehicles. Although poorly adapted to local characteristic calculations, the methods are shown to produce very precise results at a high speed. Besides their application to ideal fluids, these methods can take into account viscous effects (such as friction) and hypersonic phenomena (such as real-gas effects, the viscous interaction, and the molecular free zone). HABP and SHABP results are compared with experimental values obtained for a variety of geometries ranging from simple to complex. R.R.

A88-46338
VALIDATION OF METHODS FOR THE CALCULATION OF LOW-REYNOLDS-NUMBER HYPERSONIC FLOW BY WIND TUNNEL TESTS [VALIDATION DES METHODES DE CALCUL D'ECOULEMENTS HYPERSONIQUES A BAS REYNOLDS PAR DES ESSAIS EN SOUFFLERIE]

J. P. BEZ (Aerospatiale, Division Systemes, Les Mureaux, France) Colloque d'Aerodynamique Appliquee, 24th, Poitiers, France, Oct. 26-28, 1987. 25 p. In French.
(AAAF PAPER NT-87-14)

Global aerodynamic coefficients have been obtained during wind tunnel tests in order to validate Monte Carlo, Navier-Stokes (NS), and parabolized NS (PNS) codes developed for the calculation of high-Mach-number low-Reynolds-number flow. Pseudounsteady NS results are presented, along with the results of PNS equations for the cases of cones, a delta wing, and a cylindroconical shape. Good general agreement is found between calculation results and experimental results for small incidence. It is suggested that the range of applicability of the methods can be extended by performing Monte Carlo calculations for Reynolds numbers Re sub L of not less than 500 and by performing NS and PNS calculations for Re sub L values of less than 40,000. R.R.

A88-46341
FUNDAMENTAL EXPERIMENTS ON THE PASSIVE CONTROL OF THE TRANSONIC SHOCK/BOUNDARY-LAYER INTERACTION [EXPERIENCES FONDAMENTALES SUR LE CONTROLE PASSIF DE L'INTERACTION ONDE DE CHOC-COUCHE LIMITE EN TRANSSONIQUE]
BRUNO CHANETZ and THIERRY POT (ONERA, Chatillon-sous-Bagneux, France) Colloque d'Aerodynamique Appliquee, 24th, Poitiers, France, Oct. 26-28, 1987. 52 p. In French. refs
(AAAF PAPER NT-87-17)

An experimental study has been performed in order to explore the use of passive control of the shock/boundary-layer interaction as a means of improving profile performance at transonic velocities. With the use of the control, it is shown that the normal shock wave which forms when the boundary is impermeable is replaced by a lambda system generally associated with normal interactions with extended separation. In the control zone, the boundary layer is found to thicken significantly and to undergo a strong destabilization process, resulting in an increase in momentum thickness. This behavior is related to an increase in friction drag. R.R.

A88-46344
STUDY OF THE REDUCTION OF FRICTION AND PRESSURE FLUCTUATIONS DOWNSTREAM OF 'AVIATION PROFILE'-TYPE MANIPULATORS IN TANDEM [ETUDE DE LA REDUCTION DU FROTTEMENT ET DES FLUCTUATIONS DE PRESSION EN AVAL DE MANIPULATEURS DE TYPE 'PROFILE AVIATION' EN TANDEM]
P. OLIVERO, P. BALLY, J. A. ASTOLFI, and B. E. FORESTIER Colloque d'Aerodynamique Appliquee, 24th, Poitiers, France, Oct. 26-28, 1987. 21 p. In French. refs
(AAAF PAPER NT-87-20)

Boundary layer manipulators have been tested in the turbulent boundary layer of a flat plate for a Reynolds number of 2500. In the present experimental arrangement, NACA 0009 profiles are placed in tandem according to an optimal configuration. The results show a relative friction reduction of up to 20 percent downstream of the manipulators. The rms pressure fluctuations are reduced 20 percent for the natural boundary layers relative to the manipulated boundary layer. A negative angle of incidence between the manipulators is found to significantly increase the pressure fluctuations at low frequencies. R.R.

A88-46346
DRAG REDUCTION IN TWO-DIMENSIONAL FLOW BY VORTEX EMISSION CONTROL USING CAVITIES [REDUCTION DE TRAINEE EN ECOULEMENT BIDIMENSIONNEL PAR CONTROLE DE L'EMISSION TOURBILLONNAIRE A L'AIDE DE CAVITES]
E. POULAIN (ONERA, Chatillon-sous-Bagneux; Lille I, Universite, Villeneuve d'Ascq, France) Colloque d'Aerodynamique Appliquee, 24th, Poitiers, France, Oct. 26-28, 1987. 52 p. In French. refs
(AAAF PAPER NT-87-22)

An exerimental investigation of subsonic drag reduction in two-dimensional flow by wake control using cavities is presented. Rocket models with two-dimensional cavities in their tail-ends were tested for a variety of cavity geometries. Optimum drag reduction was achieved for stall angles of between 16 and 20 deg. The cavity depth and shape was found to be less important than cavity opening size in reducing drag. It is suggested that drag reduction is related to unsteady phenomena observed near the cavities such as the periodic ejection of vortices at the cavity resonant frequency. Further increases in drag reduction are found when two cavities are placed in series. R.R.

A88-46347
DRAG REDUCTION FOR BUSINESS AIRCRAFT [LA REDUCTION DE TRAINEE POUR LES AVIONS D'AFFAIRES]
J. MAESTRATI Colloque d'Aerodynamique Appliquee, 24th, Poitiers, France, Oct. 26-28, 1987. 36 p. In French.
(AAAF PAPER NT-87-23)

Future prospects for drag reduction in business aircraft are addressed, and aircraft modifications are discussed with respect to their impact on aircraft operating range, aircraft velocity, and passenger comfort. Drag sources considered include skin friction, the separations due to the shock/boundary-layer interaction, the equilibration of the aircraft aerodynamic moment, and the unproductive overvelocity produced by lift. It is projected that in the 1990's the fuel consumption of business aircraft will be reduced by about 15 percent due to laminar flow techniques, about 20-35 percent due to engine improvements, about 7 percent due to mass reduction, and about 3 percent due to the use of active control techniques. R.R.

A88-46894
STEADY-STATE MOTIONS OF A HEAVY AXISYMMETRIC BODY IN A MEDIUM WITH DRAG [OB USTANOVIVSHIKHSIA DVIZHENIIAKH TIAZHELOGO OSESIMMETRICHNOGO TELA V SOPROTIVLIAIUSHCHEISIA SREDE]
V. A. PRIVALOV Akademiia Nauk SSSR, Izvestiia, Mekhanika Tverdogo Tela (ISSN 0572-3299), May-June 1988, p. 19-21. In Russian.

A quasi-static interaction model is used to analyze the steady-state plane-parallel translational descent of a heavy axisymmetric body interacting with the medium. It is shown that a critical case occurs in the stability analysis of this type of motion with a finite angle of attack. An instability of the motion is shown which is a 'rough' property of the object considered. The results are pertinent to the study of aerodynamic effects on parachute descent. B.J.

A88-47071#
ENHANCED MIXING OF SUPERSONIC JETS
T. G. TILLMAN, W. P. PATRICK, and R. W. PATERSON (United Technologies Research Center, East Hartford, CT) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 18 p. Research supported by United Technologies Corp. refs
(Contract N00014-85-C-0506)
(AIAA PAPER 88-3002)

Novel supersonic nozzle geometry concepts that promote enhanced mixing via the generation of axial vorticity, with potential applications in jet exhaust noise reduction and improved flow distribution within engine combustors, have been experimentally studied for the case of jet mixing conditions typical of turbofan engine operation. Jet total temperature, total pressure, static pressure, and velocity distributions, were measured to characterize the mixing process for baseline slot and circular nozzles as well as several mixer nozzles. The axial vortex mixing mechanism previously found to yield rapid mixing in low speed subsonic flows is found to be effective in a supersonic flow environment as well. O.C.

A88-47252#
AN IMPROVED TECHNIQUE FOR THE SOLUTION OF INVISCID TRANSONIC 3D FLOWS
E. ARAD, R. GORDON, and R. ARIELI (Rafael Armament

Development Authority, Haifa, Israel) IN: Israel Annual Conference on Aviation and Astronautics, 29th, Haifa, Israel, Feb. 25, 26, 1987, Collection of Papers. Haifa, Technion - Israel Institute of Technology, 1987, p. 1-8. refs

A numerical procedure is presented, for simulating transonic flow over finite wings, using the three-dimensional full potential formulation. The equation is written in strongly conservative form, in a body-fitted coordinate system. An improved version of the Strongly Implicit Procedure is used as a relaxation scheme. A comparative study of several commonly used algorithms for two-dimensinal and three-dimensional transonic flows is presented. The study clearly indicates the advantage of the new technique over the other methods. Author

A88-47255#
CALCULATION OF TRANSONIC FLOW ABOUT WING-BODY-FAIRING BY A FINITE ELEMENT METHOD
A. KOGAN and S. MIGEMI (Israel Aircraft Industries, Ltd., Tel Aviv) IN: Israel Annual Conference on Aviation and Astronautics, 29th, Haifa, Israel, Feb. 25, 26, 1987, Collection of Papers. Haifa, Technion - Israel Institute of Technology, 1987, p. 27-32. refs

This paper presents computational results of flow about wing-body-fairing combination (WBFC) using optimal control with finite element approximation to solve the full potential equation. The space about the WBFC is divided into tetrahedra in such a way that the resulting flux matrix has in some sense minimum band. Application of the Kutta condition for the WBFC is discussed. The artificial viscosity described in a previous paper is extended to this case. Computed Cp on WBFC are presented and compared to wind tunnel results. Author

A88-47256#
A MODEL FOR CALCULATING THE AERODYNAMIC EFFECTS OF VORTEX BREAKDOWN ON SLENDER WINGS
JOSHUA ASHENBERG (Rafael Armament Development Authority, Haifa, Israel) IN: Israel Annual Conference on Aviation and Astronautics, 29th, Haifa, Israel, Feb. 25, 26, 1987, Collection of Papers. Haifa, Technion - Israel Institute of Technology, 1987, p. 33-36. refs

This research deals with a new theoretical model for evaluating the effect of vortex breakdown on the aeroydnamics of slender wings. The potential flow and the slenderness assumptions were adopted, and a model for the wing aerodynamics was developed. The vortex breakdown phenomenon was represented by a distribution of two-dimensional sources along the vortex axis. The model was solved numerically for several delta wings, and the pressure distribution and lift were compared with wind tunnel results. Author

A88-47258#
A NEW ROBUST 3-D TRANSONIC WING DESIGN PROGRAM UTILIZING DIRICHLET-TYPE BOUNDARY CONDITIONS
B. EPSTEIN (Israel Aircraft Industries, Ltd., Tel Aviv) IN: Israel Annual Conference on Aviation and Astronautics, 29th, Haifa, Israel, Feb. 25, 26, 1987, Collection of Papers. Haifa, Technion - Israel Institute of Technology, 1987, p. 41-46. refs

In this paper a new computer program for three-dimensional transonic wing design is presented. Based on the full potential approach, it is suitable for solving the inverse aerodynamic problem of determining wing geometry according to given pressure distribution. Dirichlet-type boundary conditions are utilized to get a new flow-field which provides a new geometry of the wing. New approach to some principal points of the method (such as trailing-edge closure and leading-edge potential value definition) is suggested. This approach gives the opportunity to adjust trailing edge gaps independently at all the span stations at once, thus dramatically reducing the time of the whole computation compared to the traditional approach. The program provides a fast and robust means for practical three-dimensional transonic wing design. An example of the modification of a transonic wing is presented, together with numerical results. Author

A88-47263#
THE ASYMMETRIC PAIR OF VORTICES ADJACENT TO A SPINNING CYLINDER - A SMALL PERTURBATION SOLUTION
G. IOSILEVSKII and A. SEGINER (Technion - Israel Institute of Technology, Haifa) IN: Israel Annual Conference on Aviation and Astronautics, 29th, Haifa, Israel, Feb. 25, 26, 1987, Collection of Papers. Haifa, Technion - Israel Institute of Technology, 1987, p. 75-82. refs

A small perturbation of a previously obtained solution in which a vortex pair is asymmetric in circulation only, while remaining equidistant from a cylinder, is presently used to obtain the loci of a pair of asymmetric vortices in the wake of a two-dimensional cylinder spinning in an incompressible potential crossflow. The vortices' respective circulations are obtained as functions of mean distance from the cylinder, and of cylinder spin rate. Four modes of vortex displacement from the symmetric position are noted for a given mean distance of the vortices from the cylinder. A novel asymmetric solution for the vortex pair is found for the nonspinning cylinder. O.C.

A88-47455*# Bari Univ. (Italy).
FAST EULER SOLVER FOR TRANSONIC AIRFOILS. I - THEORY. II - APPLICATIONS
ANDREA DADONE (Bari, Universita, Italy) and GINO MORETTI (GMAF, Inc., Freeport, NY) AIAA Journal (ISSN 0001-1452), vol. 26, April 1988, p. 409-424. refs
(Contract NAS2-12355)

Equations written in terms of generalized Riemann variables are presently integrated by inverting six bidiagonal matrices and two tridiagonal matrices, using an implicit Euler solver that is based on the lambda-formulation. The solution is found on a C-grid whose boundaries are very close to the airfoil. The fast solver is then applied to the computation of several flowfields on a NACA 0012 airfoil at various Mach number and alpha values, yielding results that are primarily concerned with transonic flows. The effects of grid fineness and boundary distances are analyzed; the code is found to be robust and accurate, as well as fast. O.C.

A88-47456#
TRANSONIC POTENTIAL FLOW CALCULATIONS BY TWO ARTIFICIAL DENSITY METHODS
G. VOLPE (Grumman Corporate Research Center, Bethpage, NY) and A. JAMESON (Princeton University, NJ) AIAA Journal (ISSN 0001-1452), vol. 26, April 1988, p. 425-429. Previously cited in issue 17, p. 2468, Accession no. A86-38446. refs

A88-47466#
SLENDER WING IN GROUND EFFECT
A. PLOTKIN (San Diego State University, CA) and S. S. DODBELE (Vigyan Research Associates, Inc., Hampton, VA) AIAA Journal (ISSN 0001-1452), vol. 26, April 1988, p. 493, 494. refs

An attempt is made to analytically determine the lift coefficient for a low aspect ratio wing in ground effect, at large values of wall clearance; a panel method computation's results, for aspect ratios of 1.0. 0.6, 0.2, and 0.05, furnish the basis for comparison. It is found that the results of the analysis are valid for low aspect ratios and moderate-to-large values of the ratio of the trailing edge wall clearance to the wing semispan. O.C.

A88-47467#
MEASUREMENTS OF TURBULENT FLOW BEHIND A WING-BODY JUNCTION
O. OZCAN (Istanbul Technical University, Turkey) and M. S. OLCMEN AIAA Journal (ISSN 0001-1452), vol. 26, April 1988, p. 494-496. refs

Wind tunnel measurements have been obtained for the turbulent shear flow behind a wing mounted on a flat plate at 30-deg angle-of-attack, giving attention to such physical aspects of the flow as the skin-friction coefficient and pattern, the static pressure coefficient, and two mean velocity components. No evidence is found of the presence of a second tornado vortex, perhaps due to the attached flow conditions on the windward side of the wing,

where flow separation from the trailing edge did not lead to a sufficiently large reversed-flow region. O.C.

A88-47468*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
TURBULENT VISCOUS DRAG REDUCTION WITH THIN-ELEMENT RIBLETS
B. LAZOS and S. P. WILKINSON (NASA, Langley Research Center, Hampton, VA) AIAA Journal (ISSN 0001-1452), vol. 26, April 1988, p. 496-498.

Thin-element riblets for aircraft aerodynamic surface turbulent viscous drag reduction are presently found to be as effective as symmetric V-grooves in this role, while possessing a greater range of admissible spacings. The thin-element geometry shows the qualitatively predictable influence of independent riblet height and spacing variations. The evidence for more than one drag-reduction mechanism in thin-element riblets is found to be inconclusive. O.C.

A88-47470#
ON CONE FRUSTUM PRESSURE GRADIENT EFFECTS ON TRANSITION
KENNETH F. STETSON (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) AIAA Journal (ISSN 0001-1452), vol. 26, April 1988, p. 500-502. refs

Attention is given to the characteristic pattern for the pressure distribution on the frustum of a sphere cone in hypersonic flow; nose tip-bluntness experiments have furnished surprising results for the favorable pressure gradient region, and some interesting possible effects of the adverse pressure gradient. A further series of experiments has been conducted in a Mach 6 blowdown tunnel to yield surface pressure measurements and boundary layer transition Reynolds numbers. O.C.

A88-47475#
ON NON-LINEAR VORTEX LATTICE METHOD FOR WINGS AT LARGE ANGLE OF ATTACK IN STEADY, UNSTEADY FLOW
ZHENGYIN YE, LINCHENG ZHAO, and YONGNIAN YANG (Northwestern Polytechnical University, Xian, People's Republic of China) Northwestern Polytechnical University, Journal (ISSN 1000-2758), vol. 6, July 1988, p. 323-330. In Chinese, with abstract in English. refs

The steady and unsteady nonlinear loads of wings at large angle of attack are calculated using a form of the nonlinear vortex lattice method (NLVLM). The location of the separation line at the sharp leading edge, the relaxation factor added in wake-forming, the length of the shed vortices, and other significant parameters are addressed. For strake wings, separation is treated using unsteady NLVLM. It is shown that the separation line at the leading edge must be selected more carefully. For steady subsonic flow, the wake is determined by the moving vortices shed from a wing after the wing starts impulsively from rest. Numerical results show that the calculative results agree closely with experimental data. C.D.

A88-47771* Purdue Univ., West Lafayette, Ind.
PREDICTION OF OSCILLATING THICK CAMBERED AEROFOIL AERODYNAMICS BY A LOCALLY ANALYTIC METHOD
HSIAO-WEI D. CHIANG and SANFORD FLEETER (Purdue University, West Lafayette, IN) International Journal for Numerical Methods in Fluids (ISSN 0271-2091), vol. 8, Aug. 1988, p. 913-931. USAF-NASA-sponsored research. refs

The effects of mean-flow incidence, airfoil camber, and airfoil thickness on the incompressible aerodynamics of an oscillating airfoil are investigated theoretically, developing and applying a first-order FEM based on locally analytical solutions (LASs). Laplace equations are used to describe the steady and unsteady harmonic velocity potentials; a body-fitted computational grid is employed; grid-element solutions for both potentials are determined using a numerical LAS method; and the LASs are then assembled to obtain a complete solution. Results for a series of flat-plate and Joukowski airfoils are presented in extensive graphs and discussed in detail. T.K.

A88-47963#
UPSTREAM INFLUENCE AND SEPARATION SCALES IN FIN-INDUCED SHOCK TURBULENT BOUNDARY-LAYER INTERACTION
D. S. DOLLING (Texas, University, Austin) and P. E. RODI Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 25, March-Apr. 1988, p. 102-108. refs

An experimental study has been made of the effects of leading-edge geometry on the upstream influence and separated flow length scales in fin-induced shock wave turbulent boundary-layer interaction. The fins used had wedge-shaped, hemicylindrical and elliptic leading edges and were tested under adiabatic conditions at Mach 4.9. The primary objective was to determine if the length scales generated by different leading edges could be understood within a common framework. To a first approximation the normalized centerline length scales correlate with fin leading-edge drag coefficient. Attempts to correlate additional data at Mach 1.98 and 2.48 from other studies resulted in a reasonable correlation for upstream influence, but that for the separation length showed a clear influence of Mach number. The fact that the upstream influence can be reasonably well correlated in this form lends further support to the view that large-scale three-dimensional vortical separated flows of this type may be largely inviscid dominated. Author

A88-47982*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
STAGNATION FLOW FIELD ANALYSIS FOR AN AEROASSIST FLIGHT EXPERIMENT VEHICLE
ROOP N. GUPTA (Scientific Research and Technology, Inc., Hampton, VA) and ANN L. SIMMONDS (NASA, Langley Research Center, Hampton, VA) AIAA, Thermophysics, Plasmadynamics and Lasers Conference, San Antonio, TX, June 27-29, 1988. 16 p. refs
(Contract NAS1-17919)
(AIAA PAPER 88-2613)

Continuum methods are used to analyze the stagnation flow field of the aeroassist flight experiment (AFE) vehicle. For the lower altitude portion of an AFE trajectory, the viscous shock-layer equations are employed. At higher altitudes, the full Navier-Stokes equations with chemical nonequilibrium and surface slip are used. Particular attention is given to the effect of surface catalyticity on surface heating, electron number density, and flow field structure. K.K.

A88-48083
COMPARISON OF NUMERICAL METHODS FOR THE CALCULATION OF SUPERSONIC NOZZLES [SRAVNENIE CHISLENNYKH METODOV RASCHETA SVERKHZVUKOVYKH SOPL]
IU. V. GORA, S. M. IVANOV, and A. A. LENDA Kosmicheskaia Nauka i Tekhnika (ISSN 0321-4508), no. 2, 1987, p. 31-36. In Russian. refs

Integral and local parameters obtained by the Godunov, Mac Cormack, and Kolgan marching methods are compared for two axisymmetric Laval nozzles, contoured by the method of characteristics. Two formulations of the Euler equations with respect to the Cartesian components of the momentum are used for these methods. The advantages of strong conservative difference schemes over weak ones are shown. B.J.

A88-48131
THREE-DIMENSIONAL PERTURBATION EVOLUTION IN A BOUNDARY LAYER WITH A PRESSURE GRADIENT [RAZVITIE PROSTRANSTVENNYKH VOZMUSHCHENII V POGRANICHNOM SLOE S GRADIENTOM DAVLENIIA]
V. M. GILEV, A. V. DOVGAL', IU. S. KACHANOV, and V. V. KOZLOV Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza (ISSN 0568-5281), May-June 1988, p. 85-91. In Russian. refs

Experimental data on the three-dimensional stability of a boundary layer with a pressure gradient obtained in a low-turbulence subsonic wind tunnel are reported. The evolution of a three-dimensional harmonic (with respect to time) wave packet in the boundary layer of a wing model is examined, and the resulting amplitude-phase distributions of pulsations in the wave packet are investigated using Fourier analysis. The effect of the pressure gradient on the evolution of the three-dimensional spectral components of the perturbations and flow dispersion characteristics are analyzed. V.L.

A88-48143
A STUDY OF NONSTATIONARY SEPARATED FLOWS OVER DEPRESSIONS [ISSLEDOVANIE NESTATSIONARNYKH SRYVNYKH TECHENII NAD VYEMKAMI]
L. G. GVOZDEVA, IU. P. LAGUTOV, D. K. RAEVSKII, A. I. KHARITONOV, and IU. L. SHAROV Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza (ISSN 0568-5281), May-June 1988, p. 185-191. In Russian. refs

The propagation of a plane shock wave over a shallow rectangular depression normal to the wave propagation direction is investigated experimentally by analyzing schlieren and interference patterns and by using piezotransducers to measure pressure. The nonstationary interaction of the shock wave with the depression and quasi-stationary flow of a hot gas past the depression in the wake of the shock wave are examined with reference to experimental results obtained in the Mach range 1.2-5.0 at initial pressures of 600-29,000 N/sq m. The results obtained are also compared with wind tunnel data obtained at similar Re numbers. V.L.

A88-48201
METHODS OF ANALOGY IN THE AERODYNAMICS OF FLIGHT VEHICLES [METODY ANALOGII V AERODINAMIKE LETATEL'NYKH APPARATOV]
AL'BERT OSKAROVICH DITMAN, VIKTOR DMITRIEVICH SAVCHUK, and IOSIF RAFAILOVICH IAKUBOV Moscow, Izdatel'stvo Mashinostroenie, 1987, 152 p. In Russian.

The electromagnetic, electrohydrodynamic, and gas-hydraulic analogy methods are considered. Attention is given to the possibility of applying methods of four-dimensional geometrical physics to the aerodynamics of flight vehicles. Lorentz transformations are used to derive similarity relationships for subsonic and supersonic flow past bodies. The details of analog simulation are outlined, and the appropriate analog devices are described. B.J.

A88-48301
COMPUTER ANALYSIS OF THE EFFECT OF THE LOCATION OF THE VERTICAL TAIL SURFACE ON THE STATIC LATERAL STABILITY OF A TAILLESS AIRCRAFT [ISSLEDOVANIE NA EVM VLIIANIIA POLOZHENIIA VERTIKAL'NOGO OPERENIIA NA STATICHESKUIU BOKOVUIU USTOICHIVOST' LETATEL'NYKH APPARATOV TIPA 'BESKHVOSTKA']
E. D. KOVALEV and M. M. OVCHAROV Samoletostroenie - Tekhnika Vozdushnogo Flota (ISSN 0581-4634), no. 54, 1987, p. 3-5. In Russian.

A mathematical model is developed for investigating the influence of the location of the vertical tail surface on the static lateral stability of a tailless aircraft in the case of separated flow past the delta-wing leading edges. It is shown that, as the wing aspect ratio increases, intense vortex filaments are formed which have a powerful effect on the flow past the vertical tail surface. Calculations are compared with experimental data. B.J.

A88-48302
AN EXPLICIT ITERATIVE METHOD FOR DETERMINING THE INTENSITY OF A WING VORTEX SHEET [IAVNYI ITERATSIONNYI METOD OPREDELENIIA INTENSIVNOSTI VIKHREVOGO SLOIA KRYLA]
V. G. LEBED' Samoletostroenie - Tekhnika Vozdushnogo Flota (ISSN 0581-4634), no. 54, 1987, p. 5-9. In Russian.

The discrete-vortex method for determining the lift properties of wings is considered. It is shown that the problem of determining lift properties using this method can be reduced to an explicit iterative method for solving a linear system of algebraic equations. The convergence of the method is demonstrated. B.J.

A88-48303
THE EFFECT OF CONTOUR DEFORMATION ON THE WAVE DRAG OF A THIN AIRFOIL [VLIIANIE DEFORMATSII KONTURA NA VOLNOVOE SOPROTIVLENIE TONKOGO PROFILIA]
V. I. KHOLIAVKO Samoletostroenie - Tekhnika Vozdushnogo Flota (ISSN 0581-4634), no. 54, 1987, p. 10-14. In Russian.

The linear theory of supersonic flows is used to investigate steady inviscid flow past a thin airfoil with allowance for the deformation of the skin due to its elastic properties under the effect of external aerodynamic loading. General formulas are obtained for calculating variations of the wave drag of the airfoil. Flow past a symmetric airfoil is considered as a calculation example. B.J.

A88-48312
COMPARISON OF EXPERIMENTAL AND THEORETICAL RESULTS CONCERNING THE EFFECT OF AIR SUCTION ON THE AERODYNAMIC CHARACTERISTICS OF A WING [SRAVNENIE EKSPERIMENTAL'NYKH I TEORETICHESKIKH REZULTATOV VLIIANIIA OTSASYVANIIA VOZDUKHA NA AERODINAMICHESKIE KHARAKTERISTIKI KRYLA]
B. S. BAEV Samoletostroenie - Tekhnika Vozdushnogo Flota (ISSN 0581-4634), no. 54, 1987, p. 54-57. In Russian.

Formulas are obtained for calculating the aerodynamic characteristics of aircraft with air-suction systems of boundary layer control. The proposed approach relies on the use of the theory of functions of complex variables and conformal mapping. Calculations are compared with experimental data, and good agreement is found. B.J.

A88-48483#
MODELING THE THREE-DIMENSIONAL FLOW THROUGH A SCRAMJET INLET WITH A HYBRID PNS/PPNS CODE
SASAN YAGHMAEE and DONALD W. ROBERTS (Amtec Engineering, Inc., Bellevue, WA) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 13 p. refs
(Contract N00024-86-C-5156)
(AIAA PAPER 88-2826)

Scramjet inlet flow fields are modeled using a hybrid flow analysis code, which combines an efficient parabolized Navier-Stokes (PNS) procedure with a partially parabolized Navier-Stokes (PPNS) method. The PPNS option can be activated in regions of subsonic flow where the pressure field is elliptic in the streamwise direction. Two scramjet flow fields are calculated using the hybrid analysis. Good agreement is exhibited between the calculated results and the experimental data. Author

A88-48486#
BLUNT-BODY FLOW SIMULATIONS
K. M. PEERY and S. T. IMLAY (Amtec Engineering, Inc., Bellevue, WA) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 16 p. refs
(AIAA PAPER 88-2904)

An efficient computational procedure is presented for two-dimensional and axisymmetric blunt body flow calculations. The procedure is based on an implicit upwind differencing method with automatic mesh adaption and solution control to improve its reliability and ease of use. Inefficiencies due to transient flow evolution are minimized by using surface fits for the initial flow field, and by using a graduated grid procedure. Surface pressures and heat transfer rates are presented for spherical and cylindrical blunt bodies at Mach 6 and 8, including a type IV shock/shock interaction. An unusual numerical phenomenon was encountered with the use of Roe's flux difference scheme in the region of the stagnation streamline in the bow shock; a satisfactory remedy is demonstrated. Author

A88-48491*# Amtec Engineering, Inc., Bellevue, Wash.
A BLOCK SPACE-MARCHING METHOD FOR THE NAVIER-STOKES EQUATIONS
SCOTT T. IMLAY and DONALD W. ROBERTS (Amtec Engineering, Inc., Bellevue, WA) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 11 p. refs
(Contract NAS8-37303)
(AIAA PAPER 88-3199)

A solution procedure is presented for predominantly supersonic viscous flows. The procedure approximately solves the Navier-Stokes equations by marching blocks of grid points in the streamwise direction and solving the fully elliptic equations within each block. In this manner elliptic effects of limited streamwise extent may be accurately calculated. Results are presented for calculations of a Mach 2 laminar flat-plate shock/boundary-layer interaction, and for a Mach 10 hypervelocity interceptor. Author

A88-48746
DEVELOPMENT OF A THREE-DIMENSIONAL PERTURBATION WAVE PACKET IN THE BOUNDARY LAYER OF A YAWED WING [RAZVITIE PROSTRANSTVENNOGO VOLNOVOGO PAKETA VOZMUSHCHENII V POGRANICHNOM SLOE SKOL'ZIASHCHEGO KRYLA]
A. V. DOVGAL', V. V. KOZLOV, and O. A. SIMONOV (AN SSSR, Institut Teoreticheskoi i Prikladnoi Mekhaniki, Novosibirsk, USSR) Akademiia Nauk SSSR, Sibirskoe Otdelenie, Izvestiia, Seriia Tekhnicheskie Nauki (ISSN 0002-3434), June 1988, p. 43-47. In Russian. refs

The development of laminar flow perturbations on a wing with a yaw angle of 30 deg is investigated with particular reference to the case where the laminar-turbulent transition occurs in the positive-pressure-gradient area of the boundary layer. Results of low-turbulence wind tunnel experiments are presented; the propagation of harmonic oscillations excited by a local source is studied using hot-wire anemometry. It is shown that the amplification of the oscillations responsible for the laminar-turbulent transitions is largely due to the instability of the mean velocity profile. V.L.

A88-48758*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
SUMMARY OF LOW-SPEED WIND TUNNEL RESULTS OF SEVERAL HIGH-SPEED COUNTERROTATION PROPELLER CONFIGURATIONS
CHRISTOPHER E. HUGHES (NASA, Lewis Research Center, Cleveland, OH) and JOHN A. GAZZANIGA (NASA, Lewis Research Center; Sverdrup Technology, Inc., Cleveland, OH) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 34 p. Previously announced in STAR as N88-24597. refs
(AIAA PAPER 88-3149)

The low speed aerodynamic performance characteristics of several advanced counterrotation pusher propeller configurations with cruise design Mach numbers of 0.72 and 0.80 were investigated in the NASA Low Speed Wind Tunnel. The tests were conducted at Mach numbers representative of the takeoff and landing flight regime. The investigation included: (1) the propeller performance characteristics over a range of blade angle settings and rotational speeds at a Mach number of 0.20; (2) the effect on the propeller performance of varying the axial rotor spacing and mismatching the power and rotational speeds on the propeller rotors; and (3) determining the reverse thrust performance characteristics at Mach numbers of 0.0, 0.10, 0.15 and 0.20. The results of the investigation indicated that the overall low speed performance of the counterrotation propeller configurations was reasonable. Author

A88-48781#
NUMERIC SIMULATION OF PHYSICAL FLOW PHENOMENA
L. E. ERICSSON (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA) IN: AIAA, ASME, SIAM, and APS, National Fluid Dynamics Congress, 1st, Cincinnati, OH, July 25-28, 1988, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 33-41. refs
(AIAA PAPER 88-3525)

The standard measure of the accuracy of CFD solutions is presently noted to disguise the fact that the computations do not simulate the flow phenomenon observed in the physical experiment. This is shown in the cases of a 60-deg swept ramp at a freestream Mach number of about 3.0, and the flow field at a freestream Mach number of 12.65 on the windward side of a half-cone/delta-wing configuration. It is concluded that numerical simulation is not possible unless a thorough understanding of the physical flow phenomenon in question is already possessed. O.C.

A88-48786#
TIME-CONSISTENT RNS SOLUTIONS FOR UNSTEADY SUBSONIC FLOW OVER AIRFOILS
S. V. RAMAKRISHNAN and S. G. RUBIN (Cincinnati, University, OH) IN: AIAA, ASME, SIAM, and APS, National Fluid Dynamics Congress, 1st, Cincinnati, OH, July 25-28, 1988, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 68-75. refs
(Contract N00014-79-C-0849; F49620-85-C-0027)
(AIAA PAPER 88-3561)

The Reduced Navier-Stokes equations represent an asymptotic approximation derived from the full Navier-Stokes equations, encompassing the Euler, second-order boundary-layer, and triple-deck models. Applications of the RNS approximation for more complex flow fields than have thus far been considered are presently explored, with a view to the validity of the RNS procedure's application to unsteady flows with vortex shedding. Attention is given to an analysis of the flow past a Joukowski airfoil, and to the development status of strongly implicit and alternating-direction algorithms. O.C.

A88-48788#
AN EFFICIENT MULTI-METHODS COMPUTER CODE FOR THE PREDICTION OF THE INVISCID AND VISCOUS FLOW OVER MULTI-COMPONENT AIRFOILS
C. DE NICOLA (Napoli, Universita, Naples, Italy), D. COIRO (Italian Centre for Aerospace Research, Naples, Italy), and V. LOSITO (Academia Aeronautica, Pozzuoli, Italy) IN: AIAA, ASME, SIAM, and APS, National Fluid Dynamics Congress, 1st, Cincinnati, OH, July 25-28, 1988, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 84-91. Research sponsored by Aeritalia S.p.A. refs
(AIAA PAPER 88-3562)

Low Mach number viscous-inviscid interaction is considered using panel methods, direct and inverse boundary layer equations. A wide variety of different panel methods and turbulent boundary layer methods are investigated to obtain the best coupling conditions for different geometries. Carter's procedure has been used for the matching conditions in the separated regions. A computer code (MULTIM), which is fast and reliable, has been developed. Applications of the code to single and multielement airfoils in high lift conditions are shown; the comparisons with experimental data are quite satisfactory. Author

A88-48794*# Old Dominion Univ., Norfolk, Va.
APPLICATION OF MULTIPLE GRIDS TOPOLOGY TO SUPERSONIC INTERNAL/EXTERNAL FLOW INTERACTIONS
M. KATHONG, S. N. TIWARI (Old Dominion University, Norfolk, VA), and R. E. SMITH (NASA, Langley Research Center, Hampton, VA) IN: AIAA, ASME, SIAM, and APS, National Fluid Dynamics Congress, 1st, Cincinnati, OH, July 25-28, 1988, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 126-137. refs
(Contract NCC1-68)
(AIAA PAPER 88-3568)

For many aerodynamic applications, it is very difficult to construct a smooth body-fitted grid around complex configurations. An approach, called 'multiple grids' or 'zonal grids', which subdivides the entire physical domain into several subdomains, is

used to overcome such difficulties. The approach is applied to obtain the solutions to the Euler equations for the supersonic internal/external flow around a fighter-aircraft configuration. Steady-state solutions are presented for Mach 2 at 0, 3.79, 7, and 10 deg angles-of-attack. The problem of conservative treatment at the zonal interfaces is also addressed. Author

A88-48800#
ROBUST MULTIGRID COMPUTATION AND VISUALIZATION OF SEPARATION AND VORTEX EVOLUTION IN AERODYNAMIC FLOWS
KARL GUSTAFSON and ROBERT R. LEBEN (Colorado, University, Boulder) IN: AIAA, ASME, SIAM, and APS, National Fluid Dynamics Congress, 1st, Cincinnati, OH, July 25-28, 1988, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 174-184. refs
(AIAA PAPER 88-3604)

A numerical technique for studying unsteady flows past airfoils is discussed which used a grid generation scheme in which the infinite physical domain is mapped to a finite auxiliary domain on which numerical calculations are performed. The method involves solving the full Navier-Stokes equations in the stream-function/vorticity formulation. Application of the method to a constant accelerating flow from rest around a NACA 0015 airfoil reveals such flow phenomena as vortex splitting, shredding, and higher order vortical detail. The accuracy of the method is validated by comparing laboratory visualization and numerical results. R.R.

A88-48809*# Old Dominion Univ., Norfolk, Va.
UNSTEADY DELTA-WING FLOW COMPUTATION USING AN IMPLICIT FACTORED EULER SCHEME
OSAMA A. KANDIL and H. ANDREW CHUANG (Old Dominion University, Norfolk, VA) IN: AIAA, ASME, SIAM, and APS, National Fluid Dynamics Congress, 1st, Cincinnati, OH, July 25-28, 1988, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 248-255. refs
(Contract NAG1-846; NAG1-648)
(AIAA PAPER 88-3649)

The conservative unsteady Euler equations for the flow relative motion in the moving frame of reference are used to solve for the steady and unsteady flows around sharp-edged delta wings. The resulting equations are solved by using an implicit approximately-factored finite-volume scheme. Implicit second-order and explicit second- and fourth-order dissipations are added to the scheme. The boundary conditions are explicitly satisfied. The grid is generated by locally using a modified Joukowski transformation in cross-flow planes at the grid chord stations. The computational applications cover a steady flow around a delta wing whose results serve as the initial conditions for the unsteady flow around a pitching delta wing about a large angle of attack. The steady results are compared with the experimental data and the periodic solution is achieved within the third cycle of oscillation. Author

A88-48816*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
SURFACE PRESSURE FLUCTUATIONS DUE TO IMPINGING VORTICAL FLOWS UPON AN AIRFOIL
D. J. LEE (NASA, Ames Research Center, Moffett Field, CA) IN: AIAA, ASME, SIAM, and APS, National Fluid Dynamics Congress, 1st, Cincinnati, OH, July 25-28, 1988, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 303-310. refs
(AIAA PAPER 88-3657)

A vortical flow impinging upon an airfoil is studied for the case of a strong vortical flow passing close by the airfoil leading and trailing edge. The vortical flow, having a nonuniform vorticity distribution in the core, is distorted and splits as it nears the leading edge of the airfoil. Significant pressure fluctuation occurs near the leading edge, which becomes a source of noise and vibration. A vortex method and a panel method are used to calculate the highly nonlinear, unsteady and rotational flow during the interaction. The flow is assumed to be two dimensional, incompressible and inviscid. The nonuniform vorticity in the vortex core is represented by multiple, discrete vortex elements whose strengths are variable depending on the initial velocity profile. Detailed surface pressure and vortex velocity vectors are calculated. The surface pressure is decomposed into quasi-steady and unsteady pressure, sometimes called 'impulsive pressure'. The first time derivative of the pressure related the strength of the noise, and its r.m.s. values are also calculated. Author

A88-48822*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
DIRECT DRAG MEASUREMENT ON THIN-ELEMENT RIBLETS WITH SUCTION AND BLOWING
STEPHEN P. WILKINSON (NASA, Langley Research Center, Hampton, VA) IN: AIAA, ASME, SIAM, and APS, National Fluid Dynamics Congress, 1st, Cincinnati, OH, July 25-28, 1988, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 362-367. refs
(AIAA PAPER 88-3670)

Turbulent, direct drag has been measured for a series of riblet models in air with continuous, low-level suction or blowing applied through narrow streamwise slots located at the peak, base, or valley of the rectangularly shaped riblets. Riblet spacing was approximately that of low-speed wall streaks. The models were designed to test whether wall vortices which are known to occur along widely spaced riblets are integral to turbulence production by attempting to alter them with localized suction or blowing. The drag data show trends that are consistent with reduced or enhanced inflectional breakdown of wall vortices. The trends, however, may also be explained by more fundamental mean-flow effects. Author

A88-48829#
VISCOUS UNSTEADY GUST AERODYNAMICS OF A FLAT PLATE AIRFOIL
JAMES M. WOLFF and SANFORD FLEETER (Purdue University, West Lafayette, IN) IN: AIAA, ASME, SIAM, and APS, National Fluid Dynamics Congress, 1st, Cincinnati, OH, July 25-28, 1988, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 410-418. refs
(Contract F49620-88-C-0022)
(AIAA PAPER 88-3701)

A mathematical model is developed to analyze the unsteady viscous transverse gust aerodynamics of a flat plate airfoil in an incompressible laminar flow at moderate values of the Reynolds number. The steady flow is described by the Navier-Stokes equations. The unsteady viscous flow is assumed to be a small perturbation to this steady viscous flow, with the resulting system of linear partial differential equations coupled to the steady flow field through the unsteady boundary conditions. Solutions for both the steady and unsteady viscous flow fields are obtained by developing locally analytical solutions. For the steady flow, this is accomplished by first locally linearizing the nonlinear convective terms in the Navier-Stokes equations. The significant effects of Reynolds number and reduced frequency on the transverse gust generated unsteady aerodynamics on the airfoil are then demonstrated. Author

A88-48832#
NUMERICAL COMPUTATIONS OF TRANSONIC CRITICAL AERODYNAMIC BEHAVIOR
JUBARAJ SAHU (U.S. Army, Ballistics Research Laboratories, Aberdeen Proving Ground, MD) IN: AIAA, ASME, SIAM, and APS, National Fluid Dynamics Congress, 1st, Cincinnati, OH, July 25-28, 1988, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 435-444. refs
(AIAA PAPER 88-4038)

The determination of aerodynamic coefficients by shell designers is a critical step in the development of any new projectile design. Of particular interest is the determination of the aerodynamic coefficients at transonic speeds. It is in this speed regime that the critical aerodynamic behavior occurs and a rapid increase in the aerodynamic coefficients is observed. The

three-dimensional transonic flowfield computations over projectiles have been made using an implicit, approximately factored, partially flux-split algorithm. Use of a composite grid scheme has been made to provide the increased grid resolution needed for accurate numerical simulation of three-dimensional transonic flows. Details of the asymmetrically located shockwaves on the projectiles have been determined. Computed surface pressures have been compared with experimental data and are found to be in good agreement. The pitching moment coefficient, determined from the computed flowfields, shows the critical aerodynamic behavior observed in free flights. Author

A88-48834#
NUMERICAL NAVIER-STOKES SOLUTIONS OF SUPERSONIC SLOT INJECTION PROBLEMS
S. J. YOON and J. A. SCHETZ (Virginia Polytechnic Institute and State University, Blacksburg) IN: AIAA, ASME, SIAM, and APS, National Fluid Dynamics Congress, 1st, Cincinnati, OH, July 25-28, 1988, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 453-462. Research supported by Johns Hopkins University. refs
(AIAA PAPER 88-3710)

A computational procedure based on the upwind method with an adaptive grid was developed to understand supersonic slot injection problems. The compressible laminar boundary layer over a flat plate and the laminar boundary layer-shock interaction problems were chosen as sample cases. It is shown that Roe's flux difference splitting method is more accurate than van Leer's flux vector splitting method for these viscous problems. K.K.

A88-48839*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
AIRCRAFT VORTICES - JUNCTURE, WING, AND WAKE
GEORGE C. GREENE, JOHN E. LAMAR, and L. R. KUBENDRAN (NASA, Langley Research Center, Hampton, VA) IN: AIAA, ASME, SIAM, and APS, National Fluid Dynamics Congress, 1st, Cincinnati, OH, July 25-28, 1988, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 492-498. refs
(AIAA PAPER 88-3742)

Many real aircraft flows contain regions of three-dimensional separation with vortices. This paper presents selected results for three representative flows: juncture vortex, lifting-wing vortex, and wake vortex. Due to the difficulty of studying vortices, flow visualization was used as a primary research tool. Vortices are found to depend in subtle ways on details of the configuration, Reynolds number, or the environment. Examples showing the effect of filleting on the juncture flow, Reynolds number on the wing flow, and density gradients on the wake flow are presented. Author

A88-48840*# San Diego State Univ., Calif.
EFFECT OF VERTICAL EJECTOR-JET ON THE VORTEX-LIFT OF DELTA WINGS
JOSEPH KATZ (San Diego State University, CA) and DIETER KERN IN: AIAA, ASME, SIAM, and APS, National Fluid Dynamics Congress, 1st, Cincinnati, OH, July 25-28, 1988, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 507-511. refs
(Contract NCC2-458)
(AIAA PAPER 88-3842)

The effect of adding an ejector jet to a 76-deg delta wing was investigated experimentally and theoretically in terms of the resulting longitudinal aerodynamic characteristics. A small-scale wind-tunnel experiment served for the investigation and a simplified vortex lattice model was constructed to simulate the first order effects of this complex flow field. The major benefits of this combined approach over the use of more developed computer schemes lies in the relative ease in tailoring the mathematical model to a new problem. Results of both the wind-tunnel experiment and the theoretical model showed measurable lift loss due to the ejector jet throughout the whole angle-of-attack range, which will intensify at lower flight speeds. Author

A88-48841#
VORTEX-DOMINATED SLENDER-WING PROBLEMS - STUDIES BY A POINT-VORTEX METHOD
H. K. CHENG, R. H. EDWARDS, Z. X. JIA, and C. J. LEE (Southern California, University, Los Angeles, CA) IN: AIAA, ASME, SIAM, and APS, National Fluid Dynamics Congress, 1st, Cincinnati, OH, July 25-28, 1988, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 512-522. refs
(Contract AF-AFOSR-85-0318)
(AIAA PAPER 88-3744)

The paper discusses analytical and computational simulations of the vortex-dominated flow about a slender wing. Consideration is given to the applicability of the slender-body theory to vortex lift study and to the problem at high angles of attack. Computations for a slender delta wing simulate the vortical eddies produced by leading-edge flaps and confirm their significant increase in strength with moderate angles of attack as observed by Spedding, Maxworthy, and Rignot (1987) on the basis of water channel experiments. It is shown that at least 2/3 to 3/4 of the predicted eddy circulation can be realized. K.K.

A88-48842*# Vigyan Research Associates, Inc., Hampton, Va.
VORTICAL FLOW ANALYSIS FOR F-106B CONFIGURATION
JENN LOUH PAO (Vigyan Research Associates, Inc., Hampton, VA) IN: AIAA, ASME, SIAM, and APS, National Fluid Dynamics Congress, 1st, Cincinnati, OH, July 25-28, 1988, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 523-530. refs
(Contract NAS1-17919)
(AIAA PAPER 88-3745)

The three-dimensional Euler aerodynamic method is applied to basic F-106B wing-fuselage geometries over an angle-of-attack range in the subsonic and transonic speeds to examine vortical flow behavior. The use of this method to provide meaningful vortex breakdown information is explored. This Euler solution algorithm uses a C-H mesh with 80625 grid points to represent the flowfield. Contours of axial velocity and total pressure, spanwise surface pressure and velocity vectors at cross flow planes, together with contours of suction pressure and total pressure on the leeward surface of the wing, were used to examine the vortex breakdown details. K.K.

A88-48843#
THE VORTEX ROLLUP PROBLEM USING LAMB VORTICES FOR THE ELLIPTICALLY LOADED WING
CHARLES DALTON and XUEGENG WANG (Houston, University, TX) IN: AIAA, ASME, SIAM, and APS, National Fluid Dynamics Congress, 1st, Cincinnati, OH, July 25-28, 1988, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 531-538. refs
(AIAA PAPER 88-3746)

The classical roll-up of the vortex sheet trailing the elliptically loaded wing is examined here. Three factors, each of which contributed in a different, yet influential, manner were included in the analysis: use of Lamb vortices as the discrete vortices, use of a variable time step, and a redistribution of the initial vortex discretization as a variant to the traditional equal-spacing or equal-strength models. A smooth spiral roll-up was obtained for dimensionless times which exceed those of all but one previous investigators by at least a factor of ten without an increase in computation time for similar computers. In addition, very good comparison with the results of previous investigators is obtained for similar parameters. The redistribution of the initial discretization was found to prevent an early concentration of vortices in the spiral as the integration occurs. The spiral was found to form with an equal number of turns as in other calculations, but with less tightness which we attribute to the fact that Lamb vortices were used. Double precision arithmetic was necessary to obtain meaningful results. Author

A88-48853#
USE OF MODEL EQUATIONAL SPECIFICATION - A CASE STUDY IN COMPUTATIONAL AERODYNAMICS
DAVID R. POLING, LEO DADONE (Boeing Helicopters, Philadelphia, PA), XIANG GE, and NOAH PRYWES (Pennsylvania, University, Philadelphia) IN: AIAA, ASME, SIAM, and APS, National Fluid Dynamics Congress, 1st, Cincinnati, OH, July 25-28, 1988, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 605-611. refs
(Contract N00014-83-K-0560)
(AIAA PAPER 88-3792)

A comparison is made between the use of MODEL versus manual programming in aerodynamics computations. MODEL is a specification language that uses algebraic or boolean equations to express the rules. The problem involves evaluating trajectories of vortices passing by an airfoil and the changes in velocity and pressure distributions over the airfoil. It is found that all maintenance or refinement can be performed in the specification and that it supports very fast prototyping. K.K.

A88-48858#
ON THE ORDER OF PANEL METHODS
WALTER FROST (Tennessee, University, Tullahoma) and J. C. A. WANG IN: AIAA, ASME, SIAM, and APS, National Fluid Dynamics Congress, 1st, Cincinnati, OH, July 25-28, 1988, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 644-651. refs
(AIAA PAPER 88-3798)

A piecewise constant-surface-singularity panel method for the external Neuman boundary value problem was found to be capable of handling airfoils with cusped trailing edges. The formulation only changes the right-hand-side of the systems of equations while retaining the lower order formulation. An accuracy comparable to that obtained with higher order methods can be achieved using the same number of control points. K.K.

A88-48866#
EXPERIMENTS ON THE FORCED WAKE OF AN AIRFOIL
K. STUBER and M. GHARIB (California, University, La Jolla) IN: AIAA, ASME, SIAM, and APS, National Fluid Dynamics Congress, 1st, Cincinnati, OH, July 25-28, 1988, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 723-730. DARPA-sponsored research. refs
(Contract N00014-86-K-0758)
(AIAA PAPER 88-3840)

An experimental effort has been made to understand the nature of an airfoil wake whose oscillation frequency is controlled by the introduction of an external perturbation. The waves are introduced into the airfoil top and bottom surfaces' boundary layers by strip heaters; attention to the linear and nonlinear interactions of these wake waves has resulted in observation of three modes of interaction: (1) frequency locking, in which the vortex-shedding frequency is the same as the forcing frequency; (2) quasiperiodic vortex interaction, in which periodic clusters of vortices are observed in the wake; and (3) chaotic vortex interaction, in which the wake vortices exhibit a three-dimensional random structure. O.C.

A88-48869*# Old Dominion Univ., Norfolk, Va.
CONTROL OF SUPERSONIC INTERSECTION FLOWFIELDS THROUGH FILLETING AND SWEEP
B. LAKSHMANAN, S. N. TIWARI (Old Dominion University, Norfolk, VA), and M. Y. HUSSAINI (NASA, Langley Research Center, Hampton, VA) IN: AIAA, ASME, SIAM, and APS, National Fluid Dynamics Congress, 1st, Cincinnati, OH, July 25-28, 1988, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 746-759. refs
(Contract NAG1-530)
(AIAA PAPER 88-3534)

The problem of supersonic flow control using fillets and sweep for a wing/body junction has been investigated numerically using a three-dimensional Navier-Stokes code which employs the MacCormack time-split finite-volume technique. An elliptic grid generation technique with direct control over spacing has been incorporated for constructing the grid at a filleted wing/body junction. The computed results for pressure distribution, particle paths, and limiting streamlines on the flat plate and fin surface for a swept fin show a decrease in the peak pressure on the fin leading edge and in the extent of the separated flow region. Moreover, the results for the filleted juncture clearly show that the flow streamline patterns lose much of their vortical character with proper filleting. It is demonstrated that fillets with a radius of 3.5 times the fin leading edge diameter are required to weaken the usual necklace vortex interaction. Author

A88-48870*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
PASSIVE CONTROL PLATE FOR SHOCK-BOUNDARY LAYER INTERACTIONS
WESLEY L. GOODMAN and E. LEON MORRISETTE (NASA, Langley Research Center, Hampton, VA) IN: AIAA, ASME, SIAM, and APS, National Fluid Dynamics Congress, 1st, Cincinnati, OH, July 25-28, 1988, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 760-767. refs
(AIAA PAPER 88-3537)

Computational and experimental results are presented for a passive method capable of reducing or completely eliminating the separation region in shock-boundary layer interactions of the type that can result in severe performance degradation due to flow separation in supersonic and hypersonic inlets. The method involves the placement of an embedded plate in the outer portion of the boundary layer, parallel to the wall, so that the incident shock will impinge upon, and be reflected from, its surface. This will lower the pressure gradient in the low-momentum, near-wall region. A porous control plate's effect has also been investigated. O.C.

A88-48872#
UNSTEADY WING THEORY - THE KARMAN/SEARS LEGACY
JAMES E. MCCUNE (MIT, Cambridge, MA) IN: AIAA, ASME, SIAM, and APS, National Fluid Dynamics Congress, 1st, Cincinnati, OH, July 25-28, 1988, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 774-784. refs
(Contract AF-AFOSR-86-157)
(AIAA PAPER 88-3539)

A development history is presented for computational prediction methods in unsteady wing aerodynamics, from the field's inception in the 1920's under the influence of Prandtl, through the work of von Karman, to that of his pupil, Sears. Reflection on 50 years of development in this discipline leads to surprise as to the large portion of the classical linear analysis that can be carried over into the nonlinear regime of wings in conditions of severe maneuvering. In the wake of Scott (1987), attempts have been made to establish a conclusive 'benchmark' comparison with classical linear theory. O.C.

A88-48873#
UNSTEADY AERODYNAMICS OF AN AIRFOIL IN COMBINED TRANSLATION/PITCH OSCILLATIONS BELOW AND THROUGH STALL
D. FAVIER, C. MARESCA, and C. BARBI (Aix-Marseille II, Universite, Marseille, France) IN: AIAA, ASME, SIAM, and APS, National Fluid Dynamics Congress, 1st, Cincinnati, OH, July 25-28, 1988, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 785-798. Sponsorship: Service Technique des Programmes Aeronautiques. refs
(Contract STPA-86-95001; STPA-86-95011)
(AIAA PAPER 88-3540)

An experimental study was made to investigate the unsteady aerodynamic response of an airfoil submitted to simultaneous variations of velocity V and incidence angle alpha. The experimental simulation was conducted by means of a translation/pitch oscillating device which makes it possible to drive the airfoil in

fore-and-aft motion (V variations) or in pitching motion (alpha variations), as well as in a combination of these two motions (simultaneous V and alpha variations). The phase shift Phi between the V and alpha oscillations can be adjusted from 0 to 360 deg. The present paper is focused on studying the influence of Phi on the two-dimensional unsteady behavior of a NACA 0012 airfoil below and through stall. In both cases, the time-dependent lift and drag coefficients are measured in combined motion for different values of Phi, and the results are discussed and compared to those generated either in pitch or in fore-and-aft motion. Chordwise pressure measurements are also made to document the local unsteady features generated as a function of Phi in the combined motion. Author

A88-48874*# Arizona Univ., Tucson.
THE EFFECTS OF COMPRESSIBILITY ON DYNAMIC STALL
K.-Y. FUNG (Arizona, University, Tucson) and L. W. CARR (NASA, Ames Research Center; U.S. Army, Aeroflightdynamics Directorate, Moffett Field, CA) IN: AIAA, ASME, SIAM, and APS, National Fluid Dynamics Congress, 1st, Cincinnati, OH, July 25-28, 1988, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 799-805. refs
(Contract AF-AFOSR-83-0071; AF-AFOSR-88-0163; NCA2-196)
(AIAA PAPER 88-3541)

In this paper, typical computational predictions and experimental measurements of compressible flow past an airfoil at dynamic stall conditions are studied and compared to develop an insight into the effect of compressibility on dynamic stall. The dependency of the critical Mach number on airfoil leading edge curvature, camber, and angle of attack is investigated. Evidence is presented to show that a local region of supersonic flow occurs on an oscillating airfoil, even for a freestream Mach number as low as 0.2, if the boundary layer remains attached and the angle of attack is sufficiently high; that a shock terminates this local supersonic bubble; and that the vorticity that this shock generates grows rapidly and becomes very unstable as the angle of attack increases beyond the value at which the maximum local flow speed first exceeds the speed of sound. It is suggested that these shock-induced effects compete with the dynamic viscous effects occurring in the boundary layer in determining the onset of separation, which can lead to premature dynamic stall and can significantly reduce the maximum dynamic lift that can otherwise be obtained. Author

A88-48875#
UNSTEADY SEPARATION OVER MANEUVERING BODIES
S. F. SHEN and TZUYIN WU (Cornell University, Ithaca, NY) IN: AIAA, ASME, SIAM, and APS, National Fluid Dynamics Congress, 1st, Cincinnati, OH, July 25-28, 1988, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 806-814. refs
(Contract AF-AFOSR-86-0328)
(AIAA PAPER 88-3542)

To understand unsteady separated flows over a maneuvering body requires analysis of the Navier-Stokes equations in a set of body-fixed coordinates. Effects of the extra apparent body forces in various combinations are yet to be systematically explored. The boundary layer equations in body-fixed coordinates, however, retain the usual form except for a Coriolis term which shows up, for instance, in dynamic meteorology as the Rossby number. The Coriolis term is absent in the two-dimensional case. Computed results of unsteady separation, according to the Lagrangian criterion, over a circular cylinder impulsively started into several variable motions, including acceleration, deceleration and rotation, are presented and discussed. Author

A88-48876#
UNSTEADY 3D AERODYNAMICS OF SLENDER WINGS IN SEVERE MANEUVER
J. E. MCCUNE and T. S. TAVARES (MIT, Cambridge, MA) IN: AIAA, ASME, SIAM, and APS, National Fluid Dynamics Congress, 1st, Cincinnati, OH, July 25-28, 1988, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 815-824. USAF-supported research. refs
(AIAA PAPER 88-3543)

Recent work on the nonlinear unsteady aerodynamics of two-dimensional airfoils at low Mach number, including the effects of the distortion and/or roll-up of the unsteady wake on the airfoil loading, lift, and moment, encourages the application of the same ideas to the study of the unsteady behavior of slender wings. The problem is three-dimensional but can also be usefully approached in the quasi-two-dimensional (cross-flow) sense. The use of this idea is not intended to preempt the more exact three-dimensional calculations available using lattice methods. Rather, it is hoped for the unsteady case to provide additional insight into the effects of severe and rapid imposed motions, including strong gusts, on wings of low aspect ratio. A feature of this paper is an attempt to maintain and make contact with certain classical analytical techniques of incompressible airfoil theory, and to enhance these with the help of the computer and computer graphics. Author

A88-48878*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
CONTROL OF THE BOUNDARY LAYER SEPARATION ABOUT AN AIRFOIL BY ACTIVE SURFACE HEATING
LUCIO MAESTRELLO (NASA, Langley Research Center, Hampton, VA), FOROOZ F. BADAVI (PRC Kentron, Inc., Hampton, VA), and KEVIN W. NOONAN (U.S. Army, Aerostructures Directorate, Hampton, VA) IN: AIAA, ASME, SIAM, and APS, National Fluid Dynamics Congress, 1st, Cincinnati, OH, July 25-28, 1988, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 830-838. refs
(AIAA PAPER 88-3545)

Application of active control to separated flow on the RC(6)-08 airfoil at high angle of attack by localized surface heating is numerically simulated by integrating the compressible two-dimensional nonlinear Navier-Stokes equations solver. Active control is simulated by local modification of the temperature boundary condition over a narrow strip on the upper surface of the airfoil. Both mean and perturbed profiles are favorably altered when excited with the same natural frequency of the shear layer by moderate surface heating for both laminar and turbulent separation. The shear layer is found to be very sensitive to localized surface heating in the vicinity of the separation point. The excitation field at the surface sufficiently altered both the local as well as the global circulation to cause a significant increase in lift and reduction in drag. Author

A88-48898*# Lockheed Aeronautical Systems Co., Marietta, Ga.
CENTERLINE MACH NUMBER CHARACTERISTICS OF HIGHLY HEATED FREE JETS
JAN LEPICOVSKY (Lockheed Aeronautical Systems Co., Marietta, GA) IN: AIAA, ASME, SIAM, and APS, National Fluid Dynamics Congress, 1st, Cincinnati, OH, July 25-28, 1988, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 989-999. refs
(Contract NAS3-23708)
(AIAA PAPER 88-3612)

This paper describes a detailed experimental study of Mach number centerline characteristics of highly heated free jets. The jet characteristics were obtained at a range of jet Mach numbers from 0.1 to 0.9 and jet total temperatures up to 900 K. The results show that a strong correlation exists between nozzle-exit boundary-layer conditions and free-jet development. It is clear from this investigation that experimental data on free-jet development cannot be meaningfully compared from one facility to another without specific knowledge of nozzle exit conditions. It was concluded that direct effect of the jet operating conditions (elevated flow temperature) on free jet development is much less important than the indirect effect of changed nozzle-exit boundary-layer characteristics. Author

A88-48900#
NAVIER-STOKES SOLUTIONS OF TRANSONIC NOZZLE FLOW WITH SHOCK-INDUCED FLOW SEPARATIONS
C. F. SHIEH (Rohr Industries, Inc., Chula Vista, CA) IN: AIAA, ASME, SIAM, and APS, National Fluid Dynamics Congress, 1st, Cincinnati, OH, July 25-28, 1988, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 1008-1015. refs
(AIAA PAPER 88-3614)

Transonic turbulent flows inside two-dimensional and conical nozzles have been analyzed by solving two-dimensional Navier-Stokes equations. The governing equations are written in a conservative form of a general curvilinear coordinate system and are solved by a hopscotch numerical method. An algebraic two-layer turbulence model is used in the computation. Good agreement is obtained between the solutions and experimental measurements for all of the cases investigated, including both the forward-thrust and thrust-vectoring cases. Among these cases, a two-dimensional nozzle in a stalled condition, i.e., a reverse flow occurring at the nozzle exit, as well as the case of a supersonic exhaust nozzle with an external flow turning, are of particular interest due to the strong viscous and inviscid flow interaction. Good agreement is achieved between computed and measured pressure distributions. The viscous effects on shock location and shock strength are accurately predicted. Author

A88-48901*# Ohio State Univ., Columbus.
STRUCTURE OF A REATTACHING SUPERSONIC SHEAR FLOW
M. SAMIMY (Ohio State University, Columbus) and B. A. K. ABU-HIJLEH IN: AIAA, ASME, SIAM, and APS, National Fluid Dynamics Congress, 1st, Cincinnati, OH, July 25-28, 1988, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 1016-1021. refs
(Contract NAG3-764; N00014-87-K-0169)
(AIAA PAPER 88-3615)

A Mach 1.83 fully developed turbulent boundary layer with boundary layer thickness, free stream velocity, and Reynolds number of 7.5 mm, 476 m/s, and 6.2 x 10 to the 7th/m, respectively, was separated at a 25.4-mm backward step and formed a shear layer. Fast-response pressure transducers, schlieren photography, and LDV were used to study the structure of this reattaching shear flow. The preliminary results show that large-scale relatively organized structures with limited spanwise extent form in the free shear layer. Some of these structures appear to survive the recompression and reattachment processes, while others break down into smaller scales and the flow becomes increasingly three-dimensional. The survived large-scale structures lose their organization through recompression/reattachment, but regain it after reattachment. The structures after reattachment form a 40-45-degree angle relative to the free stream and deteriorate gradually as they move downstream. Author

A88-48905#
THE CIRCULATION OF AN AIRFOIL STARTING VORTEX OBTAINED FROM INSTANTANEOUS VORTICITY MEASUREMENTS OVER AN AREA
R. E. FALCO, C. C. CHU, M. H. HETHERINGTON, and C. P. GENDRICH (MIchigan State University, East Lansing) IN: AIAA, ASME, SIAM, and APS, National Fluid Dynamics Congress, 1st, Cincinnati, OH, July 25-28, 1988, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 1048-1054. refs
(Contract AF-AFOSR-87-0047)
(AIAA PAPER 88-3620)

By dissolving a photochromic chemical in an organic liquid and exciting it with ultraviolet light, a colored line can be created anywhere in the liquid. A device has been constructed which divides a laser beam into n lines which are made to intersect to form a grid. Introducing two sets of these lines into the flowing fluid produces a grid of 100-micron colored fluid lines with a mesh spacing of approximately 1 mm. The color change persists long enough so that the grid lines are distorted by the flow before disappearing. The process is completely nonintrusive. The lines are analyzed by an image processing algorithm to allow the grid intersection points to be located quickly and with high precision. The movement of the intersection points in a unit of time results in temporal gradients of position, which in conjunction with estimates of the circulation around each grid box can be used to obtain the vorticity. Additionally, differencing again across a grid box results in spatial gradients of velocity. Experiments in a Stokes flow indicate that the vorticity can be measured to + or - 1/sec. Application to the measurement of the formation of lift on an impulsively started airfoil has been made and compared with known results. Author

A88-48906#
A STUDY OF THE ENCOUNTER BETWEEN A HELICAL VORTEX AND A CIRCULAR CYLINDER
N. M. KOMERATH, S. G. LIOU, A. G. BRAND, and H. M. MCMAHON (Georgia Institute of Technology, Atlanta) IN: AIAA, ASME, SIAM, and APS, National Fluid Dynamics Congress, 1st, Cincinnati, OH, July 25-28, 1988, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 1055-1063. refs
(Contract DAAG29-82-K-0084)
(AIAA PAPER 88-3622)

Flows around rotary-wing configurations involve unsteady interaction phenomena between curved vortices and solid surfaces. An attempt has been made here to capture the details of such an interaction using synchronized flow visualization and measurements of velocity and surface pressure fluctuations. A two-bladed rotor in a wind tunnel is used to generate a vortex-dominated wake which interacts periodically with an instrumented hemisphere-cylinder body. The core of the rotor tip vortex is visualized using a laser sheet until it reaches the surface of the cylinder. Velocity profiles before, during, and after the interaction are measured using a laser velocimeter. The motion of the vortex is qualitatively consistent with the 'image vortex' model. Upon impingement, it changes into two vortices of opposite senses of rotation. The remains of the original vortex continue along a retarded trajectory, and appear to rise from the surface as a vortex with a much smoother core velocity profile, while the secondary vortex is convected rapidly downstream. The pressure variation exhibits high stagnation pressures and low core static pressures, as expected. High axial velocities and velocity gradients are observed in the vortex core. Author

A88-48908#
LIQUID CRYSTALS FOR UNSTEADY SURFACE SHEAR STRESS VISUALIZATION
DANIEL C. REDA (Sandia National Laboratories, Albuquerque, NM) IN: AIAA, ASME, SIAM, and APS, National Fluid Dynamics Congress, 1st, Cincinnati, OH, July 25-28, 1988, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 1069-1072. refs
(Contract DE-AC04-76DP-00789)
(AIAA PAPER 88-3841)

Oscillating airfoil experiments were conducted to test the frequency response of thermochromic liquid crystal coatings to unsteady surface shear stresses under isothermal-flow conditions. The model was an NACA-0015 airfoil, exposed to an incompressible flow at a freestream Reynolds number (based on chord) of 1.14 x 10 to the 6th. Angle-of-attack forcing functions were sine waves of amplitude + or - 10 deg about each aof three mean angles of attack: 0, 10, and 20 deg. Frequencies of oscillation were 0.2, 0.6 and 1.2 hertz, corresponding to reduced frequencies of 0.0055, 0.0164, and 0.0328. Data acquisition was accomplished by video recording. Observations showed the liquid crystal technique capable of visualizing high surface shear stress zones over the stated dynamic range in a continuous and reversible manner. Author

A88-48911#
INSTABILITIES IN THE WAKE/MIXING-LAYER REGION OF A SPLITTER PLATE SEPARATING TWO SUPERSONIC STREAMS

SAAD A. RAGAB (Virginia Polytechnic Institute and State University, Blacksburg) IN: AIAA, ASME, SIAM, and APS, National Fluid Dynamics Congress, 1st, Cincinnati, OH, July 25-28, 1988, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 1095-1102. refs
(Contract N00014-87-K-0168)
(AIAA PAPER 88-3677)

The stability of the laminar wake of a splitter plate is investigated using linear inviscid spatial theory. The two streams are supersonic but have different velocities and temperatures, thus the wake is not symmetric. The basic state is obtained by solving the Navier-Stokes equations using a finite difference code. The equations are solved starting from an assumed initial state, which is given by a surface of discontinuity (i.e. a vortex sheet), and a steady laminar flow is obtained for the three cases considered. The variation of growth rates and phase speeds with frequency are determined. The results show a strong stabilizing effect of the Mach number. Author

A88-48912*# High Technology Corp., Hampton, Va.
GOERTLER VORTICES IN SUPERSONIC BOUNDARY LAYERS
R. E. SPALL and M. R. MALIK (High Technology Corp., Hampton, VA) IN: AIAA, ASME, SIAM, and APS, National Fluid Dynamics Congress, 1st, Cincinnati, OH, July 25-28, 1988, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 1103-1110. refs
(Contract NAS1-18240)
(AIAA PAPER 88-3678)

The problem of Goertler vortices in compressible boundary layers over concave walls is studied by solving parabolic partial differential equations. The numerical scheme used is based upon a fourth-order accurate compact difference scheme. The results show that both the velocity and temperature fluctuations may lead to a Goertler vortex. The vortex growth rates determined from the present method are found to differ somewhat from those given by normal mode solution. The effects of cooling, heating and pressure gradient are also studied. At a Mach number of 3.5, cooling has a small destabilizing effect. The effect of adverse pressure gradient is also found to be destabilizing on a Mach 8 boundary layer. Author

A88-48920#
FLOW DEVELOPMENT ON AN AIRFOIL WITH A SHARP TRAILING EDGE STARTED IMPULSIVELY FROM REST
RUBEN ROJAS-OVIEDO (Tuskegee University, AL) and JAMES C. WILLIAMS, III (Auburn University, AL) IN: AIAA, ASME, SIAM, and APS, National Fluid Dynamics Congress, 1st, Cincinnati, OH, July 25-28, 1988, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 1196-1203. Research supported by Auburn University. refs
(AIAA PAPER 88-3712)

A study is made of the unsteady boundary layer development on a symmetrical airfoil with a sharp trailing edge (a Karman-Trefftz airfoil) at zero angle of attack, which is impulsively set into uniform motion. The boundary layer development is calculated using a simple implicit finite difference technique. Special attention is paid to the development of the boundary layer near the airfoil trailing edge and to the nature and motion of separation. The results obtained are compared with those obtained earlier in a study of a cusped trailing edge airfoil (a Joukowski airfoil) impulsively set into motion. It is shown that a separation singularity originates at the airfoil trailing edge immediately after the start of the motion and moves forward along the body as time increases, until finally the separation singularity becomes stationary at the steady state separation point. The computed characteristics of the boundary layer near separation support the Moore-Rott-Sears model of unsteady separation. Author

A88-48923#
HOT-WIRE MEASUREMENTS OF NEAR WAKES BEHIND AN OSCILLATING AIRFOIL
S. O. PARK, J. S. KIM, and B. I. LEE (Korea Advanced Institute of Science and Technology, Seoul, Republic of Korea) IN: AIAA, ASME, SIAM, and APS, National Fluid Dynamics Congress, 1st, Cincinnati, OH, July 25-28, 1988, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 1217-1223. refs
(AIAA PAPER 88-3715)

An experimental investigation of unsteady wakes behind a sinusoidally pitching airfoil was carried out. Data were taken at mean incidence angles of 0, 2, and 4 deg at reduced frequencies of 0.1 and 0.2. For all the cases, the amplitude of oscillation was 7.4 deg. Ensemble averaged mean velocity and turbulence intensity profiles and the periodic change of semi-wake thickness are presented. The phase lag based on velocity profile was estimated at various downstream stations. The relative time of the occurrence of boundary layer breakdown is discussed in terms of the phase lag characterizing the situation. Pictures of smoke-wire flow visualization at some chosen phases are included to aid in understanding the overall flow characteristics. Author

A88-48934*# Analytical Services and Materials, Inc., Hampton, Va.
DESIGN OF LOW REYNOLDS NUMBER AIRFOILS. II
W. PFENNINGER, C. S. VEMURU, S. MANGALAM, and R. EVANGELISTA (Analytical Services and Materials, Inc., Hampton, VA) IN: AIAA, ASME, SIAM, and APS, National Fluid Dynamics Congress, 1st, Cincinnati, OH, July 25-28, 1988, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 1305-1319. refs
(Contract NAS1-18235)
(AIAA PAPER 88-3764)

Low Reynolds number airfoils were designed for high lift-to-drag ratios. Design considerations of low Re-airfoils are discussed and design examples are presented. It is shown that the performance of advance low Reynolds airfoils critically depends on proper laminar separation and transition control for the minimum profile drag coefficient with minimum turbulator device drag. This transition control close to the laminar separation is possible by enforcing transition on the upper surface either directly by means of spanwise rows of three-dimensional roughness elements, bleed or suction holes, or indirectly by means of destabilizing the upper surface boundary layer by means of backward facing surface steps, two-dimensional or zig-zag tapes or weak boundary layer blowing. Pneumatic turbulators are found to be advantageous because they can be adjusted to different external flow conditions better than mechanical ones. R.B.

A88-48936#
TRANSONIC SHOCK/BOUNDARY-LAYER INTERACTION STUDIES - ASYMPTOTIC THEORIES, NUMERICAL SOLUTIONS, AND THE ROLE OF TURBULENCE MODELING
RAMESH K. AGARWAL, JERRY E. DEESE, and G. R. PETERS (McDonnell Douglas Research Laboratories, Saint Louis, MO) IN: AIAA, ASME, SIAM, and APS, National Fluid Dynamics Congress, 1st, Cincinnati, OH, July 25-28, 1988, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 1331-1339. refs
(AIAA PAPER 88-3800)

The development and evaluation of numerical methods and turbulence models for predicting two-dimensional and three-dimensional shock-separated turbulent-boundary-layer interaction flowfields are considered. Numerical results for weak-interaction nonseparated flows are compared with those of triple-deck theories and experimental data for both laminar and turbulent flows. Test cases considered include the three-dimensional shock/turbulent-boundary-layer interaction caused by supersonic flow along a swept compression ramp and the viscous transonic flow around NACA 0012 and RAE 2822 airfoils. R.R.

A88-48937#
CHARACTERISTICS OF MULTIPLE SHOCK WAVE/TURBULENT BOUNDARY LAYER INTERACTIONS IN RECTANGULAR DUCTS
BRUCE F. CARROLL and J. CRAIG DUTTON (Illinois, University,

Urbana) IN: AIAA, ASME, SIAM, and APS, National Fluid Dynamics Congress, 1st, Cincinnati, OH, July 25-28, 1988, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 1340-1347. Research supported by University of Illinois. refs
(Contract N00014-85-K-0665)
(AIAA PAPER 88-3803)

Multiple shock wave/turbulent boundary layer interactions in a rectangular duct have been investigated using wall pressure measurements, surface oil flow visualization, and spark Schlieren photography. At Mach 2.45 the shock structure was a neutrally stable pattern of oblique shocks followed by repeated normal shocks with the level of flow confinement having only a small effect on the interaction. AT Mach 1.6 the pattern consisted of a bifurcated normal shock followed by weaker unbifurcated normal shocks. At this lower Mach number the interaction was much steadier with the length of the interaction scaling directly with the level of flow confinement. Author

A88-48942#
ANALYSIS OF SYMMETRIC WAKE BEHIND A CIRCULAR CYLINDER USING A DIRECT SOLUTION TECHNIQUE AND NEWTON'S METHOD
A. B. RICE (Structural Dynamics Research Corp., Milford, OH), K. N. GHIA, G. A. OSSWALD, and U. GHIA (Cincinnati, University, OH) IN: AIAA, ASME, SIAM, and APS, National Fluid Dynamics Congress, 1st, Cincinnati, OH, July 25-28, 1988, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 1391-1398. refs
(Contract N00014-85-K-0049; AF-AFOSR-87-0074)
(AIAA PAPER 88-3608)

An analysis of the symmetric wake behind a circular cylinder is developed, using the two-dimensional form of the unsteady incompressible Navier-Stokes equations in terms of vorticity and stream function. The conservation-law form of the equations is employed in generalized orthogonal curvilinear coordinates. A fully-implicit direct time-marching scheme consisting of the alternating direction implicit-block-Gaussian elimination (ADI-BGE) technique is employed. This method has overall second-order spatial accuracy and, therefore, avoids the introduction of any artificial viscosity. After the major structure of the flowfield has been established with the direct technique, an algorithm which corresponds to Newton's method is applied to increase the rate of convergence and the accuracy of the solution. The asymptotic flow structure which results from this analysis of the half-cylinder configuration compares favorably with existing numerical and analytical solutions. Author

A88-48961#
NAVIER-STOKES ANALYSIS OF THE PERFORMANCE AND FLOW FIELD OF SINGLE AND COUNTER-ROTATION PROPELLERS
R. GANESH RAJAGOPALAN (Iowa State University of Science and Technology, Ames) and RONALD R. FRYE IN: AIAA, ASME, SIAM, and APS, National Fluid Dynamics Congress, 1st, Cincinnati, OH, July 25-28, 1988, Technical Papers. Part 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 1584-1590. Research supported by Iowa State University of Science and Technology. refs
(AIAA PAPER 88-3638)

A novel numerical solution procedure is used to solve the flow over an axisymmetric nacelle and propeller. From known geometric characteristics of the propeller and nacelle and aerodynamic characteristics of the airfoil used for the propeller blades, the performance and all the flow field variables are calculated implicitly by solving the steady, incompressible, laminar, Navier-Stokes equations in an axisymmetric coordinate system. The solid body is represented by blocked off regions in the flow with all three velocity components set to zero. The effect of the spinning propeller blades are time averaged and are introduced through the source terms of the momentum equations. It is observed that the agreement of performance characteristics with experimental data is very good and that the flow field characteristics are qualitatively correct. Flow field characteristics are displayed with the help of streamlines and contour plots of pressure and tangential velocity. Author

A88-48962#
PERIODIC ROTOR BLADE AERODYNAMICS INCLUDING LOADING EFFECTS
STEVEN R. MANWARING and SANFORD FLEETER (Purdue University, West Lafayette, IN) IN: AIAA, ASME, SIAM, and APS, National Fluid Dynamics Congress, 1st, Cincinnati, OH, July 25-28, 1988, Technical Papers. Part 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 1591-1598. refs
(Contract F49620-88-C-0022)
(AIAA PAPER 88-3639)

A series of experiments are performed to investigate and quantify the effects of steady aerodynamic loading on the unsteady gust aerodynamics of a first stage rotor blade at realistic values of the reduced frequency. These are accomplished in an extensively instrumented axial flow research compressor, with the high reduced frequency gusts generated by the wakes from the inlet guide vanes. The multistage effects associated with compressor rotor-stator blade row operation in the superresonant flow regime wherein acoustic waves propagate are also considered. Author

A88-48964#
THREE DIMENSIONAL FINITE ELEMENT ANALYSIS FOR AERODYNAMIC DESIGN OF FAN BLADES
M. N. DHAUBHADEL, H. U. AKAY (Technalysis, Inc., Indianapolis, IN), and H. N. CHARLES (Bendix Electronics, Ltd., Chatham, Canada) IN: AIAA, ASME, SIAM, and APS, National Fluid Dynamics Congress, 1st, Cincinnati, OH, July 25-28, 1988, Technical Papers. Part 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 1608-1615. Research sponsored by Bendix Electronics, Ltd. refs
(AIAA PAPER 88-3641)

Three-dimensional full potential equations as applied to compressible flows through rotating fan blade passages are solved by a finite element method. Automated grid generation with options to change blade geometry in various ways allows analysis and performance comparison of blade geometries in a more efficient and convenient manner. Results in terms of pressure, Mach number, lift, efficiency, etc., are presented for various geometries derived from an initial geometry. A design is selected from performance runs of these geometries at various mass flow rates. Author

A88-48973#
AERODYNAMICS FORCES ON AIRFOILS AT HIGH ANGLES OF ATTACK
S. RAGHUNATHAN (Belfast, Queen's University, Northern Ireland) IN: AIAA, ASME, SIAM, and APS, National Fluid Dynamics Congress, 1st, Cincinnati, OH, July 25-28, 1988, Technical Papers. Part 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 1710-1717. refs
(AIAA PAPER 88-3696)

Experimental investigations in a low speed wind tunnel of NACA 0021 airfoil, isolated and in a cascade of 90 deg stagger are reported in this paper. The aerodynamic force coefficients on a single airfoil over a wide range of incidences are compared with the momentum theory and airfoil results from other test facilities. When compared with isolated airfoil data the aerodynamic force coefficients on an airfoil in cascade are larger and increased with the number of airfoils in the cascade. Author

A88-48983#
COMPUTATION OF THREE DIMENSIONAL TRANSONIC FLOW IN A CENTRIFUGAL IMPELLER USING EULER EQUATIONS
M. M. ABDELRAHMAN (Cairo University, Egypt) IN: AIAA, ASME, SIAM, and APS, National Fluid Dynamics Congress, 1st, Cincinnati, OH, July 25-28, 1988, Technical Papers. Part 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p.

1820-1827. refs
(AIAA PAPER 88-3731)

A finite difference computer code is proposed for calculating the three-dimensional, steady, inviscid, transonic flow within the impeller passage of a centrifugal compressor. The starting point is the set of the unsteady Euler equations governing the three-dimensional fluid flow. The equations are simplified by using the steady form of the energy equation and are expressed in a rotating, nonorthogonal curvilinear coordinate system in which the coordinate surfaces coincide with the hub, shroud, inlet, outlet, and blade surfaces of the impeller. The differential equations are integrated over microcontrol volumes associated with each grid node to derive the finite difference equations. These equations are solved by a time-marching technique using an implicit time scheme. A blade-to-blade choked flow is studied as a two-dimensional case and the transonic flow in a centrifugal compressor impeller as a three-dimensional case. C.D.

A88-48985#
COMPUTATION AND ANALYSIS OF THE SHAPES OF S1 AND S2 STREAMSURFACES IN A TRANSONIC COMPRESSOR ROTOR

JIALIN ZHANG (Chinese Academy of Sciences, Institute of Engineering Thermophysics, Beijing, People's Republic of China) IN: AIAA, ASME, SIAM, and APS, National Fluid Dynamics Congress, 1st, Cincinnati, OH, July 25-28, 1988, Technical Papers. Part 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 1836-1842. refs
(AIAA PAPER 88-3734)

Based on Wu's (1952) stream-surface theory and a solved three-dimensional transonic flowfield of an axial-flow compressor rotor, a method to compute three-dimensional streamlines and stream surfaces in the flowfield has been proposed. The shapes of S1 and S2 stream surfaces have been computed and shown by figures. With these figures, the three-dimensional effects of transonic flow in turbomachinery have been analyzed. The computation and analysis show that there are strong interactions within the flows in subsonic and supersonic stream tubes which make stream surfaces twist and lead to discrepancies between the quasi-three-dimensional and the fully three-dimensional calculations. Author

A88-48986#
FULL 3-D ITERATIVE SOLUTION OF TRANSONIC FLOW FOR A SWEPT WING TEST CHANNEL

XIAOLU ZHAO (Chinese Academy of Sciences, Institute of Engineering Thermophysics, Beijing, People's Republic of China) IN: AIAA, ASME, SIAM, and APS, National Fluid Dynamics Congress, 1st, Cincinnati, OH, July 25-28, 1988, Technical Papers. Part 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 1843-1848. refs
(AIAA PAPER 88-3735)

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

A88-48995#
THE EFFECT OF BOUNDARY LAYER ON TRANSONIC CASCADE FLOW

YAONAN HUA and BAOGUO WANG (Chinese Academy of Sciences, Institute of Engineering Thermophysics, Beijing, People's Republic of China) IN: AIAA, ASME, SIAM, and APS, National Fluid Dynamics Congress, 1st, Cincinnati, OH, July 25-28, 1988, Technical Papers. Part 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 1976-1982. Previously cited in issue 09, p. 1301, Accession no. A88-26587. refs
(AIAA PAPER 88-3782)

A88-49005*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
TRANSONIC FLOW MODES OF AN AXISYMMETRIC BLUNT BODY

KEITH KOENIG (Mississippi State University, Starkville), GARY T. CHAPMAN (NASA, Ames Research Center, Moffett Field, CA), and DAVID H. BRIDGES AIAA, ASME, SIAM, and APS, National Fluid Dynamics Congress, 1st, Cincinnati, OH, July 25-28, 1988. 7 p. USAF-supported research. refs
(Contract NCA2-52)
(AIAA PAPER 88-3536)

An experimental investigation of transonic flow past a plane-nosed circular cylinder with a plane-nosed circular probe extended coaxially ahead is reported. The possibilities of significant transonic drag reduction and the fluid mechanic phenomena which occur are examined. The probe length and diameter and the approaching flow Mach number are the independent variables. The relations which exist among the probe/cylinder geometry, Mach number, and flow field as revealed by measurements of the drag forces acting on the body are explored. C.D.

A88-49010#
TWO COMPLEMENTARY APPROACHES TO TRANSONIC POTENTIAL FLOW ABOUT OSCILLATING AIRFOILS

H. SCHIPPERS and M. H. L. HOUNJET (Nationaal Lucht- en Ruimtevaartlaboratorium, Amsterdam, Netherlands) Journal of Aircraft (ISSN 0021-8669), vol. 25, May 1988, p. 395-398. Research supported by the Nederlands Instituut voor Vliegtuigontwikkeling en Ruimtevaart. Previously cited in issue 24, p. 3535, Accession no. A86-49586. refs

A88-49012*# Massachusetts Inst. of Tech., Cambridge.
COMPARISON OF EXPERIMENTAL AND NUMERICAL RESULTS FOR DELTA WINGS WITH VORTEX FLAPS

KENNETH G. POWELL, EARLL M. MURMAN (MIT, Cambridge, MA), RICHARD M. WOOD, and DAVID S. MILLER (NASA, Langley Research Center, Hampton, VA) Journal of Aircraft (ISSN 0021-8669), vol. 25, May 1988, p. 405-412. Previously cited in issue 17, p. 2464, Accession no. A86-37848. refs
(Contract NAG1-358)

A88-49016#
EULER CALCULATIONS FOR WING-ALONE CONFIGURATION

S. Y. RUO (Lockheed-Georgia Co., Marietta) and L. N. SANKAR (Georgia Institute of Technology, Atlanta) Journal of Aircraft (ISSN 0021-8669), vol. 25, May 1988, p. 436-441. Previously cited in issue 08, p. 1033, Accession no. A87-22419. refs

A88-49017*# Vigyan Research Associates, Inc., Hampton, Va.
COMPUTATION OF VORTICAL INTERACTION FOR A SHARP-EDGED DOUBLE-DELTA WING

C.-H. HSU, P.-M. HARTWICH (Vigyan Research Associates, Inc., Hampton, VA), and C. H. LIU (NASA, Langley Research Center, Hampton, VA) Journal of Aircraft (ISSN 0021-8669), vol. 25, May 1988, p. 442-447. Previously cited in issue 08, p. 1035, Accession no. A87-22484. refs
(Contract NAG1-455; NAS1-17919)

A88-49019#
EVALUATION OF METHODS FOR PREDICTING COMPLEX AIRCRAFT FLOWFIELDS

A. CENKO (U.S. Navy, Naval Air Development Center, Warminster, PA) and F. TESSITORE (Grumman Aerospace Corp., Bethpage, NY) Journal of Aircraft (ISSN 0021-8669), vol. 25, May 1988, p. 453-458. Previously cited in issue 07, p. 834, Accession no. A86-19855. refs

A88-49020#
METHODOLOGY FOR ANALYSIS OF AFTERBODIES FOR THREE-DIMENSIONAL AIRCRAFT CONFIGURATIONS

EUGENE H. MILLER (Grumman Corp., Aircraft Systems Div., Bethpage, NY) Journal of Aircraft (ISSN 0021-8669), vol. 25, May 1988, p. 459-464. refs

Today's modern fighter design, with multifunction nozzles, is

placing an increased emphasis on nozzle/airframe integration. The current tools available to the aircraft designer for aft-end design and evaluation are model test reports, being disseminated mainly by government laboratories, and three-dimensional numerical computation codes. Test data utilization usually is limited by the suitability of the area that has been tested. The second approach, analysis, usually requires time-consuming three-dimensional configuration data input. Recognizing the need for a quicker means of solution, useful in a preliminary design environment, a semiempirical computer methodology for determining three-dimensional aircraft afterbody performance has been developed. The essence of the approach is to construct equivalent bodies of revolution of three-dimensional bodies and then to utilize a straight or hybrid axisymmetric analysis. This approach has been developed for single- and twin-engine axisymmetric and two-dimensional afterbodies. The methodology has been verified by comparisons of afterbody drag and axial and longitudinal pressure distributions. Author

A88-49022#
CALCULATION OF LIFT-CURVE SLOPE USING A WING TIP BIASED VORTEX DISTRIBUTION
JAMES D. LOWE (Toronto, University, Canada) Journal of Aircraft (ISSN 0021-8669), vol. 25, May 1988, p. 472, 473. refs

The horseshoe vortex model presently used to calculate the lift-curve slope of a flat, untwisted rectangular wing is based on wingtip-biased cascades of vortices modifying a central vortex core. If the cascades are confined to the outer portions of the wing, the lift-curve slope may be calculated to an adequate degree of accuracy over a broad range of aspect ratios, using seven vortex elements. The resulting aerodynamic calculations are not computationally intensive, and attempt to model the qualitative properties of the flow. O.C.

A88-49024#
SPANWISE DISPLACEMENT OF A LINE VORTEX ABOVE A WING - A SIMPLE CALCULATION SCHEME
YUNGGUI JUNG and DONALD D. SEATH (Texas, University, Arlington) Journal of Aircraft (ISSN 0021-8669), vol. 25, May 1988, p. 476-478. refs
(Contract DAAG29-84-K-0131)

It is found that, in the case of the low subsonic flow conditions considered, the detailed temporal variation of a wing's trailing vortex sheet due to the deforming vortex has little effect on the motion of the vortex line over the wing surface. Attention is accordingly given to a method based on the lifting-line solution of the spanwise load distribution. The calculated bound vorticity is redistributed along the chord in accordance with 'thin airfoil theory', and surprisingly good results are obtained. O,C.

A88-49177#
APPLICATION OF VISCOUS FLOW COMPUTATIONS FOR THE AERODYNAMIC PERFORMANCE OF A BACKSWEPT IMPELLER AT VARIOUS OPERATING CONDITIONS
C. HAH, A. C. BRYANS, Z. MOUSSA, and M. E. TOMSHO (General Electric Co., Schenectady, NY) ASME, Transactions, Journal of Turbomachinery (ISSN 0889-504X), vol. 110, July 1988, p. 303-311. refs
(ASME PAPER 88-GT-39)

Three-dimensional flowfields in a centrifugal impeller with backswept discharge at various operating points have been numerically investigated with a three-dimensional viscous flow code. Numerical results and experimental data were compared for the detailed flowfields and overall performance of the impeller at three operating conditions (optimum efficiency, choke, and near-surge conditions). The comparisons indicate that for engineering applications the numerical solution accurately predicts various complex real flow phenomena. The overall aerodynamic performance of the impeller is also well predicted at design and off-design conditions. Author

A88-49178#
INTERACTION MECHANISMS BETWEEN TIP LEAKAGE FLOW AND THE PASSAGE VORTEX IN A LINEAR TURBINE ROTOR CASCADE
A. YAMAMOTO (National Aerospace Laboratory, Chofu, Japan) ASME, Transactions, Journal of Turbomachinery (ISSN 0889-504X), vol. 110, July 1988, p. 329-338. refs

In order to study the loss generation mechanisms due to the tip-leakage flow in turbine rotor passages, extensive traverse measurements were made of the three-dimensional flows in a low-speed linear cascade for various tip-clearance sizes and for various cascade inlet flow angles (or incidences). Effects of the leakage flow on the cascade downstream flow fields and interactions between the leakage flow and the passage vortices are discussed in detail based on the traverse measurements and flow-visualization tests in terms of secondary flows and the associated losses. Other traverses were also performed of the tip-casting endwall flows both inside and outside the tip-clearance gap using a micro five-hole pitot tube to reveal the axial development of the interaction throughout the cascade passage. Overall loss characteristics of the present high-turning cascade with blunt leading and trailing edges are obtained and compared with those predicted by the Ainley-Mathieson method. Author

A88-49180#
A FULL QUASI-THREE-DIMENSIONAL CALCULATION OF FLOW IN TURBOMACHINES
M. RIBAUT (Brown Boveri and Co., Ltd., Baden, Switzerland) ASME, Transactions, Journal of Turbomachinery (ISSN 0889-504X), vol. 110, July 1988, p. 401-404. refs

The problem of calculating a three-dimensional flow with three families of two-dimensional solutions is considered. From a throughflow solution and several blade-to-blade solutions the boundary values of a set of transverse solutions are obtained. The resulting overdetermined boundary condition problem is solved by means of a compatibility function defining the divergence of the transverse velocity field. The influence of the latter on the blade-to-blade solution is formulated in two different ways and compared with the experiment. The new method should considerably improve the prediction of three-dimensional cascade flow presenting a large amount of streamwise vorticity in the meridional direction. Author

N88-25436 Oklahoma Univ., Norman.
AERODYNAMICS OF LIFTING BODIES WITH COMBINED TRANSVERSE AND LONGITUDINAL CURVATURE Ph.D. Thesis
SHEAM-CHYUN LIN 1987 125 p
Avail: Univ. Microfilms Order No. DA8729877

Explicit, closed form, approximate analytical results were obtained for hypersonic flow past a body whose cross section deviates slightly from a right circular cone as a result of combined transverse and longitudinal curvature. The results are developed in the framework of hypersonic small disturbance theory and presented in similarity form. The analytic nature of the solution is particularly suitable for conducting parametric design studies of lifting body configurations. By means of these flow field solutions, a new class of waverider configurations can be constructed. The lift and drag and other pertinent characteristics can be determined by means of quadratures. An average skin friction coefficient is used to take the viscous drag into account and to be studied parametrically in a rational basis. The results indicate that combined longitudinal and transverse curvature can be used effectively to efficiently integrate volumetric, propulsion, and aerodynamic requirements for a variety of hypersonic vehicles. Dissert. Abstr.

N88-25438*# National Aeronautics and Space Administration, Washington, D.C.
A CHARACTERISTIC METHOD FOR CALCULATING THE GENERALIZED FLAT FLUTTER AERODYNAMIC FORCES
INGOLF TEIPEL Jun. 1988 17 p Transl. into ENGLISH from Ein Charakteristikenverfahren zur Berechnung der Verallgemeinerten Ebenen Flatterlufkraefte, Zeitschrist fuer

Flugwissenschaften (Federal Republic of Germany), v. 10, 1962 p 374-379 Transl. by SCITRAN, Inc., Santa Barbara, Calif. Original document prepared by Inst. for Theoretical Gasdynamics of the German Test Facility for Aerodynamics and Space Flight (DVL), Aachen, (Federal Republic of Germany)
(Contract NASW-4307)
(NASA-TT-20300; NAS 1.77:20300) Avail: NTIS HC A03/MF A01 CSCL 01A

The supersonic 2-D flow past an oscillating profile is calculated by means of a method of characteristics. The deformation of the wing chord is considered as well. In order to linearize the problem, amplitudes are assumed small. A linear method of characteristics is obtained with six dependent variables, namely amplitude and phase of the velocity components and of the pressure. Besides the lateral and rotating motion of the wing, two further mode shapes of the uniform unrestrained beam are given. The calculation is carried out for different Mach numbers and different reduced frequencies. Author

N88-25441*# Vigyan Research Associates, Inc., Hampton, Va.
A LOW SPEED WIND TUNNEL INVESTIGATION OF REYNOLDS NUMBER EFFECTS ON A 60-DEG SWEPT WING CONFIGURATION WITH LEADING AND TRAILING EDGE FLAPS
DHANVADA M. RAO and KEITH D. HOFFLER Aug. 1988 69 p
(Contract NAS1-17919)
(NASA-CR-181684; NAS 1.26:181684) Avail: NTIS HC A04/MF A01 CSCL 01A

A low-speed wind tunnel test was performed to investigate Reynolds number effects on the aerodynamic characteristics of a supersonic cruise wing concept model with a 60-deg swept wing incorporating leading-edge and trailing-edge flap deflections. The Reynolds number ranged from 0.3 to 1.6 x 10 to the 6th, and corresponding Mach numbers from .05 to 0.3. The objective was to define a threshold Reynolds number above which the flap aerodynamics basically remained unchanged, and also to generate a data base useful for validating theoretical predictions for the Reynolds number effects on flap performance. This report documents the test procedures used and the basic data acquired in the investigation. Author

N88-25442*# Southampton Univ. (England).
EMPTY TEST SECTION STREAMLINING OF THE TRANSONIC SELF-STREAMLINING WIND TUNNEL FITTED WITH NEW WALLS
M. C. LEWIS Jul. 1988 31 p
(Contract NSG-7172)
(NASA-CR-181680; NAS 1.26:181680; AASU-MEMO-86/10)
Avail: NTIS HC A03/MF A01 CSCL 01A

The original flexible top and bottom walls of the Transonic Self-Streamlining Wind Tunnel (TSWT), at the University of Southampton, have been replaced with new walls featuring a larger number of static pressure tappings and detailed mechanical improvements. This report describes the streamling method, results, and conclusions of a series of tests aimed at defining sets of aerodynamically straight wall contours for the new flexible walls. This procedure is a necessary prelude to model testing. The quality of data obtained compares favorably with the aerodynamically straight data obtained with the old walls. No operational difficulties were experienced with the new walls. Author

N88-25443*# Wichita State Univ., Kans. Inst. for Aviation Research.
CALIBRATION OF AVERAGING TOTAL PRESSURE FLIGHT WAKE RAKE AND NATURAL-LAMINAR-FLOW AIRFOIL DRAG CERTIFICATION
E. IRANI and M. H. SNYDER Feb. 1988 26 p
(NASA-CR-181630; NAS 1.26:181630; AR-87-1) Avail: NTIS HC A03/MF A01 CSCL 01A

An averaging total pressure wake rake used by the Cessna Aircraft Company in flight tests of a modified 210 airplane with a laminar flow wing was calibrated in wind tunnel tests against a five-tube pressure probe. The model generating the wake was a full-scale model of the Cessna airplane wing. Indications of drag trends were the same for both instruments. Author

N88-25444*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
PARAMETRIC FLUTTER STUDIES OF AN ARROW-WING CONFIGURATION: SOME EARLY RESULTS
MICHAEL H. DURHAM, STANLEY R. COLE, F. W. CAZIER, JR., DONALD F. KELLER, ELLEN C. PARKER, and W. KEATS WILKIE (Army Aerostructures Directorate, Hampton, Va.) May 1988 22 p Presented at the Aerospace Flutter and Dynamics Council Meeting, Las Vegas, Nev., 28-30 Oct. 1987
(NASA-TM-100608; NAS 1.15:100608) Avail: NTIS HC A03/MF A01 CSCL 01A

Some early experimental results from a combined experimental and analytical study being conducted at NASA-Langley of the transonic flutter characterisitics of a generic arrow wing configuration are presented. The planned study includes the parametric variation of a variety of structural and geometric characteristics. Presented here are flutter results of the basic arrow wing, for the basic wing with the addition of two simulated lower-surface-mounted engine nacelles, and for the basic wing with the addition of both the fin and the engine nacelles. Author

N88-25624# Joint Publications Research Service, Arlington, Va.
AERODYNAMIC ANALYSIS OF NATURAL LAMINAR FLOW AIRFOIL
N. KAWAI and N. HIROSE *In its* JPRS Report: Science and Technology. Japan p 51-54 4 May 1988 Transl. into ENGLISH from Kogiken Nyusu (Tokyo, Japan), Jan. 1988 p 5-6
Avail: NTIS HC A06/MF A01

Research into technology for laminar flow wings to greatly reduce aerodynamic frictional drag is being carried out as part of the research and development effort for innovative aviation technology to dramatically improve the performance of aircraft. Numerical analysis of natural laminar flow is discussed. Using methods of computational aerodynamics, the aerodynamic characteristics of natural laminar flow airfoils are analyzed. Specifically, using the beam warming method, a numerical analysis of the Navier-Stokes equation is performed by using a Baldwin-Lomax turbulence mode. The transition determination is modeled by empirical rules; that is, both the widely used Baldwin-Lomax determination and Michel's determination method are used and compared. Author

N88-25636# Nagoya Univ. (Japan).
NUMERICAL CALCULATION OF SUPERSONIC FLOW BY THE PNS EQUATIONS
MICHIRU YASUHARA and YOSHIAKI NAKAMURA *In* National Aerospace Lab., Proceedings of the 5th NAL Symposium on Aircraft Computational Aerodynamics p 43-48 Nov. 1987 In JAPANESE; ENGLISH summary
Avail: NTIS HC A12/MF A01

The Parabolized Navier-Stokes (PNS) equations are examined. The Euler equation was previously solved by the finite volume method. The results showed good agreement with experimental results. Then, this was extended to include viscous effect by solving the Navier-Stokes equations, using the Beam-Warming scheme. These results also showed good agreement with the Euler code. Thermal effects on the Shuttle-like body could also be obtained. The PNS equations were employed in order to reduce CPU time. Actually the calculation time was reduced to some thousands as much as the thin layer Navier-Stokes equations. The two cases were calculated. One is a hemisphere cylinder, and the other is a hemisphere-elliptic cylinder at an attack angle. The first case was compared with the time-dependent thin-layer NS equations. The comparison between them was good. The second case showed the clear effect of the attack angle as the turn of the flow from the lower surface to the upper surface. Author

N88-25637# Fuji Heavy Industries Ltd., Utsunomiya (Japan).
NAVIER-STOKES ANALYSIS OF TRANSONIC TRANSPORT AIRCRAFT EMPENNAGE
YASUHIRO KOSHIOKA, KEISUKE KAMO, and KANICHI AMANO (Japan Aircraft Development Corp., Tokyo.) *In* National Aerospace Lab., Proceedings of the 5th NAL Symposium on Aircraft Computational Aerodynamics p 49-54 Nov. 1987 In JAPANESE; ENGLISH summary
Avail: NTIS HC A12/MF A01

Flow field simulations over transonic aircraft empennage were performed based on three-dimensional Navier-Stokes equations. The computations were done for the flow fields of various Mach numbers and angles of attack to investigate the variation of the lift curve slope with the Mach number at low angle of attack, and the variation of the lift coefficient with the angle of attack at low Mach number. The value of the lift curve slope obtained by the computations show good agreement with those by experiments. While the difference between computations and experiments looks a little large about lift coefficient verses angle of attack. Author

N88-25638# Kyoto Univ. (Japan). Dept. of Engineering.
NUMERICAL SOLUTIONS OF THE EULER EQUATIONS FOR THE FLOW FIELD AROUND COUNTER-ROTATING PROPELLERS
MAKOTO KOBAYAKAWA and MASAHIRO NAKAO (Mitsubishi Heavy-Industries Ltd., Nagoya, Japan) *In* National Aerospace Lab., Proceedings of the 5th NAL Symposium on Aircraft Computational Aerodynamics p 55-63 Nov. 1987 In JAPANESE; ENGLISH summary Original language document was announced in IAA as A88-13544
Avail: NTIS HC A12/MF A01

In order to investigate the flow field around the ATP through numerical methods for its optimal design, 3D-Euler equations are most prominent. The flow field around counterrotating propellers in advancing 0.8 Mach is obtained. Two spaces including front and rear blades are solved separately. The interaction between both blades are taken into the calculation by the connecting surfaces. The noniterative implicit ADI scheme is used in order to solve Euler equations. The periodic steady and averaged steady solutions are obtained. The latter is simplified by averaging the variables at the connecting surface. This shortens the calculation time to one-third compared with the periodic steady analysis which simulates the relative motion of the blades exactly. Numerical calculations are performed for two counter rotating ATP's with SR-1 and SR-3 blades. Both results show that they are similar to each other, and the propeller efficiencies increase compared with single rotating ATP with the same blades. Author

N88-25640# Tokyo Univ. (Japan). Inst. of Computational Fluid Dynamics.
COMPUTATION OF FLOW AROUND NACA0012 AIRFOIL AT HIGH ANGLE OF ATTACK
YOSHIFUMI SHIDA and KUNIO KUWAHARA *In* National Aerospace Lab., Proceedings of the 5th NAL Symposium on Aircraft Computational Aerodynamics p 73-79 Nov. 1987 In JAPANESE; ENGLISH summary Previously announced in IAA as A87-42448
Avail: NTIS HC A12/MF A01

Transonic flow around a NACA0012 airfoil at high angle of attack is simulted 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 was done. Small vortices are observed between the leading edge and the center of the chord. Author

N88-25641# National Aerospace Lab., Tokyo (Japan).
AERODYNAMIC SIMULATION FOR COMPLETE ASKA AIRCRAFT CONFIGURATION
SUSUMU TAKANASHI and KEISUKE SAWADA (Kawasaki Heavy Industries Ltd., Kagamihara, Japan) *In its* Proceedings of the 5th NAL Symposium on Aircraft Computational Aerodynamics p 81-84 Nov. 1987 In JAPANESE; ENGLISH summary
Avail: NTIS HC A12/MF A01

A numerical simulation of transonic flows over complete ASKA aircraft configuration is performed. A computational grid system is constructed using the algebraic multi-block method. The Euler equations are numerically solved by the upwind finite volume scheme. Author

N88-25642*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
NUMERICAL SIMULATION OF VISCOUS FLOWS OVER TRANSONIC AIRCRAFT CONFIGURATIONS
SUSUMU TAKANASHI, MASAHIRO YOSHIDA, KOZO FUJII, KISA MATSUSHIMA (Fujitsu Ltd., Tokyo, Japan), and SHIGERU OBAYASHI *In* National Aerospace Lab., Proceedings of the 5th NAL Symposium on Aircraft Computational Aerodynamics p 85-89 Nov. 1987 In JAPANESE; ENGLISH summary
Avail: NTIS HC A12/MF A01

Numerical simulation of compressible viscous flow fields is performed for a transonic transport configuration. A single structured grid system is constructed using analytical transformations such as conformal mapping, shearing/twisting/rotating/clustering/stretching transformations. The Reynolds-averaged, thin-layer Navier-Stokes equations are solved on a supercomputer, FACOM VP-400, using the LU-ADI factorization method. Author

N88-25643# National Aerospace Lab., Tokyo (Japan).
CALCULATIONS OF UNSTEADY AERODYNAMICS FOR A FULL AIRCRAFT CONFIGURATION USING BOUNDARY ELEMENT METHOD
MITSUNORI YANAGIZAWA, YOSHIYUKI MORITA, and SHIGEFUMI TATSUMI (Mitsubishi Heavy-Industries Ltd., Nagoya, Japan) *In its* Proceedings of the 5th NAL Symposium on Aircraft Computational Aerodynamics p 91-101 Nov. 1987 In JAPANESE; ENGLISH summary
Avail: NTIS HC A12/MF A01

A boundary element method is presented for determining aerodynamic loadings on arbitrary configurations in oscillatory subsonic flow. Formulas (modified Morino's method) are given for the unsteady pressure distributions or unsteady force experienced in subsonic flow by the wing-store combination, oscillating in the torsional oscillations about a fixed axis parallel to the span and other oscillating modes (flapping, plunging). Interference effects from an underwing pylon store were analyzed. The method if finally verified through comparison with experiment for the model at angles of attack from -5 to +5 degrees, and reduced frequencies from 0.65 to 1.3 at low subsonic flow. Author

N88-25644# National Aerospace Lab., Tokyo (Japan).
RAREFIED GAS NUMERICAL WIND TUNNEL 3. UNIVERSAL CODE FOR THREE DIMENSIONAL BODIES
KATSUHISA KOURA, KINUYO NAKAMURA, TOSHIO ISOBE, KAZUYO SUEMATSU, MASAYUKI HATAKEYAMA, and TOSHIYUKI SHIMOJI (Facom Hitac Co. Ltd., Japan) *In its* Proceedings of the 5th NAL Symposium on Aircraft Computational Aerodynamics p 103-107 Nov. 1987 In JAPANESE; ENGLISH summary
Avail: NTIS HC A12/MF A01

The rarefied gas numerial wind tunnel is under construction using the null-collision direct-simulation Monte Carlo method. It is confirmed that the universal code (RGNWT) for three dimensional bodies is valid for general use. The vectorized code (RGNWTV) for the NAL NS system is successfully in progress. Author

N88-25665# Tsukuba Univ. (Japan). Inst. of Engineering Mechanics.
GRID GENERATION OF A HELICOPTER ROTARY-WING
ALAIN CARCASSES and Y. YOSHIZAWA *In* National Aerospace Lab., Proceedings of the 5th NAL Symposium on Aircraft Computational Aerodynamics p 247-253 Nov. 1987 In JAPANESE; ENGLISH summary
Avail: NTIS HC A12/MF A01

A method of an elliptic grid generation for a helicopter rotary-wing is proposed. The main purpose of this work is flexibility

for expected several flight conditions of helicopters. The elliptic grid generation is reduced to the method of solution of a large scale simultaneous equations. Three-dimensional grid points are rearranged into one-dimensional vectors, of which components are all the grid points in a surface of generated curvilinear coordinates. The SOR method is applied to the one-dimensional vectors in a checker board manner, and the conjugate gradient method is used to solve each equation. In the range of test calculation the proposed method is satisfactory from the viewpoints of numerical calculations. More efficiency, however, would be required for the grid generation in a larger scale of calculation.
Author

N88-26330# Tokyo Univ. (Japan). Inst. of Space and Astronautical Science.
ON THE DYNAMIC BEHAVIOR OF BALLOON DURING ITS LAUNCH; APPLICATION OF PANEL METHOD AND EXTENSION TO UNSTEADY PROBLEM
YOSHIFUMI INATANI Jul. 1987 25 p
(ISAS-RN-622; ISSN-0285-6808) Avail: NTIS HC A03/MF A01

The boundary integral method (Panel method) has been applied and extended to investigate the unsteady problem in which body shape is deformed dynamically due to flow effects inside or outside the body. Such an unsteady effect has been represented by use of an extension of the conventional panel method. The interaction between the deformation of the body and the flow field is represented as a Virtual Mass Matrix, and the motion of the body surface and the flow field are solved by tracing the control points distributed on the body surface. Integral relations of the singularity distributed on the panel are also presented. Techniques developed are applied to the dynamic simulation of a balloon launching. A series of simulation studies was carried out and the deformation of the balloon during its launch has been followed. The dynamic behavior of the balloon during launching and the load history of the balloon membrane are obtained. Author

N88-26331# Georgia Inst. of Tech., Atlanta.
WALL INTERFERENCE ASSESSMENT/CORRECTION OF DATA FROM TESTS OF A CAST 10-2/DOA 2 AIRFOIL IN THE LANGLEY 0.3-M TRANSONIC CRYOGENIC TUNNEL M.S. Thesis
CLYDE R. GUMBERT May 1988 68 p
Avail: NTIS HC A04/MF A01

A Wall Interference Assessment/Correction (WIAC) procedure developed for the 8- by 24-inch slotted wall airfoil test section of the Langley 0.3-m Transonic Cryogenic Tunnel was applied to data from three tests of the CAST 10-2/DOA 2 airfoil. The uncorrected data from these tests contained dissimilarities attributable to different model sizes and differences in test section conditions. It is shown that the upstream flow angle required as a boundary condition in the WIAC code can be deduced from the first pass through the correction code by considering the front of the model to be a flow angle probe. It is also shown that a model aspect ratio factor such as that proposed by Murthy is required to more properly account for the sidewall boundary layer contribution to the blockage interference and hence the Mach number correction. The resulting angle of attack and Mach number corrections make data from the three tests collapse over most of the range of Mach number and Reynolds number where the tests overlap. Author

N88-26332*# Texas A&M Univ., College Station. Dept. of Aerospace Engineering.
AN INITIAL INVESTIGATION INTO METHODS OF COMPUTING TRANSONIC AERODYNAMIC SENSITIVITY COEFFICIENTS Semiannual Progress Report, 1 Jan. - 30 Jun. 1988
LELAND A. CARLSON Jul. 1988 138 p
(Contract NAG1-793)
(NASA-CR-183061; NAS 1.26:183061; TAMRF-5802-88-02)
Avail: NTIS HC A07/MF A01 CSCL 01A

The initial effort was concentrated on developing the quasi-analytical approach for two-dimensional transonic flow. To keep the problem computationally efficient and straightforward, only the two-dimensional flow was considered and the problem was modeled using the transonic small perturbation equation.
B.G.

N88-26334# McDonnell-Douglas Corp., Long Beach, Calif.
IMPROVED POTENTIAL FLOW COMPUTATIONAL METHODS WITH EULER CORRECTIONS FOR AIRFOIL AND WING/BODY DESIGN Final Report, 15 Sep. 1985 - 15 Sep. 1987
L. T. CHEN and T. Q. DANG 30 Sep. 1987 60 p
(Contract N00167-85-C-0134; W23-03)
(AD-A192303; MDC-K0445; DTRC-AD-CR-01-87) Avail: NTIS HC A04/MF A01 CSCL 01A

The development of two and three dimensional Euler correction methods based on the Clebsch transformation is described. In these methods, the velocity field is decomposed into irrotational and rotational parts. A multi-grid full potential method based on both the finite difference and finite volume formulations is modified to solve for the rotational part. Two approaches are developed to solve for the rotational field. The approximate Euler-Clebsch approach assumes the entropy is convected along mesh lines, while the exact Euler-Clebsch approach solves the convection of entropy numerically along streamlines. The two approaches agree well in the airfoil application. Only the approximate Euler-Clebsch approach is employed in the three dimensional calculations. A study of finite difference and finite volume formulations of the full potential equation is also included. Solutions are presented for various airfoils, wings and an F-14 wing/body and are compared with results of the full potential and the time marching Euler methods. GRA

N88-26335*# Stanford Univ., Calif. Dept. of Aeronautics and Astronautics.
NUMERICAL STUDY OF DELTA WING LEADING EDGE BLOWING
DAVID YEH, DOMINGO TAVELLA, and LEONARD ROBERTS Jul. 1988 130 p
(Contract NCC2-341)
(NASA-CR-183101; NAS 1.26:183101; JIAA-TR-86) Avail: NTIS HC A07/MF A01 CSCL 01A

Spanwise and tangential leading edge blowing as a means of controlling the position and strength of the leading edge vortices are studied by numerical solution of the three-dimensional Navier-Stokes equations. The leading edge jet is simulated by defining a permeable boundary, corresponding to the jet slot, where suitable boundary conditions are implemented. Numerical results are shown to compare favorably with experimental measurements. It is found that the use of spanwise leading edge blowing at moderate angle of attack magnifies the size and strength of the leading edge vortices, and moves the vortex cores outboard and upward. The increase in lift primarily comes from the greater nonlinear vortex lift. However, spanwise blowing causes earlier vortex breakdown, thus decreasing the stall angle. The effects of tangential blowing at low to moderate angles of attack tend to reduce the pressure peaks associated with leading edge vortices and to increase the suction peak around the leading edge, so that the integrated value of the surface pressure remains about the same. Tangential leading edge blowing in post-stall conditions is shown to re-establish vortical flow and delay vortex bursting, thus increasing C sub L sub max and stall angle. Author

N88-26337*# National Aeronautics and Space Administration, Washington, D.C.
LUDWIG PRANDTL COLLECTED TREATISES ON APPLIED MECHANICS, HYDRO- AND AERODYNAMICS, PART 1
WALTER TOLLMIEN, HERMANN SCHLICHTING, and HENRY GOERTLER Jul. 1988 50 p Transl. into ENGLISH from Ludwig Prandtl Gesammelte Abhandlungen zur Angewandten Mechanik, Hydro- und Aerodynamik, Erster Teil. Berlin (Federal Republic of Germany), Springer-Verlag, 1961 p 254-289 Transl. by SCITRAN, Inc., Santa Barbara, Calif.
(Contract NASW-4307)
(NASA-TT-20316; NAS 1.77:20316) Avail: NTIS HC A03/MF A01 CSCL 01A

The manifold peculiarities of the laws of air resistance are able to support entirely satisfactorily the aerodynamic theory of air resistance explained here. The shape of the rear portion of the body is in many instances more important for resistance than the shape of the front section. By means of appropriate design, the resistance of aircraft bodies and similar vehicles can be reduced to close to theoretical value zero. Author

N88-26338*# National Aeronautics and Space Administration, Washington, D.C.
LUDWIG PRANDTL COLLECTED TREATISES ON APPLIED MECHANICS, HYDRO- AND AERODYNAMICS, PART 2, IV INTERFACES AND RESISTANCE
WALTER TOLMIEN, HERMANN SCHLICHTING, and HENRY GOERTLER Jul. 1988 14 p Transl. into ENGLISH from Ludwig Prandtl Gesammelte Abhandlungen zur Angewandten Mechanik, Hydro- und Aerodynamik, Zweiter Teil. Ueber Fluessigkeitsbewegung bei Sehr Kleiner Reibung, Berlin (Fed. Republic of Germany), Springer-Verlag, 1961 p 575-584 Transl. by SCITRAN, Inc., Santa Barbara, Calif.
(Contract NASW-4307)
(NASA-TT-20315; NAS 1.77:20315) Avail: NTIS HC A03/MF A01 CSCL 01A
This study describes tests and confirmation of the theories of Ludwig Prandtl concerning hydrodynamics, aerodynamics, interfaces, and drag. Author

N88-26341# National Aerospace Lab., Amsterdam (Netherlands).
CALCULATION OF 2-D UNSTEADY TRANSONIC FULL POTENTIAL FLOW ABOUT OSCILLATING AIRFOILS BY TWO COMPLEMENTARY APPROACHES
H. SCHIPPERS and M. H. L. HOUNJET 1986 16 p Presented at the 4th AIAA Applied Aerodynamics Conference, 9-11 Jun. 1986, San Diego, Calif. Previously announced in IAA as A86-49586 Sponsored by Nederlands Inst. voor Vliegtuigontwikkeling en Ruimtevaart, Delft
(PB88-127519; NLR-MP-86035-U) Avail: NTIS HC E03/MF E01; copy not available from STI Facility CSCL 01A
Results of 2-D unsteady transonic flow calculations for AGARD standard aeroelastic configurations are presented, which were obtained by numerical methods for the solution of the unsteady full potential equation. Two complementary methods were applied to oscillating transonic flow about thick blunt-nosed airfoils: (1) the time-integration TULIPS method; and (2) the time-linearized FIRANC method. The calculations were performed for the subsonic and transonic flow about the supercritical NLR 7301 airfoil, both undergoing sinusoidal pitching oscillations. The results of both methods are extensively compared. GRA

N88-26343*# Florida Univ., Gainesville. Dept. of Engineering Science, Mechanics and Aerospace Engineering.
THE DETERMINATION OF THE TOPOLOGICAL STRUCTURE OF SKIN FRICTION LINES ON A RECTANGULAR WING-BODY COMBINATION
LESLIE A. YATES and RICHARD L. FEARN Aug. 1988 13 p
(Contract NAG1-368)
(NASA-CR-4168; NAS 1.26:4168) Avail: NTIS HC A03/MF A01 CSCL 01A
A short tutorial in the application of topological ideas to the intepretation of oil flow patterns is presented. Topological concepts such as critical points, phase portraits, topological stability, and indexing are discussed. These concepts are used in an ordered procedure to construct phase portraits of skin friction lines with oil flow patterns for a wing-body combination and two angles of attack. The relationship between the skin friction phase portrait and planar cuts of the velocity field is also discussed. Author

03

AIR TRANSPORTATION AND SAFETY

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

A88-46074
COMMERCIAL OPERATION OF INTERNATIONAL AIRLINES [KOMMERCHESKAIA EKSPLUATATSIIA MEZHDUNARODNYKH VOZDUSHNYKH LINII]
VASILII GRIGOR'EVICH AFANAS'EV Moscow, Izdatel'stvo Transport, 1987, 280 p. In Russian. refs
International airline trends are examined with particular reference to Aeroflot's experience. Consideration is given to the management of the commercial activity of airline companies, marketing aspects, and the organization of ticket sales and reservations. Problems of cost setting and commercial policy are examined along with the characteristics of pool and charter airlines. Ways to enhance the efficiency of airline operations are discussed. B.J.

A88-46253
THE CERTIFICATION ASPECTS OF MICROWAVE LANDING SYSTEMS - AIRWORTHINESS CONSIDERATIONS
SIMON A. WITTS (Civil Aviation Authority, Design and Manufacturing Standards Div., Redhill, England) IN: MLS - An operational and technical review; Proceedings of the Symposium, London, England, Feb. 9, 1988. London, Royal Aeronautical Society, 1988, p. 16-25.
An outline is presented of the certification requirements that could be applied for an MLS. The importance of a research program such as the joint Boeing/British Airways/Civil Aviation Authority trial is demonstrated. The trial seeks to establish and incorporate certification requirements for straight-in 3-deg MLS approaches. K.K.

A88-46508
APPLICATION OF TEAM CONCEPT/SYSTEMS APPROACH TO INVESTIGATION OF MAJOR MISHAPS
RUDOLF KAPUSTIN (Intercontinental Aviation Safety Consultants, Baltimore, MD) IN: Information systems: Failure analysis; Proceedings of the NATO Advanced Research Workshop, Bad Windsheim, Federal Republic of Germany, Aug. 18-22, 1986. Berlin and New York, Springer-Verlag, 1987, p. 59-65. refs
The application of the team concept/systems approach (TCSA) is illustrated by a case history involving the PSA/Cessna midair collision over San Diego on September 25, 1978. It is suggested that the TCSA can be applied to the investigation of any catastrophic or noncatastrophic event or system failure. The nucleus of the investigation team and a comprehensive investigation plan must be in place and in a state of readiness at all times, and may be specifically tailored to the system that may be subject to failure and subsequent investigation. A paragraph relating to accident investigation is recommended for inclusion in a future NATO document. B.J.

A88-46511* Miami Univ., Coral Gables, Fla.
FALLIBLE HUMANS AND VULNERABLE SYSTEMS - LESSONS LEARNED FROM AVIATION
EARL L. WIENER (Miami, University, Coral Gables, FL) IN: Information systems: Failure analysis; Proceedings of the NATO Advanced Research Workshop, Bad Windsheim, Federal Republic of Germany, Aug. 18-22, 1986. Berlin and New York, Springer-Verlag, 1987, p. 163-181. refs
(Contract NCC2-377)
It is suggested that the problems being experienced in complex automatic systems are essentially due to the failure of information management and communication. The failure covers the entire spectrum: display devices and techniques, coding information so as to reduce human error, and information economy, i.e., resisting the temptation to bombard the operator with unlimited information

simply because the system possesses the capability to do so. Since there has been great progress in hardware engineering, it is suggested that further attention is needed in the 'soft' side of systems. The approach should focus on (1) preventing human cognitive slips and (2) making the systems less vulnerable to such slips when they do occur. Most of the examples are taken from studies of cockpit automation. B.J.

A88-46973
AIRPORT LOAD LEVELING BY ACTIVITY ANALYSIS
JAMES L. DUDA (Transportation Systems Center, Cambridge, MA) and CHARLES I. BARTFELD (American University, Washington, DC) IN: 1987 Annual Summer Computer Simulation Conference, 19th, Montreal, Canada, July 27-30, 1987, Proceedings. San Diego, CA, Society for Computer Simulation, 1987, p. 521-524.

A simulation model can be used to develop and analyze alternative policies for relieving airport saturation and associated travel delays, or for postponing the onset of airport saturation. An airport capacity and delay model is described as well as the data required, methodology, and assumptions. Short term, long term, physical, and nonphysical means can be identified and examined by means of simulation models of varying complexity. Author

A88-48545* National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
AIRCRAFT JOLTS FROM LIGHTNING BOLTS
FELIX L. PITTS, BRUCE D. FISHER (NASA, Langley Research Center, Hampton, VA), VLADISLAV MAZUR (NOAA, National Severe Storms Laboratory, Norman OK), and RODNEY A. PERALA (Electro Magnetic Applications, Inc., Denver, CO) IEEE Spectrum (ISSN 0018-9235), vol. 25, July 1988, p. 34-38.

The trend toward the use of composite materials and digital electronics has renewed the need to quantify the effects of lightning strikes to airplanes, since composite structures do not provide shielding equivalent to that of metal aircraft, and digital systems are potentially more susceptible to upset by electrical transients than are analog electronic systems. A research program, called the Storm Hazards Program, has been run by the National Aeronautics and Space Administration (NASA) for the past eight years and has provided the first statistically significant measurements of the electromagnetic interaction between lightning and aircraft. A NASA-owned F-106B airplane has been flown through thunderstorms about 1500 times at altitudes between 5,000 and 40,000 feet (1,500 to 12,000 meters). The airplane, lightning-hardened and outfitted with special instruments, was hit by lightning 714 times. The types of measurements made and the results are described. I.E.

N88-25448# Events Analysis, Inc., Oakton, Va.
CURRENT FIRE SAFETY DESIGN ASPECTS OF COMMUTER AIRCRAFT Final Report
RICHARD CLARKE, DEBORAH KANE, and CARLA STEWART Mar. 1988 85 p
(Contract DTFA03-86-C-00062)
(DOT/FAA/CT-87/32) Avail: NTIS HC A05/MF A01

Fire safety systems, cabin design and materials in cabin areas of ten common commuter aircraft are described. The trend in these commuter aircraft is increasing sophistication in application of materials similar to those in large commercial aircraft. Among the ten aircraft two are older, piston powered aircraft, simple in design and materials applications. Of the other larger eight aircraft, two are no longer delivered. Four newer and larger designs feature large, separate baggage compartments. Only two aircraft have overhead storage bins. One aircraft has a large interior with standing headroom. The others are much more compact, with interior storage limited to bins at the entry point. Thermoplastics and composite materials are used in the newer aircraft. Each aircraft originally was equipped with polyurethane cushions; currently, operators and manufacturers are protecting cushions with fire blocking materials. Piston powered aircraft use gasoline cabin heaters and ram cooling airflow. The other eight aircraft are turboprop using engine bleed air for cabin heating and cooling. Six aircraft are unpressurized and four are pressurized. Author

N88-25449# National Transportation Safety Board, Washington, D. C.
AIRCRAFT ACCIDENT REPORT: NORTHWEST AIRLINES, INC., MCDONNELL DOUGLAS DC-9-82, N312RC, DETROIT METROPOLITAN WAYNE COUNTY AIRPORT, ROMULUS, MICHIGAN, AUGUST 16, 1987
10 May 1988 143 p
(PB88-910406; NTSB/AAR-88/05) Avail: NTIS HC A07/MF A01 CSCL 01C

At 2046 EDT on 16 August 1987, Northwest Airlines, Inc., flight 255 crashed shortly after taking off from runway 3 center at the Detroit Wayne County Airport, Romulus, Michigan. Flight 255, a McDonnell Douglas DC-9-82, U.S. Registry N312RC, was a regularly scheduled passenger flight and was en route to Phoenix, Arizona. According to witnesses, flight 255 began its takeoff rotation about 1,200 to 1,500 feet from the end of the runway and lifted off near the end of the runway. After liftoff, the wings of the airplane rolled to the left and the right about 35 deg in each direction. The plane collided with the obstacles northeast of the runway when the left wing struck a light pole located 2,760 feet beyond the end of the runway. Thereafter the plane struck other light poles, the roof of a car rental facility, and then the ground. It continued to slide along a path aligned generally with the extended centerline of the takeoff runway. The airplane broke up as it slid across the ground and postimpact fires erupted along the wreckage path. Aboard Flight 255, 148 passengers and 6 crewmembers were killed; 1 passenger, a 4-year-old was seriously injured but survived. On the ground, two persons were killed, one seriously injured, and four suffered minor injuries. The National Transportation Safety Board determines that the probable cause of the accident was the flightcrew's failure to use the taxi checklist to ensure that the flaps and slats were extended for takeoff. Contributing to the accident was the absence of electrical power to the airplane takeoff warning system which thus did not warn the flightcrew that the airplane was not configured properly for takeoff. The reason for the absence of electrical power could not be determined. Author

N88-25450# National Transportation Safety Board, Washington, D. C.
AIRCRAFT ACCIDENT REPORT: AIR NEW ORLEANS, DBA CONTINENTAL EXPRESS FLIGHT 962 BRITISH AEROSPACE 3101 (JETSTREAM 31), N331CY, NEW ORLEANS INTERNATIONAL AIRPORT, KENNER, LOUISIANA, MAY 26, 1987
31 May 1988 63 p
(PB88-910408; NTSB/AAR-88/06) Avail: NTIS HC A04/MF A01 CSCL 01C

On 26 May 1987, at 1645 central daylight time, Air New Orleans, doing business as Continental Express flight 962, departed runway 19 at New Orleans International Airport on a scheduled commuter flight to Eglin AFB, Fla. There were two pilots and nine passengers. As the airplane reached an altitude between 150 and 200 feet, the crew felt a severe yawing motion and observed the engine torque fluctuate erratically. The captain proceeded to make an emergency landing in the departure overrun of runway 19. Follow one bounce and final touchdown, maximum braking and full reverse thrust were applied. The airplane then rolled off the overrun, across an airport access road, through an airport security fence, through a concrete highway barrier, and across a highway. The airplane struck several vehicles on the roadway during the accident sequence. Two passengers suffered serious injuries. In addition, both pilots, seven passengers, and two occupants of ground vehicles received minor injuries. The airplane was destroyed.
Author

N88-26344*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
INFLUENCE OF WIND SHEAR ON THE AERODYNAMIC CHARACTERISTICS OF AIRPLANES
DAN D. VICROY Aug. 1988 62 p Sponsored by NASA, Washington, D.C. and DOT, Washington, D.C.
(NASA-TP-2827; L-16439; NAS 1.60:2827; DOT/FAA/PS-88/15)
Avail: NTIS HC A04/MF A01 CSCL 01C

The aerodynamic effect of shear flow through a series of sensitivity studies of the wind velocity gradients and wing planform geometry parameters is investigated and characterized. The wind shear effect is computed using a modified vortex-lattice computer program and characterized through the formulation of wind shear aerodynamic coefficients. The magnitudes if the aerodynamic effects are demonstrated by computation of the resultant change in the aerodynamics of a conventional wing and horizontal stability configuration on a fixed flight path through a simulated microburst. The results indicate that as much as 20 percent of the control authority of the airplane may be required to counteract the wind-shear-induced forces and moments in the microburst environment. Author

N88-26345# National Transportation Safety Board, Washington, D. C.
AIRCRAFT ACCIDENT REPORT: JOE FOSTER EXCAVATING, INC., BELL 206B, N49606, IN-FLIGHT COLLISION WITH TREES, ALAMO, CALIFORNIA, AUGUST 3, 1986
2 May 1988 27 p
(PB88-910405; NTSB-AAR-88-04) Avail: NTIS HC A03/MF A01 CSCL 01C

On August 3, 1986, at 1235 Pacific daylight saving time, a Bell 206B helicopter, N49606, owned and operated by Joe Foster Excavating, Inc., Danville, California, crashed in a wooded area in Alamo, California, while circling a residence. Visual meteorological conditions prevailed at the time. The pilot and passenger, the owner of the helicopter, sustained fatal injuries; the helicopter was destroyed. The National Transportation Safety Board determines that the probable cause of this accident was the pilot's incapacitation resulting from a myocardial event. Contributing to the cause of the accident was the pilot's failure to comply with the provisions of both his medical and pilot certificates and the inadequate procedures used by the Federal Air Surgeon to medically recertify the pilot. Author

N88-26346# National Transportation Safety Board, Washington, D. C.
AIRCRAFT ACCIDENT REPORT: MIDAIR COLLISION OF SKYWEST AIRLINES SWEARINGEN METRO 2, N163SW, AND MOONEY M20, N6485U, KEARNS, UTAH, JANUARY 15, 1987
15 Mar. 1988 71 p
(PB88-910404; NTSB-AAR-88-03) Avail: NTIS HC A04/MF A01 CSCL 01C

On January 15, 1987, at about 1252 mountain standard time, SkyWest flight 1834, a Swearingen SA-226TC (METRO 2), and a Mooney M20 collided in flight over Kearns, Utah, in visual meteorological conditions. The two pilots and six passengers aboard the METRO 2 and the two pilots aboard the Mooney were killed in the accident which occurred within the confines of the Salt Lake City airport radar service area. The National Transportation Safety Board determines that the probable cause of this accident was lack of navigational vigilance by the Mooney instructor pilot which led to the unauthorized intrusion into the Salt Lake City airport radar service area. Contributing to the accident were the absence of a mode-C transponder on the Mooney airplane and the limitations of the air traffic control system to provide collision protection under the circumstances of this accident. Author

N88-26347*# Princeton Univ., N. J. Dept. of Mechanical and Aerospace Engineering.
INTELLIGENT GUIDANCE AND CONTROL FOR WIND SHEAR ENCOUNTER Biannual Progress Report
ROBERT F. STENGEL 21 Jul. 1988 101 p
(Contract NAG1-834)
(NASA-CR-183060; NAS 1.26:183060; PR-150-6549-1) Avail: NTIS HC A06/MF A01 CSCL 01C

The principal objective is to develop methods for assessing the likelihood of wind shear encounter, for deciding what flight path to pursue, and for using the aircraft's full potential for combating wind shear. This study requires the definition of both deterministic and statistical techniques for fusing internal and external information, for making go/no-go decisions, and for generating commands to the aircraft's cockpit displays and autopilot for both manually controlled and automatic flight. The program has begun with the development of a real-time expert system for pilot aiding that is based on the results of the FAA Windshear Training Aids Program. A two-volume manual that presents an overview, pilot guide, training program, and substantiating data provides guidelines for this initial development. The Expert System to Avoid Wind Shear (ESAWS) currently contains over 140 rules and is coded in the LISP programming language for implementation on a Symbolics 3670 LISP machine. Author

N88-26350# Boeing Commercial Airplane Co., Seattle, Wash.
ENHANCED EMERGENCY SMOKE VENTING Final Report
ELLIOTT L. MAYLOR Jul. 1988 96 p
(Contract DTFA03-87-C-00038)
(DOT/FAA/CT-88/22) Avail: NTIS HC A05/MF A01

This study evaluated two concepts modifying the air conditioning systems of large commercial airplanes to enhance the venting of smoke that may be continuously injected into the passenger cabin during inflight fire emergencies. Data from past fire accidents and airplane tests provided a basis for creating four fire/smoke scenarios and deriving five sets of equations to predict the smoke venting effectiveness of current airplanes and the proposed concepts. Concept A would modify the air conditioning packs by adding high flow modes with dual outflow valves and Concept B would add ram air ventilation with an added dump valve. The estimated costs to incorporate Concept A or B in the U.S. fleet were about 381 or 587 million dollars, respectively. The effectiveness equations predicted that both concepts would provide only slightly significant smoke venting enhancement. Furthermore, the study showed that both concepts would have been negated by reported crew actions and/or fire damage in past fires. It was concluded that current U.S. fleet airplanes will keep a majority of the passenger cabin free of smoke during inflight fires while the air conditioning systems are kept operating. Author

04

AIRCRAFT COMMUNICATIONS AND NAVIGATION

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

A88-46251
MLS - AN OPERATIONAL AND TECHNICAL REVIEW; PROCEEDINGS OF THE SYMPOSIUM, LONDON, ENGLAND, FEB. 9, 1988
Symposium sponsored by the Royal Aeronautical Society. London, Royal Aeronautical Society, 1988, 80 p. For individual items see A88-46252 to A88-46259.

The conference presents papers on MLS development and UK requirements, the certification aspects of microwave landing systems, UK MLS operational trails, and the FAA viewpoint on MLS operational benefits. Other topics include RAF plans for MLS, an industry view of the future of MLS, and the opinion of an international airline. Consideration is also given to the UK regional airline point of view. K.K.

A88-46252
MLS DEVELOPMENT AND UK REQUIREMENTS
J. L. LAWSON (Civil Aviation Authority, London, England) IN: MLS - An operational and technical review; Proceedings of the Symposium, London, England, Feb. 9, 1988. London, Royal Aeronautical Society, 1988, p. 1-15.

The program developed by the UK Civil Aviation Authority to meet the international transition requirements of MLS is described. The program strives to produce an equipment specification to meet an MLS proving phase and subsequent UK procurement program

before the peak worldwide demand arises. The environment is discussed as well as the ground system, ground and flight inspection, and operational data. K.K.

A88-46254
UK MLS OPERATIONAL TRIALS
B. TREMAIN (British Airways, PLC, Hounslow, England) IN: MLS - An operational and technical review; Proceedings of the Symposium, London, England, Feb. 9, 1988. London, Royal Aeronautical Society, 1988, p. 26-41.

The participation by British Airways in the UK operational trials program at Heathrow is described. Particular attention is given to a Boeing 757 which was equipped with three MLS receivers and an additional flight data recording system for the purpose of these trials. It is noted that the MLS installation already has many of the features that will be required for MLS automatic landings. K.K.

A88-46255
MLS: OPERATIONAL BENEFITS - THE FAA VIEWPOINT
J. M. DEL BALZO (FAA, Washington, DC) IN: MLS - An operational and technical review; Proceedings of the Symposium, London, England, Feb. 9, 1988. London, Royal Aeronautical Society, 1988, p. 42-50.

The reasons for aircraft delays at the major airports are outlined and initiatives being pursued by the FAA and the airline industry to reduce delays are outlined. It is believed that MLS will dramatically improve airport capacity. It can make better use of terminal airspace, provide independent arrival and departure streams at major airports, reduce airspace conflicts, and minimize noise impacts near airports. K.K.

A88-46256
RAF PLANS FOR MLS
K. G. BENNETT (Ministry of Defence /Air/, Directorate of Signals, England) IN: MLS - An operational and technical review; Proceedings of the Symposium, London, England, Feb. 9, 1988. London, Royal Aeronautical Society, 1988, p. 51-56.

The reasons for NATO's decision to replace PAR with the time-referenced scanning beam MLS at all its main bases are outlined. From a military point of view, offset or curved approaches will increase runway utilization. Thus, recovering aircraft will be able to avoid nearby missile engagement zones. The system only needs to radiate when an aircraft is on the approach; it can be triggered from the air. The plans for MLS in the RAF are discussed in detail. K.K.

A88-46257
AN INDUSTRY VIEW OF THE FUTURE OF MLS
P. J. TAYLOR (Plessey Radar Systems, Ltd., Cowes, England) IN: MLS - An operational and technical review; Proceedings of the Symposium, London, England, Feb. 9, 1988. London, Royal Aeronautical Society, 1988, p. 57-62.

A general industry view of the future of MLS is given on the basis of comparison between MLS and ILS. MLS offers many technical advantages, including smaller transmitter systems that are easier and cheaper to install, and more accurate guidance information. In a discussion of a manufacturer's view of the MLS market, consideration is given to operational requirement and user need, market size, market timescales, competition, and threats. K.K.

A88-46258
AN INTERNATIONAL AIRLINE'S OPINION
J. TEEUW (KLM Royal Dutch Airlines, Schiphol, Netherlands) IN: MLS - An operational and technical review; Proceedings of the Symposium, London, England, Feb. 9, 1988. London, Royal Aeronautical Society, 1988, p. 63-70.

It is believed that the replacement of ILS with MLS as a standard ICAO approach system can only be justified if it is needed to solve the limitations of ILS for the straight-in approach. It is maintained that this replacement means a great investment for the States and the airlines. In the transition from ILS to MLS, consideration should be given to the airlines' low visibility operation. K.K.

A88-46259
THE UK REGIONAL AIRLINE VIEW
D. HENRY (Air UK Leisure, England) IN: MLS - An operational and technical review; Proceedings of the Symposium, London, England, Feb. 9, 1988. London, Royal Aeronautical Society, 1988, p. 71-74.

The advantages and disadvantages of the MLS program are outlined. While MLS does provide frequency protection, it is maintained that, for the regional operator, the cost of MLS is too high to justify its use when ILS has itself advanced considerably. The operational impact of the change is considered with emphasis placed on the interim period when both ILS and MLS will be operational, and then the long-term use of MLS only. K.K.

A88-46263
SOME ASPECTS OF AUTOMATIC SPEECH RECOGNITION UNDER HELICOPTER VIBRATION
G. M. ROOD and C. LEEKS (Royal Aircraft Establishment, Human Engineering Div., Farnborough, England) IN: Helicopter vibration and its reduction; Proceedings of the Symposium, London, England, Nov. 16, 1987. London, Royal Aeronautical Society, 1987, p. 31-49. refs

Attention is given to the problem of helicopter vibration-induced performance degradation in cockpit direct voice input (DVI) control systems. The problem is especially acute at the two resonant frequencies of the larynx. Data have been obtained for DVI of single digits and triple digits; the latter is understandably the more severely affected by the 20-Hz vertical vibration condition. Speech recognition is also substantially affected and calls for additional helicopter noise-reduction efforts. O.C.

A88-46512
ERROR AUDITING IN AIR TRAFFIC CONTROL
JACOB EMPSON (Hull, University, England) IN: Information systems: Failure analysis; Proceedings of the NATO Advanced Research Workshop, Bad Windsheim, Federal Republic of Germany, Aug. 18-22, 1986. Berlin and New York, Springer-Verlag, 1987, p. 191-198. refs

Langan-Fox and Empson (1985) applied the technique of error auditing in the setting of ATC. This paper summarizes their results and evaluates the implications for improving safety in ATC in the contexts of training, maintenance of standards, and the improvement of the working environment. Central to the error-auditing approach is the notion that errors are not merely accidental but are seen as the consequence of poor planning or the inadequate execution of reasonable plans. B.J.

A88-46521
PROJECT ROSAR - A HIGH-RESOLUTION, ALL-WEATHER VISIBILITY METHOD FOR HELICOPTERS [PROJEKT ROSAR - EIN HOCHAUFLOESENDES ALLWETTERSICHTVERFAHREN FUER HUBSCHRAUBER]
HELMUT KLAUSING, WOLFGANG KEYDEL (DFVLR, Institut fuer Hochfrequenztechnik, Oberpfaffenhofen, Federal Republic of Germany), and HORST KALTSCHMIDT (Messerschmitt-Boelkow-Blohm GmbH, Ottobrunn, Federal Republic of Germany) DFVLR-Nachrichten (ISSN 0011-4901), June 1988, p. 29-32. In German.

The development of a rescue method using helicopters with an all-weather visibility system aboard is discussed. The use of an expanded antenna aperture and of synthetic aperture radar (SAR) as solutions to the visibility problem is addressed. The concept of a rotating SAR, or ROSAR, for all-weather visibility is described. C.D.

A88-47194
BEACON NAVIGATION
A. C. FRY (British Aerospace, PLC, London, England) IN: Remotely

piloted vehicles; Proceedings of the Sixth International Conference, Bristol, England, Apr. 6-8, 1987, Conference Papers. Bristol, England, University of Bristol, 1987, p. 21.1-21.4.

The present beacon navigation system for RPVs employs a ground-emplaced beacon that remains quiescent until interrogated in a code that is unique to that specific beacon. Prior to launch, the RPV's memory would be loaded with various instructions; the approximate positions of all beacon emitters previously dropped onto the area of interest would be known, together with their individual codes. The interrogation technique can be used to progress from one beacon to another, using them as way-points to provide midcourse guidance to the area of interest. O.C.

N88-26353# Eurocontrol Experimental Centre, Bretigny (France).
STATISTICAL PROPERTIES OF REAL TIME EVENTS IN AN ATC (AIR TRAFFIC CONTROL) SYSTEM
H. P. ENGLMEIER and P. HUNT Jun. 1987 28 p
(PB88-118781; EEC-205) Avail: NTIS HC E04/MF E04; copy not available from STI Facility CSCL 17G

The analysis of the flow of data in a processing system concerning air traffic control is described. It was found that the frequency of events or interrupts when expressed as a function of the time interval between two consecutive events or interrupts follows a lognormal distribution or a superposition of several lognormal distributions. The analysis, the validity of the results, the theoretical background and possible applications for real time systems are treated. Author

05

AIRCRAFT DESIGN, TESTING AND PERFORMANCE

Includes aircraft simulation technology.

A88-46062
DESIGN OF AIRCRAFT STRUCTURES [PROEKTIROVANIE KONSTRUKTSII SAMOLETOV]
ELENA SERGEEVNA VOIT, ASKOL'D IVANOVICH ENDOGUR, ZAVEN ASHOTOVICH MELIK-SARKISIAN, and IGOR' MIKHAILOVICH ALIAVDIN Moscow, Izdatel'stvo Mashinostroenie, 1987, 416 p. In Russian. refs

This work elaborates the principles underlying the design of aircraft structural components (wings, fuselages, tail assemblies, etc.) and considers methods for assuring structural stability with minimum weight. Algorithms for the design of junctions between components are examined, and requirements on the total structural design of an aircraft are presented along with criteria for the optimization of design solutions. The role of fabrication processes and the materials used in the choice of design is considered. B.J.

A88-46212
DESIGN CONSIDERATIONS FOR THE AVOIDANCE OF G-LOC
C. HANSFORD (British Aerospace, PLC, London, England) IN: High G and high G protection - Aeromedical and operational aspects; Proceedings of the Symposium, London, England, Oct. 21, 1987. London, Royal Aeronautical Society, 1987, p. 78-88.

A speculative treatment is presented for high pilot reclination cockpit configurations aimed at minimizing the effects of high +G(z) on pilot performance. These high-reclination seating arrangements pose fundamental questions of canopy visibility, instrument visibility, and ejection seat type and trajectory. In the future, the threat posed by pilot-blinding laser weapons may substantially alter the role of external visibility in pilot seating geometries. A totally supine pilot position yields near-ideal G tolerance in both normal flight and cockpit-capsule ejection. O.C.

A88-46242
FLIGHT-TEST OF TURBULENT SKIN-FRICTION REDUCTION BY RIBLETS
J. DOUGLAS MCLEAN, DEZSO N. GEORGE-FALVY, and PETER P. SULLIVAN (Boeing Commercial Airplane Co., Seattle, WA) IN: Turbulent drag reduction by passive means; Proceedings of the International Conference, London, England, Sept. 15-17, 1987. Volume 2. London, Royal Aeronautical Society, 1987, p. 408-424. refs

Plastic riblet film developed by the 3M Company was flight tested on the upper surface of the wing of a T-33 airplane. Increments in the average skin friction of the riblet surface relative to a smooth surface were determined by rakes of pitot tubes at 83 percent chord. For optimum combinations of groove spacing and Reynolds number, average skin-friction reductions of about 6 percent were observed. The local scaling relationship implied by earlier NASA data was found to apply in an average sense over the length of the test surface, and the riblets were found to remain effective in the adverse pressure gradient on the aft portion of the wing. Finite-difference calculations of the boundary-layer development, with a modification to the eddy viscosity to account for the riblet effect, were found to be helpful in interpreting the data. Author

A88-46260
HELICOPTER VIBRATION AND ITS REDUCTION; PROCEEDINGS OF THE SYMPOSIUM, LONDON, ENGLAND, NOV. 16, 1987
Symposium sponsored by the Royal Aeronautical Society. London, Royal Aeronautical Society, 1987, 154 p. For individual items see A88-46261 to A88-46270.

The present conference discusses the origin of helicopter vibration and its control methods, the physiological effects of helicopter vibration, effective automatic speech recognition methods in a helicopter vibration environment, and the assessment of helicopter vibration exposure in operators. Also discussed are civil helicopter operations; helicopter vibration control in the UK's fleet air arm; efficient rotor track and balance diagnostics; RAF vibration control methods; UK Army experience with the Lynx helicopter's head absorber; and helicopter vibration minimization through blade design, higher harmonic pitch, and active structural response control methods. O.C.

A88-46261
HELICOPTER VIBRATION - ITS ORIGIN AND METHODS OF CONTROL
D. E. H. BALMFORD (Westland Helicopters, Ltd., Yeovil, England) IN: Helicopter vibration and its reduction; Proceedings of the Symposium, London, England, Nov. 16, 1987. London, Royal Aeronautical Society, 1987, p. 1-19. refs

Of the various methods available for the control of helicopter vibration, the most important are the minimization of rotor-generated loads, attention to fuselage design, and in-service diagnostic and remedial procedures. Emphasis is presently placed on the control of rotor loads, since while compensatory structural modifications of the fuselage are possible at the development stage, rotor system redesign is virtually impossible. Reliable mathematical models for rotor load control are noted to be essential. O.C.

A88-46265
CIVIL OPERATIONS
K. KNIGHT (Bristow Helicopters, Ltd., Redhill, England) IN: Helicopter vibration and its reduction; Proceedings of the Symposium, London, England, Nov. 16, 1987. London, Royal Aeronautical Society, 1987, p. 70-85.

The aim of a Health and Usage Monitoring system is to supplant subjective pilot reports as to helicopter vibration levels in civil operations, thereby obviating engineering data gathering on routine flights. By pinpointing the most likely maintenance requirements of the rotor systems in question, engineering effort will be reduced, aircraft availability will be improved, and operating costs will be lowered. O.C.

A88-46266
HELICOPTER VIBRATION CONTROL IN THE FLEET AIR ARM
P. J. LEGGE (Ministry of Defence, London, England) IN: Helicopter vibration and its reduction; Proceedings of the Symposium, London, England, Nov. 16, 1987. London, Royal Aeronautical Society, 1987, p. 86-92.

The structured vibration-control organization based on Vibration Control Cells at UK Royal Navy Fleet Air Arm stations has proven capable of obtaining significant reductions in in-service vibration levels for Sea King helicopters. The 1R and 5R main rotor vibration levels now average between 50 and 75 percent of specified thresholds. In addition, the compilation of data bases for each type of vibration, relating maintenance actions to vibration levels, is improving understanding of vibration problems. O.C.

A88-46268
VIBRATION CONTROL AT RAF ODIHAM
A. M. VERDON (Ministry of Defence, London, England) IN: Helicopter vibration and its reduction; Proceedings of the Symposium, London, England, Nov. 16, 1987. London, Royal Aeronautical Society, 1987, p. 98-106.

The RAF has resorted to Rotor Track and Balance (RTB) advanced equipment and techniques to address serious rotor-generated vibration problems with the Chinook helicopter. One such RTB method developed for the Chinook has involved the balancing of the main-rotor head assemblies on the aircraft at 100 percent rotor rpm, with the blades removed; increasing numbers of blades have been exhibiting chordwise mass imbalance. The various RTB techniques have proven to be applicable to Puma, Sea King, and Wessex helicopters as well. O.C.

A88-46269
ARMY EXPERIENCE WITH LYNX HEAD ABSORBER
M. R. NEWBY (Ministry of Defence, Logistic Executive /Army/, England) IN: Helicopter vibration and its reduction; Proceedings of the Symposium, London, England, Nov. 16, 1987. London, Royal Aeronautical Society, 1987, p. 107-115.

The UK Army's Lynx helicopter, designed for high speed and agility, experiences high inherent levels of 4R main rotor vibration; attention has consequently been given to the use of a rotor head vibration absorber that employs the structural deformation of beams as a spring mechanism. The absorber operates in the rotor disk plane and is tuned to the main rotor blade passing frequency. An optimum tuning method has been developed, whereby the absorber is tuned to the lowest overall vibration level. O.C.

A88-46270
BLADE DESIGN, HIGHER HARMONIC PITCH AND ACTIVE STRUCTURAL RESPONSE CONTROL FOR HELICOPTER VIBRATION MINIMISATION
S. P. KING and P. T. W. JUGGINS (Westland Helicopters, Ltd., Yeovil, England) IN: Helicopter vibration and its reduction; Proceedings of the Symposium, London, England, Nov. 16, 1987. London, Royal Aeronautical Society, 1987, p. 116-151.

Attention is given to the problem of helicopter main-rotor-blade passing-frequency vibrations, which are equal to the product of the number of blades and the rotor speed. Unlike the 1R vibration, which can be controlled by careful rotor track and balance, the blade passing-frequency vibration is inherent in the rotor's aerodynamics. A mathematical model is formulated to analyze blade response, in the space and time domains, in terms of modal and harmonic coordinates. O.C.

A88-46311
MODERN COMBAT AIRCRAFT DESIGN
KLAUS HUENECKE Annapolis, MD, Naval Institute Press, 1987, 253 p. Translation. refs

Recent advances in the design of combat aircraft are traced in extensive photographs, drawings, and tables of numerical data and discussed. Topics addressed include the combat and handling capabilities required of modern aircraft, the phases of the aircraft design process, aerodynamics, stability and control, and engines. Particular attention is given to air-intake design, problems in the design of aircraft tails, performance parameters, armament, avionics, cockpit instrumentation, CCV designs, and new materials. T.K.

A88-46324#
THE USE OF CFD IN HELICOPTER AERODYNAMIC DESIGN
PATRICK H. WHYTE (Bell Helicopter Textron, Fort Worth, TX) Canadian Aeronautics and Space Journal (ISSN 0008-2821), vol. 34, June 1988, p. 92-101. refs

The present discussion of CFD techniques' application in helicopter aerodynamic design gives attention to the design and analysis of main rotor blade airfoils, comparing pertinent experimental data with the analytical results obtained, and discussing the generation of semiempirical airfoil data tables; these tables play a central role in the prediction of hover and forward flight performance. An evaluation of current CFD limitations in these applications is followed by projections of future helicopter aerodynamics CFD methods' performance. O.C.

A88-46439
IMPACT OF ELECTRICAL FLIGHT CONTROL SYSTEMS ON A320 FLIGHT SIMULATOR DATA ACQUISITION
E. CHATRENET, M. LEIBER, and N. WARNER (Airbus Industrie, Blagnac, France) IN: The acquisition and use of flight simulation technology in aviation training; Proceedings of the International Conference, London, England, Apr. 27-29, 1987. Volume 2. London, Royal Aeronautical Society, 1987, p. 282-316.

The paper examines how the electrical flight control system (EFCS) of the A320 will improve the quality of the data and enhance the overall fidelity of simulation. It is shown that the global accuracy mainly relies on control-law modeling. It is concluded that the EFCS technology provides for a unique opportunity to feed analytical inputs to aircraft control surfaces which can easily be duplicated in the simulators, and permits an automatic identification program to be implemented by the aircraft manufacturer, which improves the overall accuracy of the aerodynamic model. B.J.

A88-47183
REMOTELY PILOTED VEHICLES; PROCEEDINGS OF THE SIXTH INTERNATIONAL CONFERENCE, BRISTOL, ENGLAND, APR. 6-8, 1987, CONFERENCE PAPERS AND SUPPLEMENTARY PAPERS
Conference sponsored by the Royal Aeronautical Society and University of Bristol. Bristol, England, University of Bristol, 1987, p. Conference Papers, 135 p.; Supplementary Papers, 75 p. For individual items see A88-47184 to A88-47200.

The present conference on RPV systems and component technologies discusses topics in RPV operational philosophy, navigation and guidance techniques, and relationships among imaging systems, data-links, and ground stations. Attention is given to NATO RPV-development initiatives, an operational evaluation of military RPVs, a highly maneuverable unmanned aircraft, the Seafly 200 sea-skimming target for close-in weapon simulation, the BMAD/NPT 171 propulsion system, and compact electromechanical actuators for high-performance RPV flight control. Also discussed are operational software for numerical RPV autopilot design, integrated fly-by-sensor controls for air vehicles and sensor platforms, automated route planning using knowledge-based systems, IR linescan for RPV applications, and a covert and ECM-resistant data-link for RPV airborne surveillance. O.C.

A88-47184
DESIGN AND OPERATION OF LOW COST REMOTELY-PILOTED AIRCRAFT FOR SCIENTIFIC FIELD RESEARCH
D. J. THURLING (Oxford Polytechnic, England) IN: Remotely piloted vehicles; Proceedings of the Sixth International Conference, Bristol, England, Apr. 6-8, 1987, Conference Papers. Bristol, England, University of Bristol, 1987, p. 5.1-5.8. refs

A development status evaluation is presented for the use of low-cost RPVs as civilian research tools, with a view to prospective technology-development and applications trends. Applications that

have been conducted to date encompass aerial photography, atmospheric monitoring, pesticide-spraying, and insect trapping. At present, low-cost systems with limited range and maneuverability are popular; RPVs with greater operating ranges and payloads are, however, becoming more widely used, and universally applicable, mass-produced commercial RPVs with interchangeable payload modules of substantial capacity are expected to emerge. O.C.

A88-47187
UMMA - DOING IT DIFFERENTLY
NOEL FALCONER (Eyrie Enterprises, England) IN: Remotely piloted vehicles; Proceedings of the Sixth International Conference, Bristol, England, Apr. 6-8, 1987, Conference Papers. Bristol, England, University of Bristol, 1987, p. 9.1-9.8.

The Un-Manned Micro-Aircraft (UMMA) project is a proprietary attempt to develop an RPV for civil applications that uniquely employs an all-wing, 'Merlin' configuration in conjunction with Ni-Cd battery-powered electrical propulsion. Attention is presently given to the prospects currently emerging for improved battery-powered electrical propulsion power and efficiency, as well as to the considerable difficulties encountered in the stabilization of the UMMA's all-wing configuration. The payload for this RPV is a single camera. O.C.

A88-47211
TESTING LARGE AIRCRAFT STRUCTURES
R. C. SCHWARZ (Grumman Corp., Aircraft Systems Div., Bethpage, NY) IN: Dynamic failure; Proceedings of the 1987 SEM Fall Conference, Savannah, GA, Oct. 25-28, 1987. Bethel, CT, Society for Experimental Mechanics, Inc., 1987, p. 107-111.

Static and fatigue test methods for large aircraft structures of fiber-reinforced composite materials are described and illustrated with examples involving the horizontal stabilizer for the B-1 bomber. Consideration is given to the static loading tests (at temperatures up to 127 C), the design of the 138-step fatigue-test sequence to simulate mission loading, the failing-load test (which found a failure load equal to 132 percent of the ultimate design load), and the fatigue-test instrumentation. Diagrams, drawings, graphs, and photographs are provided. T.K.

A88-47213
DAMAGE TOLERANCE OF A COMPOSITE MULTIRIB WING BOX
RAY E. HORTON (Boeing Military Airplane Co., Seattle, WA) and EDVINS DEMUTS (USAF, Flight Dynamics Laboratory, Wright-Patterson AFB, OH) IN: Dynamic failure; Proceedings of the 1987 SEM Fall Conference, Savannah, GA, Oct. 25-28, 1987. Bethel, CT, Society for Experimental Mechanics, Inc., 1987, p. 150-159.

The design and damage-tolerance testing of a 2.5 x 4 x 8-ft multirib CFRP wing box for a large transport aircraft are described and illustrated with extensive diagrams, drawings, graphs, and photographs. The problem of visibly undetectable impact damage is discussed; the overall design concept and FEM analysis of the wing box are outlined; and the inspection, damage-induction, and test procedures are characterized in detail. The box survived two cyclic load lifetimes and was then tested to failure, which occurred at the damaged sites at about 105 percent of the design goal. T.K.

A88-48025#
PTA FLIGHT TEST OVERVIEW
D. T. POLAND, H. W. BARTEL (Lockheed Aeronautical Systems Co., Marietta, GA), and P. C. BROWN (United Technologies Corp., Hamilton Standard Div., Windsor Locks, CT) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference and Exhibit, 24th, Boston, MA, July 11-13, 1988. 12 p. refs
(AIAA PAPER 88-2803)

The propfan offers on the order of 20-percent improvement in propulsive efficiency at Mach 0.7-0.85, with commensurate benefits in DOC when compared with turbofans. In August 1984, NASA-Lewis initiated a program for the design, modification, and flight testing of a propfan propulsion system on a Gulfstream GII aircraft. Descriptions are presented of the testbed aircraft modifications, test instrumentation, and flight test program. Preliminary test results are presented for propfan structural behavior, near-field noise, and far-field noise. Author

A88-48451
SUKHOI FLANKER
Air International (ISSN 0306-5634), vol. 35, Aug. 1988, p. 69-76.

An account is given of the design features, observed armaments, and likely performance capabilities of the Soviet Union's Sukhoi Su-27 air defense fighter, designated 'Flanker' by NATO. The Flanker-B variant, which is the production version towards which development test program of the Flanker-A preproduction aircraft led, possesses two wingtip missile launchers for self-defense together with four underwing and four fuselage-belly pylons for longer-range interception missiles. The single-seat aircraft incorporates two new Tumansky turbofans of 0.5-1.0 bypass ratio and nearly 30,000 lbs thrust output, which in conjunction with a 50,000 lb takeoff weight (with full internal fuel load and six 'Alamo' AAMs) afford a speed of Mach 2.0 on afterburners. O.C.

A88-48453
THE HIGH TECHNOLOGY TEST BED PROGRAM
HUGH W. COPELAND and SANDRA K. HOFFMANN (Lockheed Aeronautical Systems Co., Marietta, GA) Lockheed Horizons (ISSN 0459-6773), May 1988, p. 36-46.

The proprietary High Technology Test Bed (HTTB) program was launched in 1984 in order to perform in-flight validation of technologies anticipated to be essential in achieving the performance requirements of future tactical transport aircraft. A stretched-fuselage commercial version of the C-130 was chosen as the technology-integration test vehicle, and fitted with a real-time performance data monitoring system composed of 1024 data channels. In order to accomplish the requisite STOL mission, many improvements have been made to the HTTB's control surfaces and flight control system. Fly-by-wire controlled composite-material spoilers on the wing upper surfaces furnish direct lift control; these, in concert with extended-chord ailerons, enhance low-speed lateral control characteristics. O.C.

A88-48458
AVANTI- PUSHING AHEAD TO CERTIFICATION
HARRY HOPKINS Flight International (ISSN 0015-3710), vol. 134, July 23, 1988, p. 22-26.

A flight test report is presented for the P.180 Avanti seven-seat exectutive aircraft, which is currently undergoing certification-related trials for entry into the U.S. market. Attention is given to the design details of this 'three-surface' canard-and-tailplane configuration, whose propulsion system encompasses two pusher turboprops mounted at the inboard portions of high aspect ratio (and accordingly high natural laminar flow) wings, as well as to the design's adequacy in the reconciliation of conflicting requirements for stability and high maneuverability. A climb to 27,000 ft was noted to take only 14 min from liftoff. A cruise of Mach 0.61 (370 kt) was then achieved. At the high altitude of 32,000 ft, Mach 0.635 (385 kt) was possible. O.C.

A88-48471
CALCULATION OF AIRCRAFT FATIGUE AND DAMAGE TOLERANCE [CALCUL DES AVIONS EN FATIGUE ET EN TOLERANCE AUX DOMMAGES]
C. PETIAU and R. J. CAZES (Avions Marcel Dassault Breguet Aviation, Saint-Cloud, France) Revue Francaise de Mecanique (ISSN 0373-6601), no. 1, 1988, p. 5-12. In French.

Classical fatigue analysis and damage tolerance methods for determining aircraft service life are reviewed for both metallic and composite structures. Limitations of the safe-life criteria and of crack initiation analysis methods based on the Wohler curves are pointed out. The more comprehensive fail-safe method involves the local stress analysis of critical zones, the calculation of stress intensity factors, and the analysis of crack propagation. Although

carbon-resin composites are not significantly affected by fatigue, in contrast to metallic materials, it is noted that the possibilities of damage by fabrication defects or accidental impact must be taken into account. R.R.

A88-48472
COMMERCIAL AIRCRAFT STRUCTURE FATIGUE - ANALYSIS OF EXPECTED IN-SERVICE LOADING AND THE PREDICTION OF STRUCTURAL COMPONENT BEHAVIOR [LA FATIGUE D'UNE STRUCTURE D'AVION CIVIL - ANALYSE DES SOLLICITATIONS ATTENDUES EN SERVICE ET PREVISIONS DU COMPORTEMENT DES ELEMENTS STRUCTURAUX]
B. HECIAK (Aerospatiale, Toulouse, France) Revue Francaise de Mecanique (ISSN 0373-6601), no. 1, 1988, p. 13-22. In French. refs

A method for incorporating fatigue and damage tolerance aspects into the design of the structure of a commercial aircraft is presented. Design goals include extending aircraft life without increasing mass. The development of calculation methods for analyzing the loading spectra which take into account the propagation delay phenomena is considered. The importance of acquiring material data on crack propagation and fatigue resistance using aircraft models is pointed out. The present method is demonstrated with the analysis of a structural detail of the A310-200. R.R.

A88-48476#
INTEGRATED AIRCRAFT FLIGHT TEST APPROACHES FOR FAULT-TOLERANT AVIONICS SYSTEMS
SHAHID SIDDIQI (Aviation Advanced Technology Applications, Orlando, FL) and J. A. ABRAHAM (Illinois, University, Urbana) AIAA, Flight Test Conference, 4th, San Diego, CA, May 18-20, 1988. 8 p. refs
(AIAA PAPER 88-2170)

Flight testing problems for highly integrated aircraft (aircraft in which sensors interface with data and control computers, which actuate reconfigurable controls) are reviewed. The flight test program for such aircraft must evolve techniques for reliably testing both the hardware and the software modules after they have been integrated into the aircraft. Some techniques based on the theory of fault tolerance are briefly discussed: these problems demand a more integrated flight-test team and appraoch than presently followed. A special flight simulator that is used to develop and test the software (in conjunction with the flight-test aircraft) is suggested. Author

A88-49008#
REVIEW OF UNCONVENTIONAL AIRCRAFT DESIGN CONCEPTS
ROY H. LANGE (Lockheed Aeronautical Systems Co., Marietta, GA) (ICAS, Congress, 15th, London, England, Sept. 7-12, 1986, Proceedings. Volume 1, p. 191-200) Journal of Aircraft (ISSN 0021-8669), vol. 25, May 1988, p. 385-392. Previously cited in issue 24, p. 3541, Accession no. A86-48995. refs

A88-49013#
INSIGHTS FROM LINEAR PREDICTIONS OF AIRCRAFT RESPONSE TO DAMAGED AIRFIELDS
JAMES J. OLSEN (USAF, Flight Dynamics Laboratory, Wright-Patterson AFB, OH) Journal of Aircraft (ISSN 0021-8669), vol. 25, May 1988, p. 413-419.

This paper examines the dynamic response of a simplified mathematical model of an aircraft that taxies over two arbitrary disturbances. It produces the idea of the bump multiplier that determines explicitly whether the second discrete disturbance will amplify or attenuate the response from the first disturbance. While the assumptions are very severe, the results can be useful to gain physical insight, to guide more elaborate nonlinear calculations, and to plan test programs. Author

A88-49021#
HELICOPTER TRANSMISSION FATIGUE LIFE ESTIMATION
K. F. FRASER and C. N. KING (Defence Science and Technology Organization, Melbourne, Australia) Journal of Aircraft (ISSN 0021-8669), vol. 25, May 1988, p. 465-471. Previously cited in issue 05, p. 591, Accession no. A87-17929. refs

A88-49025*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
DIVERGENCE STUDY OF A HIGH-ASPECT-RATIO, FORWARD SWEPT WING
STANLEY R. COLE (NASA, Langley Research Center, Hampton, VA) Journal of Aircraft (ISSN 0021-8669), vol. 25, May 1988, p. 478-480. Previously cited in issue 07, p. 843, Accession no. A86-19632. refs

A88-49061#
SUPERMANEUVERABILITY - FIGHTER TECHNOLOGY OF THE FUTURE
WILLIAM D. SIURU, JR. Airpower Journal (ISSN 0897-0823), vol. 2, Spring 1988, p. 50-61. refs

Advanced 'Supermaneuverability' technologies, which are capable of accomplishing post-stall maneuvering in fighter aircraft combat situations, encompass the vectoring of engine thrust, the incorporation of control configured vehicle aerodynamic surfaces in addition to wings and empennage, and the use of novel wing structural concepts allowing mission-adaptive sweep and chamber changes. It is presently noted that the weakest point in the constitution of a supermaneuverable fighter, such as the X-31 that is currently under U.S./West German development, is the pilot, whose vulnerability to G-induced loss of consciousness will pose a constant problem. O.C.

N88-25452*# Lockheed-California Co., Burbank. Structures and Materials Lab.
FUEL CONTAINMENT AND DAMAGE TOLERANCE IN LARGE COMPOSITE PRIMARY AIRCRAFT STRUCTURES. PHASE 2: TESTING
J. P. SANDIFER, A. DENNY, and M. A. WOOD Apr. 1985 278 p
(Contract NAS1-16856)
(NASA-CR-172519; NAS 1.26:172519) Avail: NTIS HC A13/MF A01 CSCL 01C

Technical issues associated with fuel containment and damage tolerance of composite wing structures for transport aircraft were investigated. Material evaluation tests were conducted on two toughened resin composites: Celion/HX1504 and Celion/5245. These consisted of impact, tension, compression, edge delamination, and double cantilever beam tests. Another test series was conducted on graphite/epoxy box beams simulating a wing cover to spar cap joint configuration of a pressurized fuel tank. These tests evaluated the effectiveness of sealing methods with various fastener types and spacings under fatigue loading and with pressurized fuel. Another test series evaluated the ability of the selected coatings, film, and materials to prevent fuel leakage through 32-ply AS4/2220-1 laminates at various impact energy levels. To verify the structural integrity of the technology demonstration article structural details, tests were conducted on blade stiffened panels and sections. Compression tests were performed on undamaged and impacted stiffened AS4/2220-1 panels and smaller element tests to evaluate stiffener pull-off, side load and failsafe properties. Compression tests were also performed on panels subjected to Zone 2 lightning strikes. All of these data were integrated into a demonstration article representing a moderately loaded area of a transport wing. This test combined lightning strike, pressurized fuel, impact, impact repair, fatigue and residual strength. M.G.

N88-25453*# Systems Control Technology, Inc., Arlington, Va.
ZERO/ZERO ROTORCRAFT CERTIFICATION ISSUES. VOLUME 1: EXECUTIVE SUMMARY Final Report
RICHARD J. ADAMS Jul. 1988 33 p
(Contract NAS2-12478)
(NASA-CR-177483-VOL-1; NAS 1.26:177483-VOL-1; DOT/FAA/PS-88/8-VOL-1; DOT/FAA/DS-88/2-VOL-1) Avail: NTIS HC A03/MF A01 CSCL 01C

This report analyzes the Zero/Zero Rotorcraft Certification Issues from the perspectives of manufacturers, operators, researchers and the FAA. The basic premise behind this analysis is the zero/zero, or at least extremely low visibility, rotorcraft operations are feasible today from both a technological and an operational standpoint. The questions and issues that need to be resolved are: What certification requirements do we need to ensure safety. Can we develop procedures which capitalize on the performance and maneuvering capabilities unique to rotorcraft. Will exptremely low visibility operations be economically feasible. This is Volume 1 of three. It provides an overview of the Certification Issues Forum held in Phoenix, Arizona in August of 1987. It presents a consensus of 48 experts from government, manufacturer, and research communities on 50 specific Certification Issues. The topics of Operational Requirements, Procedures, Airworthiness, and Engineering Capabilities are discussed. Author

N88-25454*# Systems Control Technology, Inc., Arlington, Va.
ZERO/ZERO ROTORCRAFT CERTIFICATION ISSUES. VOLUME 2: PLENARY SESSION PRESENTATIONS Final Report
RICHARD J. ADAMS Jul. 1988 84 p
(Contract NAS2-12478)
(NASA-CR-177483-VOL-2; NAS 1.26:177483-VOL-2; DOT/FAA/DS-88/2-VOL-2; DOT/FAA/PS-88/8-VOL-2) Avail: NTIS HC A05/MF A01 CSCL 01C

This report analyzes the Zero/Zero Rotorcraft Certification Issues from the perspectives of manufacturers, operators, researchers and the FAA. The basic premise behind this analysis is that zero/zero, or at least extremely low visibility, rotorcraft operations are feasible today from both a technological and an operational standpoint. The questions and issues that need to be resolved are: What certification requirements do we need to ensure safety. Can we develop procedures which capitalize on the performance and maneuvering capabilities unique to rotorcraft. Will extremely low visibility operations be economically feasible. This is Volume 2 of three. It presents the operator perspectives (system needs), applicable technology and zero/zero concepts developed in the first 12 months of research of this project. Author

N88-25455*# Systems Control Technology, Inc., Arlington, Va.
ZERO/ZERO ROTORCRAFT CERTIFICATION ISSUES. VOLUME 3: WORKING GROUP RESULTS Final Report
RICHARD J. ADAMS Jul. 1988 62 p
(Contract NAS2-12478)
(NASA-CR-177483-VOL-3; NAS 1.26:177483-VOL-3; DOT/FAA/DS-88/2-VOL-3; DOT/FAA/PS-88/8-VOL-3) Avail: NTIS HC A04/MF A01 CSCL 01C

This report analyzes the Zero/Zero Rotorcraft Certification Issues from the perspectives of manufacturers, operators, researchers and the FAA. The basic premise behind this analysis is that zero/zero, or at least extremely low visibility, rotorcraft operations are feasible today from both a technological and an operational standpoint. The questions and issues that need to be resolved are: What certification requirements do we need to ensure safety. Can we develop procedures which capitalize on the performance and maneuvering capabilities unique to rotorcraft. Will extremely low visibility operations be economically feasible. This is Volume 3 of three. It provides the issue-by-issue deliberations of the experts involved in the Working Groups assigned to deal with them in the Issues Forum. Author

N88-25627# Joint Publications Research Service, Arlington, Va.
VIBRATION TESTING OF ACT FUSELAGE
In its JPRS Report: Science and Technology. Japan p 58-59 4 May 1988 Transl. into ENGLISH from Kogiken Nyusu (Tokyo, Japan), Jan. 1988 p 10-11
Avail: NTIS HC A06/MF A01

The ACT fuselage model vibration testing was done in order to determine the vibration characteristics of the whole fuselage model before wind tunnel testing and then feed them back into the data analysis. A special frame for vibration testing was set up, and in order to obtain the vibration characteristics at any state during flight, sliding parts built into the model of the wind tunnel testing were used, only the front back and left right displacement of the model were constrained, and the center of gravity of the model was suspended with a spring coil in such a way as to not affect the vibration characteristics of the whole fuselage model. The vibration mode was determined using a small semiconductor gauge type accelerometer; 75 points on the entire fuselage were chosen as measurement points, and in taking measurements the positions of the detectors were moved about. The frequency response function was measured with a two channel Fast Fourier Transform analyzer, the modal analysis was done with a personal computer, and the modal parameters were determined, including the frequency, damping and vibration form. Author

N88-26360*# Lockheed Aeronautical Systems Co., Marietta, Ga.
PROPFAN TEST ASSESSMENT TESTBED AIRCRAFT STABILITY AND CONTROL/PERFORMANCE 1/9-SCALE WIND TUNNEL TESTS Final Report
B. H. LITTLE, JR., K. H. TOMLIN, A. S. ALJABRI, and C. A. MASON May 1988 157 p
(Contract NAS3-24339)
(NASA-CR-182121; NAS 1.26:182121; LG88ER0056) Avail: NTIS HC A08/MF A01 CSCL 01C

One-ninth scale wind tunnel model tests of the Propfan Test Assessment (PTA) aircraft were performed in three different NASA facilities. Wing and propfan nacelle static pressures, model forces and moments, and flow field at the propfan plane were measured in these tests. Tests started in June 1985 and were completed in January 1987. These data were needed to assure PTA safety of flight, predict PTA performance, and validate analytical codes that will be used to predict flow fields in which the propfan will operate. Author

N88-26361*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, Calif.
FLIGHT RESEARCH AND TESTING
TERRILL W. PUTNAM and THEODORE G. AYERS Jun. 1988 24 p Presented at the Transonic Symposium, Hampton, Va., Apr. 1988
(NASA-TM-100439; H-1483; NAS 1.15:100439) Avail: NTIS HC A03/MF A01 CSCL 01C

Flight research and testing form a critical link in the aeronautic R and D chain. Brilliant concepts, elegant theories, and even sophisticated ground tests of flight vehicles are not sufficient to prove beyond doubt that an unproven aeronautical concept will actually perform as predicted. Flight research and testing provide the ultimate proof that an idea or concept performs as expected. Ever since the Wright brothers, flight research and testing have been the crucible in which aeronautical concepts have advanced and been proven to the point that engineers and companies have been willing to stake their future to produce and design new aircraft. This is still true today, as shown by the development of the experimental X-30 aerospace plane. The Dryden Flight Research Center (Ames-Dryden) continues to be involved in a number of flight research programs that require understanding and characterization of the total airplane in all the aeronautical disciplines, for example the X-29. Other programs such as the F-14 variable-sweep transition flight experiment have focused on a single concept or discipline. Ames-Dryden also continues to conduct flight and ground based experiments to improve and expand the ability to test and evaluate advanced aeronautical concepts. A review of significant aeronautical flight research programs and experiments is presented to illustrate both the progress made and the challenges to come. Author

N88-26362# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
FLIGHT MECHANICS PANEL SYMPOSIUM ON ROTORCRAFT DESIGN FOR OPERATIONS: TECHNICAL EVALUATION REPORT
F. REINA (Agusta Sistemi S.p.A., Varese, Italy) Mar. 1988 17

p Symposium held in Amsterdam, Netherlands, 13-16 Oct. 1986 (AGARD-AR-243; ISBN-92-835-0450-X) Avail: NTIS HC A03/MF A01

The expanding roles of the helicopter and the intensified threat perceived by its potential users have led to proposals for future rotorcraft with characteristics significantly different from existing types. The resulting rapid evolution of rotorcraft configurations, in response to user demands, now requires a translation into design criteria to permit the aerospace research and development community to provide appropriate and cost effective responses to these demands. The objective of this symposium is to explore the impact of operational needs on the evolution of rotorcraft design and to identify priorities and neglected topics. Three specific issues are central to this problem: (1) the translation of operational mission requirements into design criteria; (2) the evaluation of techniques to incorporate user defined needs into the design and methods of test and verification; and (3) the identification of design areas where unusual or new user needs are demanding special or radical features. All papers were obtained by invitation. The Conference Proceedings, commissioned by the AGARD Flight Mechanics Panel are published separately as AGARD CP 423. This Advisory Report was prepared at the request of the Flight Mechanics Panel of AGARD. Author

N88-26364# Deutsche Airbus G.m.b.H., Munich (West Germany).
AIRBUS 1987: SUCCESS IN EUROPE [AIRBUS 1987 - ERFOLG IN EUROPA]
1987 36 p In GERMAN
(ETN-88-92099) Avail: NTIS HC A03/MF A01

The European Airbus-program initiated in 1969 with emphasis on the 6 Airbus versions from A300 to A340-300 is reviewed. Data concern dimensions performance, capacity, weight and flight length. Advantages and main aerodynamic and flight characteristics of each model are given. ESA

N88-26365# Societe Nationale Industrielle Aerospatiale, Suresnes (France). Direction Centrale de la Qualite.
SENSITIVITY TO CRACK INITIATION IN THICK ASSEMBLIES. TEST REPORT 48-444 [SENSIBILITE DE DETECTION DE CRIQUES DANS LES ASSEMBLAGES EPAIS. PROCES-VERBAL 48-444]
J. ODORICO and D. LECURU 10 Feb. 1987 27 p In FRENCH
(Contract STPA-85-96-032)
(REPT-48-444; ETN-88-92147) Avail: NTIS HC A03/MF A01

The safe detection values for cracks starting at bolt holes in aluminum plates thicker than 5 mm is studied. The choice and preparation of the assembly to be controlled are discussed. A control procedure based on low frequency (200 Hz) eddy currents is described. The study of an Airbus structural element shows that the estimates of crack length distribution are in accordance with the measurements. ESA

N88-26366# National Aerospace Lab., Amsterdam (Netherlands). Flight Div.
TRAJECTORY MEASUREMENT OF THE FOKKER 100 AIRCRAFT DURING AUTOLAND TESTING
R. KRIJN and J. C. T. VANDERVEEN 6 Feb. 1986 16 p Presented at the 1986 Aerospace Industries/Test Measurement Symposium, Seattle, Wash., 5-8 May 1986 Sponsored by the Netherlands Agency for Aerospace Programs
(NLR-MP-86010-U; B8803803; ETN-88-92602) Avail: NTIS HC A03/MF A01

An accurate, fast, and flexible trajectory measurement system was developed for the automatic landing trials of the Fokker 100 prototype. The system combines the photogrammetrical forward-looking camera method with inertial navigation. Accuracy is 0.3 m standard deviation along track, and 0.15 m cross track and height. Turnaround time is less than 12 hr, and location can be changed at 24 hr notice. ESA

N88-26367*# Boeing Vertol Co., Philadelphia, Pa.
HOVER PERFORMANCE TESTS OF BASELINE METAL AND ADVANCED TECHNOLOGY BLADE (ATB) ROTOR SYSTEMS FOR THE XV-15 TILT ROTOR AIRCRAFT Final Report
K. BARTIE, H. ALEXANDER, M. MCVEIGH, S. LAMON, and H. BISHOP Oct. 1986 151 p
(Contract NAS2-11250)
(NASA-CR-177436; NAS 1.26:177436; D210-12380-1) Avail: NTIS HC A08/MF A01 CSCL 01C

Rotor hover performance data were obtained for two full-scale rotor systems designed for the XV-15 Tilt Rotor Research Aircraft. One rotor employed the rectangular planform metal blades (rotor solidity = 0.089) which were used on the initial flight configuration of the XV-15. The second rotor configuration examined the nonlinear taper, composite-construction, Advanced Technology Blade (ATB), (rotor solidity = 0.10) designed to replace the metal blades on the XV-15. Variations of the baseline ATB tip and cuff shapes were also tested. A new six-component rotor force and moment balance designed to obtain highly accurate data over a broad range of thrust and torque conditions is described. The test data are presented in nondimensional coefficient form for the performance results, and in dimensional form for the steady and alternating loads. Some wake and acoustic data are also shown. Author

N88-26520# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick (West Germany). Inst. fuer Flugmechanik.
FLIGHT VEHICLE SYSTEM IDENTIFICATION: STATUS AND PROSPECTS
P. G. HAMEL *In its* System Identification in Vehicle Dynamics p 51-90 1987
Avail: NTIS HC A18/MF A01; DFVLR, VB-PL-DO, 90 60 58, 5000 Cologne, Fed. Republic of Germany, 109 Deutsche marks

The state of the art of flight vehicle parameter identification techniques from flight test data is reviewed. Model structure aspects for basic and highly augmented airframes are emphasized. Results on system identification related to highly augmented flight vehicles as well as to high angle-of-attack maneuvers are presented. ESA

N88-26525# Centre d'Etudes et de Recherches, Toulouse (France). Dept. d'Automatique.
MULTIVARIABLE IDENTIFICATION OF A FLEXIBLE TRANSPORT AIRCRAFT
M. CLIQUE, G. MONNIER, M. LABARRERE, A. BUCHARLES, and J. L. PAC (Ecole Nationale Superieure de l'Aeronautique et de l'Espace, Toulouse, France) *In* DFVLR, System Identification in Vehicle Dynamics p 173-192 1987
Avail: NTIS HC A18/MF A01; DFVLR, VB-PL-DO, 90 60 58, 5000 Cologne, Fed. Republic of Germany, 109 Deutsche marks

A method for the identification of multivariable linear systems is presented. Fourier analysis was used to obtain power spectral densities from measured signals and to compute each transfer function in the frequency domain. The modes of the system were located using Steiglitz identification techniques for the different input-output pairs. The proposed algorithm leads to the determination of a multivariable state space representation. The application to a flexible transport aircraft is given; the results show that the proposed method is adapted to multi-input, multi-output systems. ESA

N88-26526# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick (West Germany). Inst. fuer Flugmechanik.
A TWO-POINT AERODYNAMIC MODEL FOR IDENTIFICATION [EIN 2-PUNKT-AERODYNAMIKMODELL FUER DIE IDENTIFIZIERUNG]
W. MOENNICH *In its* System Identification in Vehicle Dynamics p 193-207 1987 In GERMAN
Avail: NTIS HC A18/MF A01; DFVLR, VB-PL-DO, 90 60 58, 5000 Cologne, Fed. Republic of Germany, 109 Deutsche marks

An aerodynamic model for the identification of lateral aircraft

motion using maximum likelihood identification programs is presented, in which airfoil/fuselage and the horizontal tail surface are separated (two-point model). This separation allows one to consider several nonlinearities. The model takes into account elevator, elevator trimming, and direct lift control flap input signals as well as thrust effects on aerodynamics (interference between driving jet and horizontal tail surface). The method can be applied to all fixed-wing aircraft if compressibility effects can be neglected. The results show that a good or very good adaptation of the identification model output to the flight test measuring signals is obtained. The standard deviation of the identified parameters is so small that the reliability of the results can be considered as good. ESA

N88-26527# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick (West Germany). Inst. fuer Flugmechanik.

THE IDENTIFICATION OF THE DIRECT LIFT CONTROL FLAP SYSTEM OF THE RESEARCH AIRCRAFT ATTAS [ZUR IDENTIFIZIERUNG DES DLC-KLAPPENSYSTEMS DES FORSCHUNGSFLUGZEUGS ATTAS]

D. ROHLF and W. MOENNICH *In its* System Identification in Vehicle Dynamics p 209-222 1987 In GERMAN

Avail: NTIS HC A18/MF A01; DFVLR, VB-PL-DO, 90 60 58, 5000 Cologne, Fed. Republic of Germany, 109 Deutsche marks

A simple replacement model for the direct lift control (DLC) flap control system was developed, and the DLC-flap efficiency of three landing flap positions was determined with a view to the identification of the ATTAS DLC-flap system. Starting from flight test data, a linear transfer behavior of second order in the frequency domain was determined; this model was extended by taking into account nonlinearities. The DLC-flap efficiencies were identified together with all other system parameters. Good adaptations to the time evolution, as well as small scatter in the identified parameters are obtained. The effect of the DLC-flap on buoyancy, drag, and pitching moment was determined as a function of the landing flap position. ESA

N88-26528# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick (West Germany). Inst. fuer Flugmechanik.

PARAMETRIC ESTIMATION OF AERODYNAMIC NONLINEARITIES IN ROLLING MOMENT DUE TO SIDESLIP USING MAXIMUM LIKELIHOOD METHOD

R. V. JATEGAONKAR *In its* System Identification in Vehicle Dynamics p 223-234 1987

Avail: NTIS HC A18/MF A01; DFVLR, VB-PL-DO, 90 60 58, 5000 Cologne, Fed. Republic of Germany, 109 Deutsche marks

The utility of nonlinear maximum likelihood procedures for unconventional problems of estimating discontinuous complex aerodynamic nonlinearities is treated. It is demonstrated that a maximum likelihood procedure in which the need for explicit sensitivity equations is overcome by approximating the sensitivity coefficients through a numerical procedure can handle conveniently different general nonlinear system models. As examples cubic nonlinearity and aerodynamic hysteresis, characterized by a discontinuous relationship in rolling moment due to sideslip, which can possibly lead to uncommanded roll oscillations in aircraft motion, were identified from the simulated responses. ESA

N88-26529# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick (West Germany). Inst. fuer Flugfuehrung.

FLIGHT TEST PREPARATION AND MEASURING DATA VALIDATION FOR PARAMETER IDENTIFICATION [FLUGVERSUCHSVORBEREITUNG UND MESSDATENUEBERPRUEUNG FUER DIE PARAMETER-IDENTIFIKATION]

K.-O. PROSKAWETZ *In its* System Identification in Vehicle Dynamics p 235-249 1987 In GERMAN

Avail: NTIS HC A18/MF A01; DFVLR, VB-PL-DO, 90 60 58, 5000 Cologne, Fed. Republic of Germany, 109 Deutsche marks

Flight test preparation and flight test data validation are explained. Using the results of the process analysis, the excitation signals are optimized, the regulating variables are fixed, and the flight tests are planned. After the flight tests, the compatibility of the test data among each other is checked using a maximum likelihood identification program for nonlinear systems, and the errors are corrected. The procedure can also be applied to other domains of aircraft engineering in order to guarantee a high parameter estimation quality. ESA

N88-26530# Technische Hogeschool, Delft (Netherlands).

A NEW METHOD FOR THE ESTIMATION OF AIRCRAFT INERTIA CHARACTERISTICS

R. C. DEJONG and J. A. MULDER *In* DFVLR, System Identification in Vehicle Dynamics p 251-265 1987

Avail: NTIS HC A18/MF A01; DFVLR, VB-PL-DO, 90 60 58, 5000 Cologne, Fed. Republic of Germany, 109 Deutsche marks

A 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 multidegree of freedom oscillations using a high accuracy instrumentation system. A suspension rig, in which the aircraft can simultaneously rotate about the pitch and yaw axis and translate along the roll and pitch-axis was used to demonstrate the validity of the method. Inertia moments, inertia products, and the three coordinates of the center of gravity are simultaneously estimated from measurements of a single oscillation. The experiment is less time-consuming than previous methods, since no separate center-of-gravity nor rig reconfigurations are needed. ESA

N88-26532# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick (West Germany). Inst. fuer Flugmechanik.

UTILIZATION OF IDENTIFICATION METHODS IN THE TIME AND FREQUENCY DOMAIN FOR THE DETERMINATION OF THE XV-15 (TILT-ROTOR) DYNAMICS FOR LATERAL MOTION IN HOVER FLIGHT [ANWENDUNG VON IDENTIFIZIERUNGSVERFAHREN IM ZEIT- UND FREQUENZBEREICH ZUR BESTIMMUNG DER XV-15 (TILT-ROTOR) DYNAMIK FUER DIE SEITENBEWEGUNG IM SCHWEBEFLUG]

J. KALETKA and M. B. TISCHLER (Army Aviation Research and Development Command, Moffett Field, Calif.) *In its* System Identification in Vehicle Dynamics p 287-307 1987 In GERMAN; ENGLISH summary

Avail: NTIS HC A18/MF A01; DFVLR, VB-PL-DO, 90 60 58, 5000 Cologne, Fed. Republic of Germany, 109 Deutsche marks

Mathematical models for the open loop dynamics of the XV-15 aircraft (tilt-rotor) were developed from flight test data using the frequency domain identification and the time domain identification approaches. The flight tests and the evaluation of test results are described. The results from the two approaches compare favorably. However, the differences clearly demonstrate the effects of the inherent weighting of each individual technique; they also indicate the relative strengths and weaknesses of the approaches. Based on the results a proposal for a coordinated system identification approach, using the advantages of both methods is given. ESA

N88-26533# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick (West Germany). Inst. for Flight Mechanics.

APPLICATION OF COMPLEMENTARY PARAMETER IDENTIFICATION TECHNIQUES TO FLIGHT TEST DATA OF A TRANSPORT AIRCRAFT

B. KRAG, M. LABARRERE, G. W. FOSTER, and J. H. BREEMAN (National Aerospace Lab., Amsterdam, Netherlands) *In* DFVLR, System Identification in Vehicle Dynamics p 309-342 1987

Avail: NTIS HC A18/MF A01; DFVLR, VB-PL-DO, 90 60 58, 5000 Cologne, Fed. Republic of Germany, 109 Deutsche marks

The experience gained from the application of different parameter identification techniques to the same set of flight test data is presented. The basic equations in the techniques used

(maximum likelihood estimates and Kalman filter technique) are presented. The results of flight path reconstruction and parameter identification are discussed. It is shown that differences in the results can be attributed to the different models. ESA

06

AIRCRAFT INSTRUMENTATION

Includes cockpit and cabin display devices; and flight instruments.

A88-45952
AIRBUS AND ATR SYSTEM ARCHITECTURE AND SPECIFICATION
PASCAL TRAVERSE (Aerospatiale, Toulouse, France) IN: Software diversity in computerized control systems. Vienna and New York, Springer-Verlag, 1988, p. 95-104. refs

The application of software diversity to produce fault-tolerant control systems for the A300-A320 and ATR42 transport aircraft is briefly reviewed. Consideration is given to the safety and reliability objectives for fly-by-wire, AFC, and flight-instrument systems; the system architecture; design fault detection and tolerance; roll and pitch controllers; the specification process; and the experience accumulated to date. The means of diversification in hardware, project organization, inherent differences, and forced differences are listed in a table. T.K.

A88-46053
A PILOT'S PERSPECTIVE OF THE ADVANCED FIGHTER TECHNOLOGY INTEGRATION AUTOMATED MANEUVERING ATTACK SYSTEM
MARK STUBBEN (USAF, Flight Test Center, Edwards AFB, CA) SAE, Aerospace Vehicle Conference, Washington, DC, June 8-10, 1987. 11 p.
(SAE PAPER 871349)

The Advanced Fighter Technology Integration (AFTI)/F-16 test program conducted developmental test flights on new technologies designed to enhance the weapons system effectiveness and survivability of fighter aircraft. This paper will focus on the pilot acceptance of the new technologies integrated into the automated maneuvering attack system (AMAS), to include pilot confidence in flying an automated maneuvering system at low altitude; pilot acceptance of automated flying qualities; and pilot-to-vehicle interface consideration including avionics integration, cockpit controls, cockpit displays, and voice actuated avionics. Author

A88-46965
SIMULATION OF CLUTTER RETURN FOR AN AIRBORNE PULSE DOPPLER RADAR
ROGER E. WAKEFIELD (Mitre Corp., Bedford, MA) IN: 1987 Annual Summer Computer Simulation Conference, 19th, Montreal, Canada, July 27-30, 1987, Proceedings. San Diego, CA, Society for Computer Simulation, 1987, p. 251-255. USAF-supported research. refs

This paper describes a clutter simulation computer program developed for the analysis of airborne pulse Doppler radar with a broadside pointing antenna. The program was developed on a VAX 8200 computer and executed on an AT&T 6300 personal computer (PC) with the arithmetic coprocessor. Phased array radars of various sizes, operating at different radar frequencies and pulse repetition frequencies (PRFs) were analyzed. Horizontal and vertical gain patterns are individually specified. Distributed clutter from ground and birds is modeled. Clutter cross section versus frequency (Doppler shift) is stored and plotted for analysis. The results proved useful in the determination of target detection capability. Performance against the original goals of fast execution and accurate results are discussed. Author

A88-46970
SIMULATION OF AN AIR-TO-AIR TRACKING SYSTEM FOR AN ELECTRONICALLY STEERED ANTENNA
JAMIL R. HASHIMI, SAMUEL S. BLACKMAN, and STUART P. ICKOVIC (Hughes Aircraft Co., Los Angeles, CA) IN: 1987 Annual Summer Computer Simulation Conference, 19th, Montreal, Canada, July 27-30, 1987, Proceedings. San Diego, CA, Society for Computer Simulation, 1987, p. 279-284.

A simulation was developed for an air-to-air multiple target tracking (MTT) system that uses an electronically steered antenna (ESA), which offers an advantage over the conventional mechanically steered antenna (MSA) in that it has the ability to reposition the radar beam almost instantaneously without overshooting the desired beam position. The results of Monte Carlo simulation, used to weigh the relative benefits of improved tracking performance versus the developmental and computational costs of employing the ESA, demonstrated that the ESA MTT system can be expected to provide significantly improved performance over that of a typical MSA track-while-scan system. The simulation makes it possible to evaluate future system enhancements. Block diagrams are presented. I.S.

A88-47030
THE DEVELOPMENT OF A DIRECTIONAL GYROSCOPE FOR REMOTELY PILOTED VEHICLES AND SIMILAR APPLICATIONS
D. W. ALFORD (Ferranti Instrumentation, Ltd., Bracknell, England) IN: International Conference on the Mechanical Technology of Inertial Devices, Newcastle-upon-Tyne, England, Apr. 7-9, 1987, Proceedings. London, Mechanical Engineering Publications, Ltd., 1987, p. 1-8. Research supported by the Ministry of Defence Procurement Executive.

The paper describes the development of a small, light, rugged, d.c. powered, two gimbal gyroscope that incorporates new technology features to improve its performance. These include a precision low noise multiple wiper linear potentiometer pick-off on the azimuth axis and an additional potentiometer pick-off on the inner gimbal axis for the approximate correction of the geometric heading errors due to airframe pitch and roll motion. A novel pneumatic pulse-torque inner gimbal erection system enables in-flight performance to be improved. Author

A88-47031
A TWO DEGREE OF FREEDOM GYROSCOPE WITH FRICTIONLESS INNER AND OUTER GIMBAL PICK-OFFS
R. E. J. SWAIN (British Aerospace, PLC, Stevenage, England) IN: International Conference on the Mechanical Technology of Inertial Devices, Newcastle-upon-Tyne, England, Apr. 7-9, 1987, Proceedings. London, Mechanical Engineering Publications, Ltd., 1987, p. 9-16. Research supported by the Ministry of Defence Procurement Executive.

A two degree of freedom gyroscope for rapid start, short operating time, applications is described. Design features include thermoplastic gimbals with in situ moulded bearings, stored energy power sources in the form of either a spring or high pressure cold gas, obtained from a superplastic formed titanium pressure vessel, and noncontacting pick-offs. Inner gimbal angle is derived from a mark to space signal which is modulated linearly by areas of differing reflectivity on the surface of a spherical rotor. The outer gimbal pick-off is an absolute encoder which obtains multitrack accuracy from a single track by using a scale coded with a psuedorandom binary sequence. Author

A88-47032
OSCILLOGYRO DESIGN, MANUFACTURE AND PERFORMANCE
J. WELLBURN and D. A. REID (Ferranti Defence Systems, Ltd., Edinburgh, Scotland) IN: International Conference on the Mechanical Technology of Inertial Devices, Newcastle-upon-Tyne, England, Apr. 7-9, 1987, Proceedings. London, Mechanical Engineering Publications, Ltd., 1987, p. 17-27.

The Oscillogyro is a two-degree of freedom, dry tuned, displacement gyroscope of unorthodox design, capable of

temperature wild operation. The principles of operation are explained together with details of design and manufacture. Many applications have been found for the instrument ranging from a 1 nm/hr accuracy inertial navigation system to an oil well survey tool. All applications require good performance and modelable characteristics over a wide temperature range. A description of the automatic test equipment required to characterize each instrument is given. Aspects of instrument serviceability are discussed and the main failure mechanisms examined. Author

A88-47199
A LOW COST OPTICAL ALTIMETER FOR RPV APPLICATIONS
J. MANSBRIDGE and G. M. S. JOYNES (Plessey Electronic Systems Research, Ltd., Romsey, England) IN: Remotely piloted vehicles; Proceedings of the Sixth International Conference, Bristol, England, Apr. 6-8, 1987, Supplementary Papers. Bristol, England, University of Bristol, 1987, p. 18.1-18.4.

An account is given of the design features and performance capabilities of an optical altimeter, for use by towed or remotely piloted targets simulating sea-skimming missiles, which can be manufactured significantly more cheaply than existing radar altimeters. Altitude is measured by means of a CW subcarrier modulation scheme. Attention is given to the effects of weather conditions on the operating envelope of such an altimeter, as well as to its optical components' configuration and signal processing system. While the altimeter was designed primarily for use over the sea surface, it will yield acceptable performance in overland flight. O.C.

N88-25456# National Bureau of Standards, Boulder, Colo. Electromagnetic Fields Div.
AIRCRAFT FIELD DEGRADATION AND ELECTROMAGNETIC COMPATIBILITY
K. H. CAVCEY and D. S. FRIDAY Jan. 1988 100 p Sponsored by Army Aviation Systems Command, St. Louis, Mo.
(PB88-183975; NBSIR-88/3083) Avail: NTIS HC A05/MF A01
CSCL 01D

The paper discusses the first tests undertaken to study the problem of field degradation in army aircraft (helicopters and one fixed wing airplane) due to the deterioration of electronic and electrical systems. The electromagnetic compatibility (EMC) of such systems was investigated by passive measurement of the aircraft as a collection of radio frequency sources. Methods for detection of these sources were developed that included sensitivity to both stationary and nonstationary noise that existed. The collected data were studied to see if there existed any obvious factors derived from the data that one could use to correct potential problems that might affect flight safety. Emphasis was placed upon making such test methods appropriate, inexpensive, and easily performed by army field personnel. In addition, applications to quality control or acceptance testing, as related to the Environmental Stress Screening (ESS) program, were examined. GRA

N88-26368# National Aerospace Lab., Amsterdam (Netherlands). Flight Div.
DEVELOPMENT OF AN AIRBORNE FACILITY FOR ADVANCED AVIONICS RESEARCH
N. VANDRIEL 1 Mar. 1987 17 p Presented at the 53rd AGARD Avionics Panel Symposium, Las Vegas, Nev., 27 Apr. - 1 May 1987 Previously announced in IAA as A88-23801
(NLR-MP-87012-U; B8803804; ETN-88-92607) Avail: NTIS HC A03/MF A01

A program to equip an aircraft with avionics research instruments is outlined. A Fairchild Metro 2 will be equipped with a programmable electronic flight instrument system (EFIS), programmable flight management computer (FMC), programmable flight control computer, Navstar GPS, microwave landing system (MLS), and a digital data link. Applications of the system include: research on MLS approaches (e.g., interception angles, segment lengths and orientations, equipment requirements); research on the use of EFIS, for conventional and unconventional presentations; research on the use of digital data links; research on the use of FMC's; and research on the use of satellite navigation systems especially for RNAV operations and approaches. ESA

07

AIRCRAFT PROPULSION AND POWER

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

A88-46075
THEORY AND DESIGN OF JET ENGINES (SECOND REVISED AND ENLARGED EDITION) [TEORIIA I RASCHET VOZDUSHNO-REAKTIVNYKH DVIGATELEI /2ND REVISED AND ENLARGED EDITION/]
S. M. SHLIAKHTENKO, ED. Moscow, Izdatel'stvo Mashinostroenie, 1987, 568 p. In Russian. No individual items are abstracted in this volume.

The theory behind various types of jet engines is elaborated, with attention given to the thermodynamic-cycle characteristics and principles for choosing optimal parameters. Particular consideration is given to the specific parameters of gas turbine engines (GTEs), the operating characteristics of GTDs, ramjet and combination turbojet/ramjet engines, and the theoretical principles behind the design of GTEs. B.J.

A88-46348
THRUST-REVERSER EFFICIENCY [EFFICACITE DES INVERSEURS]
C. CASTAN (Aerospatiale, Toulouse, France) Colloque d'Aerodynamique Appliquee, 24th, Poitiers, France, Oct. 26-28, 1987. 54 p. In French.
(AAAF PAPER NT-87-24)

Experimental data and simulation results on thrust reversers have been obtained in order to study their braking efficiency and problems such as reingestion, failure in flight, loading, the effect of reverse flows on the control systems, and the accidental opening of the thrust reverser in flight. Thrust-reverser concepts considered include the cascade thrust reverser, the pivoting-door fan-stream thrust reverser used on the A320, and the pivoting-clamshell thrust reverser for the combined core/fan flow. The simulation employing a turbine-powered model is found to provide a good representation of real phenomena and to confirm flight results obtained in a wind tunnel. Disadvantages of the 'blown jet' test method are pointed out. R.R.

A88-46491*# Boeing Commercial Airplane Co., Seattle, Wash.
SUPERSONIC PROPULSION SYSTEMS AND COMMUNITY NOISE SUPPRESSION CONCEPTS
GENE L. NIHART and JEFFREY J. BROWN (Boeing Commercial Airplane Co., Seattle, WA) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 9 p. refs
(Contract NAS1-18377)
(AIAA PAPER 88-2986)

After a brief evaluation of advanced SST propulsion cycles, the ability of various alternative designs to meet community noise suppression requirements during prospective international airport operations are discussed. Attention is given to the noise suppression features that may allow SST variable thermodynamic cycle engines incorporating numerous variable-geometry features to expose airport communities to noise levels no greater than those of current wide-body subsonic airliners. O.C.

A88-46492#
PERFORMANCE EVALUATION OF A TWO DIMENSIONAL CONVERGENT-DIVERGENT EJECTOR EXHAUST SYSTEM
JOHN F. FEDERSPIEL and ANDREW P. KUCHAR (General Electric

Co., Cincinnati, OH) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 11 p. (AIAA PAPER 88-2999)

The results of a parametric test of two-dimensional convergent-divergent (2DCD) ejector nozzles are presented. Data were obtained from scale model cold flow testing. The geometries tested were representative of current technology aircraft engine nozzles. The thrust and pumping performance trends with geometry and with operating levels are shown and compared to those of axisymmetric ejector nozzles of similar geometry obtained from a statistical data base. The performance characteristics of axisymmetric ejector nozzles had been extensively investigated and well documented. However, very little test data existed for 2DCD ejector nozzles. The 2DCD nozzles showed slightly higher thrust levels but overall, comparisons were well within a range expected by statistical error. Pumping/air handling performance was comparable. Author

A88-46495#
OVERVIEW OF FLIGHT TESTING OF GE AIRCRAFT ENGINES' UDF ENGINE
CARLYLE REID (General Electric Co., Cincinnati, OH) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 13 p.
(AIAA PAPER 88-3082)

This paper provides a brief overview of the results of the two flight test programs completed on the (UDF) proof-of-concept demonstrator engine. This is a revolutionary engine featuring directly driven (i.e., no gearbox) counterrotating, ultra-high bypass, variable-pitch, unducted fans. With a propulsive efficiency in the mid-90-percent range at subsonic speeds equivalent to current turbofan-powered aircraft, this engine provides the next major breakthrough in fuel efficiency for commercial and military subsonic transports. Flight testing in a modified B727 and MD-80 successfully checked out the engine and associated aircraft characteristics with respect to operability, performance and acoustic signatures. The capability of projecting installed altitude flight performance and acoustic characteristics from scale model wind tunnel and full scale sea level bench testing was also confirmed. Future potential commercial and military applications for a product UDF engine and planned test activity for the demonstrator, engines and wind tunnel models are presented. Author

A88-46498#
UNIQUE TRANSIENT COMBUSTOR TEST CAPABILITY
T. J. ROSFJORD, J. HALEY, JR. (United Technologies Research Center, East Hartford, CT), and J. M. BONNELL (Pratt and Whitney, West Palm Beach, FL) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 11 p.
(AIAA PAPER 88-3197)

An account is given of the design features and performance capabilities of a test apparatus able to obtain controlled airflow and fuel-flow rate transients in combustor models; these transients may be either monotonic or oscillatory, or a combination of the two. A time variation of the combustor inlet air is also obtainable. A dedicated control system furnishes modes for transient profile development, manual, and automatic operation. All operational modes have been experimentally verified. O.C.

A88-46500#
PROPULSION CONTROL SPECIFICATIONS IN INTEGRATED FLIGHT PROPULSION CONTROL SYSTEMS
STEPHEN M. ROCK, ABBAS EMAMI-NAEINI, and ROBERT P. ANEX (Systems Control Technology, Inc., Palo Alto, CA) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 12 p. Research supported by Systems Control Technology, Inc. refs
(AIAA PAPER 88-3236)

A technique is presented for generating specifications that define how subsystems must perform within an integrated control system in order to assure performance goals are met when the integrated system is implemented. These specifications provide the mechanism for communicating performance requirements and operational constraints that account for coupling and modeling uncertainties. The advantage of these specifications is that they make it possible to partition large control design problems into elements that can be addressed by individual experts. An example of the application of this procedure to an integrated flight/propulsion control problem is presented. Author

A88-46501#
AN ENGINEERING MODEL FOR ANALYSIS OF SCRAMJET COMBUSTOR PERFORMANCE WITH FINITE RATE CHEMISTRY
MARIA V. PULSONETTI, JOHN I. ERDOS, and KEVIN EARLY (General Applied Science Laboratories, Inc., Ronkonkoma, NY) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 14 p. Research supported by Pratt and Whitney and USAF. refs
(AIAA PAPER 88-3258)

An engineering model of diffusion and reaction-limited supersonic combustion is described. The key feature of this model is that it divides the flowfield into three parallel, one-dimensional streams: one is the fuel stream, another is the oxidizer stream and the third is the product stream. Fuel and oxidier are continuously fed into the product stream in accordance with an empirical mixing model and allowed to react at finite rate. Comparisons with experimental data for hydrogen-air combustion are presented. The model is clearly over-simplified compared to the complex two- and three-dimensional turbulent mixing and induced shock train processes known to exist in supersonic combustors. Nevertheless it includes sufficient physics to provide reasonably good agreement with the data and enables rapid interpretation of the global features of the experiments. Accordingly it may be useful in conceptual design studies. Author

A88-46502#
CFD ANALYSIS OF 3-D EFFECTS IN SCRAMJET EXHAUST FLOW FIELDS
ROBERT RAY, CHRIS NIGGEMEIER, and JOHN I. ERDOS (General Applied Science Laboratories, Inc., Ronkonkoma, NY) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 11 p. USAF-sponsored research. refs
(AIAA PAPER 88-3262)

A coordinate free three-dimensional space-marching Euler code is used to examine three-dimensional effects in the underexpanded exhaust flowfield from single and multiple module scramjets on a flat plate afterbody. The calculations are compared with experimental data for the single module scramjet. Two-dimensional and three-dimensional force and moment coefficients on the afterbody are compared. Improvements in the implementation of the boundary conditions described by Ray and Kassing (1986) have been made. Author

A88-46504#
ENHANCED FIGHTER ENGINE OPERABILITY USING FULL AUTHORITY DIGITAL ELECTRONIC CONTROL SYSTEMS
CARL F. SIMMONS and GARRY BRANT (Pratt and Whitney, West Palm Beach, FL) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 8 p.
(AIAA PAPER 88-3266)

Full authority digital electronic control (FADEC) systems under consideration for next-generation military aircraft powerplants enhance engine operability by reliably processing aircraft, pilot, engine, and atmospheric data to achieve optimum propulsive capability. Attention is presently given to the features and projected performance of such advanced FADEC systems as the Highly Integrated Digital Electronic Control development program for the F100-PW-229 engine. O.C.

A88-46571
THE DEVELOPMENT OF THE UNDUCTED FAN
BRUCE J. GORDON (General Electric Co., Lynn, MA) Aerospace (UK) (ISSN 0305-0831), vol. 15, July 1988, p. 22-26.

The turbomechanical and thermodynamic rationales for the

'unducted fan', or UDF aircraft powerplant configuration are explored, by comparison with state-of-the-art high bypass turbofan and next-generation ultrahigh bypass ducted turbofan engines. An account is given of the conceptual development of the UDF, which was initially prompted by aircraft fuel price projections in 1980, for 1988, of about $4.00/gal. The advantages of the UDF engine were assessed for the case of a 160-passenger airliner of B727/MD-80 class, giving attention to cabin interior noise and vibration characteristics. O.C.

A88-47073#
STATIC TEST RESULTS OF AN EXTERNALLY MOUNTED THRUST VECTORING VANE CONCEPT
B. F. TAMRAT and D. L. ANTANI (Northrop Corp., Hawthorne, CA) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 14 p.
(AIAA PAPER 88-3221)

An experimental investigation was carried out to measure the effectiveness of an externally mounted vane exhaust-flow vectoring concept for a high angle-of-attack research vehicle. A cold flow static test of a one-sixteenth scale axisymmetric convergent nozzle model with an externally mounted vane was conducted. The data show that effective side-force generation was possible for the max nozzle at all vane deflection angles. Moreover, the vane cut-outs did not degrade side-force generation effectiveness. K.K.

A88-47189
AUXILIARY ELECTRICAL POWER SOURCES FOR UNMANNED AIRCRAFT
M. C. PUTTOCK (Thorn EMI Electronics, Ltd., Feltham, England) IN: Remotely piloted vehicles; Proceedings of the Sixth International Conference, Bristol, England, Apr. 6-8, 1987, Conference Papers. Bristol, England, University of Bristol, 1987, p. 13.1-13.7. Research supported by the Ministry of Defence Procurement Executive.

A development history and development status assessment is presented for small alternators applicable to unmanned aircraft, giving attention to the comparative advantages and disadvantages of batteries and rotating machines as RPV power sources. If a mission is of short duration, a battery will furnish the most weight-effective solution; otherwise, the weight advantage offered by alternators becomes demonstrable. Samarium-cobalt magnets are noted to be excellent bases for alternators, notwithstanding their considerable cost. O.C.

A88-48029#
MULTI-STEP DUMP COMBUSTOR DESIGN TO REDUCE COMBUSTION INSTABILITIES
K. C. SCHADOW, E. GUTMARK, K. J. WILSON, and R. A. SMITH (U.S. Navy, Naval Weapons Center, China Lake, CA) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference and Exhibit, 24th, Boston, MA, July 11-13, 1988. 10 p. Navy-supported research. refs
(AIAA PAPER 88-2854)

Based on the understanding of the critical role of large-scale structures as drivers of pressure oscillations, a multistep dump was successfully tested to suppress pressure oscillations in a coaxial dump combustor. The multistep concept, which prevents development of large-scale structures, was studied in nonreacting air and water flows, and in an annular diffusion flame, before it was applied to the dump combustor burning gaseous fuel. O.C.

A88-48032*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
THE CHALLENGES AND OPPORTUNITIES OF SUPERSONIC TRANSPORT PROPULSION TECHNOLOGY
WILLIAM C. STRACK (NASA, Lewis Research Center, Cleveland, OH) and SHELBY J. MORRIS, JR. (NASA, Langley Research Center, Hampton, VA) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference and Exhibit, 24th, Boston, MA, July 11-13, 1988. 13 p. Previously announced in STAR as N88-23806. refs
(AIAA PAPER 88-2985)

The major challenges confronting the propulsion community for civil supersonic transport applications are identified: high propulsion system efficiency at both supersonic and subsonic cruise conditions, low-cost fuel with adequate thermal stability at high temperatures, low noise cycles and exhaust systems, low emission combustion systems, and low drag installations. Both past progress and future opportunities are discussed in relation to perceived technology shortfalls for an economically successful airplane that satisfies environmental constraints. Author

A88-48456
ACTIVE-CONTROL ENGINES
LEE PADDON Flight International (ISSN 0015-3710), vol. 134, July 9, 1988, p. 33, 34.

Full-authority digital engine controllers (FADECs) of the simplest type are direct replacements for their hydromechanical counterparts, monitoring various engine parameters as well as the throttle setting to control the amount of fuel entering an aircraft engine; they allow a pilot to move the throttle instantaneously from idle to wide-open settings without ill effects. As FADECs assume more control functions, their current multichannel-redundancy system will have to be extended to enhance safety. Eventually, pilot control inputs will constitute instructions to a computer which will in turn optimize the most effective way of achieving the desired effects, in view of existing engine operation and aerodynamic constraints. O.C.

A88-48473
HIGH-TEMPERATURE DIMENSIONING OF TURBINE DISKS [DIMENSIONNEMENT A CHAUD DES DISQUES DE TURBOMACHINES]
A. BOUCHERIT and J.-P. MASCARELL (SNECMA, Moissy-Cramayel, France) Revue Francaise de Mecanique (ISSN 0373-6601), no. 1, 1988, p. 23-28. In French. refs

A dimensioning procedure for investigating the temporal evolution of the damage and viscoplastic behavior of an experimental disk subjected to the high-temperature multiaxial loading conditions characteristic for turbine disks is presented. The dimensioning philosophy for predicting life duration is discussed. A finite element analysis performed on a model disk made of INCO 718 reveals the values of parameters, associated with the stabilized cycle, which are used to calculate the fatigue life duration of two critical zones of the disk. It is noted that the large number of cycles which must be calculated in order to determine the stabilized response makes this type of analysis relatively expensive. R.R.

A88-48490#
FROM XG15 DEMONSTRATOR TO PRODUCTION PEGASUS 11-61 - IMPROVED POWER PLANT FOR AV8B
DAVID J. MARTIN and WILLIAM J. LEWIS (Rolls-Royce, PLC, Bristol, England) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 9 p. Research supported by Rolls-Royce, PLC and Ministry of Defence of England.
(AIAA PAPER 88-3185)

The XG15 growth engine demonstrator development program was launched in 1983 in order to furnish higher-thrust engines for aircraft of the Harrier family, such as the AV-8B, which required a more powerful engine. Attention was given to the improvement of fan and compressor aerodynamics and to the improvement of combustion chamber aerothermodynamics, as well as to the effective matching of the resulting rise in turbine temperatures by the use of single-crystal casting as the basis of the new engine's turbine blades. An account is given of development program scheduling. O.C.

A88-48752*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
A NUMERICAL STUDY OF THE HOT GAS ENVIRONMENT AROUND A STOVL AIRCRAFT IN GROUND PROXIMITY
THOMAS J. VANOVERBEKE and JAMES D. HOLDEMAN (NASA, Lewis Research Center, Cleveland, OH) AIAA, ASME, SAE, and

ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 27 p. Previously announced in STAR as N88-23729. refs
(AIAA PAPER 88-2888)

The development of Short Takeoff Vertical Landing (STOVL) aircraft has historically been an empirical- and experience-based technolgoy. In this study, a 3-D turbulent flow CFD code was used to calculate the hot gas environment around an STOVL aircraft operating in ground proximity. Preliminary calculations are reported for a typical STOVL aircraft configuration to identify key features of the flow field, and to demonstrate and assess the capability of current 3-D CFD codes to calculate the temperature of the gases ingested at the engine inlet as a function of flow and geometric conditions. Author

A88-48759*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
EXPERIMENTAL VIBRATION DAMPING CHARACTERISTICS OF THE THIRD-STAGE ROTOR OF A THREE-STAGE TRANSONIC AXIAL-FLOW COMPRESSOR
FREDERICK A. NEWMAN (NASA, Lewis Research Center, Cleveland, OH) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 23 p. Previously announced in STAR as N88-24642. refs
(AIAA PAPER 88-3229)

Rotor blade aerodynamic damping is experimentally determined in a three-stage transonic axial flow compressor having design aerodynamic performance goals of 4.5:1 pressure ratio and 65.5 lbm/sec weight flow. The combined damping associated with each mode is determined by a least squares fit of a single degree of freedom system transfer function to the nonsynchronous portion of the rotor blade strain gage output power spectra. The combined damping consists of the aerodynanmic damping and the structural and mechanical damping. The aerodynamic damping varies linearly with the inlet total pressure for a given corrected speed, weight flow, and pressure ratio while the structural and mechanical damping is assumed to remain constant. The combined damping is determined at three inlet total pressure levels to obtain the aerodynamic damping. The third-stage rotor blade aerodynamic damping is presented and discussed for the design equivalent speed with the stator blades reset for maximum efficiency. The compressor overall performance and experimental Campbell diagrams for the third-stage rotor blade row are also presented. Author

A88-48997#
EXPERIMENTAL INVESTIGATION OF THREE-DIMENSIONAL FORCED MIXER LOBE FLOW FIELDS
S. A. SKEBE, R. W. PATERSON, and T. J. BARBER (United Technologies Research Center, East Hartford, CT) IN: AIAA, ASME, SIAM, and APS, National Fluid Dynamics Congress, 1st, Cincinnati, OH, July 25-28, 1988, Technical Papers. Part 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 1999-2006. refs
(AIAA PAPER 88-3785)

This paper describes an experimental investigation of three-dimensional flow field development within contoured lobes similar to those employed in turbofan forced mixer nozzles and mixer-ejectors. Laser Doppler Velocimetry and total pressure loss measurements were performed on several lobe configurations in order to elucidate the underlying physics of the forced mixing flow process and to establish data sets suitable for the development of related computational fluid dynamic procedures. A principal result of this study is that the flows within forced mixers are predominantly inviscid, with boundary layer effects confined to lobe surface regions. Thus, the streamwise vortex array emanating from the trailing edge of such convoluted lobe surfaces is basically inviscid in origin. Author

A88-49015#
PREDICTION OF PROPFAN NOISE BY A FREQUENCY-DOMAIN SCHEME
H. GOUNET and S. LEWY (ONERA, Chatillon-sous-Bagneux, France) (ICAS, Congress, 15th, London, England, Sept. 7-12, 1986, Proceedings. Volume 2, p. 1442-1450) Journal of Aircraft (ISSN 0021-8669), vol. 25, May 1988, p. 428-435. Research supported by the Service Technique des Programmes Aeronautiques, DRET, and ONERA. Previously cited in issue 24, p. 3546, Accession no. A86-49125. refs

N88-25457# Air Force Occupational and Environmental Health Lab., Brooks AFB, Tex.
FIRST ARTICLE NOISE SURVEY OF THE A/F32T-9 LARGE TURBO FAN ENGINE ENCLOSED NOISE SUPPRESSOR SYSTEM, FAR-FIELD NOISE, ELLSWORTH AFB, SOUTH DAKOTA Final Report, period ending 13 Oct. 1987
ALI Y. ALI Feb. 1988 274 p
(AD-A191938; USAFOEHL-88-018EH0060ANA) Avail: NTIS HC A12/MF A01 CSCL 21E

The A/F32T-9 Large Turbo Fan Engine, Enclosed Noise Suppressor System (T-9 NSS) at Ellsworth AFB SD was surveyed to determine noise levels at 100 meters (m). With an F101 engine operating at afterburner power the highest measured Overall Sound Level, A-Weighted (OASLA) was 78.4 dB(A). The measured OASLA values exceeded the 77 dB(A) criterion at only 7 of the 18 sampling positions at a range from 0.3 to 1.4 dB(A). GRA

N88-25458*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
OVERVIEW OF NASA RESEARCH IN FIBER OPTICS FOR AIRCRAFT CONTROLS
GARY T. SENG 1988 9 p Proposed for presentation at the ISA/88 International Conference and Exhibit, Houston, Tex., 16-21 Oct. 1988; sponsored by the Instrument Society of America
(NASA-TM-100919; E-4156; NAS 1.15:100919) Avail: NTIS HC A02/MF A01 CSCL 01C

The challenge of those involved in aircraft control system hardware development is to accommodate an ever-increasing complexity in aircraft control, while limiting the size and weight of the components and improving system reliability. A technology that displays promise towards this end is fiber optics. The primary advantages of employing optical fibers, passive optical sensors and optically controlled actuators are weight/volume reduction, immunity from electromagnetic effects, high bandwidth capabilities and freedom from short circuits/sparking contacts. Since 1975, NASA Lewis has been performing in-house, contract and grant research in fiber optic sensors, high temperature electro-optic switches and fly-by-light control system architecture. Passive optical sensor development is an essential yet challenging area of work and has therefore received much attention during this period. A major effort to develop fly-by-light control system technology, known as the Fiber Optic Control System Integration (FOCSI) program, was initiated in 1985 as a cooperative effort between NASA and DOD. Phase 1 of FOCSI, completed in 1986, was aimed at the design of a fiber optic integrated propulsion/flight control system. Phase 2 will provide subcomponent and system development and system testing. In addition to a summary of the benefits of fiber optics, the FOCSI program, sensor advances, and future directions in the NASA Lewis program are discussed. Author

N88-26369# Argonne National Lab., Ill.
AN EFFICIENT COMPUTATIONAL TOOL FOR RAMJET COMBUSTOR RESEARCH
S. P. VANKA, J. L. KRAZINSKI, and A. S. NEJAD 1988 14 p Presented at the 26th AIAA Aerospace conference, Reno, Nev., 10 Jan. 1988
(Contract W-31-109-ENG-38)
(DE88-010034; CONF-880139-4; AIAA-88-0060) Avail: NTIS HC A03/MF A01

A multigrid based calculation procedure is presented for the efficient solution of the time-averaged equations of a turbulent elliptic reacting flow. The equations are solved on a non-orthogonal curvilinear coordinate system. The physical models currently incorporated are a two equation k-epsilon turbulence model, a four-step chemical kinetics mechanism, and a Lagrangian particle tracking procedure applicable for dilute sprays. Demonstration

calculations are presented to illustrate the performance of the calculation procedure for a ramjet dump combustor configuration. DOE

N88-26371# Pratt and Whitney Aircraft, West Palm Beach, Fla. Engineering Div.
ENGINE COMPONENT RETIREMENT FOR CAUSE. VOLUME 1: EXECUTIVE SUMMARY Final Report, Aug. 1980 - Nov. 1986
JOHN A. HARRIS, JR. Aug. 1987 60 p
(Contract F33615-80-C-5160)
(AD-A192730; PWA-FR-18301-VOL-1; AFWAL-TR-87-4069-VOL-1)
Avail: NTIS HC A04/MF A01 CSCL 21E

This program developed and integrated materials behavior characteristics, component life analysis, nondestructive evaluation and cost-risk technology to establish and demonstrate the retirement for cause maintenance concept as it applies to rotating components of military gas turbine engines. As such it provides the basis for elimination of classical time or cyclic limits currently imposed for retirement of gas turbine rotor components by substituting a life management system in which each individual component is retired from service when the unique, economical safe life of that component is exhausted. The methodology was demonstrated on and validated for the U.S. Air Force F100 engine's rotor components and has been implemented on that engine system by the USAF Air Logistics Command. Use of Retirement for Cause is projected to result in life cycle cost savings in excess of $1 billion for that engine-system. The Retirement for Cause methodology developed is generic, and may be applied to not only other gas turbine engines, but to components of any life limited system. GRA

N88-26373# National Aerospace Lab., Amsterdam (Netherlands). Structures and Materials Div.
CORROSION PREVENTION IN GAS TURBINES
A. J. A. MOM 13 May 1987 36 p In DUTCH; ENGLISH summary Presented at the Corrosiedag 1986 van de NCC-sector Energie, Arnhem, Netherlands, 16 Sep. 1986
(NLR-MP-87029-U; B8805308; ETN-88-92611) Avail: NTIS HC A03/MF A01

Corrosion prevention and reduction in gas turbines is discussed. Preventative measures concentrate on the environment in the gas turbine, using filters, washing, scouring with rice husks, choice of fuel. Corrosion can be mitigated by the use of coatings or other materials. Good corrosion prevention requires developing an integral plan whereby the effects of the various preventive measures and the costs entailed are reviewed and considered as a whole. ESA

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AIRCRAFT STABILITY AND CONTROL

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

A88-46046#
SYNTHESIS OF AN ADAPTIVE FLIGHT CONTROLLER UNDER UNKNOWN DETERMINISTIC DISTURBANCES
KIMIO KANAI, SHIGERU UCHIKADO (Defense Academy, Yokosuka, Japan), PETER N. NIKIFORUK, and NORIYUKI HORI (Saskatchewan, University, Saskatoon, Canada) Japan Society for Aeronautical and Space Sciences, Transactions (ISSN 0549-3811), vol. 31, May 1988, p. 1-17. refs

Two methods of designing an adaptive flight control system are developed using an algebraic polynomial method. The first is based on the direct control method, which identifies the plant parameters implicitly, and the second on the indirect method, which does this explicitly. The controllers which are designed using these schemes are able to take account of the uncertainties in the aircraft's stability and control derivatives, and are robust against the deterministic disturbances. Their application to the flight control of small, high-performance aircraft is examined using numerical simulations which show that the proposed schemes are effective. Author

A88-46049#
LARGE MOTION ROBUST FLIGHT CONTROL OF AIRCRAFT BY EQUIVALENT NONLINEAR ELIMINATION
SHOKICHI KANNO (Ichinoseki National College of Technology, Japan) and TATSUO CHUBACHI (Iwate University, Ueda, Japan) Japan Society for Aeronautical and Space Sciences, Transactions (ISSN 0549-3811), vol. 31, May 1988, p. 48-60. refs

This paper is concerned with the large motion robust flight control of aircraft by the theory of approximate perfect servo and equivalent nonlinear elimination method. The perfect servo means that the transfer matrix is I(m), and the output, follows asymptotically any bounded arbitrary command inputs. The nonlinear dynamics of aircraft are equivalently eliminated by the equivalent elimination, and this operation does not need any numerical computation of aircraft dynamics. This system is robust and stable, being indifferent to the change of flight conditions and to the variation of aircraft dynamics. Simulations about a high speed aircraft showed very good results. Author

A88-46702*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, Calif.
APPLICATION OF FREQUENCY-DOMAIN HANDLING QUALITIES CRITERIA TO THE LONGITUDINAL LANDING TASK
SHAHAN K. SARRAFIAN and BRUCE G. POWERS (NASA, Flight Research Center, Edwards, CA) (Guidance, Navigation and Control Conference, Snowmass, CO, Aug. 19-21, 1985, Technical Papers, p. 1-12) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 11, July-Aug. 1988, p. 291, 292. Abridged. Previously cited in issue 22, p. 3228, Accession no. A85-45877.

A88-46707*# Rice Univ., Houston, Tex.
GAMMA GUIDANCE SCHEMES FOR FLIGHT IN A WINDSHEAR
A. MIELE, T. WANG (Rice University, Houston, TX), W. W. MELVIN (Delta Air Lines, Inc., Atlanta, GA), and R. L. BOWLES (NASA, Langley Research Center, Hampton, VA) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 11, July-Aug. 1988, p. 320-327. Research supported by Boeing Commercial Airplane Co. and Air Line Pilots Association. refs
(Contract NAG1-516)

This paper is concerned with guidance strategies for near-optimum performance in a windshear. The takeoff problem is considered with reference to flight in a vertical plane. In addition to the horizontal shear, the presence of a downdraft is assumed. A gamma guidance scheme, based on the absolute path inclination, is presented. This approach needs local information on the windshear and the downdraft. The gamma guidance scheme produces trajecories that preserve the basic properties of the optimal trajectories. The relation between the gamma guidance scheme and the acceleration guidance scheme is explored. In logic, these two guidance schemes are complementary to one another; in implementation, they yield almost identical results. Although local information on the windshear and the downdraft will be available in future aircraft, it might not be available on current aircraft. Hence, a simplified gamma guidance scheme (quick transition to horizontal flight) is presented which is useful for flight in severe windshears. The simplified gamma guidance scheme yields trajectories that are close to the optimal trajectories in severe windshears; in addition, it is easy to implement as a practical piloting technique. Author

A88-47191
COMPACT ELECTROMECHANICAL ACTUATION FOR HIGH PERFORMANCE RPV FLIGHT CONTROL
DAVID WARD (Kollmorgen Corp., Inland Motor Div., Radford, VA) IN: Remotely piloted vehicles; Proceedings of the Sixth International

Conference, Bristol, England, Apr. 6-8, 1987, Conference Papers. Bristol, England, University of Bristol, 1987, p. 15.1-15.9.

An evaluation is made of recent advancements in the design and application of high-performance electromechanical actuators to RPV flight controls, in order to increase actuation torques and thrusts, expand the actuation frequency-response envelope, and minimize mechanical systems' size and weight. Attention is given to electromechanical actuators' control electronics, state-of-the-art dc motors and rare-earth permanent-magnet (i.e., samarium-cobalt) motors, and the representative AQTB-0701-A rotary actuator and ABM-0702-A/EC1023 linear actuator systems. O.C.

A88-47931
ANALYTICAL REDUNDANCY USING BAND-LIMITING FILTERS
J. G. JONES and M. J. CORBIN (Royal Aircraft Establishment, Farnborough, England) IEE Proceedings, Part D - Control Theory and Applications (ISSN 0143-7054), vol. 135, pt. D, no. 4, July 1988, p. 257-267. refs

The paper presents a method in which control system faults may be detected on the basis of the generation and crosscomparison of bandlimited signals from dissimilar sources. While signals measured at different points in the system may differ widely when viewed over a wide bandwidth, it is shown that, over limited pass bands, there are simple relationships that can be verified by means of appropriate filtering and comparison logic. In effect, the band-limiting filters are used to monitor the propagation of information originating in the structure of external inputs through the system. K.K.

A88-47932
ANALYSIS OF THE TECHNIQUE OF ROBUST EIGENSTRUCTURE ASSIGNMENT WITH APPLICATION TO AIRCRAFT CONTROL
S. K. MUDGE and R. J. PATTON (York, University, England) IEE Proceedings, Part D - Control Theory and Applications (ISSN 0143-7054), vol. 135, pt. D, no. 4, July 1988, p. 275-281. refs

Given the linear state-space representation of a dynamic system, a method for computing allowable eigenvector subspaces using singular value decomposition for both real and complex eigenvalues is illustrated. Once these spaces have been determined, it is possible to assign the eigenvectors in two ways: one which performs desirable weightings of the system states for each mode permitting system decoupling, and the second which assigns eigenvectors iteratively to make the corresponding eigenvalues as insensitive to perturbations in the system matrices as possible. A computational procedure for each of these techniques is described. The work is illustrated using the stability augmentation system control design problem for the lateral motion model of a nonlinear aircraft system. The modal requirements for this problem are well known, and this enables a comparison of the two methods to be made. Author

A88-48494#
FLUTTER SUPPRESSION WITHIN REACH
HOLT ASHLEY (Stanford University, CA) Aerospace America (ISSN 0740-722X), vol. 26, Aug. 1988, p. 14-16.

The control of aeroelastic degrees-of-freedon in currently operational aircraft can be reliably and advantageously achieved through application of the principles of aeroservoelasticity. It is presently noted that flutter suppression can be made part of active control in future aircraft from the outset of preliminary design. The technologies required encompass highly redundant and benignly degrading avionics, high-bandwidth sensors and aerodynamic surface actuators, and optimum control laws for the system software that maximize hydraulic power savings. O.C.

A88-48495*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
FILLING THE EXPERTISE GAP
IRVING ABEL (NASA, Langley Research Center, Hampton, VA) Aerospace America (ISSN 0740-722X), vol. 26, Aug. 1988, p. 16, 17.

Aeroelasticity, structures, and stability-and-control specialists can work in concerted fashion during the early design phases of future aircraft to achieve active control of naturally unstable configurations. In order to take full advantage of active control, attention must be given by designers to control-law synthesis, and to tools for the efficient synthesis and analysis of complex flexible-aircraft control systems. Analysts must consider interfaces among unsteady aerodynamics, structures, and control theory, as explored by the theory of analytic continuation for unsteady aerodynamics. O.C.

A88-48496#
COUPLING STRUCTURE AND CONTROLS DESIGN
TERRENCE A. WEISSHAAR (Purdue University, West Lafayette, IN) Aerospace America (ISSN 0740-722X), vol. 26, Aug. 1988, p. 18, 20.

While it is in principle easy to mathematically optimize both aircraft structures and control laws simultaneously, by adding measures of control performance to measures of structural performance to arrive at a global cost function, the interdisciplinary complexity of actual projects defies such straightforward treatment. Attention is presently given to the 'multilevel decomposition' approach developed at NASA-Langley, in which a chief engineer coordinates various disciplinary design groups and chooses, if necessary, a less-than-desirable solution in a given discipline for the sake of overall cohesiveness. The various groups also share a common data base. O.C.

A88-48497#
ACTIVE CONTROL IN TOMORROW'S MARKETPLACE
NICK A. RADOVICH (Lockheed Aeronautical Systems Co., Sunland, CA) Aerospace America (ISSN 0740-722X), vol. 26, Aug. 1988, p. 20, 22.

Aeroservoelastic solutions to fundamental aircraft design problems are in competition with the potential contributions of advanced materials, aeroelastic tailoring, and improved aerodynamics; aeroservoelasticians must accordingly engage emergent configuration design opportunities for active control system application at the outset of the design process. While active control reliability of the order of 10 to the -6th may be adequate for gust or maneuver loads control, aeroservoelastic stability (flutter) control applications will require the reliability levels of basic structure if flutter speeds without active control exist within the flight envelope in question. O.C.

A88-48697
SYSTEMS OF AUTOMATIC AIRCRAFT CONTROL (2ND REVISED AND ENLARGED EDITION) [SISTEMY AVTOMATICHESKOGO UPRAVLENIIA SAMOLETOM /2ND REVISED AND ENLARGED EDITION/]
IVAN ALEKSANDROVICH MIKHALEV, BARIT NIKOLAEVICH OKOEMOZ, and MANUIL SERGEEVICH CHIKULAEV Moscow, Izdatel'stvo Mashinostroenie, 1987, 240 p. In Russian. refs

This work describes parametric-optimization methods for application to automatic aircraft control systems. Particular consideration is given to an analysis of the mathematical model of the motion of an aircraft as a control plant; the fundamental principles underlying the design of automatic control systems for aircraft; the synthesis of stability and controllability automata structures; and the synthesis of structures for automatic stabilization and control in connection with pitch and bank. Particular consideration is given to an examination of longitudinal flying qualities. B.J.

A88-48723
A METHOD FOR CONTROLLING AIRCRAFT DURING THE EXECUTION OF A VERTICAL MANEUVER [SPOSOB UPRAVLENIIA SAMOLETOM PRI VYPOLNENII VERTIKAL'NOGO MANEVRA]
A. M. PETROV, V. A. KONDRATENKOV, and S. P. PSHENETSKII (Kievskoe Vysshee Inzhenernoe Aviatsionnoe Uchilishche, Kiev, Ukrainian SSR) Matematicheskaia Fizika i Nelineinaia Mekhanika (ISSN 0233-7568), no. 9, 1988, p. 26-29. In Russian.

A new method for controlling aircraft during the execution of

maneuvers in a vertical plane is proposed which is based on the use of an integral flight parameter that directly reflects the evolution of motion in space. It is demonstrated that this parameter, the angular rotation rate of the velocity vector, remains constant throughout the execution of vertical maneuvers. V.L.

A88-49009#
FLUTTER PREDICTION INVOLVING TRAILING-EDGE CONTROL SURFACES
M. FRENCH, T. NOLL, D. COOLEY (USAF, Flight Dynamics Laboratory, Wright-Patterson AFB, OH), R. MOORE, and F. ZAPATA (USAF, Aeronautical Systems Div., Wright-Patterson AFB, OH) (Structures, Structural Dynamics and Materials Conference, 28th, Monterey, CA, Apr. 6-8, 1987 and AIAA Dynamics Specialists Conference, Monterey, CA, Apr. 9, 10, 1987, Technical Papers. Part 2B, p. 657-663) Journal of Aircraft (ISSN 0021-8669), vol. 25, May 1988, p. 393, 394. Previously cited in issue 14, p. 2110, Accession no. A87-33718.

A88-49023#
FLUTTER MODES OF HIGH ASPECT RATIO TAILLESS AIRCRAFT
J. R. BANERJEE (City University, London, England) Journal of Aircraft (ISSN 0021-8669), vol. 25, May 1988, p. 473-476.

An examination is conducted of the flutter modes of the 'Ricochet' tailless sailplane, and the results obtained are contrasted with those obtained for the 'Kestrel' aircraft of similar configuration. The interaction between the rigid-body modes and the elastic modes is highlighted by illustrating the contribution of rigid-body modes and elastic modes to the resulting flutter mode. Results are presented only for the symmetric motion of the aircraft. O.C.

A88-49143#
A DECENTRALIZED APPROACH TO AUTOMATIC FLIGHT CONTROL DESIGN
M. VUKOBRADOVICH and R. STOJICH Academie Serbe des Sciences et des Arts, Bulletin, vol. 93, Classe des Sciences Techniques (ISSN 0490-642X), no. 23, 1987, p. 45-66. refs

An approach to decoupled control of large-scale nonlinear systems is applied to a dynamic flight control. Control synthesis is performed in two steps. First, the nominal, programmed control is synthesized using the complete model of flight dynamics. At the second step the tracking of the nominal trajectory is realized. The system is viewed as a set of decoupled subsystems and, for each subsystem, local control is synthesized. Then, the stability of the overall system is analyzed and the global control is introduced to compensate for coupling among some of the subsystems. A simulation of flight control with the proposed control law is presented. Author

A88-49198* Rice Univ., Houston, Tex.
QUASI-STEADY FLIGHT TO QUASI-STEADY FLIGHT TRANSITION FOR ABORT LANDING IN A WINDSHEAR - TRAJECTORY OPTIMIZATION AND GUIDANCE
A. MIELE, T. WANG (Rice University, Houston, TX), and W. W. MELVIN (Delta Air Lines, Inc., Atlanta, GA) Journal of Optimization Theory and Applications (ISSN 0022-3239), vol. 58, Aug. 1988, p. 165-207. Research supported by Boeing Commercial Airplane Co. and Air Line Pilots Association. refs
(Contract NAG1-516)

Trajectory optimization and trajectory-guidance problems for abort-landing maneuvers in the presence of low-altitude wind shear are investigated by means of numerical simulations, with a focus on methods designed to achieve quasi-steady flight recovery (final values of the relative velocity, path inclination, and angle of attack equal to those for quasi-steady steepest climb). The derivation of the governing equations is outlined; the modeling techniques are explained; and results for a B-727 transport aircraft approaching a sea-level airfield at temperature 100 F are presented in extensive tables and graphs and characterized in detail. The techniques developed are shown to be effective in restoring the aircraft to stable quasi-steady flight. T.K.

N88-25461*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
FLIGHT-MANAGEMENT STRATEGIES FOR ESCAPE FROM MICROBURST ENCOUNTERS M.S. Thesis - George Washington Univ.
DAVID A. HINTON Aug. 1988 29 p
(NASA-TM-4057; L-16448; NAS 1.15:4057) Avail: NTIS HC A03/MF A01 CSCL 01C

An effort is underway by NASA, FAA, and industry to reduce the threat of convective microburst wind shear phenomena to aircraft. The goal is to develop and test a candidate set of strategies for recovery from inadvertent microburst encounters during takeoff. Candidate strategies were developed and evaluated using a fast-time simulation consisting of a simple point-mass performance model of a transport-category airplane and an analytical microburst model. The results indicate that the recovery strategy characteristics that best utilize available airplane energy include an initial reduction in pitch attitude to reduce the climb rate, followed by an increase in pitch up to the stick shaker angle of attack. The stick shaker angle of attack should be reached just as the airplane is exiting the microburst. The shallowest angle of climb necessary for obstacle clearance should be used. If the altitude is higher than necessary, an intentional descent to reduce the airspeed deceleration should be used. Of the strategies tested, two flight-path-angle based strategies had the highest recovery altitudes and the least sensitivity to variations in the encounter scenarios. Author

N88-25462*# Bolt, Beranek, and Newman, Inc., Cambridge, Mass.
F-14 MODELING STUDY Final Report
WILLIAM H. LEVISON Jul. 1988 54 p
(Contract NAS1-17648)
(NASA-CR-4164; NAS 1.26:4164; BBN-6579) Avail: NTIS HC A04/MF A01 CSCL 01C

This study explored application of a closed loop pilot/simulator model to the analysis of some simulator fidelity issues. The model was applied to two data bases: (1) a NASA ground based simulation of an air-to-air tracking task in which nonvisual cueing devices were explored, and (2) a ground based and inflight study performed by the Calspan Corporation to explore the effects of simulator delay on attitude tracking performance. The model predicted the major performance trends obtained in both studies. A combined analytical and experimental procedure for exploring simulator fidelity issues is outlined. Author

N88-26374*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
LOW-SPEED WIND-TUNNEL TEST OF A STOL SUPERSONIC-CRUISE FIGHTER CONCEPT
PAUL L. COE, JR. and DONALD R. RILEY Jul. 1988 43 p
(NASA-TM-4050; L-16422; NAS 1.15:4050) Avail: NTIS HC A03/MF A01 CSCL 01C

A wind-tunnel investigation was conducted to examine the low-speed static stability and control characteristics of a 0.10 scale model of a STOL supersonic cruise fighter concept. The concept, referred to as a twin boom fighter, was designed as a STOL aircraft capable of efficient long range supersonic cruise. The configuration name is derived from the long twin booms extending aft of the engine to the twin vertical tails which support a high center horizontal tail. The propulsion system features a two dimensional thrust vectoring exhaust nozzle which is located so that the nozzle hinge line is near the aircraft center of gravity. This arrangement is intended to allow large thrust vector angles to be used to obtain significant values of powered lift, while minimizing pitching moment trim changes. Low speed stability and control information was obtained over an angle of attack range including the stall. A study of jet induced power effects was included. Author

N88-26375 Princeton Univ., N. J.
CONTROL OF FLIGHT THROUGH MICROBURST WIND SHEAR USING DETERMINISTIC TRAJECTORY OPTIMIZATION Ph.D. Thesis
MARK LOCKWOOD PSIAKI 1987 392 p
Avail: Univ. Microfilms Order No. DA8800331

Aircraft control strategies that minimize the hazard of longitudinal flight through microburst wind shear are developed and analyzed, principally using deterministic trajectory optimization and to a lesser extent using classical control. The purpose is to determine the ultimate limits to safe performance in a microburst and develop control strategies that achieve such performance. Several tragic microburst-related accidents have demonstrated the need for improved control strategies. Over 1,100 optimal trajectories were computed for jet transport and general aviation aircraft flying through idealized and actual microbursts. They were generated using a Successive Quadratic Programs trajectory optimization algorithm, which directly handles inequality constraints. Qualitative aspects of the best strategies provide a composite picture of good control in a microburst. Variations of the optimal performance with microburst type, intensity, length scale, and location define safe-performance limits. These studies provide guidelines for design and evaluation of practical microburst-encounter control laws. Controllers should replicate the pitch steering and throttle strategies found in the composite picture of good control. Evaluation should include frequency response analysis and comparison of closed-loop safe-performance limits with optimal limits. Dissert. Abstr.

N88-26376*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
COMPUTER SIMULATION OF A SINGLE PILOT FLYING A MODERN HIGH-PERFORMANCE HELICOPTER
MARK E. ZIPF, WILLIAM G. VOGT, MARLIN H. MICKLE, RONALD G. HOELZEMAN, FEI KAI, and JAMES R. MIHALOEW (Pittsburgh Univ., Pa.) Jul. 1988 25 p
(Contract NAG3-729)
(NASA-TM-100182; E-3759; NAS 1.15:100182) Avail: NTIS HC A03/MF A01 CSCL 01C

Presented is a computer simulation of a human response pilot model able to execute operational flight maneuvers and vehicle stabilization of a modern high-performance helicopter. Low-order, single-variable, human response mechanisms, integrated to form a multivariable pilot structure, provide a comprehensive operational control over the vehicle. Evaluations of the integrated pilot were performed by direct insertion into a nonlinear, total-force simulation environment provided by NASA Lewis. Comparisons between the integrated pilot structure and single-variable pilot mechanisms are presented. Static and dynamically alterable configurations of the pilot structure are introduced to simulate pilot activities during vehicle maneuvers. These configurations, in conjunction with higher level, decision-making processes, are considered for use where guidance and navigational procedures, operational mode transfers, and resource sharing are required. Author

N88-26377*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
COMPUTER SIMULATION OF MULTIPLE PILOTS FLYING A MODERN HIGH PERFORMANCE HELICOPTER
MARK E. ZIPF, WILLIAM G. VOGT, MARLIN H. MICKLE, RONALD G. HOELZEMAN, FEI KAI, and JAMES R. MIHALOEW (Pittsburgh Univ., Pa.) Jul. 1988 32 p
(Contract NAG3-729)
(NASA-TM-100183; E-3760; NAS 1.15:100183) Avail: NTIS HC A03/MF A01 CSCL 01C

A computer simulation of a human response pilot mechanism within the flight control loop of a high-performance modern helicopter is presented. A human response mechanism, implemented by a low order, linear transfer function, is used in a decoupled single variable configuration that exploits the dominant vehicle characteristics by associating cockpit controls and instrumentation with specific vehicle dynamics. Low order helicopter models obtained from evaluations of the time and frequency domain responses of a nonlinear simulation model, provided by NASA Lewis Research Center, are presented and considered in the discussion of the pilot development. Pilot responses and reactions to test maneuvers are presented and discussed. Higher level implementation, using the pilot mechanisms, are discussed and considered for their use in a comprehensive control structure. Author

N88-26378*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
A HIGH FIDELITY REAL-TIME SIMULATION OF A SMALL TURBOSHAFT ENGINE
MARK G. BALLIN Jul. 1988 95 p
(NASA-TM-100991; A-88151; NAS 1.15:100991) Avail: NTIS HC A05/MF A01 CSCL 21E

A high-fidelity component-type model and real-time digital simulation of the General Electric T700-GE-700 turboshaft engine were developed for use with current generation real-time blade-element rotor helicopter simulations. A control system model based on the specification fuel control system used in the UH-60A Black Hawk helicopter is also presented. The modeling assumptions and real-time digital implementation methods particular to the simulation of small turboshaft engines are described. The validity of the simulation is demonstrated by comparison with analysis-oriented simulations developed by the manufacturer, available test data, and flight-test time histories. Author

N88-26524# York Univ. (England). Dept. of Electronics.
FREQUENCY DOMAIN IDENTIFICATION OF THE DYNAMICS OF A SCALED REMOTELY-PILOTED HELICOPTER
P. YOUNG and R. J. PATTON *In* DFVLR, System Identification in Vehicle Dynamics p 153-172 1987 Sponsored by the United Kingdom Science and Engineering Research Council and the United Kingdom Ministry of Defence
Avail: NTIS HC A18/MF A01; DFVLR, VB-PL-DO, 90 60 58, 5000 Cologne, Fed. Republic of Germany, 109 Deutsche marks

A linear digital simulation of a radio-controlled model helicopter was performed to evaluate the validity of applying frequency domain identification to structural estimation of a complex nonlinear system. The control and telemetry systems, the sensors and the associated signal conditioning developed for the radio-controlled helicopter facility are described. Sine-wave frequency sweeps were applied to each input in turn to excite all the dominant modes of the system, and the time series data were analyzed to obtain the system transfer functions. The closed-loop transfer functions are found by least-squares curve fitting, and the poles and zeros are determined for each case. Comparing these modes with the corresponding elements in the transfer function matrix obtained from the Levernier algorithm gives results which demonstrate the usefulness of the frequency domain approach in identification. ESA

N88-26535# Technische Univ., Brunswick (West Germany). Inst. fuer Regelungstechnik.
NONLINEAR IDENTIFICATION OF AN AIRCRAFT FOR THE DIRECT CALCULATION OF AN ANTICIPATORY CONTROL [NICHTLINEARE IDENTIFIZIERUNG EINES FLUGZEUGS ZUR DIREKTEN BERECHNUNG EINER VORSTEUERUNG]
M. HAVERLAND and U. LINDEMANN *In* DFVLR, System Identification in Vehicle Dynamics p 363-374 1987 In GERMAN
Avail: NTIS HC A18/MF A01; DFVLR, VB-PL-DO, 90 60 58, 5000 Cologne, Fed. Republic of Germany, 109 Deutsche marks

Using the example of the identification and control of an aircraft, a predictive control method for nonlinear sections is presented. In many cases a linear controller is not sufficient for the control of nonlinear sections, but the combination of a linear controller and predictive control gives better results. The proposed method allows the determination of predictive control coefficients directly from measured quantities. It is shown that the coefficients build up quickly, allowing to follow section parameter variations and providing a high safety level. The method can be used for the identification of nonlinear systems that can be described by a

model that is linear in the coefficients. Dynamic effects can also be taken into account. ESA

09

RESEARCH AND SUPPORT FACILITIES (AIR)

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

A88-45931#
THE WALL PRESSURE SIGNATURE MATRIX METHOD FOR SOLID WALL INTERFERENCE CORRECTION OF LOW-SPEED WIND TUNNEL
GUIQING JIANG (China Aerodynamics Research and Development Centre, Sichuan, People's Republic of China) Acta Aerodynamica Sinica (ISSN 0258-1825), vol. 6, June 1988, p. 204-212. In Chinese, with abstract in English.

The wall pressure signature matrix method for a low-speed wind tunnel with a solid wall is described. Its starting system of equations is briefly derived. The paper provides the detailed solutions and formulations of corrections. The present method and its procedures have been demonstrated through the numerical simulation tests and the physical model tests, and their check results are presented here. Analyses and calculations are also given for the swept effect, the axial translation acceleration effects, the test section length and the departure of model from tunnel center-line, etc. Author

A88-45933#
THE APPLICATION OF COLOUR HELIUM BUBBLE IN THE WIND TUNNEL TEST
DONG ZHAO and MINZHONG TANG (Harbin Aerodynamic Research Institute, People's Republic of China) Acta Aerodynamica Sinica (ISSN 0258-1825), vol. 6, June 1988, p. 220-225. In Chinese, with abstract in English. refs

The color helium bubble flow visualization method is a new and unique technique. Flow visualization in the wind tunnel using colored helium bubbles has been achieved at Harbin Aerodynamic Research Institute in March, 1984. Rich and varied paths were obtained. Clear color video tape recording and color photographs were taken. Shortly after, car, coach, building, ship's rudder, fish scale wave surface, slender body, cylinder, parachute and various aircraft models were tested. Author

A88-46271
HELICOPTER FLIGHT SIMULATION - A QUESTION OF FIDELITY
MIKE GROVER (Rediffusion Simulation, Ltd., Crawley, England) ICAO Bulletin (ISSN 0018-8778), vol. 43, May 1988, p. 13-16.

Problems of helicopter flight simulation are examined, presenting developments to make helicopter simulation more effective. Developments in computer-generated imagery, digital processors for controlling and monitoring the simulator environment, rotor modelling, and touch-screen technology are discussed. The integration of available devices to present the full range of operating conditions, the role of the instructor in simulator training, and prospects for future developments in simulator technology are also considered. R.B.

A88-46272
SIMULATION DATA VALIDATION SYSTEM DEVELOPED
J. SHLIEN (CAE Electronics, Ltd., Montreal, Canada) ICAO Bulletin (ISSN 0018-8778), vol. 43, May 1988, p. 17-19.

An automated system designed to rapidly analyze digital simulation checkout data is presented. Previous methods for checking airplane manufacturer's validation data against simulation-model response are discussed. Capabilities of the automated system include interaction between various utilities, a master data file of pilot input and resultant aircraft response, a manual means to generate the digital data base of the aircraft plots if magnetic tapes are not provided by the manufacturer, and header information to identify each static and dynamic test. R.B.

A88-46273
AIRBUS TRAINING FACILITY COMBINES FLIGHT SIMULATION WITH COMPUTER-BASED INSTRUCTION
HELENE CHARMENSAT (Aeroformation, Toulouse, France) ICAO Bulletin (ISSN 0018-8778), vol. 43, May 1988, p. 20, 21.

An airbus training facility is examined, describing a computer-based instruction and flight simulators. The instructional system includes a microcomputer connected to a video disk reader and monitor. The program and simulator are integrated and allow the student to check the results of an action immediately. The facility equipment includes cockpit system simulators for flight crew training, a maintenance simulator, and an emergency evacuation trainer for the instruction of maintenance personnel and flight attendants. R.B.

A88-46333
TEST METHODS IN HYPERSONICS [MOYENS D'ESSAIS EN HYPERSONIQUE]
J. P. CHEVALLIER (ONERA, Chatillon-sous-Bagneux, France) Colloque d'Aerodynamique Appliquee, 24th, Poitiers, France, Oct. 26-28, 1987. 55 p. In French. refs
(AAAF PAPER NT-87-09)

The performance of various hypersonic test methods are compared with respect to flow velocity, volumetric mass, temperature, and duration. The elementary shock tube is limited in Mach number, and it is shown how the Mach number can be increased by direct steady expansion, how flow duration can be increased, and how the radiation barrier can be extended by unsteady effects. The principle and performance of the light-gas guns used in hyperballistic firing tunnels are considered. It is noted that the F4 short-trajectory wind tunnel has a high level of performance, has a long flow duration, and allows the use of models of the order of 40 cm. R.R.

A88-46427
THE ACQUISITION AND USE OF FLIGHT SIMULATION TECHNOLOGY IN AVIATION TRAINING; PROCEEDINGS OF THE INTERNATIONAL CONFERENCE, LONDON, ENGLAND, APR. 27-29, 1987. VOLUMES 1 & 2
Conference sponsored by the Royal Aeronautical Society. London, Royal Aeronautical Society, 1987, p. Vol. 1, 186 p.; vol. 2, 248 p. For individual items see A88-46428 to A88-46445.

The present conference discusses the military perspective on future flight simulation, UK Ministry of Defense procurement of simulators and trainers for aircraft, acquisition management considerations for simulator procurement, and funding sources for simulator financing. Also discussed are the acquisition of training systems by the USAF, the integration of low cost trainers in a commercial pilots' license syllabus, integrated ground training for an advanced turboprop aircraft, and a comparison of military and civilian simulator procurement and program-management practices. Consideration is given to the CAA approach to simulator approval, regional-airline requirements for training and training devices, the integration of avionics in simulators, total training-system management, and the use of knowledge-based techniques in the formulation and bidding of simulator projects. O.C.

A88-46429
FUTURE FLIGHT SIMULATION - A MILITARY VIEW
I. W. STRACHAN (RAF, London, England) IN: The acquisition and use of flight simulation technology in aviation training; Proceedings of the International Conference, London, England, Apr. 27-29, 1987. Volume 1. London, Royal Aeronautical Society, 1987, p. 9-21.

A development history is presented for UK military aircraft flight simulation equipment, in order to evaluate emerging technological capabilities against prospective military aviation requirements and ascertain the most likely route to cost-effectiveness in such

equipment. Attention is given to air combat simulators, very wide field-of-view systems, IR sensor-based air combat navigation and targeting simulators, motion-cueing techniques, and the inclusion of EW effects on instruments. O.C.

A88-46438
ACCEPTANCE PROCEDURES TO IMPROVE THE HANDLING FIDELITY OF MILITARY FLIGHT SIMULATORS
A. D. WHITE (Royal Aircraft Establishment, Bedford, England) IN: The acquisition and use of flight simulation technology in aviation training; Proceedings of the International Conference, London, England, Apr. 27-29, 1987. Volume 2. London, Royal Aeronautical Society, 1987, p. 269-281. refs

A number of in-service UK flight training simulators have recently been the subject of criticism in connection with handling fidelity. As a result of these criticisms, a review of Ministry of Defence acceptance procedures is underway. This paper examines some of the problems that have been experienced, summarizes the proposed new Acceptance Test Schedule items for dynamic handling qualities, and considers some of the implications for simulator specifications and data sources. B.J.

A88-46440
FAA'S ADVANCED SIMULATION PLAN INFLUENCE ON SIMULATOR DESIGN AND DATA ACQUISITION
JOHN E. HOPE (Boeing Commercial Airplane Co., Seattle, WA) IN: The acquisition and use of flight simulation technology in aviation training; Proceedings of the International Conference, London, England, Apr. 27-29, 1987. Volume 2. London, Royal Aeronautical Society, 1987, p. 317-324.

The impact of the Advanced Simulation Plan on simulator design and data acquisition is discussed from a Boeing perspective. It is noted that the introduction and maturing of the Plan has provided a uniform set of achievable standards which would not otherwise have been economically feasible. The generation of flight test data for simulator use has required increased emphasis on controlled test conditions, data resolution, and timing accuracy. Correspondingly, simulators have required the development of hydrostatic digital control loading systems and powerful instructor stations able to perform FAA Approval Test Guide testing speedily, accurately, and conveniently. Growth in simulator computing demand due to greatly increased data package demand has led to increasing interest in computing configurations able to provide expansion flexibility at minimum cost. B.J.

A88-46441
THE INTEGRATION OF AIRPLANE AVIONICS EQUIPMENT IN FLIGHT SIMULATORS
W. D. HASS (Deutsche Lufthansa AG, Frankfurt am Main, Federal Republic of Germany) IN: The acquisition and use of flight simulation technology in aviation training; Proceedings of the International Conference, London, England, Apr. 27-29, 1987. Volume 2. London, Royal Aeronautical Society, 1987, p. 325-332.

The problems new-generation digital avionics equipment presents to flight simulators are examined. Possible solutions for the integration of this equipment is considered, including the simulation of the avionics functions by software running in the simulator host computer and the 'simulation' of avionics functions using modified aircraft computers. The creation of an industry standard is considered along with the implementation of ARINC 610 recommendations. B.J.

A88-46977
AEROSPACE SYSTEM SIMULATION AT SANDIA NATIONAL LABORATORIES
ALFRED C. WATTS (Sandia National Laboratories, Albuquerque, NM) IN: 1987 Annual Summer Computer Simulation Conference, 19th, Montreal, Canada, July 27-30, 1987, Proceedings. San Diego, CA, Society for Computer Simulation, 1987, p. 777-781.

The development of navigation, guidance and control systems for flight test vehicles associated with advanced weapons systems is discussed. Computing facilities used in all-digital simulations, real-time digital simulations and hybrid, hardware-in-the-loop simulations using various elements of guidance hardware and a three-axis motion simulator are examined. The methodology for the validation of flight software and the performance validation for guidance and control hardware is presented. R.B.

N88-25463# Systems Control Technology, Inc., Arlington, Va. Program Engineering Service.
FOUR URBAN HELIPORT CASE STUDIES Final Report
DEBORAH PEISEN and JACK THOMPSON Mar. 1988 57 p (Contract DTFA01-87-C-00014)
(DOT/FAA/PM-87/32; DOT/FAA/PP-88/2; REPT-5542-6A3)
Avail: NTIS HC A04/MF A01

State and city governments generally realize that continued vitality depends on a steady expansion of industry and services as a function of planned growth. The helicopter is a proven catalyst for enhancement of those desired growth patterns. Case histories are developed for public use heliports built in the Central Business District of several major cities. Within each case history, common denominators are identified that are useful for planners in assessing the vitality of heliport proposals in cities that exhibit similar demographic characteristics. Each case study provides a general background as a setting and an inventory of pertinent heliport data: including location, cost, history, funding and revenue sources, operational characteristics, etc.; it addresses social concerns such as the local industrial base, neighboring land uses and zoning; and the public and governmental attitudes toward the heliport. Histories of four heliports are presented, specifically: the Bank-Whitmore Heliport (aka Nashua Street Heliport) in Boston, the Downtown Heliport in Indianapolis; the Downtown Heliport in New Orleans; and the Western and Southern Heliport in Cincinnati. Author

N88-25466*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
WIND TUNNEL WALL INTERFERENCE (JANUARY 1980 - MAY 1988): A SELECTED, ANNOTATED BIBLIOGRAPHY
MARIE H. TUTTLE (Vigyan Research Associates, Inc., Hampton, Va.) and KAREN L. COLE Aug. 1988 88 p
(NASA-TM-4061; L-16465; NAS 1.15:4061) Avail: NTIS HC A05/MF A01 CSCL 14B

This selected bibliography lists 423 entries on the subject of wall interference during testing in wind tunnels. It is the third in a series of bibliographies on the subject. The first, NASA TM-87639, August 1986, is concerned with the reduction of wall interference by the use of adaptive walls. The second, NASA TP-89066, December 1986, is on wall interference in V/STOL and high lift testing. This, the third in the series, covers the wall interference literature published during the period January 1980 through May 1988, generally excluding those topics covered in the first two parts. Author

N88-26379# Air Force Human Resources Lab., Brooks AFB, Tex.
FLIGHT SIMULATOR: FIELD OF VIEW UTILIZED IN PERFORMING TACTICAL MANEUVERS Final Report, Jan. 1983 - Dec. 1984
LINDA A. WIEKHORST and FRANK T. VACCARO Apr. 1988 26 p Supersedes AFHRL-TP-86-29
(AD-A192412; AFHRL-TP-87-50; AFHRL-TP-86-29) Avail: NTIS HC A03/MF A01 CSCL 05F

This paper documents the field of view (FOV) utilized by experienced fighter pilots when performing specified portions of air-to-air and air-to-ground maneuvers. The FOV measurements were taken in the Simulator for Air-to-Air Combat (SAAC) and the Advanced Simulator for Pilot Training (ASPT). During the air-to-ground data collection, measurements were also taken while subjects performed the same tasks with a limited field of view (LFOV). Results of the data collected indicate that the FOV utilized varied widely between air-to-air and air-to-ground maneuvers. In nearly all cases, the FOV utilized for air-to-air maneuvers was symmetrical and that for air-to-ground maneuvers was skewed to one side. When air-to-ground tasks were performed in an LFOV, significantly poorer bomb scores and significantly higher release

altitudes were found when compared to wide-FOV performance. A noticeable performance change in the LFOV condition was a tendency of the pilots to turn tighter into the target. The true effect of this change in flight path still needs to be investigated. Specifying one optimal LFOV for all maneuvers to be performed or trained in an operational flight simulator would be difficult if both cost and performance were to be considered. The variability of the FOV leads to the conclusion that placement of LFOV will be an important decision when considering what tasks will be performed. Full training implications cannot be determined until further transfer-of-training experiments are completed. GRA

N88-26380# *Naval Postgraduate School, Monterey, Calif.*
ANALYSIS OF GAS TURBINE TEST CELL NUMBER 1, LEMOORE NAVAL AIR STATION, CALIFORNIA M.S. Thesis
KEVIN D. SMITH Dec. 1987 136 p
(AD-A192870) Avail: NTIS HC A07/MF A01 CSCL 01C

A three-dimensional numerical analysis of Gas Turbine Test Cell 1 at Lemoore Naval Air Station, California, is given. The Parabolic, Hyperbolic, or Elliptic Numerical Integration Code (PHOENICS) is used to determine the steady-state aerothermal characteristics within the test cell during the full power run-up of a GE F404 gas turbine engine (afterburner in operation). The method in which PHOENICS arrives at a solution is discussed as well as how the code was applied to this problem. The solution of the problem is presented in tabular form and the results are discussed. Recommendations for the future application of PHOENICS to this project are given. GRA

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CHEMISTRY AND MATERIALS

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

A88-46424
TITANIUM ALLOYS IN HELICOPTER ROTOR HEAD DESIGNS
D. P. DAVIES (Westland Helicopters, Ltd., Yeovil, England) Metals and Materials (ISSN 0266-7185), vol. 4, July 1988, p. 417-422. Research supported by the Ministry of Defence Procurement Executive. refs

Within current design concept constraints, three methods for the improvement of titanium alloy helicopter rotor head fatigue, toughness, and mechanical property performance are considered: (1) the use of beta-forging processes and beta heat treatments; (2) solution-treated and overaged (thermal treatment) processing of the alpha-beta processed material just before the beta transus; and (3) the evaluation and optimization of high strength alpha-beta titanium alloys, or metastable beta titanium alloys. Useful mechanical performance improvements are found to be obtainable by changing from an annealed form of the Ti-6Al-4V alloy to a solution-treated and overaged one. O.C.

A88-46425
MATERIALS TRENDS IN MILITARY AIRFRAMES
C. A. STUBBINGTON Metals and Materials (ISSN 0266-7185), vol. 4, July 1988, p. 424-431. refs

While future combat aircraft will incorporate increasing percentages of CFRP composites in their primary structures, the predominant material is presently projected to remain the family of aircraft aluminum alloys. It is also expected that the successful development of Al-Li alloys will reinforce the dominance of aluminum alloys among airframe materials. Evaluations are also presented of military airframe incorporation trends for SPF/DB aluminum and titanium alloy structures, undercarriage-component steels, high corrosion-resistance Mg casting alloys, and such advanced airframe composite systems, PES and PEEK thermoplastic matrix resins, P/M Al-Fe-Ce alloys, rapid solidification processes for refractory alloys, metal-matrix composites, and the Arrall aluminum/kevlar-epoxy hybrid laminate. O.C.

A88-48031*# Akron Univ., Ohio.
COMPUTERIZED LIFE AND RELIABILITY MODELLING FOR TURBOPROP TRANSMISSIONS
M. SAVAGE (Akron, University, OH), K. C. RADIL, D. G. LEWICKI (U.S. Army, Propulsion Directorate, Cleveland, OH), and J. J. COY (NASA, Lewis Research Center, Cleveland, OH) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference and Exhibit, 24th, Boston, MA, July 11-13, 1988. 11 p. Previously announced in STAR as N88-23220. refs
(AIAA PAPER 88-2979)

A generalized life and reliability model is presented for parallel shaft geared prop-fan and turboprop aircraft transmissions. The transmission life and reliability model is a combination of the individual reliability models for all the bearings and gears in the main load paths. The bearing and gear reliability models are based on classical fatigue theory and the two parameter Weibull failure distribution. A computer program was developed to calculate the transmission life and reliability. The program is modular. In its present form, the program can analyze five different transmission arrangements. However, the program can be modified easily to include additional transmission arrangements. An example is included which compares the life of a compound two-stage transmission with the life of a split-torque, parallel compound two-stage transmission as calculated by the comaputer program. Author

A88-48040#
SUBSONIC AND SUPERSONIC COMBUSTION USING NONAXISYMMETRIC INJECTORS
E. GUTMARK, K. C. SCHADOW, and K. J. WILSON (U.S. Navy, Naval Weapons Center, China Lake, CA) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference and Exhibit, 24th, Boston, MA, July 11-13, 1988. 7 p. refs
(AIAA PAPER 88-3141)

Nonreacting and combustion tests were performed for subsonic, sonic, and supersonic conditions using noncircular injectors in a gas generator combustor. The noncircular injectors, including square, equilateral, and isosceles triangular nozzles, were compared to a circular ejector. The flow field of the jets was mapped with hot wire anemometry and visualized using spark Schlieren photography. The combustion characteristics were visualized by high speed photography and thermal imaging; the temperature distribution was measured by a rake of thermocouples. The large scale mixing at the flat sides with the fine scale mixing at the vertices is beneficial for combustion. Author

A88-48182*# Cincinnati Univ., Ohio.
A CRYSTALLOGRAPHIC MODEL FOR NICKEL BASE SINGLE CRYSTAL ALLOYS
L. T. DAME (International TechneGroup, Inc., Milford, OH) and D. C. STOUFFER (Cincinnati, University, OH) ASME, Transactions, Journal of Applied Mechanics (ISSN 0021-8936), vol. 55, June 1988, p. 325-331. refs
(Contract NAG3-511)

The purpose of this research is to develop a tool for the mechanical analysis of nickel-base single-crystal superalloys, specifically Rene N4, used in gas turbine engine components. This objective is achieved by developing a rate-dependent anisotropic constitutive model and implementing it in a nonlinear three-dimensional finite-element code. The constitutive model is developed from metallurgical concepts utilizing a crystallographic approach. An extension of Schmid's law is combined with the Bodner-Partom equations to model the inelastic tension/compression asymmetry and orientation-dependence in octohedral slip. Schmid's law is used to approximate the inelastic response of the material in cube slip. The constitutive equations model the tensile behavior, creep response and strain-rate sensitivity of the single-crystal superalloys. Methods for deriving the material constants from standard tests are also discussed.

The model is implemented in a finite-element code, and the computed and experimental results are compared for several orientations and loading conditions. Author

A88-48454
ELECTRICALLY CONDUCTING PLASTICS - NEW MATERIALS FROM AEROSPACE RESEARCH
TEH S. KUAN and RANDY CAMERON (Lockheed Aeronautical Systems Co., Burbank, CA) Lockheed Horizons (ISSN 0459-6773), May 1988, p. 48-56.

An account is given of the development status and range of currently available compositions and performance properties of electrically conducting plastics. The first of these, the serendipitously discovered polyacetylene, was useful as a battery electrode in rechargeable cells but was found to be dangerously unstable in air. Attention is given to novel proprietary conducting plastic compositions that are stable in air or water at all conductivity levels (of which the highest are fully comparable to those of metals) and which are stable in mutual contact; this latter property allows the production of circuit boards. The new plastics are noted to be produced in conducting or semiconducting form for less that $1.00/lb (by contrast to semiconducting silicon, which costs about $100,000.00/lb), and can be blended with structural plastics to form high-strength conductive materials applicable to aircraft construction. O.C.

A88-48455
CERAMICS FIRE THE FUTURE
CHRIS DREWER Flight International (ISSN 0015-3710), vol. 134, July 9, 1988, p. 26, 27, 30, 31.

Turbine blade superalloys currently operating at temperatures of 80 percent of their melting point require the bleeding of substantial amounts of compressor air for cooling, leading to a substantial efficiency penalty. As military gas turbine thrust-weight ratios surpass values of 10, the use of structural ceramic materials for turbine blade and stator vane construction is presently noted to become imperative, allowing higher turbine inlet temperatures to be reached without resort to air cooling. Candidate materials are of both carbon/carbon composite and ceramic-matrix composite types; the matrix ceramic compositions under intensive development are silicon nitride and silicon carbide. O.C.

A88-49202
CYCLIC OXIDATION OF ALUMINIZED TI-14AL-24NB ALLOY
J. SUBRAHMANYAM (Defence Metallurgical Research Laboratory, Hyderabad, India) Journal of Materials Science (ISSN 0022-2461), vol. 23, June 1988, p. 1906-1910. refs

Titanium aluminides are considered as replacements for superalloys in applications in gas turbine engines because of their outstanding properties. Ti3Al has a superior creep strength up to 815 C, but has poor oxidation resistance above 650 C. Two approaches can be followed to improve the oxidation resistance of Ti3Al above 650 C. One is alloying and the other obtaining a protective surface coating. Niobium was found to improve the oxidation resistance, when added as an alloying element. Recent investigations showed that a TiAl3 surface layer considerably improves the oxidation resistance of titanium. In the present work, a TiAl3 layer was obtained on a Ti-14Al-24Nb (wt pct) alloy using a pack aluminizing process. The cyclic oxidation behavior of aluminized and uncoated samples was evaluated. Author

N88-25623# Joint Publications Research Service, Arlington, Va.
BASIC RESEARCH IN SUPERSONIC COMBUSTION
In its JPRS Report: Science and Technology. Japan p 48-51 4 May 1988 Transl. into ENGLISH from Kogiken Nyusu (Tokyo, Japan), Jan. 1988 p 2-4
Avail: NTIS HC A06/MF A01

An attempt is made to explain the mechanism by which supersonic combustion operates and to obtain the basic support data needed for designing stable, efficient combustion methods. This research begins by using laser Schlieren to make a two dimensional visualization of the flow when hot air simulating fuel is injected into the mainflow moving at M=2, and macroscopic observations are made by simultaneously measuring the static pressure distribution on the wall. Author

N88-26458# Technische Hogeschool, Delft (Netherlands). Dept. of Aerospace Engineering.
CORROSION IN AIRCRAFT STRUCTURES. PART 1: TEXT [CORROSIE VAN VLIEGTUIGCONSTRUCTIFS. DEEL 1: TEKST]
H. F. DEJONG Jun. 1987 123 p In DUTCH
(LR-527-PT-1; B8733279; ETN-88-92467) Avail: NTIS HC A06/MF A01

The relation between aircraft manufacturer and aircraft user with respect to corrosion, and the economic and safety aspects of corrosion are presented. Corrosion theory aspects are explained. Electrode reaction kinetics are treated. The corrosion of metals and alloys in acid, neutral and strongly alkaline media, as well as the significance of pH-diagrams are discussed. The different kinds of corrosion occurring in aircraft structures are overviewed. The different forms of local corrosion are presented. ESA

N88-26459# Technische Hogeschool, Delft (Netherlands). Dept. of Aerospace Engineering.
CORROSION IN AIRCRAFT STRUCTURES. PART 2: FIGURES [CORROSIE VAN VLIEGTUIGCONSTRUCTIES. DEEL 2: FIGURES]
H. E. DEJONG Jun. 1986 53 p In DUTCH
(LR-527-PT-2; B8733281; ETN-88-92468) Avail: NTIS HC A04/MF A01

Graphs, tables, drawings, and photographs illustrating aircraft corrosion are presented. ESA

N88-26492# North Dakota Univ., Grand Forks. School of Engineering and Mines.
FEASIBILITY OF PRODUCING JET FUEL FROM GPGP (GREAT PLAINS GASIFICATION PLANT) BY-PRODUCTS Quarterly Report, 17 Aug. - 16 Nov. 1987
W. G. WILLSON, C. L. KNUDSON, and J. R. RINDT 1987 48 p
(Contract DE-AC22-87PC-90016)
(DE88-010233; DOE/PC-90016/T2) Avail: NTIS HC A04/MF A01

The technical and economic feasibility of producing aviation turbine fuel from by-product streams of the Great Plains Gasification Plant (GPGP) in Beulah, ND, is assessed. A secondary goal of the project is to assess the conversion of the by-product streams into a new, higher-density aviation fuel. GPGP currently produces 150 MM SCFD of synthetic natural gas from 16,000 tpd of North Dakota lignite. In addition the plant generates three liquid hydrocarbon streams : 730 barrels per day (BPD) naphtha, 880 BPD phenols, and 3200 BPD tar/oil. Work at the University of North Dakota Energy and Mineral Research Center has focused on two tasks performed in support of these objectives. The first task consisted of a detailed analysis of the by-product streams under consideration. Of the three streams, the tar oil stream is the largest and shows the most promise for upgrading to aviation turbine fuel. Detailed characterization data on the tar/oil were presented in the previous quarterly. A true boiling point (TBP) distillation was performed on the GPGP phenol stream, yielding nine fractions which were characterized using NMR, GC, and GC/MS. The second task involves an engineering evaluation of by-product upgrading. Two methods are under investigation for the production of aviation fuel: single-stage, in which heteroatom removal and hydrogenation are accomplished in a single step, and two-stage, in which the heteroatoms are removed in the first-stage, and hydrogenation occurs during the second stage. Hydrogenation was improved by increased pressure and temperature, although the measured effect on aromatic content awaits further analyses. Data indicates that, to achieve complete nitrogen and sulfur removal, the preferred operating conditions are temperatures of 610 to 645 F and pressures of at least 2000 psig. DOE

N88-26495*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
ANTIMISTING KEROSENE: LOW TEMPERATURE DEGRADATION AND BLENDING Final Report, Jun. 1983 - Aug. 1985
A. YAVROUIAN, P. PARIKH, and V. SAROHIA Jun. 1988 57 p (Contract NAS7-100; DTFA03-80-A-00215)
(NASA-CR-182725; JPL-PUB-D-5518; NAS 1.26:182725; DOT/FAA/CT-86/3) Avail: NTIS HC A04/MF A01 CSCL 21D

The inline filtration characteristics of freshly blended and degraded antimisting fuels (AMK) at low temperature are examined. A needle valve degrader was modified to include partial recirculation of degraded fuel and heat addition in the bypass loop. A pressure drop across the needle valve of up to 4,000 psi was used. The pressure drop across a 325 mesh filter screen placed inline with the degrader and directly downstream of the needle valve was measured as a function of time for different values of pressure drop across the needle valve. A volume flux of 1 gpm/sq in was employed based on the frontal area of the screen. It was found that, at ambient temperatures, freshly blended AMK fuel could be degraded using a single pass degradation at 4,000 psi pressure drop across the needle valve to give acceptable filterability performance. At fuel temperatures below -20 C, degradation becomes increasingly difficult and a single pass technique results in unacceptable filtration performance. Recirculation of a fraction of the degraded fuel and heat addition in the bypass loop improved low temperature degradation performance. The problem is addressed of blending the AMK additive with Jet A at various base fuel temperatures. Author

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ENGINEERING

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

A88-45929#
THE HIGHLY ACCURATE CONVECTIVE DIFFERENCE SCHEMES
SHUQUAN LU (Nanjing Aeronautical Institute, People's Republic of China) Acta Aerodynamica Sinica (ISSN 0258-1825), vol. 6, June 1988, p. 182-189. In Chinese, with abstract in English. refs

For the generalized convective difference schemes, two methods, namely the method of analyzing the truncated error and the method of estimating the error after the event, are applied to derive the optimum a values in order to make the errors minimum. It differs from the other schemes in that one can derive them from the convection-diffusion equation itself. Many results show that the method of analyzing the truncated error is highly accurate. The errors of the method of estimating the error after the event are smaller or much smaller than the errors of the ordinary schemes, except in very few special cases. However, for some complex problems, there may be some difficulty in applying the first method, but none in applying the second one. Author

A88-46048#
SOME THOUGHTS ON POWER-AUGMENTED-RAM WING-IN-GROUND (PAR-WIG) EFFECT VEHICLE
SHIGENORI ANDO (Nagoya University, Japan) Japan Society for Aeronautical and Space Sciences, Transactions (ISSN 0549-3811), vol. 31, May 1988, p. 29-47. refs

The PAR (Power-Augmented-Ram) WIG (Wing-in-Ground) effect vehicle is promising as an overwater commuter transport vehicle. Three important requirements, PAR effect, ability of off-ground effect flight, and ability of automatic IGE (in-ground effect) flight, are described. Many useful materials for designing WIG are presented. New concepts are proposed, which contain some new devices. Ability of 'stick-free' IGE flight is especially desirable, hence the phugoid mode should be suppressed sufficiently. Author

A88-46060
ASYMPTOTIC THEORY OF SEPARATED FLOWS [ASIMPTOTICHESKAIA TEORIIA OTRYVNYKH TECHENII]
VLADIMIR VASIL'EVICH SYCHEV, ANATOLII IVANOVICH RUBAN, VIKTOR VLADIMIROVICH SYCHEV, and GEORGII L'VOVICH KOROLEV Moscow, Izdatel'stvo Nauka, 1987, 256 p. In Russian. refs

Results of theoretical studies of separation flows of an incompressible fluid at large Reynolds numbers using asymptotic methods are examined. Particular attention is given to problems of self-induced separation in stationary and nonstationary flows, theory of local separations at the leading and trailing edges of thin airfoils, and investigations of the global field structure of flows in the wake of blunt bodies. Numerical methods for solving problems of the interaction between a boundary layer and a potential flow are discussed. V.L.

A88-46181#
UNSTEADY HEAT TRANSFER COEFFICIENT ESTIMATION FOR LONG DURATION
JAMES K. HODGE, ALICE J. CHEN (USAF, Institute of Technology, Wright-Patterson AFB, OH), and JAMES R. HAYES (USAF, Wright Aeronautical Laboratories, Wright-Patterson, AFB, OH) Journal of Thermophysics and Heat Transfer (ISSN 0887-8722), vol. 2, July 1988, p. 218-226. Previously cited in issue 07, p. 905, Accession no. A87-21534. refs

A88-46226#
INFLUENCE OF DESIGN CONCEPT AND LIQUID PROPERTIES ON FUEL INJECTOR PERFORMANCE
J. R. CUSTER and N. K. RIZK (General Motors Corp., Indianapolis, IN) Journal of Propulsion and Power (ISSN 0748-4658), vol. 4, July-Aug. 1988, p. 378-384. Previously cited in issue 11, p. 1542, Accession no. A86-26638. refs
(Contract N00014-83-C-8894)

A88-46274
SPEECH RECOGNITION INTEGRATED WITH ATC SIMULATION
ARTHUR GERSTENFELD (UFA, Inc., Newton; Worcester Polytechnic Institute, MA) ICAO Bulletin (ISSN 0018-8778), vol. 43, May 1988, p. 22, 23.

A system simulator with the capability of speech recognition and speech synthesis for air traffic controller training is presented. The computer synthesizes the voices of both the pilot responses and the instructor. The simulator recognizes the speech of a single speaker and moves the aircraft on the radar display as the trainee gives directions and clearances orally. The speaker must train the system by repeating the words in the system vocabulary several times allowing for a reliability of recognition above 90 percent. The systems can be integrated making it possible for one instructor to train up to six students. R.B.

A88-46323#
INFLUENCES OF ENVIRONMENT AND STRESS HISTORY ON THE COMPOSITE PATCH REPAIR OF CRACKED METALLIC STRUCTURES
P. HUCULAK, M. D. RAIZENNE, and R. F. SCOTT (National Research Council of Canada, Ottawa) Canadian Aeronautics and Space Journal (ISSN 0008-2821), vol. 34, June 1988, p. 85-91. Research supported by the Defence Research Establishment Pacific. refs

Test data related to the development of procedures for bonded composite material-patch repairs of damaged metallic structures are presented. Attention is given to patched preconditioned center-cracked tension specimens subjected to constant-amplitude loading and 100 percent relative humidity at 100 C. Cycling the load in these conditions resulted in significantly higher crack growth rates; these rates are compared to those from laboratory air tests

and those from unpatched specimens loaded at 100 C. Fatigue crack growth rates obtained in patched and unpatched specimens loaded according to the sequence in the Fighter Aircraft Loading Standard for Fatigue Evaluation spectrum are presented, together with adhesive shear moduli yielded by three different techniques. O.C.

A88-46335
METHODS FOR MEASURING CONVECTION FLUX IN THE R2 AND R3 WIND TUNNELS AT CHALAIS-MEUDON - CURRENT IMPLEMENTATION AND FUTURE DEVELOPMENTS [METHODES DE MESURE DE FLUX DE CONVECTION DANS LES SOUFFLERIES R2 ET R3 DE CHALAIS-MEUDON - MISE EN OEUVRE ACTUELLE ET DEVELOPPEMENTS ENVISAGES]
H. CONSIGNY, V. MENTRE, and A. BETREMIEUX (ONERA, Chatillon-sous-Bagneux, France) Colloque d'Aerodynamique Appliquee, 24th, Poitiers, France, Oct. 26-28, 1987. 25 p. In French. refs
(AAAF PAPER NT-87-11)

The principles, advantages, and disadvantages of the three convection-flux measurement methods employed in the R2 and R3 gust wind tunnels at Chalais-Meudon are discussed. While the calorimetric method has the advantages of high precision and the use of thermocouples which do not require calibration, it is not suitable for studying unsteady phenomena or thin surfaces. While offering flexibility, low cost, and great detail, the thermosensitive painting visualization method does not permit the visualization of certain zones and cannot measure exchange coefficients which are less than about 0.005 W/sq cm per K. The surface-temperature method, which makes possible the study of extremely fast phenomena, is illustrated with examples such as the measurement of the stagnation enthalpy in a plasma-generating wind tunnel. R.R.

A88-46345
FATIGUE STRENGTH CALCULATION
A. BUCH (Technion - Israel Institute of Technology, Haifa) Aedermannsdorf, Switzerland, Trans Tech Publications (Materials Science Surveys, No. 6), 1988, 473 p. refs

Calculation of the fatigue strength of a structural component is much more difficult than that of its static strength, due to the prominence of such factors as notch effects, size effects, and surface quality effects. The present work undertakes a general treatment of fatigue, and gives attention to the fatigue limit of unnotched specimens, the fatigue limit of notched specimens, the construction of idealized S-N curves, fatigue damage accumulation, special surface treatments, and aircraft fatigue. Also presented are extensive fatigue data sheets. O.C.

A88-46663
THE TRICK WITH LIGHT-EMITTING DIODES - HOW TO RECOGNIZE A WING'S AERODYNAMIC QUALITY AT A GLANCE
New-Tech News, no. 2, 1988, p. 12-15.

LEDs have been integrated with advanced computational resources to investigate model wing and model engine wake flows. This system follows the pendular motion of a pressure sensor immersed in the flow to be studied by means of a diode, thereby rendering the shape and size of the turbulence visible in terms of colored light. The vortical flow structures thus visualized have proven useful in discerning the disturbance of wing flows by air circulating around wingtips, around flap and aileron edges, and around wing fairings and engine nacelles. O.C.

A88-46826
QUANTITATIVE CHARACTERIZATION OF IMPACT DAMAGE IN COMPOSITE MATERIALS - A COMPARISON OF COMPUTERIZED VIBROTHERMOGRAPHY AND X-RAY TOMOGRAPHY
P. POTET (Compiegne, Universite de Technologie, France), C. BATHIAS, and B. DEGRIGNY Materials Evaluation (ISSN 0025-5327), vol. 46, July 1988, p. 1050, 1051, 1053, 1054. Research supported by the Service Technique des Constructions et Armes Navales. refs

X-ray computerized tomography (CT) and computerized vibrothermography for the detection of impact damage in composite materials are compared, using CT as a reference method for the sake of comparison. A computer program was developed to compute heat-source maps from the experimental temperature fields. Damages indicated by the heat-source map corresponded to those detected by CT on the impacted side of the specimen. Damage located in the surface ply on the opposite impacted side was not detected by CT. It is found that vibrothermography accurately locates damage, but cannot determine its size and shape. Because of the attenuation of heat through the thickness, vibrothermography can only detect damage in the first plies of the specimen. R.B.

A88-46913
CALCULATION OF SUPERSONIC FLOW PAST A CYLINDRICAL SHELL WITH ALLOWANCE FOR AEROELASTIC DEFORMATION [RASCHET SVERKHZVUKOVOGO OBTEKANIIA TSILINDRICHESKOI OBOLOCHKI S UCHETOM AEROUPRUGOI DEFORMATSII]
N. N. BELIAEV and V. K. KHRUSHCH (Dnepropetrovskii Gosudarstvennyi Universitet, Dnepropetrovsk, Ukrainian SSR) Gidromekhanika (ISSN 0367-4088), no. 57, 1988, p. 16-19. In Russian.

The problem considered here is the coupled stationary aeroelasticity problem of transverse supersonic flow of a viscous ideal gas past a cylindrical shell. In particular, the effect of shell deformation on the drag is analyzed. Displacememts in the shell are determined for a pressure distribution corresponding to a rigid nondeformed cylinder and for the coupled problem where gas flow and shell deformation are calculated simultaneously. A numerical algorithm for solving the problem is developed which uses the method of flows to solve the Euler equations and the finite difference method to solve the Karman equations. V.L.

A88-46914
INTERACTION BETWEEN A COMPLIANT SURFACE AND THE VISCOUS SUBLAYER OF A TURBULENT BOUNDARY LAYER [O VZAIMODEISTVII PODATLIVOI POVERKHNOSTI S VIAZKIM PODSLOEM TURBULENTNOGO POGRANICHNOGO SLOIA]
G. A. VOROPAEV and V. I. POPKOV (AN USSR, Institut Gidromekhaniki, Kiev, Ukrainian SSR) Gidromekhanika (ISSN 0367-4088), no. 57, 1988, p. 32-35. In Russian. refs

The problem of the interaction between the compliant surface of a viscoelastic material and the viscous sublayer of a turbulent boundary layer is analyzed using an approach similar to that of Sternberg (1962), with allowance made for the effect of longitudinal motions of the surface. It is demonstrated that the longitudinal displacement of the surface of the viscoelastic material and of the viscous sublayer significantly affect Reynolds stresses in the turbulent boundary layer. V.L.

A88-46994
EVALUATION OF CRACK GROWTH MODELS FOR ELEVATED-TEMPERATURE FATIGUE
GEORGE K. HARITOS (USAF, Institute of Technology, Wright-Patterson AFB, OH), THEODORE NICHOLAS (USAF, Materials Laboratory, Wright-Patterson AFB, OH), and GERALD O. PAINTER (USAF, Ballistic Missile Office, Norton AFB, CA) IN: Fracture mechanics. Philadelphia, PA, American Society for Testing and Materials, 1988, p. 206-220. refs
(Contract AF PROJECT 2302P1)

To date, only two models have been proposed for predicting crack growth rates in aircraft engine materials under typical operating conditions. Moreover, modeling to date has been performed on materials which exhibit limited amounts of time-dependent behavior. This investigation evaluates the predictive and interpolative capabilities of these models when applied to IN718 at 649 C. At this temperature, this material exhibits significant time-dependent behavior. Experimental data were generated and

used to assess the predictive and interpolative characteristics of each model. These data covered variations in frequency, stress ratio, and hold time. Values for the coefficients in the functional relationships between the constants and the test variables were obtained for the hyperbolic sine equation model. Similar functional relationships were incorporated into the modified sigmoidal equation model. Several important conclusions were drawn about the capabilities of these two models to predict crack-growth rates in turbine-engine materials at elevated temperature. Author

A88-47004
FATIGUE CRACK GROWTH AT ROOT RADII IN SHEETS WITH VARIABLE THICKNESS
MEHAN M. RATWANI, HAN-PIN KAN, and SHENG-MING HSU (Northrop Corp., Aircraft Div., Hawthorne, CA) IN: Fracture mechanics. Philadelphia, PA, American Society for Testing and Materials, 1988, p. 765-780. Research sponsored by Northrop Independent Research and Development Program. refs

Fatigue crack growth data have been obtained for cracks at root radii in sheets with variable thickness. These test data were obtained under constant-amplitude as well as spectrum loading. Analytical stress-intensity factors were developed using mathematical techniques. The Mode I stress-intensity factors were approximately 10 percent lower than that of a plate with uniform thickness. Crack growth predictions for the test specimens were made using the analytical stress-intensity factors and a crack growth equation for a skin with uniform thickness. A good correlation is shown between observed and predicted crack growth behavior. Author

A88-47042
MANUFACTURING ASPECTS OF SOME CRITICAL HIGH PRECISION MECHANICAL COMPONENTS OF INERTIAL DEVICES
A. GEDDAM (ISRO, New Bombay, India) IN: International Conference on the Mechanical Technology of Inertial Devices, Newcastle-upon-Tyne, England, Apr. 7-9, 1987, Proceedings. London, Mechanical Engineering Publications, Ltd., 1987, p. 125-135. refs

Manufacturing materials, requirements, and methods for inertial device components are described. The desired material properties and the best materials to be utilized in particular components are mentioned. Manufacturing methods for gyro wheel components, gyro gimbal-float structure, flexure elements, and inertial platform elements are examined. C.D.

A88-47043
DYNAMICS AND CONTROL OF A GYROSCOPIC FORCE MEASURING SYSTEM
P. K. SINHA (Keele, University, England) IN: International Conference on the Mechanical Technology of Inertial Devices, Newcastle-upon-Tyne, England, Apr. 7-9, 1987, Proceedings. London, Mechanical Engineering Publications, Ltd., 1987, p. 137-148. refs

This paper presents the first stage of a design and construction project for the development of a low-cost gyroscopic force measuring (GFM) system. Despite the widespread use of gyroscopes in inertial guidance and stabilization systems, relatively little is known about the dynamic behavior of a two-axis gyroscope as a force sensing device. The paper develops a linear mathematical model of a GFM system with particular reference to assessing the structural properties as well as the control problems. Author

A88-47047
A REVIEW OF THE MECHANICAL DESIGN AND DEVELOPMENT OF A HIGH PERFORMANCE ACCELEROMETER
T. G. SMITHSON (Ferranti Instrumentation, Ltd., Bracknell, England) IN: International Conference on the Mechanical Technology of Inertial Devices, Newcastle-upon-Tyne, England, Apr. 7-9, 1987, Proceedings. London, Mechanical Engineering Publications, Ltd., 1987, p. 175-190.

The factors governing the performance of a pendulous force feedback accelerometer when it is subjected to the environment found in a strapdown inertial navigation system utilizing dithered ring laser gyroscopes is discussed, together with a proposed specification aimed at achieving the desired results. The design philosophy derived to develop an instrument for use in the highest accuracy systems is outlined. Author

A88-47566
EFFECTIVE USE OF BUFFER GAS SLEEVE-TYPE SEALS IN CENTRIFUGAL COMPRESSORS
YU-MING WANG and ZHEN-QING CHEN (Tianjin Mechanical Seal Research Institute, People's Republic of China) (STLE and ASME, Tribology Conference, San Antonio, TX, Oct. 5-8, 1987) STLE Tribology Transactions (ISSN 0569-8197), vol. 31, July 1988, p. 376-381.

In this paper, the behavior of a buffer gas sleeve-type seal is explained on the basis of statistical physics. This is related to measurements made in an actual application with normal runout and vibration. Optimum utilization of this kind of seal in centrifugal compressor is discussed. It is concluded that a straight sleeve seal can be made more effective and efficient than the labyrinth seals that are usually used in such buffer seal applications. Author

A88-47669
POWER RADIATED BY AN INFINITE PLATE SUBJECT TO FLUID LOADING AND LINE DRIVE
D. INNES and D. G. CRIGHTON (Cambridge University, England) Journal of Sound and Vibration (ISSN 0022-460X), vol. 123, June 22, 1988, p. 437-450. refs
(Contract N00014-81-G-0010; N00014-86-G-0066)

Fluid-loading effects on the acoustic and vibration response of a thin elastic plate can be specified by a phase Mach number or frequency parameter M = k(0)/k(p) and an intrinsic fluid-loading parameter (epsilon). In this paper asymptotic expressions are given for the acoustic power radiated by a thin plate under line force drive, covering the entire frequency range M = O-infinity in the limit epsilon approaches zero. These expressions reflect the balance of physical mechanisms in each of four principal frequency ranges and, for the case of steel plates with water loading, are shown to agree extremely well with previously published numerical evaluations of the acoustic power. Author

A88-47686
ANALYTIC AND ANALOGUE TECHNIQUES FOR DETERMINING POTENTIAL DISTRIBUTIONS AROUND ANGLED CRACKS
D. A. GREEN, J. M. KENDALL, and J. F. KNOTT (Cambridge University, England) International Journal of Fracture (ISSN 0376-9429), vol. 37, May 1988, p. R3-R12. Research supported by SERC and British Railways. refs

Potential distributions around short cracks lying at an angle to the test-piece surface have been determined using two different methods. First, an analytical solution for a semiinfinite body containing an edge crack inclined at any angle to the surface is obtained using conformal mapping. Then, an analogue technique employing graphitized paper is used to represent a uniform conductor, enabling the effect of finite specimen boundaries to be represented and a 'zig-zag' crack profile to be treated. R.R.

A88-47873
DECAY OF SPANWISE WAVY INHOMOGENEITIES IN A THREE-DIMENSIONAL TURBULENT BOUNDARY LAYER OVER AN 'INFINITE' SWEPT CONCAVE WING
V. BASKARAN and P. BRADSHAW (Imperial College of Science and Technology, London, England) Experiments in Fluids (ISSN 0723-4864), vol. 6, no. 7, 1988, p. 487-492. Research supported by the Ministry of Defence Procurement Executive. refs

Measurements have been made in a three-dimensional turbulent boundary layer over a concave surface, whose generators were swept at 35 deg (simulating an 'infinite' swept wing). The results show that the quasi-periodic spanwise variations of skin friction,

reported in two-dimensional concave wall turbulent boundary layers, decay in the presence of a cross flow. Skin friction surveys in a companion experiment with an 'infinite' swept concave surface of variable sweep show that there exists a critical sweep angle below which the disturbances grow, and above which they decay. Author

A88-47993*# University of Southern California, Los Angeles.
FLUID DYNAMIC MODELING AND NUMERICAL SIMULATION OF LOW-DENSITY HYPERSONIC FLOW
H. K. CHENG and ERIC Y. WONG (Southern California, University, Los Angeles, CA) AIAA, Thermophysics, Plasmadynamics and Lasers Conference, San Antonio, TX, June 27-29, 1988. 16 p. refs
(Contract NAGW-1061; AF-AFOSR-88-0014)
(AIAA PAPER 88-2731)

The concept of a viscous shock-layer and several related versions of continuum theories/methods are examined for their adequacy as a viable framework to study flow physics and aerothermodynamics of relevance to sustained hypersonic flights. Considering the flat plate at angle of attack, or the wedge, as a generic example for the major aerodynamic component of a hypersonic vehicle, the relative importance of the molecular-transport effects behind the shock (in the form of the 'shock slip') and the wall-slip effects are studied. In the flow regime where the shock-transition-zone thickness remains small compared to the shock radius of curvature, a quasi-one-dimensional shock structure under the Burnett/thirteen-moment approximation, as well as particulate/collisional models, can be consistently developed. The fully viscous version of the shock-layer model is shown to provide the crucial boundary condition downstream the shock in this case. The gas-kinetic basis of the continuum description for the flow behind the bow shock, and certain features affecting the non-equilibrium flow chemistry, are also discussed. Author

A88-48146
SOLUTION OF COUPLED HEAT TRANSFER PROBLEMS IN THE CASE OF FLOW PAST THERMALLY THIN BODIES USING THE DIFFERENCE FACTORIZATION METHOD [RESHENIE SOPRIAZHENNYKH ZADACH TEPLOOBMENA PRI OBTEKANII TERMICHESKI TONKIKH TEL METODOM PROGONKI]
B. V. DAVYDENKO (AN USSR, Institut Tekhnicheskoi Teplofiziki, Kiev, Ukrainian SSR) Promyshlennaia Teplotekhnika (ISSN 0204-3602), vol. 10, no. 3, 1988, p. 36-40. In Russian.

A numerical method based on the difference factorization approach is proposed for solving an integro-differential equation describing coupled heat transfer between a thermally thin plate and a flow of a fluid. As an example, temperature distributions over the length of a plate are calculated for different boundary conditions at the ends. V.L.

A88-48147
HEAT TRANSFER IN AN IMPINGING CIRCULAR JET WITH AN INHOMOGENEOUS INITIAL VELOCITY PROFILE [TEPLOOBMEN V IMPAKTNOI KRUGLOI STRUE S NERAVNOMERNYM NACHAL'NYM PROFILEM SKOROSTI]
A. I. MAZUR, IU. I. ZAKHAROV, and I. G. DAVYDENKO (AN USSR, Institut Tekhnicheskoi Teplofiziki, Kiev, Ukrainian SSR) Promyshlennaia Teplotekhnika (ISSN 0204-3602), vol. 10, no. 3, 1988, p. 51-58. In Russian. refs

An analysis is made of experimental data on local and mean heat transfer in an impinging single circular jet issuing from a cylindrical opening of varying relative length. The relationship between the aerodynamic characteristics and heat transfer is established by means of functions of the normalized distance to the obstacle surface. It is shown that, as the relative length of the opening is reduced, the intensity of heat transfer in the region of accelerated flow on the obstacle increases. The advantages of a thin wall, however, become insignificant with an increase in the averaging surface radius and in the distance to the nozzle opening. Empirical expressions are presented for calculating heat transfer at the critical point. V.L.

A88-48148
EQUIPMENT FOR STUDYING THE THERMAL STRESSED STATE OF ROTATING GAS TURBINE COMPONENTS [APPARATURA DLIA ISSLEDOVANIIA TEPLONAPRIAZHENNOGO SOSTOIANIIA VRASHCHAIUSHCHIKHSIA DETALEI GAZOVYKH TURBIN]
E. P. DYBAN, V. N. KLIMENKO, V. IU. KHAVIN, and S. L. POLUKHIN (AN USSR, Institut Tekhnicheskoi Teplofiziki, Kiev, Ukrainian SSR) Promyshlennaia Teplotekhnika (ISSN 0204-3602), vol. 10, no. 3, 1988, p. 77-80. In Russian. refs

A tensometric device using wire strain gauges has been developed which provides for the correction of errors introduced by the contact resistances of current collectors during the measurement of the deformations of the rotating components of gas turbines. With the device described here, the level of noise introduced by the currect collector resistors does not exceed 1 mV for a signal of 1 V. V.L.

A88-48150#
ASSURING THE DURABILITY AND RELIABILITY OF SELECTED MACHINE COMPONENTS IN THE SURFACE-TREATMENT PROCESS [KSZTALTOWANIE TRWALOSCI I NIEZAWODNOSCI WYBRANYCH ELEMENTOW MASZYN W PROCESACH OBROBKI POWIERZCHNIOWEJ]
IAN BUCIOR Politechnika Slaska, Zeszyty Naukowe, Mechanika (ISSN 0434-0817), no. 87, 1987, p. 1-133. In Polish. refs

This work examines mathematical models for the effects of various surface-treatment processes on the state and properties of the surface layers of machine components. The effect of the surface layer on the durability and reliability of the machine components is analyzed in detail. The theoretical predictions have been confirmed by original experimental results. The selection of a finishing process for aircraft turbine engine blades is considered as an example. B.J.

A88-48315
EMPIRICAL RELATIONSHIPS MAKING IT POSSIBLE TO REDUCE THE NUMBER OF DESIGN PARAMETERS IN THE OPTIMIZATION OF WING PANELS [EMPIRICHESKIE ZAVISIMOSTI, POZVOLIAIUSHCHIE UMEN'SHIT' CHISLO PROEKTNYKH PARAMETROV PRI OPTIMIZATSII PANELEI KRYLA]
A. A. TSIRIUK Samoletostroenie - Tekhnika Vozdushnogo Flota (ISSN 0581-4634), no. 54, 1987, p. 66-68. In Russian.

Empirical formulas are obtained which relate the different dimensions of wing panels and make it possible to reduce the dimensionality of the panel-optimization problem. It is shown that even a significant change in the derived empirical relationships (up to 5 percent) has only a slight effect on the bearing capacity of the optimal panels. Thus, these relationships can be used effectively in wing-panel design. B.J.

A88-48319
ACCEPTABLE LEVEL OF STRESS IN AIRCRAFT STRUCTURES DURING THEIR FABRICATION OR REPAIR BY ELASTIC DEFORMATION [O DOPUSTIMOM UROVNE NAPRIAZHENNOSTI DETALEI AVIAKONSTRUKTSII, VOZNIKAIUSHCHEI PRI IKH PROIZVODSTVE ILI REMONTE UPRUGIM DEFORMIROVANIEM]
V. E. GAIDACHUK Samoletostroenie - Tekhnika Vozdushnogo Flota (ISSN 0581-4634), no. 54, 1987, p. 79-83. In Russian.

An attempt is made to develop quantitative criteria for determining the acceptable level of stresses generated in composite and metal components of high-, low-, and medium-loaded aircraft structures during manufacturing and repair processes involving elastic deformation. The analysis presented here uses the Hill energy criterion. Recommendations are developed which can be used as guidelines in determining the possibility of eliminating specific process-related defects in aircraft components through elastic deformation. V.L.

A88-48452
AUTOMATED MACHINING OF COMPLEX PARTS AND TOOLS - A DESIGN-DRIVEN MANUFACTURING INITIATIVE
JOHN R. GILBERTSON and RICHARD JOHN RICCI (Lockheed Aeronautical Systems Co., Burbank, CA) Lockheed Horizons (ISSN 0459-6773), May 1988, p. 3-12.

An account is given of the features and operational efficiencies of a major U.S. aircraft manufacturer's Automated Machining of Complex Parts and Tools system, using previous manufacturing practices as a basis for comparison. Attention is given to the application of CADAM after the engineering organization has generated three-dimensional aircraft structural element surfaces or 'lofts'; offset curves are generated by NC 'regional milling' software to drive cutter tool tips for 3- and 5-axis milling machines. This technique, while three-dimensional in its complexity, is very similar to two-dimensional NC techniques that have been in use for 20 years. O.C.

A88-48745
CONTROLLING THE DEVELOPMENT OF BOUNDARY LAYER PERTURBATIONS THROUGH NONUNIFORM SURFACE HEATING [UPRAVLENIE RAZVITIEM VOZMUSHCHENII V POGRANICHNOM SLOE PUTEM NERAVNOMERNOGO NAGREVANIIA POVERKHNOSTI]
V. V. STRUMINSKII, A. V. DOVGAL', IU. B. LEBEDEV, V. IA. LEVCHENKO, V. A. TIMOFEEV (AN SSSR, Institut Teoreticheskoi i Prikladnoi Mekhaniki, Novosibirsk, USSR) et al. Akademiia Nauk SSSR, Sibirskoe Otdelenie, Izvestiia, Seriia Tekhnicheskie Nauki (ISSN 0002-3434), June 1988, p. 38-42. In Russian. refs

A study is made of the effect of nonuniform surface heating on the stability of a boundary layer of an incompressible gas on a flat plate. Experimental data are reported in support of the predicted effect of the increasing laminar flow stability associated with the heating of the leading edge of the plate. It is also demonstrated that flow in a region located far from the leading edge can be stabilized when the heating area of the plate is located further downstream of the leading edge of the plate. The experimental data are shown to be consistent with calculations based on linear stability theory. V.L.

A88-48802*# Stanford Univ., Calif.
A STREAMWISE VORTEX EMBEDDED IN A PLANE MIXING LAYER
JAMES H. BELL and RABINDRA D. MEHTA (Stanford University, CA) IN: AIAA, ASME, SIAM, and APS, National Fluid Dynamics Congress, 1st, Cincinnati, OH, July 25-28, 1988, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 193-200. refs
(Contract NCC2-294)
(AIAA PAPER 88-3606)

Experimental results are presented on the interaction of a single streamwise vortex with a plane turbulent mixing layer. In the present setup, the vortex is generated by a half-delta wing mounted in the settling chamber of a blower-driven wind tunnel. Initially, the vortex is shown to ride just below the mixing layer, locally distorting the mean velocity and turbulence Reynolds stress distributions in the lower part of the mixing layer. Once the vortex becomes embedded within the mixing layer, the distortions are found to spread through the whole width of the layer, and the induced extra strain rates in the mixing layer result in the generation of additional, relatively large, Reynolds normal and shear stresses, mainly in the regions above the vortex. R.R.

A88-48805#
ON THE USE OF AN IMPLICIT PROCEDURE TO ACCELERATE CONVERGENCE OF FULL PSEUDOSPECTRAL SOLUTIONS TO THE NAVIER-STOKES EQUATIONS OF MOTION FOR FLOWS WITH SHOCK WAVES
LEONIDAS SAKELL (U.S. Navy, Naval Research Laboratory, Washington, DC) IN: AIAA, ASME, SIAM, and APS, National Fluid Dynamics Congress, 1st, Cincinnati, OH, July 25-28, 1988, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 215-225. Navy-sponsored research. refs
(AIAA PAPER 88-3644)

Full pseudospectral solutions to the two-dimensional, time dependent, compressible, Navier-Stokes Equations are presented. Techniques developed by the author to implement pseudospectral methods for the solution of flows with shock waves are described. MacCormack's implicit procedure is utilized to accelerate convergence. Solutions are presented for three classes of laminar flows, a normal shock wave boundary layer interaction on a flat plate, an oblique shock wave boundary layer interaction on a flat plate, and the flow over a biconvex airfoil. Both subcritical and supercritical airfoil cases are treated. Shock waves, when present, are properly resolved as sharp discontinuities at the correct location. Author

A88-48827#
TVD SOLUTION OF THE INCOMPRESSIBLE NAVIER-STOKES EQUATIONS WITH AN IMPLICIT MULTIGRID SCHEME
JOSEPH J. GORSKI (David W. Taylor Naval Ship Research and Development Center, Bethesda, MD) IN: AIAA, ASME, SIAM, and APS, National Fluid Dynamics Congress, 1st, Cincinnati, OH, July 25-28, 1988, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 394-401. refs
(Contract N00024-86-WR-10432)
(AIAA PAPER 88-3699)

The Navier-Stokes equations for steady incompressible flows, in primitive variable form, have been solved using the pseudo-compressibility concept. The present paper deals with applying a third order accurate upwind differenced Total Variational Diminishing (TVD) scheme to the convection terms coupled with standard central differences for the viscous diffusion terms. The equations are solved using approximate factorization with an implicit multigrid method for convergence acceleration. This method of solving the Navier-Stokes equations has been implemented in the David Taylor Navier-Stokes (DTNS) series of multiple block computer codes which are demonstrated here. Solutions are provided for laminar and turbulent flows along with convergence histories. These results demonstrate that the use of the multigrid scheme can increase convergence rates dramatically. In addition, it is shown that splitting geometries into multiple blocks does not slow down the convergence significantly. Author

A88-48828#
APPLICATION OF SPARSE MATRIX SOLVERS AND NEWTON'S METHOD TO FLUID FLOW PROBLEMS
E. E. BENDER and P. K. KHOSLA (Cincinnati, University, OH) IN: AIAA, ASME, SIAM, and APS, National Fluid Dynamics Congress, 1st, Cincinnati, OH, July 25-28, 1988, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 402-408. refs
(Contract F49620-85-C-0027)
(AIAA PAPER 88-3700)

The use of direct solvers with Newton's method is investigated for the solution of inviscid compressible and viscous incompressible flows. Two modifications of Newton's method are presented that reduce the method's sensitivity to the selection of an initial guess. These methods are tested on transonic inviscid flows to determine the effects of shocks on this sensitivity. Solutions are presented of the full potential equation at various transonic Mach numbers. High Reynolds number laminar separated flows are investigated using these methods. Newton's method applied to such problems exhibits high sensitivity to the initial guess. A modification of Newton's method based on the minimization of the Euclidean norm of the residual greatly reduces this sensitivity. Author

A88-48860#
VISUALIZING THE CONNECTIVITY OF VORTEX SYSTEMS FOR PITCHING WINGS
PETER FREYMUTH (Colorado, University, Boulder) IN: AIAA, ASME, SIAM, and APS, National Fluid Dynamics Congress, 1st, Cincinnati, OH, July 25-28, 1988, Technical Papers. Part 2.

Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 671-678. refs
(Contract F49620-84-C-0065)
(AIAA PAPER 88-3549)

The global visualization of vortex systems is extended to finite wings in pitching motion exposed to steady flow. The topological law that vortex strands need to be connected aids in comprehending complex vortex systems, and in assessing the quality of flow visualization. Author

A88-48862#
FLOW VISUALIZATION IN A 90 DEGREE BIFURCATION
EUGENIO S. ROSA and JOSEPH M. PRAHL (Case Western Reserve University, Cleveland, OH) IN: AIAA, ASME, SIAM, and APS, National Fluid Dynamics Congress, 1st, Cincinnati, OH, July 25-28, 1988, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 687-694. refs
(AIAA PAPER 88-3551)

Flow visualization studies of water flowing in the vicinity of a 90-degree bifurcation are conducted in a plexiglas tube for pipe Reynolds numbers from 700 to 1840 and branch flow to main flow ratios from 0.17 to 0.5, (branch flow velocity to main flow velocity ratios from 6 to 18), values encountered in blood flow in the main arteries. Dye injection and hydrogen bubbles reveal complex secondary flow patterns characterized by a pair of contrarotating vortices extending from the branching outlet downstream in the main flow. Similarities between this internal flow and the external flow in the neighborhood of inlets in a cross wind are discussed. Author

A88-48926#
MEASUREMENT AND PREDICTION OF ROUGH WALL EFFECTS ON FRICTION FACTOR - UNIFORM ROUGHNESS RESULTS
W. F. SCAGGS, ROBERT P. TAYLOR, and HUGH W. COLEMAN (Mississippi State University, Mississippi State) IN: AIAA, ASME, SIAM, and APS, National Fluid Dynamics Congress, 1st, Cincinnati, OH, July 25-28, 1988, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 1240-1247. refs
(Contract F33615-84-K-3014; AF-AFOSR-85-0075)
(AIAA PAPER 88-3754)

The results of an experimental investigation of the effects of surface roughness on turbulent pipe flow friction factors are presented and compared with predictions from a previously published discrete element roughness model. Friction factor data were acquired over a pipe Reynolds number range from 10,000 to 600,000 for nine different uniformly rough surfaces. These surfaces covered a range of roughness element sizes, spacings and shapes. Predictions from the discrete element roughness model were in very good agreement with the data. Author

A88-48948*# Virginia Polytechnic Inst. and State Univ., Blacksburg.
THE DEVELOPMENT OF FLUX-SPLIT ALGORITHMS FOR FLOWS WITH NON-EQUILIBRIUM THERMODYNAMICS AND CHEMICAL REACTIONS
B. GROSSMAN (Virginia Polytechnic Institute and State University, Blacksburg) and P. CINELLA IN: AIAA, ASME, SIAM, and APS, National Fluid Dynamics Congress, 1st, Cincinnati, OH, July 25-28, 1988, Technical Papers. Part 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 1443-1454. refs
(Contract NAG1-776)
(AIAA PAPER 88-3595)

A finite-volume method for the numerical computation of flows with nonequilibrium thermodynamics and chemistry is presented. A thermodynamic model is described which simplifies the coupling between the chemistry and thermodynamics and also results in the retention of the homogeneity property of the Euler equations (including all the species continuity and vibrational energy conservation equations). Flux-splitting procedures are developed for the fully coupled equations involving fluid dynamics, chemical production and thermodynamic relaxation processes. New forms of flux-vector split and flux-difference split algorithms are embodied in a fully coupled, implicit, large-block structure, including all the species conservation and energy production equations. Several numerical examples are presented, including high-temperature shock tube and nozzle flows. The methodology is compared to other existing techniques, including spectral and central-differenced procedures, and favorable comparisons are shown regarding accuracy, shock-capturing and convergence rates. Author

A88-48953*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
A SIMPLIFIED OIL-FILM SKIN-FRICTION METER
P. R. BANDYOPADHYAY and L. M. WEINSTEIN (NASA, Langley Research Center, Hampton, VA) IN: AIAA, ASME, SIAM, and APS, National Fluid Dynamics Congress, 1st, Cincinnati, OH, July 25-28, 1988, Technical Papers. Part 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 1487-1499. refs
(Contract NAS1-18235)
(AIAA PAPER 88-3601)

The oil-film method of skin friction measurement, which does not require calibration, nevertheless entails that interferometric measurements of the oil film be obtained. The oil-film method is presently simplified by eliminating interferometry and its requisite polished surface, by taking direct and dynamic measurements of the oil-film slope with a small position-sensing photodiode. This technique has undergone verification in incompressible turbulent and laminar flows in flat-plate boundary layers and pipe flows; the meter is judged to be inexpensive, simple, and robust. O.C.

A88-48958*# Battelle Pacific Northwest Labs., Richland, Wash.
REDUCED GRAVITY BOILING AND CONDENSING EXPERIMENTS SIMULATED WITH THE COBRA/TRAC COMPUTER CODE
JUDITH M. CUTA (Battelle Pacific Northwest Laboratories, Richland, WA) and WILLIAM KROTIUK (General Electric Co., Astro-Space Div., Princeton, NJ) IN: AIAA, ASME, SIAM, and APS, National Fluid Dynamics Congress, 1st, Cincinnati, OH, July 25-28, 1988, Technical Papers. Part 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 1563-1571. DOE-NASA-USAF-supported research. refs
(AIAA PAPER 88-3634)

A series of reduced-gravity two-phase flow experiments has been conducted with a boiler/condenser apparatus in the NASA KC-135 aircraft in order to obtain basic thermal-hydraulic data applicable to analytical design tools. Several test points from the KC-135 tests were selected for simulation by means of the COBRA/TRAC two-fluid, three-field thermal-hydraulic computer code; the points were chosen for a 25-90 percent void-fraction range. The possible causes for the lack of agreement noted between simulations and experiments are explored, with attention to the physical characteristics of two-phase flow in one-G and near-zero-G conditions. O.C.

A88-48970#
THREE-DIMENSIONAL COMPUTATION OF ROTORDYNAMIC FORCE DISTRIBUTIONS IN A LABYRINTH SEAL
D. L. RHODE (Texas A & M University, College Station) and S. J. HENSEL IN: AIAA, ASME, SIAM, and APS, National Fluid Dynamics Congress, 1st, Cincinnati, OH, July 25-28, 1988, Technical Papers. Part 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 1664-1673. USAF-supported research. refs
(AIAA PAPER 88-3691)

A numerical method employing a finite difference approach for calculating the rotordynamic force on eccentric, whirling, labyrinth seals has been developed. The SIMPLER algorithm along with QUICK differencing is used to calculate the flowfield within a seal. A modified bipolar coordinate system accurately describes the geometry of an eccentric seal. The high Reynolds number k-epsilon turbulence model is utilized, which can handle subsonic compressible or incompressible flows. A three-percent eccentric single labyrinth cavity rotating at 5000 cpm was investigated with

three different inlet swirl conditions, each with and without a whirl orbit frerquency of 2500 cpm. The fluid was air with an inlet axial velocity near Mach 0.2. Detailed force, pressure and shear stress distributions within the cavity are presented. The results indicate that the pressure component accounts for 99 percent of the rotordynamic force. Whirl seems to have little effect on the force, and the downstream tooth of the cavity makes a very significant contribution to this quantity. Author

A88-48978#
JET-WAKE THERMAL CHARACTERISTICS OF HEATED TURBULENT JETS IN CROSS FLOW
S. A. SHERIF (Miami, University, Coral Gables, FL) and R. H. PLETCHER (Iowa State University of Science and Technology, Ames) IN: AIAA, ASME, SIAM, and APS, National Fluid Dynamics Congress, 1st, Cincinnati, OH, July 25-28, 1988, Technical Papers. Part 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 1784-1791. Research supported by Iowa State University of Science and Technology. refs
(Contract NSF ENG-78-12901; NSF MEA-82-11713)
(AIAA PAPER 88-3725)

This paper is one in a series reporting on jets discharging to cross-flowing water streams. The experiments were carried out in the 0.61 m x 1.067 m semiclosed circuit water channel at Iowa State University. Hot water was injected vertically upward from a circular pipe located near the channel bottom to simulate the turbulent heated jet. Contours of mean and RMS temperatures both across and along the jet are reported up to lateral and downstream distances of 1.15 and 37 jet diameters, respectively, and for velocity ratios of 1, 2, 4, and 7. The contours were used to explain the complex interaction mechanism between the free stream and the jet in both the jet and wake regions. Author

A88-48987#
UNSTEADY STAGNATION-POINT HEAT TRANSFER DUE TO THE MOTION OF FREESTREAM VORTICES
E. A. BOGUCZ, E. A. DIRIK, and F. A. LYMAN (Syracuse University, NY) IN: AIAA, ASME, SIAM, and APS, National Fluid Dynamics Congress, 1st, Cincinnati, OH, July 25-28, 1988, Technical Papers. Part 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 1893-1900. refs
(AIAA PAPER 88-3771)

The effects of freestream vortices on the flow and heat transfer in a stagnation-point boundary layer are considered for the case of a circular cylinder exposed to an approaching pair of counter-rotating line vortices imbedded in an otherwise uniform crossflow. Series expansions are used to formulate a description of the unsteady hydrodynamic and thermal boundary layers in the neighborhood of the stagnation point, and the resulting governing equations are solved numerically for several vortex flow situations. Perturbations in stagnation-point heat transfer of + or - 40 percent are found to be induced by vortex pairs that have strength and separation distance suggested by recent measurements and experiments. In addition, reversed flow in the boundary layer at the stagnation point is found to be produced in cases of practical interest. The results indicate that the effects of freestream vortices may be significant in situations of current engineering interest, such as the interaction of unsteady wakes of turbomachinery blades with downstream surfaces. Author

A88-49001#
HYPERSONIC FILM COOLING EFFECTIVENESS AND AERO-OPTICAL EFFECTS
R. J. SWIGART, W. C. L. SHIH, J. H. WANG, R. SNOW (Physical Research, Inc., Torrance, CA), J. W. TROLIER (Science Applications International Corp., Valley Forge, PA) et al. IN: AIAA, ASME, SIAM, and APS, National Fluid Dynamics Congress, 1st, Cincinnati, OH, July 25-28, 1988, Technical Papers. Part 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 2116-2123. refs
(Contract N60921-85-C-0132; DASG60-85-C-0006)
(AIAA PAPER 88-3824)

A correlation parameter for film-cooling efficiency has been developed that removes the low-energy outer-flow restriction on which earlier parameters were based. The parameter is shown to collapse a large body of film-cooling efficiency data over a broad range of coolant-injectant and external-flow conditions embodying all speed ranges. The validity and accuracy of the parameter is independently validated using state-of-the-art CFD techniques. The correlation is extremely useful for the design of film-cooling systems, and should be applicable to a broad range of film-cooling applications. Computational algorithms for calculating film-cooling flow-field-induced boresight error and image-blur aerooptical effects are presented. These algorithms should be extremely useful for the prediction of flow-field effects on optical sensor performance. C.D.

A88-49004#
AN EFFICIENT PATCHED GRID NAVIER-STOKES SOLUTION PROCEDURE FOR MULTIPLE BODIES
Y. T. CHAN and B. C. WEINBERG (Scientific Research Associates, Inc., Glastonbury, CT) IN: AIAA, ASME, SIAM, and APS, National Fluid Dynamics Congress, 1st, Cincinnati, OH, July 25-28, 1988, Technical Papers. Part 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 2185-2192. refs
(Contract DAAL03-87-C-0010)
(AIAA PAPER 88-3559)

A novel and efficient procedure is described for solving the time-dependent, multidimensional Navier-Stokes equations concerning multiple body configurations. In contrast to existing patched grid approaches, the present method calculates the entire flow field over both grids simultaneously, without iteration. This procedure could lead to a substantial savings in computer run time, and improved convergence rates could be obtained for steady state problems. A turbomachinery problem involving the flow field in a rotor stator stage is investigated with the procedure. A steady state flow field about a cascade of displaced tandem Joukowski airfoils is considered. The accuracy and CPU time used are compared with the results of a calculation using a continuous deformed grid algorithm and a patched grid with iteration. C.D.

A88-49176#
UNSTEADY FLOW IN A CENTRIFUGAL COMPRESSOR WITH DIFFERENT TYPES OF VANED DIFFUSERS
U. HAUPT, U. SEIDEL, M. RAUTENBERG (Hannover, Universitaet, Hanover, Federal Republic of Germany), and A. N. ABDEL-HAMID (American University, Cairo, Egypt) ASME, Transactions, Journal of Turbomachinery (ISSN 0889-504X), vol. 110, July 1988, p. 293-302. DFG-supported research. refs
(ASME PAPER 88-GT-22)

Self-excited flow oscillations have been experimentally investigated in a centrifugal compressor with a straight-channel radial-vaned diffuser; flow characteristics near the shroud wall were visualized by an oil injection method to exhibit the extent of upstream-directed reverse flow in the impeller during unsteady-flow compressor operations. The results obtained were compared with those of a previous study of the same compressor but with a cambered vane diffuser. The stability margin prior to surge, and the operating regimes in which very intense pressure fluctuation were found were different. O.C.

N88-25630# National Aerospace Lab., Tokyo (Japan).
PROCEEDINGS OF THE 5TH NAL SYMPOSIUM ON AIRCRAFT COMPUTATIONAL AERODYNAMICS
Nov. 1987 259 p In ENGLISH and JAPANESE Symposium held in Tokyo, Japan, 25-26 Jun. 1987 Original contains color illustrations
(NAL-SP-8; ISSN-0452-2982) Avail: NTIS HC A12/MF A01

Topics addressed include: grid generation; computational fluid dynamics; numerical simulations; shuttle orbiter flow; finite element analysis of astrophysical jets; aerodynamic simulation; aircraft configurations; flow characteristics; hydrogen jets; cascade flow; and Navier-Stokes equations.

N88-25634# National Aerospace Lab., Tokyo (Japan).
FINITE ELEMENT ANALYSIS OF INCOMPRESSIBLE VISCOUS FLOW AROUND MULTI-ELEMENT AEROFOILS
MASASHI SHIGEMI *In its* Proceedings of the 5th NAL Symposium on Aircraft Computational Aerodynamics p 29-35 Nov. 1987 In JAPANESE; ENGLISH summary
Avail: NTIS HC A12/MF A01

The Navier-Stokes equation was solved by the finite element method to simulate the laminar flow around airfoils. The concept of the penalty function method was introduced in the finite element method to simplify the implication of the incompressibility constraint. The streamline upwind/Petrov-Galerkin (SU/PG) method was also incorporated to avoid the numerical oscillation in the velocity field, which is known to appear when a simple finite element formulation is applied to flow problems in high Reynolds number region. Three examples were chosen to test the usability of the formulation developed. These are a flow around a symmetric airfoil with zero angle of attack, a flow around an airfoil which is known to show the laminar leading edge separation when the Reynolds number is fairly low, and a flow around an airfoil with flap. All flows obtained showed separation. The separated region of all examples experienced unsteady periodic shedding of vortices except the one on the symmetric airfoil with low Reynolds number, therefore the time marching follows of phenomena became necessary. The theta-method was used to integrate equations with respect to time, with theta between 0.5 and 0.55. The calculated result shows reasonably good agreement with the measured result which accompanies the laminar separation. Even if the airfoil is multi-elemented, there are no particular difficulties in application of this formulation in comparison with the case when the airfoil is single-elemented. Author

N88-25653# Kawasaki Heavy Industries Ltd., Kagamihara (Japan).
THE ROLE OF COMPUTATIONAL FLUID DYNAMICS IN AERONAUTICAL ENGINEERING (5). IMPROVEMENTS AND APPLICATIONS OF IMPLICIT TVD FINITE VOLUME CODE
EIJI SHIMA, KENJI YOSHIDA, and KANICHI AMANO (Japan Aircraft Development Corp., Tokyo.) *In* National Aerospace Lab., Proceedings of the 5th NAL Symposium on Aircraft Computational Aerodynamics p 169-175 Nov. 1987 In JAPANESE; ENGLISH summary
Avail: NTIS HC A12/MF A01

An automatic grid generator for multiple element airfoils was developed and the existing implicit Total Variation Diminishing (TVD) finite volume code was improved in both accuracy and efficiency, in order to make the Navier-Stokes solver a practical design tool for high lift devices. Utilizing these codes, Navier-Stokes analysis of the single slotted flap was carried out. The automatic grid generator utilizes the elliptic equation solver using the finite difference method combined with the panel method. The flow field is divided into subregions by the dividing stream lines which are calculated by the panel method and the computational grid in each subregion is generated by solving the elliptic equations (Thompson's method). Since the panel method can solve the potential flow around any number of arbitrary shaped bodies, this grid generator can generate a H-type computational grid around such bodies automatically. To obtain a high accuracy on a rapidly stretching grid, the flow solver uses the TVD formulation containing an explicit treatment of nonuniform grid spacing. Converging rate and numerical stability of the flow solver is augmented by the relaxation approach using Symmetric Point Gauss Seidel method in matrix inversion process which is necessary for an implicit scheme. Author

N88-25655# Ishikawajima-Harima Heavy Industries Co. Ltd., Mizuho (Japan).
APPLICATION OF COMPUTATIONAL FLUID DYNAMICS TO DESIGN OF COMPRESSOR CASCADE
TEIICHI TAMAKI, KAORU CHIBA, ATSUSHI SHIMIZU, and KENJI KOBAYASHI *In* National Aerospace Lab., Proceedings of the 5th NAL Symposium on Aircraft Computational Aerodynamics p 183-189 Nov. 1987 In JAPANESE; ENGLISH summary
Avail: NTIS HC A12/MF A01

One of the most important problems for the gas turbine design engineers is to estimate the compressor and turbine cascade flow conditions. At the present time, an efficient cascade design tool will be obtained with the computational fluid dynamics. The results of numerical simulation were compared with some cascade experiments. A full potential analysis scheme with boundary layer correction was in good agreement with two-dimensional stational and rotational transonic cascade measurements. A controlled diffusion cascade designed with the new design procedure was tested and shown to have a good performance. Author

N88-25660# Fujitsu Ltd., Tokyo (Japan).
ON THE STATIONARY SOLUTIONS OF THREE-DIMENSIONAL EULER EQUATIONS BY THE TVD DIFFERENCE SCHEMES
YOKO TAKAKURA, TOMIKO ISHIGURO, and SATORU OGAWA (National Aerospace Lab., Tokyo, Japan) *In* National Aerospace Lab., Proceedings of the 5th NAL Symposium on Aircraft Computational Aerodynamics p 211-216 Nov. 1987 In JAPANESE; ENGLISH summary
Avail: NTIS HC A12/MF A01

Numerical estimations are performed for the improved TVD schemes (Harten-Yee and Chakravarthy-Osher numerical fluxes) and also for the classical schemes with artificial dissipation models (Beam-Warming and Obayashi numerical fluxes) through a series of numerical experiments for three-dimensional inviscid flows around the ONERA M6 wing. Numerical experiments indicate that the two TVD numerical fluxes are excellent in the points that they capture shock waves without numerical oscillations and rapid expansions sharply and that they have the robustness and the self-adjusting mechanisms regarding the numerical viscosity. On the other hand the Obayashi numerical flux is not capable of capturing the rapid expansions sharply like the Beam-Warming numerical index, although the former captures the shock waves without numerical oscillations. Author

N88-25662# Ministry of Transportation, Tokyo (Japan). Ship Research Inst.
NUMERICAL SIMULATION OF TURBULENT FLOW USING THE EXPONENTIAL EXPRESSION OF K-EPSILON EQUATION
MUNEHIKO HINATSU and YOSHIAKI KODAMA *In* National Aerospace Lab., Proceedings of the 5th NAL Symposium on Aircraft Computational Aerodynamics p 225-232 Nov. 1987 In JAPANESE; ENGLISH summary
Avail: NTIS HC A12/MF A01

A numerical simulation of a turbulent flow around a wing section by use of the kappa-epsilon turbulence model is presented. In order to assure the positiveness of kappa and epsilon, the exponential expression of kappa-epsilon is used. The IAF method is adopted as a computational scheme. A treatment for the boundary condition on the wing surface is devised. A turbulent flow around NACA0012 wing section with 5 deg angle of attack at Re = 1 million is simulated. Author

N88-25688*# International Maritime Satellite Organization, London (England). Aeronautical Dept.
WORLD-WIDE AERONAUTICAL SATELLITE COMMUNICATIONS
PETER WOOD and KEITH SMITH *In* Jet Propulsion Lab., Proceedings of the Mobile Satellite Conference p 57-62 May 1988
Avail: NTIS HC A23/MF A01 CSCL 17B

INMARSAT decided to expand the spectrum covered by its new generation of satellites, INMARSAT-2, to include 1 MHz (subsequently increased to 3 MHz) of the spectrum designed for aeronautical use. It began a design study that led to the specifications for the system that is now being implemented. Subsequently, INMARSAT awarded contracts for the design of avionics and high gain antennas to a number of manufactures, while several of the signatories that provide ground equipment for communicating with the INMARSAT satellites are modifying their earth stations to work with the avionic equipment. As a resullt of

these activities, a world-wide aeronautical satellite system supporting both voice and data will become operational in 1989. Author

N88-25704*# Racal Avionics Ltd., London (England).
DESIGN, DEVELOPMENT AND TRIALS OF AN AIRLINE PASSENGER TELEPHONE SYSTEM
JIM SCHOENENBERGER and ROGER MCKINLAY *In* Jet Propulsion Lab., Proceedings of the Mobile Satellite Conference p 171-176 May 1988
Avail: NTIS HC A23/MF A01 CSCL 17B

The design, development and trials of a satellite telephone system for airline passengers is described. The requirements for ground and space infrastructure are discussed and the aeronautical system is described. Design criteria for the antennas and avionic boxes are given and system operation and technical flight trial requirements are discussed, together with test methodology and development towards fully commercial trials. Finally, an indication of development requirements to achieve the desired aims of airline users is given. Author

N88-25713*# Teledyne Ryan Electronics, San Diego, Calif.
MSAT-X PHASED ARRAY ANTENNA ADAPTIONS TO AIRBORNE APPLICATIONS
C. SPARKS, H. H. CHUNG, and S. Y. PENG *In* Jet Propulsion Lab., Proceedings of the Mobile Satellite Conference p 229-234 May 1988
Avail: NTIS HC A23/MF A01 CSCL 17B

The Mobile Satellite Experiment (MSAT-X) phased array antenna is being modified to meet future requirements. The proposed system consists of two high gain antennas mounted on each side of a fuselage, and a low gain antenna mounted on top of the fuselage. Each antenna is an electronically steered phased array based on the design of the MSAT-X antenna. A beamforming network is connected to the array elements via coaxial cables. It is essential that the proposed antenna system be able to provide an adequate communication link over the required space coverage, which is 360 degrees in azimuth and from 20 degrees below the horizon to the zenith in elevation. Alternative design concepts are suggested. Both open loop and closed loop backup capabilities are discussed. Typical antenna performance data are also included. Author

N88-25723*# Communications Research Centre, Ottawa (Ontario).
PERFORMANCE OF THE ICAO STANDARD CORE SERVICE MODULATION AND CODING TECHNIQUES
JOHN LODGE and MICHAEL MOHER (Miller Communications Systems Ltd., Kanata, Ontario) *In* Jet Propulsion Lab., Proceedings of the Mobile Satellite Conference p 297-302 May 1988
Avail: NTIS HC A23/MF A01 CSCL 17B

Aviation binary phase shift keying (A-BPSK) is described and simulated performance results are given that demonstrate robust performance in the presence of hardlimiting amplifiers. The performance of coherently-detected A-BPSK with rate 1/2 convolutional coding are given. The performance loss due to the Rician fading was shown to be less than 1 dB over the simulated range. A partially coherent detection scheme that does not require carrier phase recovery was described. This scheme exhibits similiar performance to coherent detection, at high bit error rates, while it is superior at lower bit error rates. Author

N88-25755*# Aeronautical Radio, Inc., Annapolis, Md. AvSat Program.
DEVELOPMENT OF AN 8000 BPS VOICE CODEC FOR AVSAT
JOSEPH F. CLARK *In* Jet Propulsion Lab., Proceedings of the Mobile Satellite Conference p 521-526 May 1988
Avail: NTIS HC A23/MF A01 CSCL 17B

Air-mobile speech communication applications share robustness and noise immunity requirements with other mobile applications. The quality requirements are stringent, especially in the cockpit where air safety is involved. Based on these considerations, a decision was made to test an intermediate data rate such as 8.0 and 9.6 kb/s as proven technologies. A number of vocoders and codec technologies were investigated at rates ranging from 2.4 kb/s up to and including 9.6 kb/s. The proven vocoders operating at 2.4 and 4.8 kb/s lacked the noise immunity or the robustness to operate reliably in a cabin noise environment. One very attractive alternative approach was Spectrally Encoded Residual Excited LPC (SE-RELP) which is used in a multi-rate voice processor (MRP) developed at the Naval Research Lab (NRL). The MRP uses SE-RELP at rates of 9.6 and 16 kb/s. The 9.6 kb/s rate can be lowered to 8.0 kb/s without loss of information by modifying the frame. An 8.0 kb/s vocoder was developed using SE-RELP as a demonstrator and testbed. This demonstrator is implemented in real time using two Compaq 2 portable computers, each equipped with an ARIEL DSP016 Data Acquisition Processor. Author

N88-25840# Massachusetts Inst. of Tech., Cambridge. Dept. of Aeronautics and Astronautics.
FLUID DYNAMICS OF HIGH PERFORMANCE TURBOMACHINES Annual Report, 19 Oct. 1986 - 18 Oct. 1987
EDWARD M. GREITZER, ALAN H. EPSTEIN, MICHAEL B. GILES, JAMES E. MCCUNE, and CHOON S. TAN Dec. 1987 131 p
(Contract F49620-85-C-0018)
(AD-A192073; AFOSR-88-0183TR) Avail: NTIS HC A07/MF A01 CSCL 20D

Within the general topic, four separate tasks are specified, i.e.: 1) Loss mechanisms and loss migration in transonic compressors, including development of advanced instrumentation for measurements of wake radial transport and analysis of unsteady vortical wake structures; 2) Experimental and theoretical study of flows in casing and hub treatment, including mechanisms for stability enhancement in compressors and unsteady fluid dynamic interactions between passage and groove flows; 3) Computational techniques for turbomachinery, including inverse (design) calculation procedures for transonic turbomachine blades accounting for viscid/inviscid interaction; and 4) Theoretical modelling of stability and unsteadiness in transonic compressor flow fields, including analyses of unsteady fluctuations due to vortex shedding. GRA

N88-25901*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
A TWIN-MIRRORED GALVANOMETER LASER LIGHT SHEET GENERATOR
DAVID B. RHODES, JOHN M. FRANKE, STEPHEN B. JONES, and BRADLEY D. LEIGHTY Jun. 1988 28 p
(NASA-TM-100587; NAS 1.15:100587) Avail: NTIS HC A03/MF A01 CSCL 20E

A galvanometer mirror-based laser light sheet system has been developed for use in the Basic Aerodynamics Research Tunnel at NASA Langley. This system generates and positions single or multiple light sheets over aeronautical research models being tested in the low speed tunnel. This report describes a twin mirrored galvanometer laser light sheet generator and shows typical light sheet arrangements in use. With this system, illumination of smoke entrained in the flow over a delta wing model reveals the vortical flow produced by the separation of the flow at the leading edge of the model. The light sheet system has proven to be very adaptable and easy to use in sizing and positioning light sheets in wind tunnel applications. Author

N88-25924*# Draper (Charles Stark) Lab., Inc., Cambridge, Mass.
SEMI-MARKOV ADJUNCTION TO THE COMPUTER-AIDED MARKOV EVALUATOR (CAME)
GENE ROSCH, MONICA A. HUTCHINS, FRANK J. LEONG, and PHILIP S. BABCOCK, IV Apr. 1988 69 p
(Contract NAS9-17560)
(NASA-CR-181645; NAS 1.26:181645) Avail: NTIS HC A04/MF A01 CSCL 14D

The rule-based Computer-Aided Markov Evaluator (CAME) program was expanded in its ability to incorporate the effect of fault-handling processes into the construction of a reliability model.

The fault-handling processes are modeled as semi-Markov events and CAME constructs and appropriate semi-Markov model. To solve the model, the program outputs it in a form which can be directly solved with the Semi-Markov Unreliability Range Evaluator (SURE) program. As a means of evaluating the alterations made to the CAME program, the program is used to model the reliability of portions of the Integrated Airframe/Propulsion Control System Architecture (IAPSA 2) reference configuration. The reliability predictions are compared with a previous analysis. The results bear out the feasibility of utilizing CAME to generate appropriate semi-Markov models to model fault-handling processes. Author

N88-25934# Technion - Israel Inst. of Tech., Haifa. Dept. of Aeronautical Engineering.
PREDICTION OF FATIGUE LIFE OF NOTCHED SPECIMENS UNDER AIRCRAFT LOADING AND IMPORTANCE OF THE RELATIVE METHOD IN THE CASE OF LOCAL STRAIN APPROACH, PART 2
A. BUCH and A. BERKOVITS May 1987 42 p Sponsored in part by the SENIEL OSTROV research fund and the TECHNION VPR fund
(TAE-595-PT-2) Avail: NTIS HC A03/MF A01

The aim of the research was to compare life predictions obtained from block-by-block counting using a versatile computer program (LSA2) with those obtained in cycle-by-cycle counting from another program. For better understanding of the effect of memory rules on the predictive accuracy, the comparison of the prediction with experiment covered both LSA versions for both corrected and uncorrected cases. The life predictions are dependent on the value of K used in Neuber's relation. Therefore, the calculations were sometimes performed in parallel using both K=K sub T and K=K sub F. Results of maneuver loading spectra for both Ti and Al alloy aircraft materials are considered. Prediction of the effect of stress concentration and material variation is verified for LSA predictions. Application of the relative method for fully randomized loading spectra is extended to a variety of steels and K sub T values. J.P.B.

N88-25935*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
IMPROVED METHOD FOR STRESS AND COMPATIBILITY ANALYSIS OF MULTICOMPONENT ROTATING SYSTEMS
GERALD A. CAREK Jun. 1988 31 p
(NASA-TM-100884; E-4117; NAS 1.15:100884) Avail: NTIS HC A03/MF A01 CSCL 20K

An improved method of analyzing multicomponent rotating assemblies for the determination of operating stresses and component compatibility has been developed. In this method, a single finite element model is developed which contains all of the separate components in the rotating assembly. This is made possible by using gap elements to simulate the contact surfaces between components. The MARC finite element computer program is then used to perform the analysis. This improved method is less time consuming and more reliable than the conventional method of analyzing such systems. Results are presented for two different stress-compatibility analyses of a six-component axial flow compressor rotor. The results for the previously used flexibility analysis method are compared with those for the improved analysis method. The stresses predicted by each method compare quite well with each other. The predictions of the component compatibility, as well as the magnitude of the forces at the contact surfaces, also compare well for these two analysis procedures. It is therefore recommended that the improved analysis method be used to determine the stress-compatibility characterstics of multicomponent rotating systems. Author

N88-26628# National Aerospace Lab., Amsterdam (Netherlands). Informatics Div.
PRELIMINARY DESIGN AND ANALYSIS OF PROCEDURES FOR THE NUMERICAL GENERATION OF 3D BLOCK-STRUCTURED GRIDS
J. W. BOERSTOEL 13 Aug. 1986 80 p
(Contract NIVR-311.1-1101/01604N)
(NLR-TR-86102-U; B8803895; ETN-88-92601) Avail: NTIS HC A05/MF A01

Aproaches to grid generation are analyzed. A grid-generation procedure for complex aircraft configurations could be based on a combination of three subprocesses: decomposition of the flow domain into 100 hexahedronal blocks; trilinear transfinite interpolation to generate initial grid point distributions; and elliptic mesh-size tuning and smoothing. To get insight into this procedure, mathematical models of the subprocesses were worked out. The results of the analysis are technical concepts required or desirable in the grid-generation procedure. ESA

N88-26632# Office National d'Etudes et de Recherches Aerospatiales, Paris (France).
PARALLELIZATION ON A MULTIPROCESSOR SYSTEM OF A SOLUTION METHOD FOR THE UNSTEADY NAVIER-STOKES EQUATIONS AT HIGH REYNOLDS NUMBERS Ph.D. Thesis - Paris VI Univ.
LAURE MANE 1987 111 p In FRENCH; ENGLISH summary Report will be announced as translation (ESA-TT-1116) Original contains color illustrations
(ONERA-NT-1987-8; ISSN-0078-3781; ETN-88-92730) Avail: NTIS HC A06/MF A01

The numerical simulation on a shared memory multiprocessor of unsteady separated flows around a body is studied. The two-dimensional equations are solved in stream function and vorticity formulations. The method combines highly accurate finite difference schemes and alternating direction implicit techniques. The algorithm parallelization is based on splitting the computational domain into subdomains. The performances of the parallel code are presented. The results of the simulation of a pulse-started NACA 0012 airfoil for different angles of attack and Reynolds numbers up to 100,000 are presented. ESA

N88-26633# Institut Franco-Allemand de Recherches, St. Louis (France).
TREATMENT OF THE SEPARATED FLOW AROUND PROFILES (NONVISCOUS, INCOMPRESSIBLE, TWO DIMENSIONAL FLOW) BY THE SINGULARITIES METHOD [TRAITEMENT DE L'ECOULEMENT (NON VISQUEUX, INCOMPRESSIBLE, BIDIMENSIONNEL) AUTOUR DE PROFILS AVEC DECOLLEMENT PAR LA METHODE DES SINGULARITES]
M. SCHAFFAR 3 Apr. 1987 67 p In FRENCH
(ISL-R-106/87; ETN-88-92732) Avail: NTIS HC A04/MF A01

The method is based on assuming linear vortices distributed over the profile divided in N segments. The wake is examined by means of turbulent layers. The profiles studied at variable incidence are described. The results depend on the procedures of wake analysis (layers with interpolation, point turbulence with or without vortex coalescence) and also on parameters such as the time step and the inertial flow around the profile. ESA

N88-26668# Central Research Inst. of Electric Power Industry, Tokyo (Japan).
STUDY ON THE HEAT RESISTING AND COOLING PROPERTY OF THE CERAMICS-METAL HYBRID STATOR VANES
TORU HISAMATSU, TOSHIO ABE, TERUHIDE HAMAMATSU, HIROSHI MIYATA, SHIRO IZIMA, TAKAHASHI, ICHIRO, and RYOICHIRO OSHIMA Jun. 1987 28 p In JAPANESE; ENGLISH summary
(DE88-753117; CRIE-W-86033) Avail: NTIS (US Sales Only) HC A03

20 MW class gas turbine stator blade was designed and test-made. Combustion gas with temperature up to 1,600°C was flown to five wings in a row. Temperature of the metal core reduced its influence as the amount of the cooling air increased; in the case of s/s with maximum allowable temperature of 600°C, required amount of cooling air was found to be roughly 0.5 percent of the total amount of the compressed air (1/10 of the metal, air-cooled blades), which coincided with the results of analysis. Concerning the temperature distribution of the ceramic shell, big difference

was found in the front edge surface (outer and inner); more temperature reduction was found at the rear edge of the blade at the time of shut-down. The results of analysis were the same as that of the heat impact test of the single ceramic body. It is hereafter desirable to consider the generation of the thermal stress amd to improve the shell structure. DOE

N88-26694*# California State Univ., Long Beach. Dept. of Mechanical Engineering.
STRESS CONCENTRATION AROUND CIRCULAR HOLE IN A COMPOSITE MATERIAL SPECIMEN REPRESENTATIVE OF THE X-29A FORWARD-SWEPT WING AIRCRAFT
HSIEN-YANG YEH Aug. 1988 22 p
(Contract NGT-05020412)
(NASA-CR-179435; H-1435; NAS 1.26:179435) Avail: NTIS HC A03/MF A01 CSCL 20K

The theory of anisotropic elasticity was used to evaluate the anisotropic stress concentration factors of a composite laminated plate containing a small circular hole. This advanced composite material was used to manufacture the X-29A forward swept wing. Observe that the usual isotropic material stress concentration factor is three. However, for composite material, it was found that the anisotropic stress concentration factor is no longer constant, and that the locations of maximum tangential stress points could shift by changing the fiber orientation with respect to the loading axis. The analysis showed that through the lamination process, the stress concentration factor could be drastically reduced, and therefore the structural performance could be improved. Both the mixture rule approach and the constant strain approach were used to calculate the stress concentration factor. The results predicted by the mixture rule approach were about 20 percent deviate from the experimental data. However, the results predicted by the constant strain approach matched the testing data very well. This showed the importance of the inplane shear effect on the evaluation of stress concentration factor for the X-29A composite plate. Author

N88-26709*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
A GENERAL-PURPOSE APPROACH TO COMPUTER-AIDED DYNAMIC ANALYSIS OF A FLEXIBLE HELICOPTER
OM P. AGRAWAL (University of Southern Illinois, Carbondale.) Jul. 1988 27 p
(NASA-TM-101002; A-88183; NAS 1.15:101002) Avail: NTIS HC A03/MF A01 CSCL 20K

A general purpose mathematical formulation is described for dynamic analysis of a helicopter consisting of flexible and/or rigid bodies that undergo large translations and rotations. Rigid body and elastic sets of generalized coordinates are used. The rigid body coordinates define the location and the orientation of a body coordinate frame (global frame) with respect to an inertial frame. The elastic coordinates are introduced using a finite element approach in order to model flexible components. The compatibility conditions between two adjacent elements in a flexible body are imposed using a Boolean matrix, whereas the compatibility conditions between two adjacent bodies are imposed using the Lagrange multiplier approach. Since the form of the constraint equations depends upon the type of kinematic joint and involves only the generalized coordinates of the two participating elements, then a library of constraint elements can be developed to impose the kinematic constraint in an automated fashion. For the body constraints, the Lagrange multipliers yield the reaction forces and torques of the bodies at the joints. The virtual work approach is used to derive the equations of motion, which are a system of differential and algebraic equations that are highly nonlinear. The formulation presented is general and is compared with hard-wired formulations commonly used in helicopter analysis. Author

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GEOSCIENCES

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

A88-49018#
USE, NONUSE, AND ABUSE OF WEATHER RADAR
EDWIN KESSLER (Oklahoma, University, Norman) *Journal of* Aircraft (ISSN 0021-8669), vol. 25, May 1988, p. 448-452. Previously cited in issue 08, p. 1136, Accession no. A87-22634. refs

A88-49037
CHARACTERISTICS OF MICROBURSTS IN THE CONTINENTAL UNITED STATES
MARILYN M. WOLFSON (MIT, Lexington, MA) The Lincoln Laboratory Journal (ISSN 0896-4130), vol. 1, Spring 1988, p. 49-74. FAA-sponsored research. refs

A number of meteorologically distinct phenomena generating strong surface outflows have come to be considered 'microbursts'; an effort is presently made to categorize these phenomena according to their meteorological basis and actual aviation-hazard potential, in order to compile a coherent body of knowledge on which automated algorithms for microburst detection and prediction can be based. Microburst-producing air mass storms pose the greatest hazard to aviation due to their relatively high frequency, rapid development, strong small-scale outflows, and lack of translational motion. Yet, storms that are indistinguishable from these both visually and on conventional aircraft radar are successfully traversed by aircraft on a regular basis. O.C.

N88-26719# National Aerospace Lab., Amsterdam (Netherlands). Informatics Div.
GEOGRAPHICAL INFORMATION FOR DESIGN PURPOSES
T. D. DEWITTE 11 Feb. 1987 28 p IN DUTCH; ENGLISH summary
(NLR-MP-87014-U; B8803802; ETN-88-92608) Avail: NTIS HC A03/MF A01

The preparation and use of geographical information for design purposes are reviewed. Digital geographical information distinguishes structured and nonstructured information. Structured information concerns numerically ordered features. Nonstructured information concerns images of areas recorded by scanning maps. This led to a geographic information base, applied to a route-planning system for aircraft. Requirements with respect to information availability, up-to-dateness, accessibility are severe, so it is necessary to provide the system with dedicated application data bases. Two steps in designing a geographical information system are distinguished: a subsystem for the preparation of the application data bases, and a subsystem for the use of the geographical data. This system uses structured (e.g., terrain elevation) and nonstructured geographical information (digital map images). Digital maps can also be composed from structured information using the specific geographical features. ESA

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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.

A88-45951
SOFTWARE DIVERSITY IN COMPUTERIZED CONTROL SYSTEMS

UDO VOGES, ED. (Kernforschungszentrum Karlsruhe GmbH, Federal Republic of Germany) Vienna and New York, Springer-Verlag (Dependable Computing and Fault-Tolerant Systems. Volume 2), 1988, 222 p. For individual items see A88-45952 to A88-45954.

The use of software diversity (SD) to achieve fault tolerance in industrial control systems is examined, reviewing the results of recent experimental investigations and applications. Topics addressed include safety systems for rail transport, experimental safety systems for nuclear reactors, the control software for the Airbus and ATR aircraft, tolerating software design faults, and reliability modeling for fault-tolerant software. Extensive diagrams and flow charts are provided. T.K.

A88-46490#
AIR BREATHING PROPULSION EDUCATION SOFTWARE FOR PCS
JACK D. MATTINGLY (USAF, Aero Propulsion Laboratory and Institute of Technology, Wright-Patterson AFB, OH) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 11 p.
(AIAA PAPER 88-2977)

User friendly, air breathing propulsion software has been developed for use in both undergraduate and graduate courses at the Air Force Academy and Air Force Institute of Technology, respectively. Specific software has been developed for use on personal computers (PCs) to facilitate learning air breathing propulsion. To date, programs have been written for compressible flow functions, normal and oblique shock functions, engine on-design (design point) analysis, engine off-design analysis, aircraft system constraint analysis, aircraft system mission analysis, conceptual fan and compressor design, and conceptual turbine design. For ease of portability to many computers, most programs are written in FORTRAN 77. The basic operation of the programs and examples of their use in air breathing propulsion courses are presented. Author

A88-46957
A SIMULATION STUDY OF A MODEL REFERENCE ADAPTIVE CONTROL LOADING SYSTEM FOR OPERATIONAL FLIGHT TRAINERS
JOHN P. GARNER (Systems Control Technology, Inc., Lexington Park, MD) IN: 1987 Annual Summer Computer Simulation Conference, 19th, Montreal, Canada, July 27-30, 1987, Proceedings. San Diego, CA, Society for Computer Simulation, 1987, p. 169-176. refs

This paper discusses a simulation study related to the design of an adaptive model reference control (AMRC) system for use in control loading subsystems for aircraft training simulators. The algorithm provides the capability to adapt Kalman filter gains and control system gains in real time to maintain control loader accuracy during motor parameter variations. The concept of AMRC is introduced and the role of control loaders in aircraft simulators is discussed. Results from the simulation study are presented and described. Author

A88-46960
PARALLEL PROCESSING SCHEMES FOR THE BLOCK-STRUCTURED SOLUTION OF TRANSONIC FLOWS
AKIN ECER and JOHN T. SPYROPOULOS (Purdue University, Indianapolis, IN) IN: 1987 Annual Summer Computer Simulation Conference, 19th, Montreal, Canada, July 27-30, 1987, Proceedings. San Diego, CA, Society for Computer Simulation, 1987, p. 191-195. refs

Parallel processing schemes developed for the block-structured solution of the three-dimensional Navier-Stokes equations are presented. These schemes allow calculation of flow fields over realistic aerodynamic configurations employing the capabilities of current computer systems. Through the introduction of a Clebsch transformation of the velocity field, an equivalent set of the steady Navier-Stokes equations is obtained. The resulting equations are solved by the finite element method employing a block-structured relaxation scheme. The solution domain is subdivided into subdomains, or blocks, and the equations are solved in an uncoupled form for each block with appropriate Dirichlet and Neumann-type boundary conditions. Parallel processing techniques for implementing the derived block-structured scheme on CRAY XMP, IBM 3090 and INTEL IPSC families of computer systems are discussed. Author

A88-46979
EVENT-DRIVEN VERSUS INTERRUPT-DRIVEN FLIGHT SIMULATION METHODOLOGIES
B. A. SATHRE (Martin Marietta Corp., Orlando, FL) IN: 1987 Annual Summer Computer Simulation Conference, 19th, Montreal, Canada, July 27-30, 1987, Proceedings. San Diego, CA, Society for Computer Simulation, 1987, p. 797-802. refs

The use of event-driven and interrupt-driven scheduling for real-time flight simulation activities is discussed. The first method activates processes triggered by external events such as setting changes as well as internal events such as responses to other processes. In interrupt-driven methodology, the triggering event becomes an internal timer, set to some predetermined frame rate per time unit; it issues an interrupt upon expiration. The simulation of real-time aircraft activities for the purpose of pilot training is used as an example of the combination of event-driven and interrupt-driven processes. K.K.

A88-47986*# Old Dominion Univ., Norfolk, Va.
AN ADAPTIVE REMESHING METHOD FOR FINITE ELEMENT THERMAL ANALYSIS
EARL A. THORNTON and GURURAJA R. VEMAGANTI (Old Dominion University, Norfolk, VA) AIAA, Thermophysics, Plasmadynamics and Lasers Conference, San Antonio, TX, June 27-29, 1988. 16 p. refs
(Contract NSG-1321)
(AIAA PAPER 88-2662)

A finite element remeshing approach that makes use of quadrilateral and triangular elements is described. The approach uses the solution on a previous mesh to create a new mesh. Meshes are completely unstructured with highly refined elements in regions of steep gradients and larger elements where gradients are smaller. Studies of convergence rates for heat conduction problems with exact solutions show that for problems with highly localized solution variations, the remeshing approach gives smaller solution errors with fewer unknowns than refinement of uniform, structured meshes. Author

A88-48830*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
ACCURATE MULTIGRID SOLUTION OF THE EULER EQUATIONS ON UNSTRUCTURED AND ADAPTIVE MESHES
DIMITRI J. MAVRIPLIS (NASA, Langley Research Center, Hampton, VA) IN: AIAA, ASME, SIAM, and APS, National Fluid Dynamics Congress, 1st, Cincinnati, OH, July 25-28, 1988, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 419-426. refs
(AIAA PAPER 88-3706)

A method for accurately solving inviscid compressible flow in the subcritical and supercritical regimes about complex configurations is presented. The method is based on the use of unstructured triangular meshes in two dimensions, and special emphasis is placed on the accuracy and efficiency of the solutions. High accuracy is achieved by careful scaling of the artificial dissipation terms, and by reformulating the inner and outer boundary conditions for both the convective and dissipative operators. An adaptive grid refinement strategy is presented which enhances the solution accuracy for complex flows. When coupled with an unstructured multigrid algorithm, this method is shown to produce an efficient solver for flows about artibrary configurations. Author

A88-49101* Arizona State Univ., Tempe.
PERFORMANCE LIMITATIONS IN PARALLEL PROCESSOR SIMULATIONS
E. PEARSE O'GRADY (Arizona State University, Tempe) and CHUNG-HSIEN WANG (Sierra Semiconductor, Inc., San Jose,

CA) Society for Computer Simulation, Transactions (ISSN 0740-6797), vol. 4, Oct. 1987, p. 311-330. refs
(Contract NAG3-113)

A jet-engine model is partitioned and simulated on a parallel processor system consisting of five 8086/8087 floating-point computers. The simulation uses Heun's integration method. A near-optimal parallel simulation (in the sense of minimum execution time) achieves speedup of only 2.13 and efficiency of 42.6 percent, in effect wasting 57.4 percent of the available processing power. A detailed analysis identifies and graphically demonstrates why the system fails to achieve ideal performance (viz., speedup of 5 and efficiency of 100 percent). Inherent characteristics of the problem equations and solution algorithm account for the loss of nearly half of the available processing power. Overheads associated with interprocessor communication and processor synchronization account for only a small fraction of the lost processing power. The effects of these and other factors which limit parallel processor performance are illustrated through real-time timing-analyzer tracers describing the run/idle status of the parallel processors during the simulation. Author

N88-26144*# Indiana Univ.-Purdue Univ., Lafayette. Engineering Div.
MODEL REDUCTION METHODS FOR CONTROL DESIGN Final Contractor Report
K. R. DUNIPACE Aug. 1988 140 p
(Contract NCC2-289)
(NASA-CR-179434; H-1499; NAS 1.26:179434) Avail: NTIS HC A07/MF A01 CSCL 09B

Several different model reduction methods are developed and detailed implementation information is provided for those methods. Command files to implement the model reduction methods in a proprietary control law analysis and design package are presented. A comparison and discussion of the various reduction techniques is included. Author

N88-26872 Mississippi State Univ., Mississippi State.
THE CONSTRUCTION OF COMPOSITE GRIDS FOR GENERAL THREE-DIMENSIONAL REGIONS Ph.D. Thesis
YEON SEOK CHAE 1987 258 p
Avail: Univ. Microfilms Order No. DA8728921

The construction of a two dimensional, two block and four block system for a coastal grid; a three dimensional single block system for a wing-body configuration, a three dimensionsl 37-block and 13-block system for a wing-body-pylon-store configuration are discussed. Eglin's EAGLE code, which has a surface and grid generation systems for general, three dimensional, composite or multiblock grids based on algebraic and elliptic grid generation techniques, is used for this research. Introduced are several symbolic surface and grid generation runstreams for single block wing-body configurations and, 37-block and 13-block wing-body-pylon-store configurations. These runstreams can be used for other types of wing-body-pylon-store configurations. The detailed construction and the editing procedure of each surface and grid generation runstream are also discussed. The purpose of this research included the generation of various grids without obtaining solutions with a flow solver. Dissert. Abstr.

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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.

A88-47060
THICKNESS NOISE OF A PROPELLER AND ITS RELATION TO BLADE SWEEP
R. K. AMIET Journal of Fluid Mechanics (ISSN 0022-1120), vol. 192, July 1988, p. 535-560. refs

Linear acoustic theory is used to determine the thickness noise produced by a supersonic propeller with sharp leading and trailing edges. The method reveals details of the calculated waveform. Abrupt changes of slope in the pressure-time waveform which are produced by singular points entering or leaving the tip blade are pointed out. It is found that the behavior of the pressure-time waveform is closely related to changes in the retarded rotor shape. The results indicate that logarithmic singularities in the waveform are produced by regions on the blade edges that move towards the observer at sonic speed, with the edge normal to the line joining the source point and the observer. R.R.

A88-47469#
AERODYNAMIC INTERACTION TONES OF A MODEL COUNTER-ROTATING PROPELLER
R. T. NAGEL and H. V. L. PATRICK (North Carolina State University, Raleigh) (ICAS, Conference, 15th, London, England, Sept. 7-12, 1986) AIAA Journal (ISSN 0001-1452), vol. 26, April 1988, p. 498-500.

A coherence analysis of the interaction between the radiated sound of contrarotating propellers and the fluctuating components of velocity between the rotors can be used to identify the existence of noise-flow relationships. The association of flow components with interaction noise can be identified through coherence peaks that are associated with the sums and differences of the blade-passing frequencies. The magnitude of the tones in the sound or flow velocity spectra were not significant in the establishment of coherence. O.C.

A88-47670* National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
EXTENSION OF KIRCHHOFF'S FORMULA TO RADIATION FROM MOVING SURFACES
F. FARASSAT (NASA, Langley Research Center, Hampton, VA) and M. K. MYERS (George Washington University, Hampton, VA) Journal of Sound and Vibration (ISSN 0022-460X), vol. 123, June 22, 1988, p. 451-460. Previously announced in STAR as N87-24160. refs
(Contract NCC1-14)

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

A88-48896#
MODE SWITCHING IN SUPERSONIC CIRCULAR JETS
E. GUTMARK, K. C. SCHADOW, and C. J. BICKER (U.S. Navy, Naval Weapons Center, China Lake, CA) IN: AIAA, ASME, SIAM, and APS, National Fluid Dynamics Congress, 1st, Cincinnati, OH, July 25-28, 1988, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 974-981. refs
(AIAA PAPER 88-3610)

An underexpanded supersonic circular jet was studied experimentally in a Mach number range of 1.1 to 2.4. Spark schlieren photography and near-field pressure measurements showed large changes in the jet structure for different Mach numbers. For nearly sonic exit velocity, the jet had a dominant

symmetric structure and spreading rate similar to subsonic conditions. For an exit velocity equivalent to M greater than 1.2 the jet switched mode to helical structure, resulting in a substantial increase in the spreading rate. A transitional region was determined for M between 1.12 and 1.18 in which the jet switched modes intermittently from axisymmetric to helical. For Mach numbers higher than 1.6, another structure change was observed, related to the emergence of a normal shock in the first shock cell. The structural changes affected the near-field pressure fluctuations of the jet. The jet with the helical structure had a strong sound emission component in the upstream direction which could be related to the higher spreading rate of the jet. Author

A88-48919*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
THE ROLE OF UNSTEADY AERODYNAMICS IN AEROACOUSTICS
S. PAUL PAO (NASA, Langley Research Center, Hampton, VA) IN: AIAA, ASME, SIAM, and APS, National Fluid Dynamics Congress, 1st, Cincinnati, OH, July 25-28, 1988, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 1188-1195. refs
(AIAA PAPER 88-3711)

The role of acoustics and unsteady aerodynamics research in understanding the fundamental physics of time-dependent fluid phenomena is reviewed. The key issues are illustrated by considering the sound radiation of turbulent jets and the aeroacoustics of rotating bodies such as helicopter rotors. The importance of computational methods as a link between aerodynamics and acoustics is also discussed. It is noted that where acoustic analogy techniques are sufficiently accurate, unsteady aerodynamics can be used for acoustic prediction. In supersonic problems where acoustics and aerodynamics are coupled, an integrated nonlinear analysis can provide an accurate problem solution. R.R.

A88-48996#
THE EFFECT OF FORWARD SKEWED ROTOR BLADES ON AERODYNAMIC AND AEROACOUSTIC PERFORMANCE OF AXIAL-FLOW FAN
JUN WEI (Shanghai Research Institute of General Machinery, People's Republic of China) and FANGYUAN ZHONG (Jiaotong University, Shanghai, People's Republic of China) IN: AIAA, ASME, SIAM, and APS, National Fluid Dynamics Congress, 1st, Cincinnati, OH, July 25-28, 1988, Technical Papers. Part 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 1983-1990.
(AIAA PAPER 88-3783)

Based on comparative experiment, this paper deals with using tangentially skewed rotor blades in axial-flow fan. It is seen from the comparison of the overall performance of the fan with skewed bladed rotor and radial bladed rotor that the skewed blades operate more efficiently than the radial blades, especially at low volume flows. Meanwhile, decrease in pressure rise and flow rate of axial-flow fan with skewed rotor blades is found. The rotor-stator interaction noise and broadband noise of axial-flow fan are reduced with skewed rotor blades. Forward skewed blades tend to reduce the accumulation of the blade boundary layer in the tip region resulting from the effect of centrifugal forces. The turning of streamlines from the outer radius region into inner radius region in blade passages due to the radial component of blade forces of skewed blades is the main reason for the decrease in pressure rise and flow rate. Author

A88-49002#
TRAILING EDGE FLOWS AND AERODYNAMIC SOUND
JONATHAN GERSHFELD, WILLIAM K. BLAKE, and CHARLES W. KNISELY (David W. Taylor Naval Ship Research and Development Center, Bethesda, MD) IN: AIAA, ASME, SIAM, and APS, National Fluid Dynamics Congress, 1st, Cincinnati, OH, July 25-28, 1988, Technical Papers. Part 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 2133-2140. Navy-supported research. refs
(AIAA PAPER 88-3826)

An experimental evaluation of trailing edge noise is given for two dimensional lifting airfoils which have asymmetrically beveled trailing edges. The flows generated by these edges are separated on the low pressure side and attached on the high pressure side. The aeroacoustic dipole strength of the trailing edge noise is quantified by statistical measurements of surface pressures, acoustic field pressures and near-wake velocity profiles. A comparison of the predicted noise using existing analytical models of trailing edge sound is made with actual noise measurements. Measurements of surface pressures and cross spectra between the surface pressures and radiated sound are related to the aeroacoustic spanwise correlation lengths of the sources and to the Green's function of the trailing edge dipoles. Author

A88-49014*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
PREDICTION OF HELICOPTER ROTOR DISCRETE FREQUENCY NOISE FOR THREE SCALE MODELS
KENNETH S. BRENTNER (NASA, Langley Research Center, Hampton, VA) Journal of Aircraft (ISSN 0021-8669), vol. 25, May 1988, p. 420-427. Previously cited in issue 08, p. 1152, Accession no. A87-22512. refs

N88-26165*# Sikorsky Aircraft, Stratford, Conn.
RESEARCH INVESTIGATION OF HELICOPTER MAIN ROTOR/TAIL ROTOR INTERACTION NOISE Final Report
J. FITZGERALD and F. KOHLHEPP Washington NASA May 1988 112 p
(Contract NAS1-17126)
(NASA-CR-4143; NAS 1.26:4143) Avail: NTIS HC A06/MF A01 CSCL 20A

Acoustic measurements were obtained in a Langley 14 x 22 foot Subsonic Wind Tunnel to study the aeroacoustic interaction of 1/5th scale main rotor, tail rotor, and fuselage models. An extensive aeroacoustic data base was acquired for main rotor, tail rotor, fuselage aerodynamic interaction for moderate forward speed flight conditions. The details of the rotor models, experimental design and procedure, aerodynamic and acoustic data acquisition and reduction are presented. The model was initially operated in trim for selected fuselage angle of attack, main rotor tip-path-plane angle, and main rotor thrust combinations. The effects of repositioning the tail rotor in the main rotor wake and the corresponding tail rotor countertorque requirements were determined. Each rotor was subsequently tested in isolation at the thrust and angle of attack combinations for trim. The acoustic data indicated that the noise was primarily dominated by the main rotor, especially for moderate speed main rotor blade-vortex interaction conditions. The tail rotor noise increased when the main rotor was removed indicating that tail rotor inflow was improved with the main rotor present. Author

N88-26166*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
SIMULATED MEASUREMENT OF POWER FLOW IN STRUCTURES NEAR TO SIMPLE SOURCES AND SIMPLE BOUNDARIES
MICHAEL C. MCGARY Jun. 1988 68 p
(NASA-TM-89124; NAS 1.15:89124) Avail: NTIS HC A04/MF A01 CSCL 20A

Advances in electronics technology along with the advent of low cost multichannel Fast Fourier analyzers have made it practical to use higher order central difference formulas to measure power flow in 1- and 2-D structures. The method discussed uses five point differencing for the spatial derivatives in 1-D and a thirteen point difference pattern for the spatial derivatives in 2-D plates and shells. It is assumed that the measuring transducers are accelerometers. An analytical study of the higher order differencing method and the conventional two accelerometer method was performed as a preliminary to the application of these methods to actual aircraft structures. Some classical problems were analyzed in order to simulate and compare the performance of the two

methods under near field measurement conditions. These near field conditions include examples of power flows near simple sources and simple boundaries. The estimates produced by the two methods were compared to the exact solution in each example. Presented are the theory and selected results of the study, which indicate that the bias errors of the two accelerometer method under near field measurement conditions may be much larger than previous studies have suggested. Author

N88-26907*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
HELICOPTER MAIN-ROTOR NOISE: DETERMINATION OF SOURCE CONTRIBUTIONS USING SCALED MODEL DATA
THOMAS F. BROOKS, J. RALPH JOLLY, JR. (Planning Research Corp., Hampton, Va.), and MICHAEL A. MARCOLINI Aug. 1988 66 p
(NASA-TP-2825; L-16399; NAS 1.60:2825) Avail: NTIS HC A04/MF A01 CSCL 20A

Acoustic data from a test of a 40 percent model MBB BO-105 helicopter main rotor are scaled to equivalent full-scale flyover cases. The test was conducted in the anechoic open test section of the German-Dutch Windtunnel (DNW). The measured data are in the form of acoustic pressure time histories and spectra from two out-of-flow microphones underneath and foward of the model. These are scaled to correspond to measurements made at locations 150 m below the flight path of a full-scale rotor. For the scaled data, a detailed analysis is given for the identification in the data of the noise contributions from different rotor noise sources. Key results include a component breakdown of the noise contributions, in terms of noise criteria calculations of a weighted sound pressure level (dBA) and perceived noise level (PNL), as functions of rotor advance ratio and descent angle. It is shown for the scaled rotor that, during descent, impulsive blade-vortex interaction (BVI) noise is the dominant contributor to the noise. In level flight and mild climb, broadband blade-turbulent wake interaction (BWI) noise is dominant due to the absence of BVI activity. At high climb angles, BWI is reduced and self-noise from blade boundary-layer turbulence becomes the most prominent. Author

N88-26909*# Duke Univ., Durham, N. C. Dept. of Mechanical Engineering and Materials Science.
AIRCRAFT INTERIOR NOISE REDUCTION BY ALTERNATE RESONANCE TUNING Semiannual Progress Report, period ending Jun. 1988
DONALD B. BLISS, JAMES A. GOTTWALD, MARK B. GUSTAVESON, and JAMES R. BURTON, III Jul. 1988 35 p (Contract NAG1-722)
(NASA-CR-182540; NAS 1.26:182540) Avail: NTIS HC A03/MF A01 CSCL 20A

Model problem development and analysis continues with the Alternate Resonance Tuning (ART) concept. The various topics described are presently at different stages of completion: investigation of the effectiveness of the ART concept under an external propagating pressure field associated with propeller passage by the fuselage; analysis of ART performance with a double panel wall mounted in a flexible frame model; development of a data fitting scheme using a branch analysis with a Newton-Raphson scheme in multiple dimensions to determine values of critical parameters in the actual experimental apparatus; and investigation of the ART effect with real panels as opposed to the spring-mass-damper systems currently used in much of the theory. Author

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SOCIAL SCIENCES

Includes social sciences (general); administration and management; documentation and information science; economics and cost analysis; law and political science; and urban technology and transportation.

A88-46422
THE 'FINANCIAL STABILITY' OF AN AIRLINE - QUO VADIS? [DIE 'WIRTSCHAFTLICHE LEISTUNGSFAEHIGKEIT' DES LUFTFAHRTUNTERNEHMENS - QUO VADIS?]
HORST GRAUMANN Zeitschrift fuer Luft- und Weltraumrecht (ISSN 0340-8329), vol. 37, June 1988, p. 129-139. In German. refs

The criteria applied by the FRG transport ministry to evaluate the financial strength and stability of a company applying for the right to provide commercial air services are examined from a legal perpective, responding to criticisms voiced by Zainhofer (1988). The text of the applicable government regulations is examined in detail, and it is argued that the provisions are compatible with recognized legal principles regarding the public safety and similar to regulations governing other means of transportation; the general reasonableness of applying financial criteria is also defended. With regard to the actual enforcement of the regulations, however, a need for greater clarity and definition, perhaps in the form of written guidelines and procedures, is indicated, and it is stressed that economic criteria cannot legally take the place of constant and thorough monitoring of actual flight-safety and aircraft-maintenance performance. T.K.

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GENERAL

A88-46339
JACK NORTHROP AND THE FLYING WING: THE STORY BEHIND THE STEALTH BOMBER
TED COLEMAN (Coleman Engineering Co., Inc., Los Angeles, CA) and ROBERT WENKAM New York, Paragon House, 1988, 304 p. refs

A development history is presented for the aircraft designs of Jack Northrop in the course of a biographical narrative, giving attention to the aerodynamic and structural design influences that led to the 'flying wing' series of experimental, fighter, and long-range bomber configurations. The first of these, built in 1929, retained a conventional empennage; aircraft begining with the N-1M of 1939, however, were of true all-wing configuration, and included the XP-56 'Silver Bullet' fighter, XB-35 turboprop-powered intercontinental bomber, YB-49 turbojet-powered intercontinental bomber, and XP-79B 'Flying Ram' interceptor. The contributions of Theodore von Karman to these design efforts are noted. O.C.

A88-48935#
A REVISIT TO SUPERSONIC-FLOW THEORY IN THE EARLY FIFTIES
H. K. CHENG (Southern California, University, Los Angeles, CA) IN: AIAA, ASME, SIAM, and APS, National Fluid Dynamics Congress, 1st, Cincinnati, OH, July 25-28, 1988, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 1320-1330. refs
(AIAA PAPER 88-3799)

Topics of theoretical studies on supersonic flows at Cornell University in the early fifties are reexamined in three areas: (1) supersonic biplane of finite span, (2) second-order theory of conical

flows, and (3) extension of the slender-body/wing theory. These studies, along with related works at Cornell Aeronautical Laboratories, are addressed in the light of subsequent development elsewhere. Author

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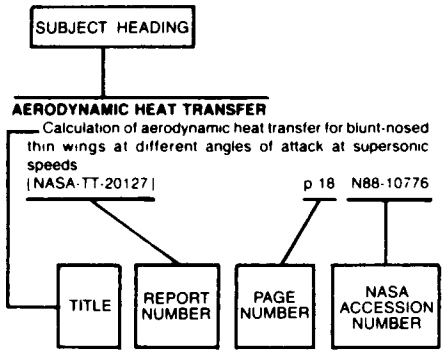

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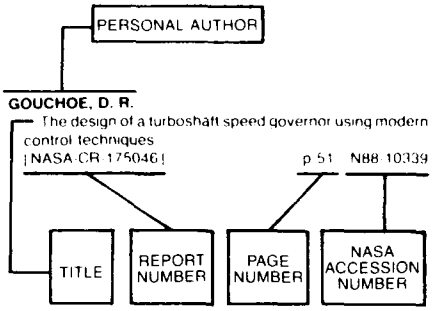

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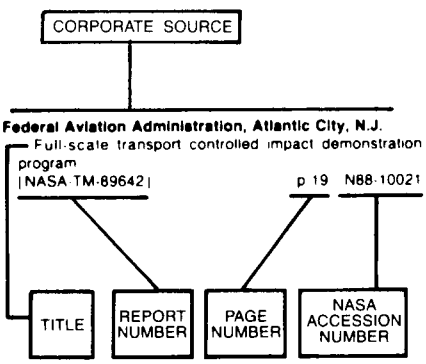

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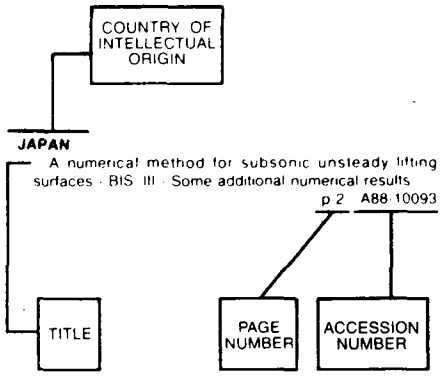

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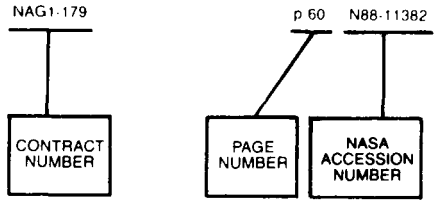

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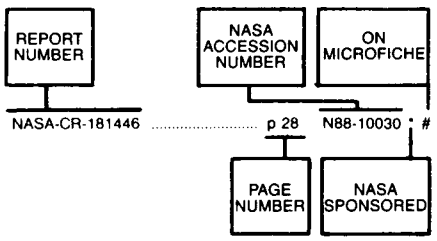

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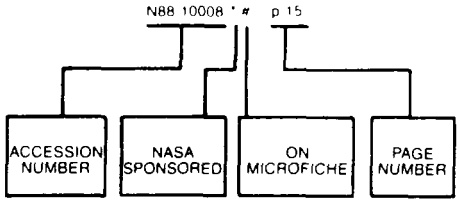

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